RESEARCH ARTICLE



Notes on the genus *Microcriodes* Breuning, with description of a new species from Xizang, China (Coleoptera, Cerambycidae, Lamiinae, Batocerini)

Wen-Xuan Bi^{1,2,†}, Mei-Ying Lin^{1,‡}

I Key Laboratory of Zoological Systematics and Evolution, Institute of Zoology, Chinese Academy of Sciences, Beichen West Road, Chaoyang, Beijing, 100101, China **2** Room 401, No. 2, Lane 155, Lianhua South Road, Shanghai, 201100 China

† http://zoobank.org/B53A211A-4D87-4478-8629-20DC127DA964
‡ http://zoobank.org/1543E619-E3AB-41E2-96D4-60C5A3E57108

Corresponding author: Mei-Ying Lin (linmeiying@ioz.ac.cn)

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Abstract

The genus *Microcriodes* Breuning is newly recorded from China upon the discovery of *M. sikkimensis* Breuning, 1943 and *M. wuchaoi* **sp. n.** from Motuo, Southeast Xizang. Illustrations of the habitus, genitalia including non-everted endophallus, as well as diagnostic features are provided.

Keywords

Microcriodes, new record, new species, taxonomy, Oriental region

Introduction

The genus *Microcriodes* was established by Breuning (1943) on the basis of an Indian species, *M. sikkimensis* Breuning, 1943. Gilmour and Dibb (1948) only referred to Breuning's original description in their revision of the Batocerini, but Gilmour (1963) redescribed the species based on the holotype and an additional pair of specimens.

The locality of one male specimen mentioned by Gilmour (1963) was written in question as China (probably erroneous). Since then, few people have referred to this genus expect for Weigel (2012), who reported *M. sikkimensis* from Arunachal Pradesh, India, and Tavakilian and Chevillotte (2014), who summarized all related information.

From 2010 to 2013, the first author and his team made several expeditions to Southeast mountainous region of Xizang and brought back a large number of cerambycid beetles. In the course of the identification work of these specimens, we found a species which was identical to *M. sikkimensis* and another similar congener.

In this paper, we describe it here as a second new species, *M. wuchaoi* sp. n., and simultaneously review *M. sikkimensis* with supplementary descriptions and notes on the variations. The male genitalia including non-everted endophallus of both species are figured to facilitate the comparison. This is the first formal record of *Microcriodes* from China though a doubtful record was presented by Gilmour (1963).

Materials are deposited in the following institutions, museums or private collections; abbreviations as shown in the text:

CBWX	Collection of Wen-Xuan Bi, Shanghai, China
CCCC	Collection of Chang-Chin Chen, Tianjin, China
IZAS	Institute of Zoology, Chinese Academy of Sciences, Beijing, China
NHML	The Natural History Museum, London, UK
SNUC	Insect Collection of Shanghai Normal University, Shanghai, China

The following abbreviations for terminology of endophallic structures are used in the text: BPH-basal phallomere; MPH-median phallomere; APH-apical phallomere; MT-medial tube; CT-central trunk; PB-preapical bulb.

Results

Microcriodes Breuning, 1943

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

- *Microcriodes* Breuning, 1943: 14. Type species: *Microcriodes sikkimensis* Breuning, 1943, by monotypy.
- *Microcriodes*; Gilmour and Dibb 1948: 99; Gilmour 1963: 483, pl. 2, figs 4-5; Rigout 1982: 10, pl. 14; Nýlander 2004: 249.

Redescription (Breuning 1943; Gilmour and Dibb 1948; partly modified). Body elongate. Eyes coarsely faceted, strongly emarginate; lower lobe large, distinctly longer than width. Frons wider than long. Antennal tubercles widely separated, moderately raised. Antennae long and smooth, more than 1.8 times (in male) or 1.1–1.5 times (in female) as long as body length; basal 3 antennomeres sparsely fringed beneath; scape long and thin, lacking cicatrix, the 3rd antennomere 1.8–2.0 times as long as scape, subequal to the 4th antennomere. Pronotum wider than long; with fine transverse grooves at the anterior and posterior margin and transverse premedian and postmedian depressions; lateral spine short to long, acute at apex; prosternal process widened and emarginate at apex, procoxal cavities slightly open posteriorly; mesosternal process without tubercle and obliquely sloped in lateral view; mesocoxal cavities open externally to epimera. Elytra elongate, more than 3 times as long as the head and pronotum united, subparallel-sided, rounded at apex, distinctly wider than the base of pronotum. Leg long and slender, mesotibia with an external oblique groove near apex, tarsus five segmented, tarsal claws divaricate.

Diagnosis. The following combination of characters apparently separate *Microcriodes* from other genera in Batocerini: Antennae smooth, without spinous rugosity or traces of spines on the surface. Antennal scape lacking a distinct cicatrix. Eye with lower lobe longer than broad.

Notes. Breuning (1943) compared this genus with *Abatocera* Thomson, 1878, suggesting that it belongs to the tribe Batocerini. All authors treated *Microcriodes* as a member of the tribe Batocerini (Gilmour and Dibb 1948; Gilmour 1963; Rigout 1982; Nýlander 2004). However, the endophallus is quite different from that of *Apriona* spp. and *Batocera* spp. according to our observations. The tribal treatment based on analysis of endophallus morphology will be discussed in the future.

Microcriodes sikkimensis Breuning, 1943

http://species-id.net/wiki/Microcriodes_sikkimensis Figures 1–4, 7–10

Microcriodes sikkimensis Breuning, 1943: 15. Type locality: Sikkim. Type depository: NHML.

Microcriodes sikkimensis; Gilmour and Dibb 1948: 100; Gilmour 1963: 483, pl. 2, figs 4–5; Rigout 1982: 10, pl. 14; Weigel 2012: 408, pl. 28, fig. h.

Type material examined. Holotype, female (sex not mentioned in its original description and misidentified as male by Gilmour 1963), "Sikkim" [white label printed]; "Microcriodes / sikkimensis / mihi Type" (handwritten) / "det. Breuning" (printed) [white label]; "Type" [white label with red circle printed] examined through four pictures taken by Yi-Kai Zhang in NHML.

Additional materials examined. (21 specimens, 14 males and 7 females): China: Xizang (Tibet) Autonomous Region: 4 males, 2 females, Xizang, Motuo County (=Mêdog County), Hanmi, 2100m, 2011.VII.23-31, leg. Wen-Xuan Bi (CBWX); 1 male, same date but 2011.VII.29 (CBWX); 1 female, same date but 2011.VII.29 (CBWX); 1 female, same date but 2011.VII.23, leg. Ye Liu (IZAS); 1 male, same date but 2011.VII.23, leg. Ye Liu (IZAS); 1 male, same date but 2013.VII.18 (CBWX); 1 male, same date but 2013.VII.22 (CBWX); 2 males, same date but 2013.VII.29 (CBWX); 1 female, same date but 2013.VII.20 (CBWX); 1 male, same date but 2013.VII.20 (CBWX); 1 male, same date but 2013.VII.20 (CBWX); 2 males, same date but 2013.VII.20 (CBWX); 1 female, same date but 2013.VII.20 (CBWX); 1 male, same date but 2013.VII.20 (CBWX); 2 males, same date but 2013.VII.20 (CBWX); 1 female, same date but 2013.VII.20 (CBWX); 1 female, same date but 2013.VII.20 (CBWX); 1 male, same date but 2013.VII.20 (CBWX); 1 female, same date but 2013.VII.20 (CCC); 1 male, same date but 2013.VII.20 (CCCC); 1 male, same date but 2013.VII.20 (



Figures 1–6. Habitus of *Microcriodes* spp. **I–4** *M. sikkimensis* Breuning, 1943 **I** male (28.0 mm), from Hanmi, Motuo, Xizang, China **2** female (31.0 mm), from 62K, Motuo, Xizang, China **3–4** right elytron, showing the varieties of maculae **5–6** *M. wuchaoi* sp. n. **5** holotype (25.5 mm), male, from 62 K, Motuo, Xizang, China **6** paratype (29.5 mm), female, from same locality. **a** head in frontal view **b** pronotum and basal part of elytra in dorsal view, showing granules on pronotal disk and elytral base. Not to scale.

1,989 m, 2013.VII.26, leg. Xiao-Dong Yang (CCCC); 1 female, same date but 2,128 m, 2013.VII.30, leg. Xiao-Dong Yang (CCCC); 1 male, Xizang, Motuo County, 80 K, 2,100 m, 2012.VII.23, leg. Xiao-Dong Yang (CCCC); 1 female, Xiang, Motuo County, 62 K, 2,780 m, 2013.VIII.13, leg. Chao Wu (CBWX).

Supplementary description. Male (Fig. 1): Length: 21.0–28.0 mm, humeral width: 6.0–9.0 mm. Female (Fig. 2): Length: 30.0–34.0 mm, humeral width: 9.0–

10.5 mm. The elytral maculae of this species is variable but generally as follows: besides some scattered small, round, yellow spots, each elytron provided with three main, bright yellow, well-defined, longitudinal but somewhat irregularly shaped maculae on basal one third, a little behind middle and near apex (Fig. 3); the middle macula commonly fused with the hind one as the holotype, but sometimes attach to the front one (Fig. 4). Antenna with 3^{rd} antennomere twice as long as scape, slightly shorter than 4^{th} in male while slightly longer than 4^{th} in female; relative length of antennomeres as follows: male: 5.5 : 1.0 : 11.8 : 12.1 : 11.4 : 10.3 : 10.1 : 9.1 : 8.7 : 8.4 : 11.9; female: 4.7 : 1.0 : 9.9 : 9.4 : 8.0 : 7.1 : 6.4 : 5.7 : 5.6 : 5.3 : 7.1. Pronotum broader than long, 0.8 times as long as basal width, the width across lateral spines about 1.3 times of basal width; lateral spine long, thickened at base with acute apex; disk smooth, with several fine setigerous granules behind middle. Elytra ca. 1.8 times as wide as pronotal base, 2.7 times as long as humeral width, with some very fine granules at base.

Male genitalia (Figs 7–10). Tegmen (Fig. 7) in lateral view strongly curved near base, ca. 3.5 mm in length, rhombic in shape and widest behind middle in ventral view; lateral lobes ca. two-ninths of total length of tegmen, provided with long setae on apical half. Median lobe (Fig. 8) slightly shorter than tegmen; moderately curved in lateral view; apex rounded subacuminate in antero-dorsal view. Tergite VIII (Fig. 9) nearly as broad as long, apex distinctly emarginate, with moderately long setae. Endophallus in non-everted condition (Fig. 10) long, about 3 times as long as median lobe, with 3 membranous parts, BPH, MPH and APH; BMP short, about one quarter of the length of median lobe; MPH long, about 2.7 times as long as median lobe, strongly curved at basal two-thirds, with MT and CT fused each other, of which delimited from PB by a distinct constriction; MT+CT sparsely provided with small spicules which become denser near swollen apex; PB provided with same kind of spicules as MT+CT, which become denser at apical half, basal part of PB rather narrow, only 0.35 times as wide as anterior part; APH short, cylindrical in shape. Ejaculatory ducts double.

Distribution. China (**new country record**): Xizang (Tibet) Autonomous Region; **India**: "Sikkim" (Breuning 1943), Arunachal Pradesh (Weigel 2012).

Microcriodes wuchaoi sp. n.

http://zoobank.org/E15E3E47-7555-490D-AF0E-B937ABB0E6E2 http://species-id.net/wiki/Microcriodes_wuchaoi Figures 5–6, 11–14

Type material. Holotype: male, "China: Xizang, Motuo, 62K / 2013.VIII.9 / 2780 m / leg. Chao Wu" [white label printed] (SNUC). **Paratype**: 1 female, "China: Xizang, Motuo, 62K / 2013.VIII.10 / 2780 m / leg. Chao Wu" [white label printed] (SNUC).

Description. Male (Fig. 5). Body length 25.5 mm, humeral width 8.0 mm. Body dark brown; most of ventral surface and legs evenly covered with dense grayish yellow pubescence. Head with mandible (base and outer face), frons, gena and vertex densely



Figures 7–14. Male genitalia of the *Microcriodes* spp. **7–10** *M. sikkimensis* Breuning, 1943 **11–14** *M. wuchaoi* sp. n. **7, 11** tegmen **8, 12** median lobe **9, 13** Tergite VIII with sternites VIII & IX **10, 14** endophallus in non-everted condition. **a** vetral view **b** lateral view **c** antero-dorsal view. Scale 1 mm. **10, 14** not to scale.

covered with grayish yellow appressed pubescence. Vertex with two vittae behind upper eyelobes only sparsely pubescent. Antenna with scape covered with same kind of pubescence as head; other parts covered with fine grayish pubescence. Pronotum covered with same kind of pubescence as head except for a median longitudinal glabrous area. Scutellum densely clothed with recumbent pubescence. Elytron densely covered with grayish yellow appressed pubescence, provided with two bright yellow, irregularly shaped maculae on basal one-third and basal two-third near lateral margin; with small, round, yellow spots scattered mainly around suture and near apex.

Body elongate, subcylindrical, feebly narrowed posteriorly. Head nearly as wide as pronotal width at base, occiput with several granules anteriorly; eyes emarginate, coarsely faceted; lower eye lobe twice as long as width, about twice as long as gena (Fig. 5a). Antenna long and thick, about 1.8 times as long as body length, approximately surpassing elytral apex at tip of sixth antennomere; scape gradually thickened apically; scape and basal third of 3rd antennomere sparsely fringed beneath by suberect short setae; 3rd antennomere 1.8 times as long as scape, subequal to 4^{th} and 5^{th} ; relative length of antennomeres as follows: 4.9 : 1.0 : 8.7 : 8.7 : 8.5 : 7.5 : 7.4 : 6.4 : 5.8 : 4.6 : 5.5.

Pronotum broader than long, 0.8 times as long as basal width, the width across lateral spines about 1.25 times of basal width; lateral spine short, thickened at base with acute apex; disk with a posteromedial longitudinally oval callus, provided with several distinct setigerous granules at both sides of callus and behind lateral spines.

Scutellum obtuse-triquetrous. Prosternum with prosternal process widened apically; procoxal cavities closed posteriorly. Mesosternal process without tubercle and obliquely sloped in lateral view.

Elytra ca. 1.8 times as wide as pronotal base, 2.4 times as long as humeral width, very slightly convergent toward apices; basal tenth of elytron provided with distinct round granules near suture and humerus, respectively; disk moderately punctured, becoming more shallow near apices.

Leg moderately slender, mesotibia with an external oblique groove near apical third, metatibia reaching elytral apex at apical one-fourth.

Male genitalia (Figs 11–14). Tegmen (Fig. 11) in lateral view moderately curved, ca. 3.8 mm in length, rhombic in shape and widest near middle in ventral view; lateral lobes ca. one-fourth of total length of tegmen, which moderately provided with short setae on apex. Median lobe (Fig. 12) shorter than tegmen; gently curved in lateral view; apex emarginate in antero-dorsal view. Tergite VIII (Fig. 13) slightly broader than long, apex slightly emarginate with short setae. Endophallus in non-everted condition (Fig. 14) moderately long, about 2.7 times as long as median lobe, with 3 membranous parts, BPH, MPH and APH; BMP short, about one-third length of median lobe; MPH long, about 2.1 times as long as median lobe, strongly curved at basal two-fifths, with MT and CT fused with each other, of which delimited from PB by a moderate constriction; MT+CT slightly swollen at apical tenth, sparsely provided with small spicules as MT+CT, which are getting denser at apical half; basal part of PB moderately narrow, ca. 0.5 times as wide as anterior part; APH short, moderately swollen at middle and rounded at apex. Ejaculatory ducts double.

Female (Fig. 6). Body length 29.5 mm, humeral width 9.4 mm. Almost identical to male in general appearance. Antenna about 1.1 times as long as body, surpassing elytral apex at the middle of tenth antennomere; relative length of antennomeres as follows: 4.6 : 1.0 : 7.4 : 6.5 : 5.7 : 4.9 : 5.0 : 4.4 : 3.7 : 3.2 : 3.8. Leg slightly shorter, metatibia hardly reach elytral apex.

Diagnosis. This new species resembles *M. sikkimensis* Breuning, 1943 by the general habitus, but is distinguishable from the latter by combination of the following characters: color of integument darker; elytron shorter in relation to the body length; antenna shorter and thicker; lower eye lobe narrower; pronotal lateral spine shorter; pronotal disk with a shiny posteromedial callus; distinctly granulated on pronotal disk

and elytral base; elytron with the main maculae relatively short and small, lacking a bright yellow macula near apex.

Etymology. The new species is dedicated to its discoverer, Mr. Chao Wu. We use the Chinese format "Wu +Chao" (family name + first name) for this name.

Distribution. China: Xizang (Tibet) Autonomous Region.

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RESEARCH ARTICLE



Review of Canadian species of the genera Gnathusa Fenyes, Mniusa Mulsant & Rey and Ocyusa Kraatz (Coleoptera, Staphylinidae, Aleocharinae)

Jan Klimaszewski^{1,†}, Reginald P. Webster^{2,‡}, David W. Langor^{3,§}, Caroline Bourdon^{1,1}, H.E. James Hammond^{3,¶}, Greg R. Pohl^{3,#}, Benoit Godin^{4,††}

I Natural Resources Canada, Canadian Forest Service, Laurentian Forestry Centre, 1055 du P.E.P.S., P.O. Box 10380, Stn. Sainte-Foy, Quebec, Quebec, Canada G1V 4C7 2 24 Mill Stream Dr., Charters Settlement, New Brunswick, Canada E3C 1X1 3 Natural Resources Canada, Canadian Forest Service, Northern Forestry Centre, 5320-122 Street, Edmonton, Alberta, Canada T6H 3S5 4 14A Thompson Rd., Whitehorse, Yukon, Canada Y1A 0C4

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 http://zoobank.org/8EB1A90E-239F-4BD3-8DC6-7E7F509C1B96

Corresponding author: Jan Klimaszewski (jan.klimaszewski@nrcan-rncan.gc.ca)

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Abstract

Four species of *Gnathusa* Fenyes (*G. alfacaribou* Klimaszewski & Langor, *G. caribou* Lohse, *G. eva* Fenyes, and *G. tenuicornis* Fenyes) occur in the Nearctic and in Canada. Three species of *Ocyusa* Kraatz (*O. asperula* Casey, *O. californica* Bernhauer, *O. canadensis* Lohse), and three species of *Mniusa* Mulsant and Ray (*M. minutissima* (Klimaszewski & Langor), *M. yukonensis* (Klimaszewski & Godin), and *M. odelli* Klimaszewski & Webster, **sp. n.**), are known from the Nearctic and all but *O. californica* occur in Canada. The recently described *Gnathusa minutissima* Klimaszewski and Langor and *Ocyusa yukonensis* Klimaszewski and Godin, are transferred here to the genus *Mniusa* Mulsant & Rey. New provincial and state records are

Copyright Her Majesty the Queen in Right of Canada. This is an open access article distributed under the terms of the Creative Commons Attribution International License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited. reported for: *G. eva* (Alberta), *G. tenuicornis* (Alberta, Oregon, and New Brunswick), *O. canadensis* (New Brunswick and Newfoundland), *M. minutissima* (New Brunswick), and *M. yukonensis* (Nova Scotia, New Brunswick, Quebec, and British Columbia). The female of *M. yukonensis* was discovered and is illustrated for the first time. The genus *Mniusa* is reported for the first time from Canada and represents the first confirmed generic record for North America. Keys for identification of all Canadian species, images of body and genital structures, maps showing distribution mainly in Canada, and new bionomics data are provided.

Keywords

Staphylinidae, Gnathusa, Mniusa, Ocyusa, Taxonomy, Canada

Introduction

Fenyes (1909) described the genus *Gnathusa* and two species from the Nearctic region, *G. eva* from California and *G. tenuicornis* from British Columbia. More recently, Lohse (Lohse et al. 1990) described a northern species, *G. caribou* from Canada (YT, NWT) and Alaska, and later Klimaszewski and Langor (Klimaszewski et al. 2011) described an additional species, *G. alfacaribou*, from Newfoundland and Labrador, a species closely related to *G. caribou*. Recently, more specimens of *Gnathusa* have become available for study, resulting in new range extensions but no additional new species. It appears that species of this genus are confined to the Rocky Mountains and northern Canada.

Gnathusa is sometimes confused in North American collections with some species of the genus Ocyusa Kraatz (1856). Ocyusa was originally described in Europe and currently includes nine species, excluding two species of Mniusa Mulsant & Rey (Smetana 2004, in Löbl and Smetana 2004). However, Palm (1972) and Ashe (2000) considered Mniusa to be a subgenus of Ocyusa. Osswald et al. (2013) proposed a molecular phylogeny of the rove beetle tribe Oxypodini where they recognised Mniusa and Ocyusa as two distinct genera. They classified Mniusa as closely related to Gnathusa, and Ocyusa as closely related to the Oxypoda, Devia, Ilyobates, Tetraleucopora and Ocalea group of genera. Assing (1998) revised species of Palaearctic Zoosetha Mulsant & Rey and provided a taxonomic history of related genera including Ocyusa. Ocyusa asperula was the first species of this genus described in the Nearctic region, from Rhode Island (Casey 1894). It was later reported by Bernhauer (1906) from Iowa and Massachusetts under the synonymic name O. brevipennis. Webster et al. (2009) reported it for the first time from Canada in New Brunswick. Bernhauer (1906) described O. californica from California, and this species is not found in Canada. Lohse (Lohse et al. 1990) described a new northern species, O. canadensis from Yukon Territory and Alaska. Brunke et al. (2012) reported this species from Ontario, and we report it here from Newfoundland and Labrador, and New Brunswick. Klimaszewski et al. (2011, 2012) described Gnathusa minutissima from the province of Newfoundland and Labrador, and Ocyusa yukonensis from Yukon Territory, but they are here transferred to the genus Mniusa on the basis of pronotal

pubescence along midline directed anteriad in apical third of median line of disc, absence of fronto-clypeal suture, L-shaped spermathecal neck connected to thin stem, and apical margin of male tergite 8 sinuate laterally and produced medially. *Mniusa minutissima* is newly recorded from New Brunswick. Recently, *M. yukonensis* was described from the Yukon Territory under the genus *Ocyusa* (Klimaszewski et al. 2012), and we now provide new records of this species from British Columbia, Quebec, Nova Scotia, and New Brunswick. Here, we have discovered and described another *Mniusa* species, *M. odelli*, which has similar genitalic features to those of *M. yukonensis*, but has a different body form. To facilitate identification of species of *Gnathusa*, *Mniusa*, and *Ocyusa* in Canada, we review their diagnostic features, and provide keys to identification. We also provide extensive illustrations of diagnostic characters, including external body images and genital structures.

Materials and methods

Over 140 adults of the genus *Gnathusa* and 100 adults of *Ocyusa* and *Mniusa* from Canada and the United States were studied, and most specimens were dissected to examine the genital structures and in some cases, mouthpart structures. The genital structures were dehydrated in absolute alcohol, mounted in Canada balsam on celluloid microslides, and pinned with the specimens from where they originated. Images of the entire body and the genital structures were taken using an image processing system (Nikon SMZ 1500 stereoscopic microscope; Nikon Digital Camera DXM 1200F, and Adobe Photoshop software).

Morphological terminology mainly follows that used by Seevers (1978) and Klimaszewski et al. (2011). The ventral side of the median lobe of the aedeagus is considered to be the side of the bulbus containing the foramen mediale, the entrance of the ductus ejaculatorius, and the adjacent ventral side of the tubus of the median lobe with internal sac and its structures (this part is referred to as the parameral side in some recent publications); the opposite side is referred to as the dorsal part. In the species descriptions, microsculpture refers to the surface of the upper forebody (head, pronotum and elytra).

The morphology of antennae and mandibles, body proportions, density of punctures on the forebody, and the shape of the median lobe of the aedeagus and the spermatheca provide the best characteristics for species identification in *Gnathusa*, *Mniusa* and *Ocyusa*.

Depository/institutional abbreviations

- AAFC Agriculture and Agri-Food Canada, Atlantic Cool Climate Crop Research Centre, St. John's, Newfoundland and Labrador, Canada.
- AMNH American Museum of Natural History, New York, New York, USA.

CNC	Canadian National Collection of Insects, Arachnids and Nematodes, Agricul-
	ture and Agri-Food Canada, Ottawa, Ontario, Canada.
ECW	Environment Canada, Whitehorse, Yukon, Canada.
LFC	Natural Resources Canada, Canadian Forest Service, Laurentian Forestry
	Centre, R. Martineau Insectarium, Quebec City, Quebec, Canada.
MUN	Memorial University Collection, St. John's, Newfoundland and Labrador,
	Canada [on long-term loan to David Langor at NoFC].
NoFC	Natural Resources Canada, Canadian Forest Service, Northern Forestry
	Centre, Edmonton, Alberta, Canada.
NSPM	Nova Scotia Provincial Museum, Halifax, Nova Scotia, Canada.
RWC	Reginald Webster Private Collection, Charters Settlement, New Brunswick,
	Canada.
USNM	United States National Museum, Washington, D.C., USA.
ZMB	Zoological Museum of Humboldt University, Berlin, Germany.

Key distinguishing Gnathusa from Mniusa and Ocyusa

1 Mandibles extremely long and narrow, distinctly longer than width of labrum, and sickle-shaped with apices long and very slender, crossing each other in resting position, right mandible bearing a spine and the left a small tooth (Figs 1h,i, 2i,j, 3h,i, 4h,i); frontal suture between eyes absent; ligula more or less deeply bilobed (Figs 11, 2m, 3l, 4l); anterior margin of mesosternum with short V-shaped basal carina Gnathusa Fenyes Mandibles moderately long and broad, each as long as the width of labrum or only insignificantly longer (Figs 5h,i, 6h,i, 7h,i, 8 h,i, 9h,i), apices gradually narrowed and pointed, right mandible bearing a small tooth and the left a slightly less developed one; frontal suture between eyes present (Ocyusa) or absent (Mniusa); ligula shallowly split apically (Figs 51, 61, 71, 81, 91); anterior margin of mesosternum without V-shaped basal carina......2 2 All pronotal setae distributed along midline of pronotum directed posteriad; fronto -clypeal phragma present and visible externally as frontal suture between antennal pits (seen better in diffused light); spermatheca S-shaped with spherical capsule bearing deep and broad invagination and sinuate moderately broad stem (Figs 8e, 9e); tubus of median lobe strongly produced ventrally in lateral view (Figs 8b, 9b); Pronotal setae along midline of pronotum directed anteriad in about apical third of midline and posteriad elsewhere; frontal suture absent; spermathecal capsule spherical or tubular and narrowly extended forming L-shaped neck, connected to thin and elongate stem (Figs 5e, 6e, 7e); tubus of median lobe approximately straight in lateral view and slightly produced ventrally (Figs 5b, 6b, 7b); Canadian species are known from forests Mniusa Mulsant & Rey

Taxonomic review

Gnathusa Fenyes

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

Fenyes 1909: 197. Type species: Gnathusa eva Fenyes.

Diagnosis. Body dark brown to black, compact and robust, subparallel (Figs 1a, 2a,b, 3a, 4a), length 3.5–4.3 mm; integument with distinct meshed microsculpture; head large with mandibles extremely long and sickle-shaped, apices very slender, each crossing the other in resting position, each mandible bearing long spine or tooth (Figs 1h,i, 2i,j, 3h,i, 4h,i); infraorbital carina strong and complete; ligula more or less deeply bilobed (Figs 11, 2m, 3l, 4l); last article of maxillary palpus needle-shaped (Figs 1k, 2l, 3k, 4k); frontal suture of head absent; anterior margin of mesosternum with short V-shaped basal carina, remaining mesosternum uncarinated; mesosternal process long, triangular basally and then narrowly produced and extending to about ¾ length of mesosternal cavities, metasternal process triangular in shape and short, isthmus short; median lobe of aedeagus with large crista apicalis, internal sac structures variable in shape (Figs 1b, 2c, 3b, 4b), paramere with narrowly elongate apical lobe bearing four macrosetae; spermatheca pipe-shaped with spherical or tubular capsule and elongate narrow stem (Figs 1e, 2d, 3e, 4e).

Key to Canadian species of Gnathusa

New provincial and territorial records are indicated in boldface font.

1	Labrum with coarse spines (Fig. 1j); antennal articles 7–10 strongly transverse
	(Fig. 1a); body length 3.5-4.0 mm; integument moderately glossy; genitalic
	structures as illustrated (Fig. 1b,e)Gnathusa eva Fenyes [AB, BC, CA, YT]
_	Labrum with fine setae (Figs 2k, 3j, 4j); antennal articles 7-10 subquadrate
	or slightly transverse (Figs 2a,b, 3a, 4a); body length 2.5-3.7 mm; integu-
	ment usually more glossy; genital structures differently shaped (Figs 2c,d,
	3b,e, 4b,e) 2
2(1)	Antennal articles 5-10 subquadrate (Fig. 2a,b); genitalia as illustrated (Figs
	2c,d); body length 2.5–3.7 mm
_	Antennal articles 5-10 slightly transverse (Figs 3a, 4a); genitalia differently
	shaped (Figs 3b,e, 4b,e); body length 2.8–3.6 mm3
3(2)	Head slightly narrower and smaller than pronotum in dorsal view (Fig. 4a);
	antennae brown or yellowish-brown; basal part of abdominal tergite III deep-
	ly impressed and moderately coarsely-densely punctate; genitalia as illustrated
	(Fig. 4b,e) Gnathusa alfacaribou Klimaszewski & Langor [NF, LB]

1. Gnathusa eva Fenyes

http://species-id.net/wiki/Gnathusa_eva Figure 1a–l, Map 1

Diagnosis. Body length 3.5–4.0 mm, sides subparallel; body colour light brown to dark brown, antennae and tarsi rust-brown, head and abdomen often dark brown; integumental microsculpture dense and surface moderately glossy; head round and almost as wide as pronotum with labrum bearing long spines; pronotum transverse, angular, wider than maximum width of elytra; elytra at suture subequal in length to pronotum; abdomen subparallel; antennal articles 6-10 moderately-to-strongly transverse, last article short and broadly oval (Fig. 1a). MALE: tergite VIII widely truncate apically (Fig. 1c); sternite VIII slightly pointed at apex (Fig. 1d); median lobe of aedeagus with tubus arcuate and apex pointed and produced ventrally in lateral view (Fig. 1b). FEMALE: tergite VIII truncate apically (Fig. 1f); sternite VIII rounded apically (Fig. 1g); spermatheca pipe-shaped, with short sac-shaped capsule and long, thin and sinuate stem, spermathecal neck weakly sclerotized and neck to capsule angle variable (Fig. 1e).

Distribution. The Canadian distribution of this native Nearctic species includes Alberta [new provincial record], British Columbia (Majka and Klimaszewski 2008), and Yukon Territory (Map 1). It is also known from California (Fenyes 1909).

Bionomics. Adults were captured in clear-cut Sitka spruce forest on Vancouver Island and in moss and gravel at the edge of small pools at other localities in the interior of British Columbia (Klimaszewski and Winchester 2002). Additional specimens were found in British Columbia in a 1-year-old harvested Douglas-fir stand. In westcentral Alberta, adults were collected in pitfall traps deployed in Upper Cordilleran coniferous forests, including subxeric lodgepole pine forests, mesic white spruce and lodgepole pine stands and spruce-dominated subhygric and hygric forests, but not in deciduous-dominated forest or in grassy or shrubby meadows. In Alberta, adults also emerged from lodgepole pine trees infested by bark beetles. In the Yukon Territory, adults were found in a squirrel midden in spring, probably overwintering, and in a coniferous woodchip pile.

Locality data. CANADA: Alberta: Lusk Creek, Kananaskis F.E.S., 14.VII.1971, J.M. & B.A. Campbell (CNC) 1 male, 4 females; vicinity of Swan Hills, 54°42'N, 115°23'W, *PicealPinus* forest, 15.VI.1990, D.W. Langor (NoFC) 2 males; Grande Prairie, 64 km S, 54.5597°N, 118.6633°W, emergence trap on MPB infested lodgepole

Gnathusa eva Fenyes 1909: 198, 1920: 352, Moore and Legner 1975: 458, Majka and Klimaszewski 2008: 88.



Figure 1. *Gnathusa eva* Fenyes: **Ia** habitus **Ib** median lobe of aedeagus in lateral view **Ic** male tergite VIII **Id** male sternite VIII **Ie** spermatheca in lateral view **If** female tergite VIII **Ig** female sternite VIII **Ih** left mandible **Ii** right mandible **Ij** labrum **Ik** maxilla **II** menthum, labial palpi and ligula. Habitus scale bar = 1.0 mm; other scale bars = 0.2 mm.

pine, 14 July 2011, col. Bleiker (NoFC) 1 female; same data except 15 July 2011, 1 female, 1 sex undetermined; Grande Prairie, 75 km S, 54.4706°N, 118.6560°W, 13 Aug. 2011, emergence trap on MPB infested lodgepole pine, col. Bleiker (NoFC) 1 sex undetermined; Fox Creek, 24 km E, 54.4575°N, 116.4377°N, emergence trap on MPB infested lodgepole pine, 9 Aug. 2011, col. Bleiker (NoFC) 1 female; Fox Creek, 7 km SW, 54.3241°N, 116.8335°W, emergence trap on MPB infested lodgepole pine, 18 July 2011, col. Bleiker (NoFC) 1 sex undetermined; 20 km NW Hinton, 4 km NW of Jarvis Lake, 53.484°N, 117.854°W, Ecosite Surrogacy Study, Ecoregion: UF, Ecosite I1, Stand 1103, pitfall trap # 4, 19.VI-3.VII.2004, J. Hammond et al. coll. (NoFC) 1 sex undetermined; 20 km S Hinton, 31.V.1990, pitfall trap, D. Langor (NoFC) 1 sex undetermined; 21.3 km NW Hinton, W.A. Switzer Prov. Pk., 53.529°N, 117.824°W, Ecosite Surrogacy Study, Ecoregion: UF, Ecosite E1, Stand E129, pitfall trap # 5, 3-17.VII.2004, J. Hammond et al. coll. (NoFC) 1 female; 23 km NW Hinton, 1.7 km W of Gregg Lake, 53.545°N, 117.821°W, Ecosite Surrogacy Study, Ecoregion: UF, Ecosite H1, Stand H101, pitfall trap # 1, 2-16.VII.2004, J. Hammond et al. coll. (NoFC) 1 female; 25 km NW Hinton, west side Hay River Rd., 53.502°N, 117.909°W, Ecosite Surrogacy Study, Ecoregion: UF, Ecosite C1, Stand C101, pitfall trap # 4, 2-17.VII.2004, J. Hammond et al. coll. (NoFC) 1 male; same data except: pitfall trap # 6, 17-31.VII.2004, J. Hammond et al. coll. (NoFC) 1 sex undetermined; 26 km SE Hinton, 7 km S of Gregg River Rd., 53.220°N, 117.343°W, Ecosite Surrogacy Study, Ecoregion: UF, Ecosite H1, Stand H104, pitfall trap # 1, 16.V-1.VI.2004, J. Hammond et al. coll. (NoFC) 2 sex undetermined; 32 km NW Hinton, 1 km W of Rock Lake Rd., 53.561°N, 117.998°W, Ecosite Surrogacy Study, Ecoregion: UF, Ecosite F1, Stand F104, pitfall trap # 1, 2–16.VI.2004, J. Hammond et al. coll. (NoFC) 1 male, 5 sex undetermined; 33 km NW Hinton, 3.75 km N of Highway 40, 53.594°N, 117.964°W, Ecosite Surrogacy Study, Ecoregion: UF, Ecosite E1, Stand E108, pitfall trap # 4, 4–18.VI.2004, J. Hammond et al. coll. (NoFC) 1 female, 1 sex undetermined; 34 km NW Hinton, 0.5 km W of Highway 40, Ecosite Surrogacy Study, Ecoregion: UF, Ecosite F1, Stand F102, pitfall trap # 4, 4–18.VI.2004, J. Hammond et al. coll. (NoFC) 3 sex undetermined; 35 km NW Hinton, 3.75 km N of Highway 40, 53.596°N, 118.002°W, Ecoregion: UF, Ecosite D1, Stand D109, pitfall trap # 4, 2–16.VII.2004, J. Hammond et al. coll. (NoFC) 1 female; 36 km NW Hinton, 3.75 W of Rock Lake Rd., 53.564°N, 118.046°W, Ecosite Surrogacy Study, Ecoregion: UF, Ecosite I1, Stand I107, pitfall trap # 4, 14.V-4.VI.2004, J. Hammond et al. coll. (NoFC) 1 female; 59 km NW Hinton, 3.5 km N of Polecat Rd., 53.902°N, 117.911°W, Ecosite Surrogacy Study, Ecoregion: UF, Ecosite H1, Stand H105, pitfall trap # 2, 3-17.VI.2004, J. Hammond et al. coll. (NoFC) 1 sex undetermined; 62 km N Hinton, 5 km W of J. Wright Rd., 53.969°N, 117.668°W, Ecosite Surrogacy Study, Ecoregion: UF, Ecosite F1, Stand F105, pitfall trap # 2, 12.V–2.VI.2004, J. Hammond et al. coll. (NoFC) 1 female, 1 sex undetermined; 63 km N Hinton, 3.75 km S of J. Wright Rd., 53.974°N, 117.449°W, Ecosite Surrogacy Study, Ecoregion: UF, Ecosite D1, Stand D102, pitfall trap # 2, 30.VI-14.VII.2004, J. Hammond et al. coll. (NoFC) 1 male, 1 female; 65 km N Hinton, 5 km W of J. Wright Rd., 53.995°N, 117.656°W, Ecosite Surrogacy Study, Ecoregion: UF, Ecosite E1, Stand E118, pitfall trap # 5, 30.VI-14.VII.2004, J. Hammond et al. coll. (NoFC) 1 sex undetermined; 67 km N Hinton, north side of J. Wright Rd., 53.998°N, 117.435°W, Ecosite Surrogacy Study, Ecoregion: UF, Ecosite D1, Stand D104, pitfall trap # 2, 2-16.VI.2004, J. Hammond et al. coll. (NoFC) 1 sex



Maps I-2.

undetermined. **British Columbia**: Fort St. James, PG13B-trap 4, 10.V. 1995 (CNC) 1 female; same data except: GP 11 km-2, 1 year post harvest (CNC) 1 male; GP 115, 30.V.1996, 1 year post harvest, R. Felix (CNC) 1 male; 20.VI.1920, GP 11 km, 2 years post harvest, D. Rodriguez (CNC) 1 female; 4.VIII.1996, Tachie-Pinchi, M. Cloet, trap 5 (CNC) 1 female; GP 11 km-2, 10.V.1995, 1 year post harvest (CNC) 3 females; 21 km SW Campbell River, 49°51'55"N, 125°27'51"W, 22.V-6.VI.1996, Balsam Cr., LT 1-T, 1-E (LFC) 2 males; Monashee Mountain near Cherryville, 12.VIII.1982, R. Baranowski (LFC, MZLU) 1 female, 1 sex undetermined [published record Majka and Klimaszewski 2008]. **Yukon Territory**: Whitehorse, Paddy's Pond, 15.V.2010, 60.7067°N 135.0917°W, 649 m, soil sifting, squirrel midden, B. Godin (ECW) 2 males, 3 females; Whitehorse, Granger subdivision, coniferous woodchip pile, 2.IX.2007, 60.7097°N, 135.0996°W, 661 m, pitfall trap, B. Godin (ECW) 1 male; same data as before except: 3.V.2008 (ECW) 2 males.

UNITED STATES OF AMERICA: **California**: Mono Co., 6 mi SW Toms Place, 9000', 8.VIII.1969, A. Smetana (CNC) 3 males, 1 female [not shown in Map 1].

2. Gnathusa tenuicornis Fenyes

http://species-id.net/wiki/Gnathusa_tenuicornis Figure 2a–m, Map 2

Gnathusa tenuicornis Fenyes 1921: 26, Moore and Legner 1975: 458, Klimaszewski and Winchester 2002: 58.

Diagnosis. Body length 2.5–3.7 mm, sides subparallel; body colour light brown to almost black, with antennae, tarsi and often elytra and apical part of abdomen rustbrown; integumental microsculpture dense and surface strongly glossy; head round (Fig. 2a) to somewhat quadrate (Fig. 2b) and almost as wide as pronotum, labrum with short fine setae but lacking coarse spines; pronotum transverse, subequal to slightly narrower than maximum width of elytra, corners somewhat angular; elytra at suture subequal in length to pronotum; abdomen subparallel; antennal articles 6–10 subquadrate, last article short and broadly oval (Fig. 2a,b). MALE: tergite VIII widely truncate apically (Fig. 2e); sternite VIII slightly pointed at apex (Fig. 2f); median lobe of aedeagus with tubus almost straight and apex pointed ventrally in lateral view (Fig. 2c). FE-MALE: tergite VIII truncate apically (Fig. 2g); sternite VIII rounded apically (Fig. 2h); spermatheca pipe-shaped, with spherical capsule and long, thin, and slightly sinuate stem, neck weakly sclerotized, and neck to capsule angle variable (Fig. 2d).

Distribution. This native Nearctic species was described from specimens captured in Glacier, British Columbia, later recorder from Yokon, and is herein recorded for the first time from Alberta and New Brunswick (four female specimens tentatively identified as this species) (Map 2). In the United States, this species was previously known from California (Fenyes 1921, Moore and Legner 1975, Klimaszewski and Winchester 2002), and is herein recorded for the first time from Oregon.



Figure 2. *Gnathusa tenuicornis* Fenyes: **2a** habitus, based on female from New Brunswick **2b** habitus based on male from Alberta **2c** median lobe of aedeagus in lateral view **2d** spermatheca in lateral view **2e** male tergite VIII **2f** male sternite VIII **2g** female tergite VIII **2h** female sternite VIII **2i** left mandible **2j** right mandible **2k** labrum **2l** maxilla **2m** menthum, labial palpi and ligula. Habitus scale bar = 1.0 mm; other scale bars = 0.2 mm.

Bionomics. Adults were captured in a clear-cut Sitka spruce forest on Vancouver Island and in moss and gravel at the edge of small pools in British Columbia (Klimaszewski and Winchester 2002). Other adults were found in a subalpine meadow at 3000 feet, in cold moss and gravel along the edges of streams. The Yukon specimens were taken from mixed aspen and spruce forest by sifting litter. In west-central Alberta, adults were collected in pitfall traps deployed in Upper Cordilleran coniferous forests, including subxeric lodgepole pine forests, mesic white spruce and lodgepole pine stands and and spruce-dominated subhygric and hygric forests, but not in deciduous-dominated forest or in grassy or shrubby meadows. The New Brunswick specimens were taken from moss and leaves under alders near a brook in an eastern white-cedar swamp and from under cobblestones and gravel in sand on a partially shaded cobblestone bar near the outflow of a brook into a river. Adults were captured from May through August.

Locality data. CANADA: Alberta: Waterton Lakes National Park, Cameron Lake, 5450', 4.VIII.1976, J.M. Campbell (CNC) 1 male; 20 km S Hinton, 20.VII.1989, pitfall trap, D. Langor coll., site C, trap 6, conifer study (NoFC) 1 male; 20 km S Hinton, 26.VI.1989, D. Langor coll., site C, trap 6, conifer study (NoFC) 1 male; 26 km SE Hinton, 7 km S of Gregg River Rd., 53.220°N, 117.343°W, Ecosite Surrogacy Study, Ecoregion: UF, Ecosite H1, Stand H104, pitfall trap # 4, 15-29.VI. J. Hammond et al. (NoFC) 2 males, 1 female; 31 km SE Hinton, 3 km of Highway 40, 53.593°N, 117.925°W, Ecosite Surrogacy Study, Ecoregion: UF, Ecosite D1, Stand D108, pitfall trap # 6, 11.V-3.VI. J. Hammond et al. (NoFC) 1 male; 32 km NW Hinton, 3 km W of Highway 40, 53.586°N, 117.954°W, Ecosite Surrogacy Study, Ecoregion: UF, Ecosite E1, Stand E103, pitfall trap # 5, 11.V-4.VI. J. Hammond et al. (NoFC) 1 male; 32 km NW Hinton, 1 km W of Hay River Rd., 53.760°N, 117.652°W, Ecosite Surrogacy Study, Ecoregion: UF, Ecosite 1102, Stand 1102, pitfall trap # 2, 13.V-3.VI. 2004, J. Hammond et al. (NoFC) 1 male, 1 female; 43 km SE Hinton, 1.5 km N Coalspur, 53.194°N, 117.046°W, Ecosite Surrogacy Study, Ecoregion: UF, Ecosite B1, Stand B103, pitfall trap # 6, 1–15.VI.2004, J. Hammond et al. (NoFC) 1 male; 55 km N Hinton, north side of Polecat Rd., 53.855°N, 117.926°W, Ecosite Surrogacy Study, Ecoregion: UF, Ecosite H1, Stand H103, pitfall trap # 3, 3-17.VI.2004, J. Hammond et al. (NoFC) 1 male, 1 female; 65 km N Hinton, 5 km W of Wright Rd., 53.995°N, 117.656°W, Ecosite Surrogacy Study, Ecoregion: UF, Ecosite E1, Stand E118, pitfall trap # 5, 2–16.VI.2004, J. Hammond et al. (NoFC) 2 females; 69.5 km N Hinton, 0.7 km NW of JV Haul Rd., 54.017°N, 117.618°W, Ecosite Surrogacy Study, Ecoregion: UF, Ecosite D1, Stand D103, pitfall trap # 5, 1–16.VI.2004, J. Hammond et al. (NoFC) 1 female. British Columbia: Glacier, Fenyes collection (CAS) 1 female [holotype]; Nitinat, Heather Mtn., subalpine meadow at 3000', 14.VII.1979, I.M. Smith, moss on seepage slope (CNC) 1 female; Forbidden Plateau, Murray Meadows, 3400', 21.VII.1975, J.M. and B.A. Campbell (CNC) 1 female; Queen Charlotte Islands, 10.5 km NW Rennell, Sound Rd., Ghost Main Rd., 900', J.M. Campbell, cold moss along stream (CNC) 1 male; Queen Charlotte Islands, Moresby Is., Mt. Moresby, 25.VII.1983, 2100', J.M. Campbell, ex gravel at edge of stream (CNC) 1 male; 20 mi E Hope, Manning Pk., 21.VI.1968, Campbell and Smetana (CNC) 1 female; Copper River Valley, A37574/ P4–1-1, 6.VI–5.VII.1996, pitfall trap, J. Lemieux (LFC) 1 female; same data except: 5.VII– 12.VIII.1996, (LFC) 1 male; Upper Carmanah Valley, UTM: 10U CK 803005, 16.VII-30.VII.1991, CC MT3, N. Winchester (LFC) 2 females [additional records from the same locality Klimaszewski and Winchester 2002]. Yukon Territory: Whitehorse, Paddy's

Pond, 6.V.2007, 60.7067°N 135.0917°W, 649 m, litter sifting, mixed aspen and spruce forest, B. Godin (ECW) 1 male [record from Klimaszewski et al. 2012]. **New Brunswick**: Restigouche Co., MacFarlane Brook Protected (Natural) Area, 47.6018°N, 67.6263°W, 25.V.2007, R.P. Webster // old growth eastern white cedar swamp, in moss & leaves under alders near stream (RWC) 2 females; Jacquet River Gorge PNA, 47.8257°N, 66.0779°W, 24.V.2010, R.P. Webster // partially shaded cobblestone bar near outflow of brook at Jacquet River, under cobblestones & gravel on sand (RWC) 1 female; Mount Atkinson, 441 m elev., 41.8192°N, 68.2618°W, 7.VII.2011, R.P. Webster // Boreal forest, small shaded spring-fed brook with mossy margin, sifting moss (LFC) 1 female.

UNITED STATES OF AMERICA: Alaska: Kenai Peninsula, 2 mi NE Soldotna, 10.VI.1978, Smetana and Becker (CNC) 1 female. Oregon: Mt. Hood, Timberline Lodge Road, 4500–5000', 28.VI.1974, A. and D. Smetana (CNC) 1 male.

Comments. We have tentatively included the females from New Brunswick as belonging to this species. The difference in body colour, the slightly different shape of pronotum and the temples of the head in the New Brunswick and western specimens we attribute to infraspecific variations because the shape of spermatheca and the tergites and sternite VIII are similar in females of both populations. The study of males from New Brunswick is critical to confirm our identification. The specimens from the north usually are darker than the specimens from more southern localities in many species of aleocharines.

3. Gnathusa caribou Lohse

http://species-id.net/wiki/Gnathusa_caribou Figure 3a–l, Map 2

Gnathusa caribou Lohse, in Lohse et al. 1990: 146; Klimaszewski et al. 2011: 55.

Diagnosis. Body length 2.8–3.6 mm, sides narrowly subparallel; body colour dark brown to almost black, with antennae bright yellow and tarsi rust-brown to yellowish; integumental microsculpture dense and surface strongly glossy; head round, about the same size as the pronotum, labrum lacking stout spines but with fine setae of unequal length; pronotum small, transverse, angular, slightly narrower than elytra; elytra at suture subequal in length to pronotum; abdomen subparallel; antennal articles 6–10 subquadrate to slightly transverse, last article short and broadly oval (Fig. 3a). MALE: tergite VIII widely truncate apically (Fig. 3c); sternite VIII slightly pointed at apex (Fig. 3d); median lobe of aedeagus with tubus almost straight and apex pointed ventrally in lateral view (Fig. 3b). FEMALE: tergite VIII truncate apically (Fig. 1f); sternite VIII rounded apically (Fig. 3g); spermatheca pipe-shaped, with spherical capsule and long and straight stem, neck well sclerotized (Fig. 3e).

Distribution. This native Nearctic species is known in Canada from the Northwest Territories and Yukon Territory (Map 2), and from Alaska (Lohse et al. 1990).

Bionomics. Adults were captured from June to July in tundra by sifting organic litter under *Salix*, moss, and a pile of leaves stored by a rodent.



Figure 3. *Gnathusa caribou* Lohse: **3a** habitus **3b** median lobe of aedeagus in lateral view **3c** male tergite VIII **3d** male sternite VIII **3e** spermatheca in lateral view **3f** female tergite VIII **3g** female sternite VIII **3h** left mandible **3i** right mandible **3j** labrum **3k** maxilla **3l** menthum, labial palpi and ligula. Habitus scale bar = 1.0 mm; other scale bars = 0.2 mm.

Locality data. CANADA: Northwest Territories: Lac Maunoir, North shore, 19–27.VII.1969, G.E. Shewell (CNC) 1 male; Reindeer Sta., Caribou Hills, 2.VII.1972, A. Smetana (CNC) 1 male, 2 females, 1 sex undetermined [paratypes];

same label data except: 30.VI.1972 (CNC) 1 female [paratype]. **Yukon Territory**: British Mts., Firth River, 250 m, 69°13'N, 140°04'W, 25.VI.1984, 84–31, tundra, sifting litter under *Salix* (CNC) 1 male [holotype]; same label data (CNC) 1 female, 3 sex undetermined [paratypes]; British Mts., Windy Ridge, 550 m, 69°27'N, 140°25'W, 2.VII.191984, 84–46, sifting moss, J.M. Campbell (CNC) 4 sex undetermined [paratypes]; British Mts., Fish Creek, 200 m, 69°27'N, 140°23'W, 5.VII.1984, 84–58, sifting moss and arctic willow on tundra, J.M. Campbell (CNC) 1 female, 4 sex undetermined [paratypes]; British Mts., Sunday Mts., 680 m, 69°14'N, 140°05'W, 24.VI.1984, sifting pile of leaves stored by rodent, J.M. Campbell (CNC) 1 male, 2 females, 4 sex undetermined [paratypes]; Dawson City, 11.VII.1968, Campbell and Smetana (CNC) 1 male, 1 female; Dempster Hwy., mi 53, North Fork Pass, 24.VII.1978, 4200', A. Smetana and J.M. Campbell (CNC) 1 female, 1 sex undetermined [paratypes].

UNITED STATES OF AMERICA: Alaska: Prudhoe Bay Rd., 9 mi N Atigun Pass, 68°14'N, 149°25'W, 6.VII.1978, 3100', J.M. Campbell and A. Smetana (CNC) 1 female, 3 sex undetermined [paratypes]; mi 104.5 Denali Hwy., Brushkana Cr., 15.VII.1978, A. Smetana and J.M. Campbell (CNC) 1 sex undetermined [paratype]; mi 110 Denali Hwy., Seattle Cr., 15.VII.1978, J.M. Campbell and A. Smetana (CNC) 1 male [paratype]; mi 24, Wales Hwy., Hess Cr., 600', 65°40'N, 149°10'W, 10.VII.1978, J.M. Campbell and A. Smetana (CNC) 1 male [non-paratype].

4. Gnathusa alfacaribou Klimaszewski & Langor

http://species-id.net/wiki/Gnathusa_alfacaribou Figure 4a–l, Map 3

Klimaszewski et al. 2011: 55–56.

Diagnosis. Body length 3.0–3.4 mm, sides subparallel; body colour dark brown, with tarsi lighter and antennae brown and often with reddish tinge; head round and almost as wide as pronotum or at most as wide as pronotum, equal in size to pronotum; pronotum transverse, angular, about as wide as maximum width of elytra; abdomen subparallel, at base as wide as elytra, widest in apical half; antennal articles 5–10 quadrate to slightly transverse (Fig. 4a). MALE: tergite VIII pointed apically (Fig. 4c); sternite VIII slightly pointed at apex (Fig. 4d); median lobe of aedeagus with tubus strongly produced ventrally in lateral view, apex pointed (Fig. 4b). FEMALE: tergite VIII truncate apically (Fig. 4f); sternite VIII rounded apically (Fig. 4g); spermatheca pipe-shaped, with small spherical capsule and long, thin and almost straight stem (Fig. 4e).

Distribution. This native Nearctic species is known only from Labrador (Map 3).

Bionomics. This epigaeic species was collected from June to October using pitfall and flight intercept traps in black spruce-lichen, spruce-moss and old fir forests.

Locality data. CANADA: **Newfoundland**: Labrador, Middle Brook, Lake Melville, Plot: MID 4, 17.VI.2005 (LFC) 1 male [holotype]; Labrador, Middle Brook, Lake Mel-



Figure 4. *Gnathusa alfacaribou* Klimaszewski and Langor: **4a** habitus **4b** median lobe of aedeagus in lateral view, partially reconstructed below broken line in Fig. **4b**, and above broken line in Fig. **4c**, **4d**; based on the holotype **4c** male tergite VIII partially reconstructed above broken line, based on the holotype **4d** male sternite VIII partially reconstructed above broken line, based on the holotype **4e** spermatheca in lateral view **4f** female tergite VIII **4g** female sternite VIII **4h** left mandible **4i** right mandible **4j** labrum **4k** maxilla **4l** menthum, labial palpi and ligula. Habitus scale bar = 1.0 mm; other scale bars = 0.2 mm.



Maps 3-4.

ville, Plot: MID 4, 17.VI.2005 (MUN) 1 male [paratype]; same data except: Plot: MID 3, 4.VII.2005 (MUN) 1 female [paratype], Plot: MID 4 (MUN) 1 female [paratype], Plot: MID 5, 18.VII.2005 (MUN) 1 female [paratype]; Labrador, Ossak Camp, Station 1, lichen-black spruce forest, 8.X.2004 (MUN) 1 female [paratype]; SW Labrador, 72 km E Labrador City, Rt. 500, km 93, 53°08.6 N, 66°05.9 W, 12–27.VIII.2001, S. and J. Peck, FIT, 600 m, spruce-moss forest 2001-34 (LFC) 1 female [paratype].

Mniusa Mulsant & Rey

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

Mniusa Mulsant & Rey, 1875. Type species: Homalota incrassata Mulsant & Rey.

Diagnosis. Body dark brown to black, compact, sides subparallel or body narrowly oval in outline (Figs 5a, 6a, 7a), length 2.0–3.2 mm; integument with distinct meshed microsculpture and moderately dense punctation and pubescence; head large with mandibles broad and long, left mandible with a small tooth (Figs 5h, 6h, 7h), and right one with a slightly larger tooth at the base of arcuate cutting edge of mandible, apices strongly narrowly elongate [more than in Ocyusa and less than in Gnathusa] (Figs 5h,i, 6h,i, 7h,i); infraorbital carina strong and complete; ligula shallowly split apically (Figs 51, 61, 71); labial palpus with three articles, second article minute, last one needle-shaped (Figs 51, 61, 71), and lacinia and galea as illustrated (Figs 5k, 6k, 7k); labrum narrow and transverse, apical edge entire (Figs 5j, 6j, 7j); frontal suture of head absent; pronotal pubescence along midline directed anteriad or obliquely anteriad in about apical third and posteriad or obliquely posteriad medio-basally; anterior margin of mesosternum without longitudinal carina; mesosternal process triangular basally and then produced and extending from 1/3 to almost 2/3 length of mesosternal cavities, metasternal process triangular in shape and short; isthmus short to long; median lobe of aedeagus strongly produced ventrally, internal sac structures as illustrated (Figs 5b, 6b, 7b); spermatheca with spherical or tubular capsule narrowed posteriorly into L-shaped neck, invagination narrow; stem narrowly elongate (Figs 5e, 6e, 7e).

Key to Canadian species of Mniusa

New provincial and territorial records are indicated in boldface font.

1. Mniusa minutissima (Klimaszewski & Langor, 2011)

http://species-id.net/wiki/Mniusa_minutissima Figure 5a–l, Map 3

Gnathusa minutissima Klimaszewski et al. 2011: 55.

Diagnosis. Body length 2.0–2.3 mm, sides subparallel; body colour dark brown, with tarsi and often tibiae rust-brown, antennae brown; forebody with dense microsculpture, glossy and with moderately dense punctation and pubescence; head round, narrower than pronotum; pronotum transverse, rectangular in shape with sides feebly arcuate, and as wide as elytra; elytra at suture as long as pronotum (Fig. 5a); abdomen subparallel, narrower than elytra with deep basal impressions on first three visible tergites; antennae with articles V-X strongly transverse, with the outer segments at least twice as wide as long (Fig. 5a). MALE: male tergite VIII widely truncate apically (Fig. 5c); sternite VIII slightly produced at apex (Fig. 5d); median lobe of aedeagus with straight venter of tubus slightly arched laterally and internal sac with band-formed, subapical structure (Fig. 5g); spermatheca with small spherical capsule with small invagination, short L-shaped neck, and long, thin and broadly curved stem (Fig. 5e).

Distribution. This native Nearctic species was described from Newfoundland and is herein recorded for the first time from New Brunswick (Map 3).

Bionomics. Adults were collected from May to July using pitfall traps in an old boreal balsam fir forest in Newfoundland; by sifting moss near a brook, sifting deep conifer litter at base of large red spruce in a mature red spruce forest, and from Lindgren funnel traps in a rich Appalachian hardwood forest in New Brunswick.

Locality data. CANADA: **Newfoundland**: Little Grand L., 2 km E. Martin Pond, 24.VI–15.VII.1992, old fir forest, pitfall 13, (LFC) 1 male [holotype]; same data except: pitfall 19, (CFS-CB) 1 male and 1 female [paratypes]; same data except: pitfall 20, 2 males and 1 female [paratypes]; pitfall 16, 1 female [paratype]; pitfall 13, 1 female [paratype]; pitfall 20, (LFC) 1 female paratype; Little Grand L., Bakeapple



Figure 5. *Mniusa minutissima* (Klimaszewski & Langor): **5a** habitus **5b** median lobe of aedeagus in lateral view **5c** male tergite VIII **5d** male sternite VIII **5e** spermatheca in lateral view **5f** female tergite VIII **5g** female sternite VIII **5h** left mandible **5i** right mandible **5j** labrum **5k** maxilla **5I** menthum, labial palpi and ligula. Habitus scale bar = 1.0 mm; other scale bars = 0.2 mm.

Brook, 24.VI–15.VII.1992, old fir forest, pitfall 1, (CFS-CB) 1 male [paratype]; same data except: pitfall 4, 1 male; pitfall 11, 1 female [paratype]; pitfall 3, (LFC) 1 female [paratype]; Manuals R., 8 km W. St. John's, 10.VI.1984, D. Langor, Lot,

(CFS-CB) 1 female [paratype]. **New Brunswick**: Sunbury Co., Acadia Research Forest, 45.9799°N, 66.3394°W, 14.V.2007, 18.VI.2007 // mature red spruce and red maple forest, sifting moss near brook, R.P. Webster (LFC, RWC) 3 males, 2 females; same locality data and forest type but 14.V.2007 // sifting deep conifer litter at base of large red spruce (RWC) 2 females: Carleton Co., Jackson Falls, "Bell Forest", 46.2200°N, 67.7231°W, 4–12.VI.2008, R.P. Webster // Rich Appalachian Hardwood Forest with some conifers, Lindgren funnel trap (RWC) 1 female; same locality data and forest type but 1–8.VI.2009, 8–16.VI.2009, R. Webster & M.-A. Giguère, Lindgren funnel trap (RWC) 2 males.

2. Mniusa yukonensis Klimaszewski & Godin

http://species-id.net/wiki/Mniusa_yukonensis Figure 6a–l, Map 6

Ocyusa yukonensis Klimaszewski & Godin, in Klimaszewski et al. 2012: 218.

Diagnosis. Body length 2.8–3.0 mm, narrowly elongate and broadest at elytra; body dark brown to almost black, sometimes with reddish tinge on elytra, reddish-brown antennae and legs; forebody with dense microsculpture, dense punctation and pubescence, and strongly glossy; head round and narrower than pronotum; pronotum transverse, with sides strongly arcuate and narrowed anteriad, slightly narrower than elytra; elytra at suture about as long as pronotum or slightly longer (Fig. 6a); abdomen broadly arcuate laterally, slightly narrower than elytra and with basal impressions on first three visible tergites; antennal articles V-X slightly transverse (Fig. 6a). MALE: male tergite VIII truncate apically (Fig. 6c); sternite VIII rounded apically and slightly produced medially (Fig. 6d); median lobe of aedeagus with tubus straight and slightly produced ventrally and with complex structures of internal sac (Fig. 6b). FEMALE: tergite VIII truncate apically with slightly acute lateral angles (Fig. 6f); sternite VIII rounded apically and slightly produced apically and slightly produced apically and slightly produced apically (Fig. 6g); spermatheca with narrowly elongate sac-shaped capsule connected with L-shaped neck and narrow and long stem (Fig. 6e).

Distribution. This native Nearctic species was recently described from the Yukon Territory (Klimaszewski et al. 2012), and is here newly reported from Nova Scotia, New Brunswick, Quebec, and British Columbia, which constitute new provincial records (Map 6).

Bionomics. Adults were collected from May to July in pitfall traps, flight intercept traps, and Lindgren funnel traps in various forest types: rich Appalachian hardwood forest with some conifers, old-growth white spruce/balsam fir forest, balsam fir and maple sugar stands, mature white spruce with feather moss, and a red spruce forest.

Locality data. CANADA: Nova Scotia: Colchester Co., Debert, 6.V.1993, J. Ogden (NSPM) 1 male; Black Duck Lake, NS, 22.VI.2003, 4U: Funnel 16: 844 WPi/ RSp (40-80 y), P. Dollin (NSPM) 1 male. New Brunswick: Carleton Co., Jackson



Figure 6. *Mniusa yukonensis* (Klimaszewski and Godin): **6a** habitus **6b** median lobe of aedeagus in lateral view **6c** male tergite VIII **6d** male sternite VIII **6e** spermatheca in lateral view **6f** female tergite VIII **6g** female sternite VIII **6h** left mandible **6i** right mandible **6j** labrum **6k** maxilla **6l** mentum, labial palpi and ligula. Habitus scale bar = 1.0 mm; other scale bars = 0.2 mm.

Falls, "Bell Forest", 46.2200°N, 67.7231°W, 4-12.VI.2008//, Rich Appalachian hardwood forest with some conifers, Lindgren funnel traps, R.P. Webster (RWC) 1 male, 2 females; same data except 12–19.VI.2008 (RWC) 1 female; same data except

31

19-27.VI.2008 (RWC) 1 female: same data except 26.V-1.VI.2009, R. Webster & M.-A. Giguère (RWC) 1 male; Restigouche Co., Dionne Brook P.N.A., 47.9064°N, 68.3441°W, 31.V-15.VI.2011 // old-growth white spruce and balsam fir forest, flight intercept trap, M. Roy & V. Webster (RWC) 1 male; same data except 31.V-1.VI.2011, Lindgren funnel trap (RWC) 3 males; same data except 15–27.VI.2011, Lindgren funnel trap (RWC) 1 female; same data except 21.VI–14.VII,2011, Lindgren funnel trap (RWC) 1 female. Quebec: Dosquet Co., Lotb. Quebec, 27.IV.1984, Claude Chantal (LFC) 1 male; Pelegrin, North of Chandler, 48°32'N, 64°54'W, SAP Lindgren, 21.06.1994 (LFC) 1 male; Tremblant, SAP Lindgren, 28.VI.1994 (LFC) 1 female; La Tuque, SAP Lindgren, 11.VII.1994 (LFC) 1 female; St-Jacques-de-Leeds, Sapinière Quebec, 31.V.1993, 9.VI.1993, 16.VI.1993, 28.VI.1993, 30.VI.1993, Lindgren 1, 2, 4 (LFC) 6 females. British Columbia: 25 km SW Campbell River, 49°50'21"N, 125°28'34"W, 23.V-6.VI.1996, Balsam Cr. LT 5-D 10, J. Lemieux (LFC) 4 males, 1 female, 1 sex undetermined; Copper River Valley, A36435/04-1-1, 07.VI-6.VII.1996, pitfall trap, J. Lemieux (LFC) 1 male. Yukon Territory: EMAN Plot (Ecological Monitoring and Assessment Network), mature white spruce and feather moss forest, 60.5963°N, 134.9522°W, 8.VII.2003, 738 m, yellow pitfall trap (LMKM31Y), (LFC) 1 male [holotype]; EMAN Plot, 60.5963°N, 134.9522°W, 24.VII.2003, 738 m, black pitfall trap (LMKM31B), (ECW) 1 male [paratype].

3. *Mniusa odelli* Klimaszewski & Webster, sp. n. http://zoobank.org/49A0754A-850F-49B6-93C2-5F630C8A61CD http://species-id.net/wiki/Mniusa_odelli Figure 7a–l, Map 5

Holotype (female). CANADA: New Brunswick, York Co., Fredericton, Odell Park, 45.9571°N, 66.6650°W, 15.V-1.VI.2012 // Old-growth eastern hemlock forest, Lindgren funnel trap, 1 m high under *Betula alleghaniensis*, C. Alderson and V. Webster (LFC). PARATYPES: New Brunswick, York Co., Odell Park, 45.9539°N, 66.66666°W, 10-24.VI.2013 // Hardwood stand, Lindgren funnel trap, 1 m high under trees (RWC) 2 females.

Diagnosis. Body length 2.8–3.2 mm, narrowly subparallel with head slightly narrower than pronotum; body colour dark brown, and with tibiae, tarsi and often basal antennal articles reddish-brown; forebody with dense microsculpture, and moderately dense punctation and pubescence, and strongly glossy; head round and slightly narrower than pronotum; pronotum slightly transverse, with sides rounded, and as wide as elytra; elytra at suture about as long as pronotum or slightly longer (Fig. 7a); abdomen subparallel, as wide as elytra and with basal impressions on first three visible tergites; antennal articles V-X slightly transverse (Fig. 7a). MALE [description of male is based on poorly preserved specimen and should be consider as tentative]: male tergite VIII truncate apically (Fig. 7c); sternite VIII rounded apically and slightly produced medially (Fig. 7d); median lobe of aedeagus with tubus straight and with complex



Figure 7. *Mniusa odelli* Klimaszewski and Webster: **7a** habitus **7b** median lobe of aedeagus in lateral view **7c** male tergite VIII **7d** male sternite VIII **7e** spermatheca in lateral view **7f** female tergite VIII **7g** female sternite VIII **7h** left mandible **7i** right mandible **7j** labrum **7k** maxilla **7l** menthum, labial palpi and ligula. Habitus scale bar = 1.0 mm; other scale bars = 0.2 mm.

structures of internal sac (Fig. 7b). FEMALE: tergite VIII truncate apically with sharp lateral angles (Fig. 7f); sternite VIII rounded apically (Fig. 7g); spermatheca with narrowly elongate sac-shaped capsule connected with L-shaped neck and narrow and long stem slightly sinuate posteriorly at apex (Fig. 7e).





Distribution. This native Nearctic species is here described from Nova Scotia, New Brunswick, and Quebec (Map 5).

Bionomics. Adults were collected from May to July in Lindgren traps in an oldgrowth eastern hemlock stand, an old hardwood stand, and in a sugar maple forest and a red spruce forest.

Etymology. This species is named after Odell Park in Fredericton, New Brunswick, where the holotype was found. This park was originally the estate of Reverend Jonathan Odell whom the park was named after. This park was established in 1954.

Other locality data [specimens in poor condition and tentatively identified as this species].

CANADA: **Nova Scotia**: Pictou Co., Marshy Hope, 17.V.1995, ethanol lure, M. LeBlanc (NSPM) 1 sex undetermined; Antigonish Co., Fairmont Tower Road, 17.V.1995, 3-Component Lure w/+/- mcol, M. LeBlanc (NSPM) 1 female; Fairmont Tower Road, 25.V.1995, 3-Component Lure w/+/- mcol, M. LeBlanc (NSPM) 1 male, 1 female; Antigonish Co., Eigg Mountain, 25.V.1995, ethanol lure, M. LeBlanc (NSPM) 1 male, 1 female; Melopseketch Lake, Guy, 14.V–2.VI.1997, young red spruce, D.J. Bishop 201 (NSPM) 1 male; Halifax, Lake Little, 14.V–2.VI.1997, regenerating red spruce, D.J. Bishop 127 (NSPM) 1 male. **Quebec**: St-Jacques-de-Leeds, Erablière Québec, 28.VI.1993, Lindgren 2 (LFC) 1 female; Mont Orford, 29.VI-6.VII.1999, Lindgren 1, Erablière, 99-3-1061 (LFC) 1 male.

Ocyusa Kraatz

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

Ocyusa Kraatz, 1856. Type species: Oxypoda maura Erichson.

Diagnosis. Body dark brown to almost black, compact, sides subparallel or body narrowly oval in outline (Figs 8a, 9a), length 2.5-3.5 mm; integument with distinct meshed microsculpture and moderate to dense punctation and pubescence; head large with mandibles broad and long, left mandible with a small tooth (Figs 8h, 9h), and right one with a slightly larger tooth at the base of arcuate cutting edge of mandible, apices moderately narrowly elongate [less than in Mniusa] (Figs 8i, 9i); infraorbital carina strong and complete; ligula shallowly split apically (Figs 81, 91); labial palpus with three articles, second article minute, last one needle-shaped and lacinia and galea as illustrated (Figs 8k, 9k); labrum narrow and transverse, apical edge entire (Figs 8j, 9j); frontal suture of head present; pronotal pubescence along midline directed posteriad or obliquely posteriad; anterior margin of mesosternum without longitudinal carina; mesosternal process triangular basally and then produced and extending to about 2/3 length of mesosternal cavities, metasternal process narrowly triangular in shape and short; isthmus short; median lobe of aedeagus strongly produced ventrally, internal sac structures as illustrated (Figs 8b, 9b); spermatheca S-shaped with spherical capsule, short neck and elongate sinuate stem (Figs 8e, 9e).

Key to Canadian species of Ocyusa

1. Ocyusa canadensis Lohse

http://species-id.net/wiki/Ocyusa_canadensis Figure 8a–l, Map 4

Ocyusa canadensis Lohse, in Lohse et al. 1990: 147; Brunke et al. 2012: 134.

Diagnosis. Body length 2.5–3.0 mm, narrowly elongate and broadest at elytra; body colour dark brown to almost black, with tarsi, two basal antennal articles and tibiae rust-brown, rest of antennal articles brown; forebody with dense microsculpture, moderate punctation and pubescence, and strongly glossy; head round and narrower than pronotum; pronotum transverse, rectangular in shape with sides strongly arcuate, and narrower than elytra; elytra at suture about as long as pronotum (Fig. 8a); abdomen broadly arcuate laterally, slightly narrower than elytra and with basal impressions on first three visible tergites; antennae with articles V-X subquadrate to slightly elongate (Fig. 8a). MALE: male tergite VIII broadly rounded apically (Fig. 8c); sternite VIII rounded apically (Fig. 8d); median lobe of aedeagus with tubus strongly bent ventrally and with pronounced structures of internal sac (Fig. 8b). FEMALE: tergite VIII truncate apically (Fig. 8f); sternite VIII rounded apically (Fig. 8g); spermatheca with semi-spherical capsule with long invagination, and S-shaped broad stem (Fig. 8e).

Distribution. This native Nearctic species is known from Alaska, Yukon Territory and Ontario (Brunke et al. 2012), and is here newly reported from the island of Newfoundland and New Brunswick [new provincial records] (Map 4).

Bionomics. Some adults were collected from June to July at lake margins, on moist soil/gravel among sedges and by treading *Carex* and grasses.

Locality data. CANADA: Newfoundland: George's Lake, Corner Brook, 29.VII.1972, J.M. Campbell (CNC) 1 male; New Brunswick: Restigouche Co., Wild Goose Lake, 419 m elevation, 47.8540°N, 68.3200°W, 21.VII.2010 // lake margin, on moist soil/gravel among sedges, R.P. Webster (RWC) 1 female; same data except: 420 m elevation, 47.8543°N, 683219°W, 7.VI.2011 // lake margin with emergent *Carex* and grasses, treading *Carex* and grasses, R.P. Webster (RWC) 1 male; same data except 20.VI.2011, (RWC) 2 males, 4 females. **Ontario**: Timiskaming Distr., 52 km South Armstrong, 27.VI.1973, R. Parry and J.M. Campbell (CNC) 4 females, 7 sex undeter-



Figure 8. *Ocyusa canadensis* Lohse: **8a** habitus **8b** median lobe of aedeagus in lateral view **8c** male tergite VIII **8d** male sternite VIII **8e** spermatheca in lateral view **8f** female tergite VIII **8g** female sternite VIII **8h** left mandible **8i** right mandible **8j** labrum **8k** maxilla **8l** menthum, labial palpi and ligula. Habitus scale bar = 1.0 mm; other scale bars = 0.2 mm.

mined; 52 km S Armstrong, 27.VI.1973, R. Parry and J.M. Campbell (CNC) 1 female. **Yukon Territory**: Dempster Hwy., mi. 122, 20.VII.1978, 2000 feet, A. Smetana and J.M. Campbell (CNC) 2 males, holotype and paratype; Dempster Hwy., mi. 147, 1900 feet, 22.VII.1978, J.M. Campbell and A. Smetana (CNC) 1 sex undetermined.
UNITED STATES OF AMERICA: Alaska: Prudhoe Bay Rd., Bonanza Creek, 900 feet, 66°40'N, 150°40'W, 2.VII.1978, A. Smetana and J.M. Campbell (CNC) 1 paratype sex undetermined; Nutirwick Creek, 67°55'N, 149°45'W, 2300 feet, 8.VII.1978, J.M. Campbell and A. Smetana (CNC) 2 sex undetermined.

2. Ocyusa asperula Casey

http://species-id.net/wiki/Ocyusa_asperula Figure 9a–l, Map 5

Ocyusa asperula Casey 1894: 305 [often cited as 1893], Webster et al. 2009: 192. *Ocyusa brevipennis* Bernhauer 1906: 344. Moore and Legner 1975: 458. Synonymy confirmed.

Diagnosis. Body length 2.8–3.0 mm, sides subparallel; body colour dark brown, with tarsi, two basal antennal articles and legs rust-brown, rest of antennal articles dark brown; forebody with moderately dense microsculpture, punctation and pubescence, and strongly glossy; head round and about as wide as pronotum; pronotum transverse, with sides strongly arcuate, widest in apical third, and as wide as elytra; elytra at suture much shorter than pronotum (Fig. 9a); abdomen broadly arcuate laterally, slightly broader than elytra at middle and with basal impressions on first three visible tergites; antennae with articles V-X subquadrate (Fig. 9a). MALE: male tergite VIII with apical margin slightly pointed medially (Fig. 9c); sternite VIII rounded apically (Fig. 9d); median lobe of aedeagus with tubus convex basally and then strongly bent ventrally and with complex structures of the internal sac (Fig. 9b). FEMALE: tergite VIII truncate apically with small projections laterally (Fig. 9f); sternite VIII rounded apically (Fig. 9g); spermatheca with small spherical capsule with long and broad invagination, and S-shaped broad stem slightly swollen posteriorly (Fig. 9e).

Distribution. This native Nearctic species was described from Rhode Island by Casey 1894 [often cited as 1893]. It was recorded also from New Brunswick in Canada (Map 5) and from Iowa and Massachusetts in the United States (Casey 1894, Bernhauer 1906 [as *brevipennis*], Moore and Legner 1975, Webster et al. 2009).

Bionomics. Some adults were collected from April to July at lake margins, on moist soil/gravel among sedges, and by treading emergent *Carex* and grasses. Webster et al. (2009) collected adults by sifting grass litter and mosses (usually sphagnum) near small pools in eastern white-cedar swamps, red maple (*Acer rubrum* L.) swamps with eastern white-cedar, and in alder swamps. Others were collected by treading green sphagnum, *Carex*, and grasses in a black spruce bog and by treading cattails and sedges in a boggy marsh.

Locality data. CANADA: New Brunswick: Charlotte Co., 3 km SW of King Brook Lake, 45.3194°N, 67.4414°W, 27.V.2007 (RWC) 1 sex undetermined; 3.0 km NW of Pomeroy Ridge, 45.3059°N, 67.4343°W, 5.VI.2008 (RWC) 1 sex undetermined; Gloucester Co., ca. 1.5 km NE of Six Roads, off Paleot Rd., 47.6292°N,



Figure 9. *Ocyusa asperula* Casey: **9a** habitus **9b** median lobe of aedeagus in lateral view **9c** male tergite VIII **9d** male sternite VIII **9e** spermatheca in lateral view **9f** female tergite VIII **9g** female sternite VIII **9h** left mandible **9i** right mandible **9j** labrum **9k** maxilla **9l** menthum, labial palpi and ligula. Habitus scale bar = 1.0 mm; other scale bars = 0.2 mm.

64.8565°W, 32.V.2010, R.P. Webster (RWC) 1 sex undetermined; Northumberland Co., Goodfellow Brook PNA, 46.8943°N, 65.3796°W, 23.V.2007 (BM) 1 sex undetermined; York Co., New Maryland, off Hwy 2, E of Baker Brook, 45.8760°N, 66.6252°W, 6.IV.2005 (RWC) 1 male; near Mazerolle Settlement, 45.8987°N,

66.7903°W, 9.IV.2006, R.P. Webster (LFC, RWC, NBM) 6 males, 3 females; 9.2 km W of Tracy off Rt. 645, 45.6837°N, 66.8809°W, 22.V.2008 (RWC) 1 female; ca. 14 km SW of Tracy, S of Rt. 645, 45.6603°N, 66.8603°W, 2.VII.2010, R.P. Webster (RWC) 1 sex undetermined.

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RESEARCH ARTICLE



The Hoosier cavefish, a new and endangered species (Amblyopsidae, *Amblyopsis*) from the caves of southern Indiana

Prosanta Chakrabarty^{1,†}, Jacques A. Prejean^{1,‡}, Matthew L. Niemiller^{1,2,§}

I Museum of Natural Science, Ichthyology Section, 119 Foster Hall, Department of Biological Sciences, Louisiana State University, Baton Rouge, Louisiana 70803, USA 2 University of Kentucky, Department of Biology, 200 Thomas Hunt Morgan Building, Lexington, KY 40506, USA

http://zoobank.org/0983DBAB-2F7E-477E-9138-63CED74455D3
 http://zoobank.org/C71C7313-142D-4A34-AA9F-16F6757F15D1
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Corresponding author: Prosanta Chakrabarty (prosanta@lsu.edu)

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Abstract

We describe a new species of amblyopsid cavefish (Percopsiformes: Amblyopsidae) in the genus *Amblyopsis* from subterranean habitats of southern Indiana, USA. The Hoosier Cavefish, *Amblyopsis hoosieri* **sp. n.**, is distinguished from *A. spelaea*, its only congener, based on genetic, geographic, and morphological evidence. Several morphological features distinguish the new species, including a much plumper, Bibendum-like wrinkled body with rounded fins, and the absence of a premature stop codon in the gene *rhodopsin*. This is the first new cavefish species described from the United States in 40 years and exemplifies how molecular data can alert us to the presence of otherwise cryptic biodiversity.

Keywords

Cryptic diversity, GenSeq, new species, subterranean, taxonomy

Introduction

The teleost family Amblyopsidae (order Percopsiformes) comprises North America's largest clade of stygobiotic (obligate cave-dwelling) fishes and has long been of interest to evolutionary biologists and ecologists studying adaptations to extreme subterranean habitats (reviewed in Niemiller and Poulson 2010). The taxonomy of Amblyopsidae has remained relative stable since the 1950s when Woods and Inger (1957) published a major taxonomic revision of the family, which included assigning *Troglichthys rosae* (Eigenmann 1898) to the genus *Amblyopsis*, recognizing *Forbesichthys papilliferus* (Forbes, 1882) as a junior synonym of *F. agassizii* (Putnam, 1872), and recognizing *Typhlichthys eigenmanni* Charlton, 1933, *T. wyandotte* Eigenmann, 1905 and *T. osborni* Eigenmann, 1905 as junior synonyms of *T. subterraneus* Girard, 1859. Cooper and Kuehne (1974) described the most recent amblyopsid to be recognized, *Speoplatyrhinus poulsoni*, a stygobiotic species known only from a single cave system in northern Alabama.

There has been a revival in amblyopsid systematics and taxonomy in recent years, as several studies have examined higher-level phylogenetic relationships as well as population level differentiation using molecular approaches (Niemiller and Fitzpatrick 2008, Dillman et al. 2011, Niemiller et al. 2012, 2013a,d). Several significant systematic revisions have been proposed, including the assignment of Amblyopsis rosae back into the genus Troglichthys (Niemiller et al. 2013a), resurrection of F. papilliferus (Niemiller et al. 2013a) and resurrection of *T. eigenmanni* (Niemiller et al. 2012) based on biogeographical and phylogenetic evidence. Eight species are currently recognized in Amblyopsidae, including three surface or primarily spring-dwelling taxa: Chologaster cornuta Agassiz 1853, Forbesichthys agassizii, and F. papilliferus; and five obligate cave-dwelling taxa: Typhlichthys subterraneus, T. eigenmanni, Troglichthys rosae, Speoplatyrhinus poulsoni and Amblyopsis spelaea DeKay 1842 (sensu Niemiller et al. 2013a,d). However, the multilocus phylogenetic study by Niemiller et al. (2012) also uncovered substantial cryptic genetic variation associated with hydrological boundaries in T. subterraneus, suggesting that biodiversity is underestimated in *Typhlichthys* and perhaps other cavefish lineages. The recognition of such cryptic species has important implications for conservation and management (e.g., Niemiller and Fitzpatrick 2008, Niemiller et al. 2013b), but also for comparative ecological and evolutionary studies (e.g., Niemiller et al. 2013a,c).

A recent study of *Amblyopsis spelaea* based on phylogeographic structure of one mitochondrial and four nuclear loci identified two evolutionary lineages associated with the modern Ohio River (Niemiller et al. 2013d): a northern lineage located north of the Ohio River in Indiana and a southern lineage in Kentucky. Niemiller et al. (2013d) suggested that these two lineages might warrant recognition as distinct species (Fig. 1).

These northern and southern lineages were recovered as reciprocally monophyletic for two of the nuclear loci, s7 and *rhodopsin*, and the mtDNA locus *nd2*. Little variation was exhibited at the nuclear loci *rag1* and *tbr*. The gene tree estimated from the mitochondrial *nd2* locus contained two strongly supported clades (Bayesian posterior probability > 0.95) separated by 27 mutational steps with observed average uncorrected



Figure 1. Phylogeny of Amblyopsidae. Modified from Niemiller et al. (2013d), showing a northern lineage of *Amblyopsis* found north of the Ohio River in Indiana (members of the new species described herein) and a southern lineage in Kentucky (*A. spelaea* sensu n.).

pairwise genetic distances of 3.1% between these lineages. Observed uncorrected pairwise genetic distances were considerably lower for all nuclear loci; however, segregating variation was observed in *s7* and *rhodopsin*. A single nucleotide substitution at *s7* segregated between the northern and southern lineages, whereas three nucleotide substitutions segregated at *rhodopsin*. The differences in *rhodopsin* include a mutation that results in a premature stop codon in the open reading frame of all individuals sampled in the southern lineage that is absent from the northern lineage.

The results of Niemiller et al. (2013d) strongly implicate the Ohio River as a significant barrier to dispersal and, consequently, an isolating mechanism facilitating divergence between populations located north and south of the river (Fig. 2). Poulson (1960) examined variation in morphology throughout much the northern distribution of *Amblyopsis spelaea* and found subtle differences in pigmentation and rudimentary eye size; however, he only examined specimens from the Mammoth Cave region for the southern range of the species. Therefore, it is unclear whether phenotypic differences exist between phylogenetic lineages identified by Niemiller et al. (2013d). In this study, we examined morphological variation from individuals of the northern and southern lineages of *Amblyopsis* identified by Niemiller et al. (2013d), and included specimens



Figure 2. Distribution of *Amblyopsis* spp., *Amblyopsis spelaea* and *A. hoosieri*, in the Mitchell Plain and Crawford-Mammoth Uplands of Indiana and Kentucky.

from populations for which material for DNA sequencing were previously unavailable. Based on our results, we describe the northern lineage as *Amblyopsis hoosieri* sp. n., from subterranean waters of southern Indiana.

Materials and methods

Institutional abbreviations are as follows: CAS (California Academy of Science); INHS (Illinois Natural History Survey); IU (Indiana University); LSUMZ (Louisiana State University Museum of Natural Science); UMMZ (University of Michigan Museum of Zoology), YPM (Yale Peabody Museum). Non-type materials examined include: *Amblyopsis spelaea*: INHS 50129 (n=1), 60573 (n=1); UMMZ 146991 (n=1); 179149 (n=1); YPM 25294 (n=8, n=1 cleared and stained). Materials examined for the new species are listed below as types. Cleared and stained specimens were prepared following modifications of the method outlined by Taylor and Van Dyke (1985). Specimens were stained in Alcian blue for two days, then bleached in a potassium hydroxide solution, neutralized in a hydrogen peroxide + potassium hydroxide mixture, then transferred into trypsin to clear. Specimens were then placed in Alizarin red for 20 minutes and subsequently transferred to distilled water for 24 hours. Specimens were then placed back into trypsin for a final clearing and slowly moved up to full glycerin using a staggered glycerin/potassium hydroxide mixture that slowly increased glycerin in 10% intervals up to 100% over a period of a week.

Radiographs were made for all specimens using a Faxitron x-ray cabinet. All meristics (numbers of fin rays and vertebrae) were counted using these radiographs.

Morphometric measurements, following Hubbs and Lagler (2004), were recorded to the nearest 0.1 mm using digital calipers and included: standard length (SL), head length (HL), head width, upper jaw length, body depth (depth of body at deepest point), pectoral-fin length, caudal-fin length, pelvic-fin length, dorsal-fin base, anal-fin base, caudal peduncle length, caudal peduncle width, caudal peduncle depth, predorsal length, prepelvic length, and preanal length. Other traditional measurements, such as, snout length, interorbital width and orbit diameter are excluded because of the absence of eyes (externally) in these taxa. An additional measurement, body width, was taken directly posterior to the opercula on the widest part of the body. We also conducted an analysis of covariance (ANCOVA) to compare body width and body depth among species with standard length as a covariate in R (v3.0.2; R Development Core Team 2013).

Results

Forty-one specimens were examined, 30 from north of the Ohio River in Indiana, and 11 from south of the river in Kentucky. Specimens from Kentucky included the type locality of *A. spelaea*, Mammoth Cave in Edmonson County. Figure 3 (A–C) shows the results of analyses of covariance (ANCOVA) comparing body depth and body width versus SL. Notably, *Amblyopsis hoosieri* has a deeper body compared to *A. spelaea* (AN-COVA, p < 0.001; Fig. 3A, C). The body is also wider in *A. hoosieri* compared to *A. spelaea* (AN-COVA, p < 0.001; Fig. 3B, C). Except for juveniles (those under 50mm), individuals of the new species are deeper and wider bodied than individuals of *A. spelaea* (Fig. 3C). Given individuals of the same standard length, one would expect those of the new species to be much more robust.



Figure 3. Plots illustrating the relationships between body depth, body width and standard length (SL). Circles in red represent specimens of *Amblyopsis hoosieri*, sp. n., from north of the Ohio River in Indiana; triangles in blue represent *Amblyopsis spelaea* from south of the Ohio River in Kentucky. (**a**) body depth versus standard length, (**b**) body width versus standard length, and (**c**) and body depth versus body width as proportions of standard length.

Systematic accounts

Amblyopsis hoosieri Niemiller, Prejean & Chakrabarty, sp. n.

http://zoobank.org/688BC3D5-7773-41E8-961F-67E3E4902BE2 http://species-id.net/wiki/Amblyopsis_hoosieri Figures 4A, 5–7; Table 1

Amblyopsis spelaea "N" Niemiller et al. 2013d: pg. 9 (Fig. 3)
Amblyopsis spelaea: Simon 2011: pg. 230–231; Fig. 146 (in part)
Amblyopsis spelaea: Poulson 1963: pg. 267, 269 Upper Twin, Spring Mill (in part)
Amblyopsis spelaea: Woods and Inger 1957: pg. 241, 243–245; Fig. 5 (in part)

Type material. Holotype. INHS 106675, Bronson's Cave (White River Dr.) Spring Mill State Park, Lawrence County, Indiana, USA; 38°44', -86°25'; 9 December 1962, W.U. Bringham [formerly in lot 102504]

Paratypes. INHS 40424 (n=12 in ETOH; n=2 cleared and stained), Bronson's Cave (White River Dr.) Spring Mill State Park, Lawrence County, Indiana, 5 April 1964, W.U. Brigham, G.W. Barlow & J. Mertz; INHS 60574 (n=1), Spring, (Lost River Dr.) Near West Baden, Orange County, Indiana, 18 January 1904, N.H. Haden; INHS 102504 (n=4), same data as holotype; LSUMZ 17419 (n=1), same as UMMZ 157175, formerly of that lot; LSUMZ 17420 (n=1), same data as UMMZ 65000, formerly of that lot; UMMZ 65000 (n=2), Twin Caves, near Mitchell, Lawrence County, Indiana, 17 May 1924, Hubbs & party; UMMZ 90379 (n=2), Sibert's Well Cave, beside Wyandotte Cave, Indiana, 17 August 1930, P. Hickie; UMMZ 113550 (n=1), Lost River, Indiana, ca. 2 mi NE of Orangeville, September 1935, J.J. & W.P. Petravicz; UMMZ 114890 (n=2), Donaldson's Cave, Spring Mills State Park, Lawrence County, 16 June 1934, A.E. Emerson; UMMZ 144604 (n=1), Stream in Sibert's Well Cave, Wyandotte, Crawford County, Indiana, 01 October 1942, L. Hubricht; UMMZ 146992 (n=1), Stream in Sheep Cave, near Wyandotte, Crawford County, Indiana, 01 September 1939, , L. Hubricht; UMMZ 146994 (n=3), Stream in Bronson Cave, Spring Mill State Park, Lawrence County, Indiana, 2 September 1939, L Hubricht; UMMZ 157174 (n=1), "possibly" Donaldson farm caves near Indiana University, Indiana, C.H. Eigenmann; UMMZ 157175 (n=1), same as previous lot; UMMZ 157176 (n=1), same as previous lot; UMMZ 160944 (n=1), Twin Cave, Mitchell, Lawrence County, Indiana, 18 June 1924, F.N. Blanchard; YPM 25304 (n=2), Donaldson Cave, Spring Mill State Park, Lawrence County, Indiana, 21 December 2007, M.L. Niemiller et al.; YPM 25305 (n=1), Blue Springs Caverns, Lawrence County, Indiana, 21 December 2007, M.L. Niemiller et al. [Note tissue samples and published sequences are available from paratypes in YPM 25304 and 25305 (Niemiller et al. 2013d) and these correspond to genseq-2 following the nomenclature of Chakrabarty et al. (2013). GenBank numbers for these sequences from the paratypes are reported in Table 2.]

Morphological diagnosis. *Amblyopsis hoosieri* can be distinguished from its only congener, *A. spelaea*, by having a more plump, fleshy and rounded body (versus sculpted



Figure 4. Comparative image of two similarly sized individuals of both species of *Amblyopisis. Amblyopsis hoosieri*, holotype, INHS 106675, 75.1 mm SL, Bronson's Cave, Lawrence Co., Indiana (**A**); a specimen of *A. spelaea* (YPM ICH 25294) of similar SL (67 mm SL) showing the more elongate and sculpted (versus plump) body, pointed fins, less prominent myomeres and more prominent papillae on the body (**B**).

and thin) with Bibendum-like wrinkles along myomeres (versus tight skin) and by having rounder pectoral fins (versus pointed; Figs 4–6). Additionally, the mechansensory papillae on the body and caudal fin are reduced in size and less elevated on the skin (versus conspicuous in *A. spelaea*).

Molecular diagnosis. Average uncorrected pairwise genetic distance at the mitochondrial NADH dehydrogenase 2 (*nd2*) locus between *A. hoosieri* and *A. spelaea* is 3.1%, with 27 mutations separating the two species. *Amblyopsis hoosieri* and *A. spelaea* can also be readily diagnosed using molecular data at the nuclear *rhodopsin* gene, a G-coupled photoreceptor expressed in the retina of the vertebrate eye. All *rhodopsin* sequences of *A. hoosieri* code for the amino acid glutamine (Q) at position 184, whereas *A. spelaea* possesses a point mutation that results in a premature stop codon at this position. In addition, *A. hoosieri rhodopsin* codes for the amino acid valine (V) at position 254, whereas *A. spelaea* codes for the amino acid phenylalanine (F). A single mutation in intron 1 of ribosomal protein S7 (*s7*) also distinguishes the two species.

Description. Robust, blind (eye not developed, Fig. 7), unpigmented cavefish typically reaching between 60–80 mm in adult standard length. Head large (about ¹/₄ body length) flat dorsally but broad; head widest part of body. Body widest at operculum, narrows to caudal fin. Body rectangular, dorsal and vertical profile of body nearly symmetrical; deepest point at dorsal-fin origin. Fleshy protuberance present anterior to dorsal-fin origin; similar protuberance at anal-fin origin. Body narrows posterior to dorsal- and anal-fin origins, narrowest point at midpoint of caudal peduncle. Body



Figure 5. Photograph of a paratype of *Amblyopsis hoosieri* in life, YPM ICH 25304, 60.7 mm SL. Photograph by M.L. Niemiller.

plump, wrinkly in appearance (as in Bibendum) prominent deep myomeres present. Deep groove on ventral side of body from operculum and anus to pelvic fin. Scales inconspicuous and cycloid.

Superficial mechanosensory neuromasts on papillae (Eigenmann 1909, Niemiller and Poulson 2010) present in rows of 5–30 on head. Papillae concentrated at mouth; fewer posteriorly on head. Most rows of papillae vertical, far fewer horizontal. Horizontal rows typically connect two to four other vertical rows. Most mechanosensory papillae on dorsal side of head concentrated and aligned posterior to, or between, nares. No mechanosensory papillae in central area of dorsal region of head. Papillae present dorsal to braincase in two horizontal rows. No lateral line on body. Mechanosensory papillae on body much smaller than those on head and aligned in vertical rows; some scattered papillae near dorsal-fin base. Inconspicuous papillae present on caudal fin in horizontal rows of two or three in both dorsal and ventral half of fin, vertical row present at base.

Anterior nares small, tube shaped; posterior nares slightly larger with small anterior flap, but otherwise circular. Lips somewhat thin and fleshy. Lower jaw slightly longer than upper jaw.

Vertical through dorsal-fin origin between more anterior pelvic-fin origin and more posterior anal-fin origin. Anal-fin and dorsal-fin insertions near same vertical plane. All fins relatively short and rounded. Anus located anteriorly on body, behind isthmus of united gill membranes (i.e., jugular). Caudal skeleton upturned and asymmetrical



Figure 6. Illustration of *Amblyopsis hoosieri* based on the holotype, INHS 106675, 75.1 mm SL. Illustration by Nathan Coussou.



Figure 7. Cleared and stained image of the head of *Amblyopsis hoosieri*. Note lack of eye or a clearly defined bony orbit. Specimen is a paratype from INHS 40424, 71.3 mm SL.

(externally appearing homocercal), with last half centrum (preural 1 + ural 1) including hypural (3-X; following Rosen 1962) and entirely associated with dorsal half of caudal fin. Five or six principal caudal-fin rays supported by each hypural plate (ventral hypural 1+2; again following Rosen 1962).

Branchiostegals six in number, robust and prominent. Papilliform flap at dorsal origin of operculum. Six or seven gill rakers on ceratobranchial of first gill arch. Rakers short, stubby and denticulated. Central and upper tooth plates also heavily denticulated.

Buccal teeth villiform, in three to five rows. Individual teeth unicuspid, slender and long; teeth deeply embedded in mouth so only top 1/3 visible. Teeth recumbent, particularly those on upper jaw. Palatine and vomerine teeth also present.

Body uniformly depigmented, including inside mouth. Body pinkish-white, reddish near gills, fins transparent. In alcohol, body color uniformly yellowish/beige, fins opaque yellow.

	A. hoosieri (Indiana)	A. spelaea (Kentucky)			
Character	N=30	N=11			
Standard length	65.2 (43.1–82.4)	59.2 (47.6–70.0)			
	Percentage of s	standard length			
Head length	34.1 (30.6–37.0)	33.0 (30.0–37.2)			
Body depth	20.3 (15.2–27.2)	13.2 (10–16.6)			
Body width	19.7 (17–23.7)	15.5 (11.4–18.3)			
Pectoral-fin length	18.2 (11.9–24.0)	24.0 (20.0–27.5)			
Pelvic-fin length	8.0 (5.6–9.7)	8.4 (5.7–10.4)			
Caudal-fin length	19.9 (12.0–25.3)	25.5 (19.1–29.4)			
Dorsal-fin base	12.0 (9.5–15.8)	11.0 (7.5–12.8)			
Anal-fin base	10.8 (6.5–14.9)	11.6 (6.6–14.0)			
Caudal-peduncle length	29.8 (27.0–34.7)	30.0 (27.7–33.2)			
Caudal-peduncle depth	11.0 (9.4–12.9)	9.7 (8.6–11.0)			
Caudal-peduncle width	6.1 (4.7–8.3)	5.9 (4.9–6.7)			
Predorsal length	59.0 (50.6–64.1)	60.3 (58.5-63.0)			
Preanal length	63.4 (58.6–67.2)	59.6 (56.0-63.1)			
Prepelvic length	55.3 (50.5–59.7)	51.8 (48.6–55.5)			
	Percentage of head length				
Head width	70.0 (51.5–82.4)	65.0 (56.3–70.4)			
Upper jaw length	32.8 (27.2–37.5)	33.4 (30.0–40.0)			
Counts					
Dorsal-fin rays	11(1), 10(16), 9(11), 8(2)	10(3), 9(8)			
Anal-fin rays	10(7), 9(21), 8(2)	10(3), 9(8)			
Vertebral Count	30(16), 29(14)	31(1), 30(9), 29(1)			

Table 1. Measurements and meristic counts of species of *Amblyopsis*. Standard length is in mm. Other measurements are percentages of standard length or head length. Values reported are means and ranges are in parentheses. For meristic counts, number of specimens with a count value is in parentheses.

Table 2. GenBank accession numbers for sequences from *Amblyopsis hoosieri* paratypes, which receive genseq-2 ranking in the classification of Chakrabarty et al. (2013). Sequences were used and derived from the study of Niemiller et al. (2013d). Genes are listed in columns: *tbr1* (T-box brain), *rag1* (recombinating activating protein 1), *s7* intron 1 (ribosomal protein s7, intron 1), *nd2* (NADH dehydrogenase subunit 2), *rhod* (rhodopsin).

Gene	the I	u da 1	.7		wheed		
Specimen #	tor1	ragi	\$/	na2	rnoa		
YPM 25304.A	JX978106	JX978036	JX977966	JX977896	JX459497		
YPM 25304.B	JX978107	JX978037	JX977967	JX977897	JX459498		
YPM 25305	JX978108	JX978038	JX977968	JX977898	JX459499		

Etymology. The specific epithet *hoosieri* is in reference to this species being from the state of Indiana. It is also a reference to Indiana University, where biologist Carl H. Eigenmann was a Professor of Zoology and studied blind cave vertebrates, including populations of *A. hoosieri* in Lawrence County just to the south of Bloomington (Eigenmann 1909). Indiana University was also home to the Father of American Ich-

thyology, David Starr Jordan, for most of his illustrious career. We derive the specific epithet from the proper noun "Hoosier." Notably, the senior author of the manuscript is a fervent fan of Indiana Hoosier basketball while the first author is an alumni of the University of Michigan and is not. Suggested common name, Hoosier Cavefish.

Distribution. *Amblyopsis hoosieri* occurs in caves developed in carbonate rock of the Crawford-Mammoth Cave Uplands and Mitchell Plain in the South-Central karst region of Indiana (Fig. 2) within the area that remained ice free throughout the Pleistocene Epoch (Woods and Inger 1957, Frushour 2012). Caves within the distribution of *A. hoosieri* are primarily developed in Mississippian-aged limestones and carbonates belonging to the St. Louis and St. Genevieve Limestone (Frushour 2012). The northernmost locality occurs 16 km from the glacial maxima of the Illinoian glaciation. The distribution of *A. hoosieri* is bounded to the north by the East Fork White River and the south by the Ohio River. The species has been documented from at least 74 localities in Crawford, Harrison, Lawrence, Orange and Washington counties, including 68 cave systems and six springs (Keith 1988, Pearson and Boston 1995, Lewis 2002a, Niemiller and Poulson 2010, Niemiller et al. 2013d). *Amblyopsis hoosieri* is known from the Lower White, Lower East Fork White, Patoka and Blue-Sinking watersheds.

Habitat. *Amblyopsis hoosieri* is found primarily in larger cave streams at or near the water table where it has been observed in pools with low flow at depths as shallow as 0.1 m to > 2 m deep. *Amblyopsis* cavefishes from Indiana have been found in association with silt-sand, gravel, cobble and bedrock substrates (Poulson 1963, Pearson and Boston 1995, Niemiller and Poulson 2010). A preference for larger pools with relatively deep, slow-moving water with large breakdown boulders has been noted (McCandless 2005). During high flow conditions, cavefish seek refuge under ledges, in crevices or in areas of breakdown (Niemiller and Poulson 2010). These habitats and preferences are similar to those found in *A. spelaea* (reviewed in Niemiller and Poulson 2010).

Life history. Poulson (1960, 1963) provided the most significant study on the ecology of the species described herein as A. hoosieri based primarily on cave populations near Mitchell in Lawrence County, Indiana, which is reviewed in Niemiller and Poulson (2010). Amblyopsis hoosieri has a well-defined annual reproductive cycle (Poulson 1963, Niemiller and Poulson 2010). Breeding presumably occurs during high water levels from February through April. Females brood eggs in their branchial cavities until hatching and continue to care for fry until yolk reserves are depleted 4-5 months later (Eigenmann 1909, Niemiller and Poulson 2010). Fry appear in late summer into early autumn. Growth rates are estimated at 1.0 mm month⁻¹ but decline with age (Niemiller and Poulson 2010). Sexually maturity is likely reached in 3-4 years (Poulson 1963). Longevity is unknown but estimated to be at least 12-15 years (but perhaps 20+ years) based on growth rates and scale formation (Louis 1999, Niemiller and Poulson 2010). Documented prey of A. hoosieri includes copepods, isopods, and amphipods. Larger individuals will feed on small crayfish (Poulson 1963, Niemiller and Poulson 2010). Predators have not been documented in nature and it's thought that individuals of Amblyopsis are one of the top predators in cave systems they inhabit (Niemiller and Poulson 2010).

Discussion

We describe a new species of North American cavefish, *Amblyopsis hoosieri*, that is distinguished from its sole congener *A. spelaea* based on body and pectoral-fin shape and the absence of a stop codon in *rhodopsin* among other molecular and morphological features. In addition, the distributions of the two species of *Amblyopsis* are separated by the Ohio River, which has downcut through major cave-bearing rock strata and has subsequently isolated populations on the north (*A. hoosieri*) and south (*A. spelaea*) sides of the river. Cavefish diversity is certainly underestimated globally but perhaps particularly in North America: this is the first new cavefish species from the U.S. in 40 years.

Notably, previous cavefish researchers did not recognize this taxon as novel. Eigenmann (1899) noted that some individuals of *Amblyopsis* had more developed cones than others and Poulson (1960) noted qualitatively greater non-external pigmentation and degenerate "eye" size of specimens of *A. spelaea* from south of the Ohio River. Unfortunately, due to the limited number of specimens available we were not able to fully examine these internal features. However, we found that there are several lines of evidence to distinguish the two species based on external morphological features, molecular data and geography.

Eigenmann (1905) described Typhlichthys wyandotte from "north of the Ohio River, from a well near Corydon, Indiana." The type locality is located within the distribution of A. hoosieri and well outside the known distribution of Typhlichthys in the Interior Plateau, which ranges from northern Alabama and northwestern Georgia through central Tennessee into south-central Kentucky (Mammoth Cave region). The type locality was believed to be destroyed (Woods and Inger 1957), although a welllike entrance into a cave has been located in Corydon, Indiana, and may be the type locality (Black, pers. comm. in Lewis 2002b). Unfortunately, the only known specimen (the holotype; formerly IU 4646, currently CAS 91988) is very badly damaged and in several pieces, with most of the head lost. In his description, Eigenmann (1905) stated that this species is more slender than Typhlichthys from south of the Ohio River. This condition is opposite of the situation in Amblyopsis, where individuals north of Ohio River are less slender than those south of the river. A survey of 200+ caves in the same drainage basin as the possible type locality has only documented Amblyopsis and has failed to find Typhlichthys (Lewis 1998). Typhlichthys wyandotte is currently considered a junior synonym of *T. subterraneus* (Woods and Inger 1957), but it is unclear whether the poorly preserved holotype is a member of *Typhlichthys* or *Amblyopsis*.

Molecular data have become an important tool to help identify cryptic or otherwise poorly recognized species level diversity, particularly among subterranean taxa (Chakrabarty 2010, Chakrabarty et al. 2012, Sparks and Chakrabarty 2012). Generally lacking eyes, pigmentation, and other common features of sighted organisms, subterranean fish species have few diagnostic features. Molecular data have been used to discover and diagnose cavefish diversity only recently, but these data are powerful and can surely help increase our understanding of this poorly studied fauna. **Conservation status.** *Amblyopsis spelaea*, and *A. hoosieri* by extension, is considered endangered in Indiana because of presumed vulnerability to groundwater pollution and other perturbations of aquatic subterranean habitats. The species is considered "Endangered" (S1) in Indiana by NatureServe (2013) because of the few occurrences of occurrences, small population sizes and being restricted to subterranean habitats that are highly vulnerable to anthropogenic activities. *Amblyopsis spelaea* is considered "Vulnerable" on the IUCN Red List (Gimenez Dixon 1996). *Amblyopsis hoosieri* should have the same threat category at minimum or be at greater risk of extinction. *Amblyopsis hoosieri* is known from at least 74 localities, but most localities appear to represent sink rather source populations (Pearson and Boston 1995, McCandless 2005). However, a few cave systems contain large populations based on direct counts during visual encounter surveys that likely are source populations, including Eric's River Cave in Crawford Co., and Blue Spring Caverns, Donaldson Cave and Upper Twin Cave, Lawrence Co. (Pearson and Boston 1995, McCandless 2005). Niemiller and Poulson 2010).

Potential threats to populations of A. hoosieri are discussed in detail (for A. spelaea) by Keith (1988), Pearson and Boston (1995), Lewis (2002a) and Niemiller and Poulson (2010). These threats include sedimentation related to agriculture, increased human visitation and collection, and groundwater pollution, particularly from pesticide, herbicide and fertilizer use. Some localities have been directly impacted by anthropogenic activities. Keith (1988) reported that two blind cavefish localities in Indiana were either partially or completely destroyed by quarrying. Groundwater contamination from pesticides was attributed to the cause of "broken-back syndrome" in the population at Donaldson Cave, Lawrence County (Keith and Poulson 1981). At least two populations are indirectly affected by commercial cave tours in Lawrence County (Pearson and Boston 1995; Niemiller and Poulson 2010). Over-collection for scientific studies during the late 1800s and early 1900s may have impacted some populations in Lawrence County. Dozens to hundreds of cavefish were collected from the "Mitchell Caves" (Bronson-Donaldson and Twin Cave systems) by Eigenmann, Payne and others (e.g., Eigenmann 1899, 1903, 1909; Ramsey 1901, Payne 1907) for experiments on cave adaptation. These caves are now protected and located within Spring Mill State Park. The state of Indiana has implemented measures to help protect populations of Amblyopsis, including restricting access to caves and regulating recreational activities permitted. However, the delineating of drainage basins and potential sources of contamination as well as protection of surface and subsurface drainage basins is probably the most important conservation measure to protect the species (Niemiller and Poulson 2010).

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RESEARCH ARTICLE



Revision of the genus Salganea Stål (Blattodea, Blaberidae, Panesthiinae) from China, with descriptions of three new species

Xiudan Wang^{1,†}, Yan Shi^{1,‡}, Zongqing Wang^{1,§}, Yanli Che^{1,1}

I Institute of Entomology, College of Plant Protection, Southwest University, Beibei, Chongqing 400716, China

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Corresponding author: Yanli Che (shirleyche2000@126.com)

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Abstract

Three new species of *Salganea* Stål, 1877 are described and illustrated: *S. quinquedentata* **sp. n.**, *S. anisodonta* **sp. n.** and *S. flexibilis* **sp. n.** *S. taiwanensis* Roth, 1979, *S. guangxiensis* (Feng & Woo, 1990), *S. incerta* (Brunner von Wattenwyl, 1893) and *S. raggei* Roth, 1979 are redescribed. *Panesthia concinna* Feng & Woo, 1990 is synonymized with *S. taiwanensis* Roth, 1979 and *Panesthia guangxiensis* Feng & Woo, 1990 is transferred to the genus *Salganea* for the first time. As well, a key to species from China is presented.

Keywords

New species, new synonym, new combination, cockroaches, Panesthia

Introduction

The blaberid genus *Salganea* belongs to the subfamily Panesthiinae (tribe Salganeini), which is subsocial and xylophagous. Some members live in biparental families (Maekawa et al. 2005), where their young nymphs are defended and fed by parents

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(Maekawa et al. 2008). They are heavy bodied insects ranging from 15.5 to >60 mm in length and the pronotum of the two sexes is usually similar (Maekawa et al. 2008), which can result in a substantial ecological impact on the decomposition of logs (Bell et al. 2007).

This genus is recognized by its T6 with lateral margin even, T7 with lateral margin serrated, and holes associated with setae in the anterolateral corners of abdominal terga. Princis (1965) listed 22 species of Salganea worldwide. Bey-Bienko (1957) listed 3 species of *Salganea* from Sichuan and Yunnan Provinces, China, 2 of which, S. amboinica (Brunner von Wattenwyl, 1893) and S. morio (Burmeister, 1838), probably referred to S. taiwanensis and S. raggei respectively (Roth 1979). Roth (1979) reported 42 species and 4 subspecies in this genus, 3 species of which were from China. In addition, he erected 5 species-groups, based on the anterior margin of the pronotum and male genital phallomere L2d, i.e., the papua species-group, the foveo*late* species-group, the *raggei* species-group, the *morio* species-group and the *nigrita* species-group, although the molecular analysis result did not conform to this conclusion completely (Maekawa et al. 2001). Asahina (1988) considered that S. taiwanensis was composed of two subspecies on the basis of the body size, male genital phallomere L2d and on distribution as well. But according to the molecular phylogeny and geographic distribution of wood-feeding cockroach genera Salganea Stål, 1877 and Panesthia Serville, 1831 in East Asia Islands, Maekawa et al. (1999a) did not agree with the subspecies designations of Asahina. Maekawa et al. (1999b) described one species and then described one species, providing the phylogenetic tree for 27 species and 3 subspecies of the genus Salganea in 2005. Up to now, there are 47 species and 6 subspecies recognized worldwide (Beccaloni 2007), of which 5 species are from China.

Herein, we redescribe *Salganea*, describe 3 new species from China, redescribe 4 species and give a key to the Chinese species. After the examination of type specimens, *Panesthia concinna* Feng & Woo, 1990 is synonymized with *Salganea* taiwanensis and *Panesthia guangxiensis* Feng & Woo, 1990 is transferred to the genus *Salganea*.

Materials and methods

The terminology of the head, body and male genitalia used in this paper mainly follows Roth (1977, 1979), and the terminology of veins follows Rehn (1951). Measurements were based on material examined, and the measurement of body length was without the tegmen. CV_{total} is the coefficient of variation of total number of veins which without radius and anal veins (Liang et al. 2012). The genital segments of the examined specimens were macerated in 10% NaOH and observed in glycerin jelly using a Motic K400 stereomicroscope. All drawings were made with the aid of a Motic K400 stereomicroscope. Photographs of the specimens were made using a Canon 50D plus a Canon EF 100mm f/2.8L IS USM Macro lens with the aid of the Helicon Focus software. The type specimens are deposited in the Insect Collection of Southwest University, Beibei, Chongqing, China (SWU) and the Museum of Hebei University, Baoding, Hebei Province, China (HBU).

Taxonomy

Family Blaberidae Brunner von Wattenwyl, 1865 Subfamily Panesthiinae Kirby, 1904

Genus Salganea Stål, 1877

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

Mylacrina Kirby, 1903: 414. Type species: *Mylacrina wrayi* Kirby, 1903. Synonymized by Roth 1977: 60.

Generic diagnosis (modified after Roth (1979)). Vertex rarely foveolate (except S. papua and S. mandelsi) and exposed. Pronotum transversal ovate, anterior margin almost straight or slightly convex, lateral margins arched, hind margin almost straight; anterior half depressed, with a pair of curved, oblique grooves; posterior half elevated and punctate. Tegmina and wings fully developed, sometimes mutilated, or reduced, or tegmina reduced but wings absent, or both tegmina and wings absent. If tegmina and wings fully developed, tegmina usually narrow and leathery with base thickened, the humeral area well developed and punctate, anterior margin slightly curved medially, subcostal vein short and unbranched. Hind wings with anal area developed with border smooth and rounded; subcostal vein (Sc) straight and simple or with a small branch at apical part, extending beyond the midline of wing length; radial vein (R) with less than five branches, with or without apical posterior branch (Ap. Post. Br.); median vein (M) simple, rarely with a terminal twigging; cubitus (Cu) with more than 8 branches, at least half of which are incomplete and fuse apically or going to the first plical vein (1Pl). Lateral margin of the 6th abdominal tergum (T6) straight; lateral margin of the 7^{th} abdominal tergum (*T7*) uneven, caudal angles produced caudally or laterocaudally; anterolateral corners of 6th and 7th abdominal terga usually with holes, sometimes holes also existing in the corners of T3, T4 or T5, which are usually accompanied with small setae or hairs. Abdominal sternites punctured, the last sternite with a marginal ridge extending along the lateral margins. Supra-anal plate transverse; paraprocts broad, left one in ventral view armed with a finger-like projection, which is curved dorsally and whose apex is sclerotized. Subgenital plate flabellate, anterior margin straight or concave, lateral margins oblique, hind margin round. Four genital phallomeres as below: first sclerite of left phallomere (L1) plate-like, well developed but usually not sclerotized, sometimes reduced or absent; second ventromedial sclerite of left phallomere (L2vm)

Salganea Stål, 1877: 37. Type species: Panesthia morio Burmeister, 1838; Roth 1979: 4; Asahina 1988: 257.

rod-like; second dorsal sclerite of the left phallomere (L2d) elongate, variable; second sclerite of right phallomere (R2) hook-shaped, reduced or absent in some species.

Remarks. Because the irregularities on lateral margin of T7 maybe subobsolete, this genus is similar to *Panesthia*. With a notch existing anterior to the laterocaudal angle of T7 sometimes, this genus resembles *Ancaudellia* Shaw, 1925. But it can be distinguished by the following characteristics: 1) anterolateral corners of 6^{th} and 7^{th} abdominal terga usually with holes and holes associated with well spaced setae (*Panesthia* rarely with holes and without setae, *Ancaudellia* with grooves and associated with dense patches of contiguous setae); 2) lateral margin of S7 with a ridge extending from anterior margin to hind margin (with a feeble and short ridge, or without a ridge in *Panesthia* and *Ancaudellia*).

Although S. amboinica, S. morio and S. passaloides passaloides (Walker, 1868) were recorded from China, none of them were found after our wide survey of collecting and examining loans from other museums. Moreover, Roth (1979) had questioned whether they were truly recorded from China. These species have been excluded in our count for the total number of species in this genus from China, and have been removed from our key to the Salganea from China.

Distribution. Few places of Palaearctic Region (China, Japan), Oriental Region, Australian Region.

Key to species of Salganea from China (males)

1	<i>L2d</i> bifurcated (<i>nigrita</i> species-group) 2
_	L2d not bifurcated (raggei species-group)
2	Tegmina and wings reduced, not reaching apex of metanotum
_	Tegmina and wings fully developed, surpassing apex of abdomen4
3	Anterior margin of pronotum with a V-shaped mesal excision and a small
	reflexed tubercle on each side of the indentation, anterolateral corners of $T5$ -
	<i>T6</i> with holes and associated setae <i>S. biglumis</i>
_	Anterior margin of pronotum hardly excised mesally or smooth, with a small
	unobvious tubercle on each side of the indentation, anterolateral corners of
	T6-T7 with holes but lacking associated setae
4	<i>R2</i> reduced, usually not hook-like or absent 5
_	<i>R2</i> developed, hook-like6
5	Hind margin of supra-anal plate with 8-13 triangular teeth (Fig. 45)
	S. taiwanensis
_	Hind margin of supra-anal plate with 10-11 obtuse rounded teeth (Fig. 22)
	S. guangxiensis comb. n.
6	Hind margin of supra-anal plate with 9-13 contiguous triangular teeth
	(Fig. 55)
_	Hind margin of supra-anal plate with relatively spaced teeth7
7	Pronotum with a pair of tubercles mesially (Fig. 33), hind margin of supra-
	anal plate with 7-8 stubby subacute teeth (Fig. 36) S. anisodonta sp. n.

-	Pronotum without tubercles (Fig. 25), hind mar	gin of supra-anal plate with
	5 relatively slender teeth, sometimes fused togethe	er or with small acute spines
	between them (Fig. 28)	S. quinquedentata sp. n.
8	Lateral margin of T7 with 5-6 obtuse teeth (Fig.	62), hind margin of supra-
	anal plate with 8-16 subequal teeth (Fig. 64)	S. raggei
_	Lateral margin of T7 with 3 subacute teeth (Fig.	70), hind margin of supra-
	anal plate with 8 unequal teeth (Fig. 72)	S. flexibilis sp. n.

Salganea quinquedentata sp. n.

http://zoobank.org/863217EA-CB48-41C7-9AC0-980E1A0B775C http://species-id.net/wiki/Salganea_quinquedentata Figs 1–4, 21–28, 80–81, 89–90

Description. Male. Body dark reddish brown, darker or black on caudal segments (Fig. 1). Eyes brown and ocelli yellowish. Antennae, upper lip, mandible, labial palpi and maxillary palpomeres brown. Legs reddish brown with coxae and trochanter brown. Abdominal sternites reddish brown with the middle of anterior three sternites brown (Fig. 2).

Vertex and face punctate, the former exposed. Anterior margin of pronotum smooth, or weakly concave; anterior half of pronotum slightly depressed, the floor punctured, denser laterally; posterior half punctured sparsely and almost evenly, without tubercles (Fig. 21). Tegmina and wings well developed, extending beyond end of abdomen, sometimes mutilated (Fig. 1). Radius of tegmen with a long apical posterior branch, which has accessory branches, or apical posterior branch absent; median vein is simple or branched (Figs 80-81). Radial vein of hind wing with posterior branch medially; median vein branched terminally or not; cubitus with 4-5 complete and 5-6 incomplete branches (Figs 89–90). Anterior ventral margin of front femur with 1–3 spines and a small distal spine, hind margin with a large distal spine. Abdominal tergites punctured, the punctures denser laterally and caudally; T5-T7 with gradually increased holes on the anterolateral corners, minute sparse hairs sometimes visible on the surfaces; caudal angles of T6weakly explored; lateral margins of T7 slightly uneven, caudal angles oblique, large and tapering (Fig. 22). Abdominal sternites densely punctured, the punctations larger and denser caudally; hind margin of the last sternite entire (Fig. 23). Supra-anal plate densely punctured, coarser than abdominal tergites; hind margin with 5 subacute and symmetrically slender teeth, which are deflexed and widely spaced, the largest one situated in the middle; teeth with margin smooth or small acute spines between the teeth, sometimes teeth fused together; lateral angles larger than the medial tooth. Cercus without setae dorsally, ventral surface convex with dense hairs (Fig. 24). Anterior margin of subgenital plate concave, anterolateral corners rounded; lateral margins concave (Fig. 25).

Male genitalia. Genital phallomere *L1* reduced, only a short lobe remaining, or absent (Fig. 26); *L2d* tapering at apex, with a relatively large lateral lobe (Fig. 27); *R2* weakly curved, hook-shaped (Fig. 28).



Figures 1–20. 1–2 Salganea quinquedentata sp. n., male: 1 holotype, dorsal view 2 same, ventral view 3–4 Salganea quinquedentata sp. n., nymph: 3 paratype, dorsal view 4 same, ventral view 5–6 Salganea anisodonta sp. n., male: 5 holotype, dorsal view 6 same, ventral view 7–8 Salganea taiwanensis Roth, 1979, male: 7 holotype of Panesthia concinna Feng & Woo, 1990, dorsal view 8 same, ventral view 9–10 Salganea guangxiensis (Feng & Woo, 1990), male: 9 holotype of Panesthia guangxiensis Feng & Woo, 1990, dorsal view 10 same, ventral view 11–12 Salganea incerta (Brunner von Wattenwyl, 1893), male: 11 dorsal view 12 ventral view 13–14 Salganea incerta (Brunner von Wattenwyl, 1893), nymph: 13 dorsal view 14 ventral view 15–16 Salganea raggei Roth, 1979, male: 15 dorsal view 16 ventral view 17–18 Salganea raggei Roth, 1979, nymph: 17 dorsal view 18 ventral view 19–20 Salganea flexibilis sp. n., male: 19 holotype, dorsal view 20 same, ventral view. Scale bars = 1.0 cm.



Figures 21–28. *Salganea quinquedentata* sp. n. **21** vertex and pronotum **22** abdominal tergum 7, dorsal view **23** abdominal sternite 7, ventral view **24** supra-anal plate and paraprocts, ventral view **25** subgenital plate, dorsal view **26** left phallomere (*L1*) **27** median phallomere (*L2vm* and *L2d*) **28** right phallomere (*R2*). Scale bars = 1.0 mm (Figs **21–23**), 0.5 mm (Figs **24–28**).

Female. Essentially similar to male, difficult to distinguish externally.

Nymph. Body yellowish brown and eyes dark. Hind margin of the supra-anal plate with 5 contiguous and triangular teeth, sometimes separated by tiny tines. Remaining external morphological features are characteristic of the adult (Figs 3–4).

Measurements. Male, $3^{th}-5^{th}$ maxillary segments: 0.57-0.67/0.48-0.87/0.61-1.00 mm; pronotum: length × width: $5.2-5.5 \times 8.8-9.3$ mm; tegmen: 24.1-25.0 mm; body length: 26.9-29.5 mm; fore leg: coxae: 2.29-2.51 mm, trochanter: 1.46-1.79 mm, femur: 3.24-3.85 mm, tibia: 1.19-2.61 mm, $1^{st}-5^{th}$ tarsus: 0.57-0.69/0.20-0.24/0.19-0.24/0.28-0.32/1.00-1.28 mm; mid leg: coxae: 2.48-2.90 mm, trochanter: 1.2/0.25-0.28/0.24-0.27/0.33-0.35/1.00-1.24 mm; hind leg: coxae: 2.14-2.53 mm, trochanter: 2.70-2.75 mm, femur: 5.23-5.81 mm, tibia: 5.47-6.14 mm, $1^{st}-5^{th}$ tarsus: 1.18-1.22/0.27-0.29/0.27-0.31/0.27-0.30/1.07-1.15 mm; cerci: 0.64-0.97 mm.

Female, $3^{th}-5^{th}$ maxillary segments: 0.73-0.79/0.84-0.85/0.93-1.08mm; pronotum: length × width: $5.0 \times 8.8-9.5$ mm; body length: 26.5-27.5mm; fore leg: coxae: 2.17-2.29mm, trochanter: 0.61-2.30mm, femur: 1.94-2.07mm, tibia: 2.16-2.64mm, $1^{st}-5^{th}$ tarsus: 0.63-0.80/0.24-0.28/0.23-0.28/0.32-0.27/0.91-1.20mm; mid leg: coxae: 2.81-2.89mm, trochanter: 2.55-2.87mm, femur: 5.31-5.76mm, tibia: 4.52-4.60mm, $1^{st}-5^{th}$ tarsus: 1.22-1.23/0.28-0.30/0.25-0.27/0.32-0.34/1.06-1.45mm; hind leg: coxae: 2.06-2.28mm, trochanter: 2.53-2.92mm, femur: 5.00-6.23mm, tibia: 5.47-7.32mm, $1^{st}-5^{th}$ tarsus: 1.36/0.35/0.29/0.36/1.39mm; cerci: 0.87-0.91mm.

Material examined. *Holotype*, male, China: Hainan Prov., Lingshui County, Mt. Diaoluoshan, 18°43.462'N, 104°52.105'E, 4 May 2013, coll. Yan Shi and Shunhua Gui (SWU). *Paratypes*, two males, three females and six nymphs, same data as holotype (SWU); one female, Hainan Prov., Mt. Wuzhishan, 2 May 1964, coll. Yuliang Luo (SWU).

Remarks. This species is assigned into the *S. nigrita* species group by the forked *L2d.* It resembles *S. incerta*, but can be distinguished by the following characteristics: 1) anterior margin of pronotum entire and without tubercles, indented and with tubercles in *S. incerta*; 2) the floor of pronotum without tubercles, with tubercles in *S. incerta*; 3) hind margin of seventh abdominal sternite entire, the latter with a medial excision; 4) hind margin of supra-anal plate with 5 distinct, subacute and slender teeth, with 9-13 triangular teeth in *S. incerta*.

Etymology. The specific epithet is derived from the Latin word "*quinquedentatus*", referring to the posterior margin of supra-anal plate with 5 distinct and slender teeth.

Salganea anisodonta sp. n.

http://zoobank.org/45FEEBFC-E670-492B-8FB2-6E9CB92C01B4 http://species-id.net/wiki/Salganea_anisodonta Figs 5–6, 29–36, 82, 91

Description. Male. Body dark reddish brown (Fig. 5). Face black, eyes dark brown, ocelli yellowish, upper lip and mandible brown; antennae, labial palpi and maxillary

palpomeres dark brown. Legs reddish brown with coxae and trochanter brown. Abdominal sternites reddish brown, darker caudally (Fig. 6).

Vertex exposed and without punctures. Face punctulated, ocelli round and with border distinct. Anterior margin of pronotum with a V-shaped excision mesially, a small recurved tubercle on the each side of the indentation; anterior 1/3 half of pronotum depressed, the floor densely granular; lateral and posterior half punctured, with a pair of small tubercles in the middle (Fig. 29). Tegmina and wings mutilated, probably well developed (Fig.5). Radial vein of tegmen with a long apical posterior branch mesially, which is branched at apex and with an accessory branch; the median vein branched before the midline (Fig. 82). Hind wing with subcostal vein branched at apical part; radial vein bifurcated at apex and forked medially; median vein simple; cubitus with 6 complete and 5 incomplete branches (Fig. 91). Anterior ventral margin of front femur without spines, hind margin with a large distal spine. Abdominal tergites punctured, the punctures denser and larger laterally; T7 with coarse surface scattered with sparse setae, and with circular depressions laterally, lateral margin crenulate, caudal angles oblique and tapering (Fig. 30). T6-T7 with small holes on the anterolateral corners, which is associated with minute sparse hairs in the openings. Abdominal sternites densely punctured; hind margin of S7 slightly convex and subgenital plate weakly exposed (Fig. 31). Supra-anal plate extremely coarse, hirsute and covered with depressions similar to T7 in density; hind margin with 7-8 relatively separated teeth, which have an uneven border with lateral ones larger than teeth in the middle, or two fused together; lateral angles equal or larger than the biggest tooth between them. Cercus basiconic, with ventral side swollen and with setae ventrally and dorsally (Fig. 32). Anterior margin of subgenital plate slightly concave or more or less straight, lateral margin curved inwards (Fig. 33).

Male genitalia. Genital phallomere *L1* reduced to a small plate (Fig. 34); *L2d* tapering and bifurcated apically, major branch with apex rounded and a little larger than the lateral one (Fig. 35); *R2* developed and curved, hook-shaped, with apex obtuse and slightly swollen (Fig. 36).

Female. Anterior margin of pronotum with smaller tubercles than male and the tubercles not recurved.

Nymph. Unknown.

Measurements. Male, $3^{th}-5^{th}$ maxillary segments: 0.53–0.69/0.76–0.78/0.61–0.97mm; pronotum: length × width: 5.0–5.1 × 8.4–8.6mm; distance between disc tubercles: 1.9–2.1mm; tegmen: 28.5mm; body length: 27.5–28.0mm; fore leg: coxae: 2.63–2.83mm, trochanter: 1.50–1.97mm, femur: 3.24–3.76mm, tibia: 1.73–2.33mm, 1st–5th tarsus: 0.73/0.35/0.26/0.34/1.30mm; mid leg: coxae: 2.70–2.93mm, trochanter: 2.19–2.72mm, femur: 4.54–4.85mm, tibia: 3.72–3.98mm, 1st–5th tarsus: 1.02–1.16/0.26–0.27/0.24–0.28/0.29–0.34/1.02–1.22mm; hind leg: coxae: 2.69–2.74mm, trochanter: 2.55–2.65mm, femur: 5.13–5.38mm, tibia: 5.37–5.76mm, 1st–5th tarsus: 1.24/0.28/0.27/0.32/1.10mm; cerci: 0.67–0.74mm.

Female, 3th-5th maxillary segments: 0.60/0.82/0.92mm; pronotum: length × width: 5.6 × 9.1mm; distance between disc tubercles: 2.2mm; body length: 29.6mm;



Figures 29–36. *Salganea anisodonta* sp. n. **29** vertex and pronotum **30** abdominal tergum 7, dorsal view **31** abdominal sternite 7, ventral view **32** supra-anal plate and paraprocts, ventral view **33** subgenital plate, dorsal view **34** left phallomere (*L1*) **35** median phallomere (*L2vm* and *L2d*) **36** right phallomere (*R2*). Scale bars = 1.0 mm (Figs **29–33**), 0.5 mm (Figs **34–36**).

fore leg: coxae: 2.45mm, trochanter: 2.05mm, femur: 3.44mm, tibia: 2.42mm, 1st-5th tarsus: 0.65/0.32/0.29/0.32/0.95mm; mid leg: coxae: 2.99mm, trochanter: 2.84mm, femur: 5.20mm, tibia: 3.90mm, 1st-5th tarsus: 1.03/0.27/0.26/0.29/1.19mm; hind leg: coxae: 2.72mm, trochanter: 3.12mm, femur: 5.75mm, tibia: 6.30mm, 1st-5th tarsus: 1.41/0.37/0.30/0.40/1.37mm; cerci: 0.66mm.

Material examined. *Holotype*, male, China: Yunnan Prov., Longling County, Longxin Township, Heishan Village, 2300m, 23–25 December 2008, coll. Jishan Xu and Zhenhua Gao (HBU). *Paratypes*, one male and one female, same data as holotype (HBU).

Remarks. This species is placed into the *S. nigrita* species group and is similar to *S. incerta*, but can be distinguished by: 1) anterior margin of pronotum with tubercles in female, without or weakly indicated in female of *S. incerta*; 2) anterior margin with two reflexed tubercles mesially, tubercles in *S. incerta* not reflexed; 3) hind margin of supra-anal plate with 7-8 relatively separated teeth, lateral ones larger than teeth in the middle, teeth in *S. incerta* contiguous and subequal; 4) *L2d* with rounded apex and lateral sclerite relatively larger, apex acute and lateral sclerite smaller in *S. incerta*.

Etymology. The scientific epithet of this species is derived from the Latin word "*an-isodontus*" which refers to the different teeth in the hind margin of the supra-anal plate.

Salganea taiwanensis Roth, 1979

http://species-id.net/wiki/Salganea_taiwanensis Figs 7–8, 37–45, 83–84, 92–93, 98–113

Salganea taiwanensis Roth, 1979:64. Salganea panesthiodes Princis (nom. nud.), Asahina 1984: 118. Salganea taiwanensis taiwanensis Asahina, 1988: 261. Panesthia concinna Feng & Woo, 1990: 214. **Syn. n.**

Description. Male. Body dark reddish brown, darker on caudal segments, or totally black (Fig. 7). Eyes black-brown and ocelli yellowish. Antennae, upper lip, mandible, labial palpi and maxillary palpomeres brown. Legs dark reddish brown, paler on coxae and trochanter. Abdominal sternites reddish brown with the middle of the first and second sternites brown (Fig.8).

Vertex with few punctations, exposed; face densely punctulated; ocelli round and distinct. Anterior margin of pronotum thickened, with a small mesial V-shaped indentation, a small reflexed protuberance on the each side of the excision; anterior half of pronotum depressed, with sparsely granular surface; posterior half punctured, with 2 oblique mounds armed with 2 tubercles at apex (Fig. 37). Tegmina and wings well developed, extending beyond the abdominal terminal (Fig. 7). In tegmen, the radius with 3 short or 1 relatively long posterior branches; median vein simple or branched (Figs 83–84). Radius in hind wing with apical posterior branch near the middle, which is associated with 2 branches and one of them sometimes branched, some veins fused partially; median vein branched or not; cubitus with 5–6 complete



Figures 37–45. *Salganea taiwanensis* Roth, 1979 **37** vertex and pronotum **38** abdominal tergum 7, dorsal view **39** abdominal sternite 7 of male, ventral view **40** abdominal sternite 7 of female, ventral view **41** supra-anal plate and paraprocts, ventral view **42** subgenital plate, dorsal view **43** left phallomere (*L1*) **44** median phallomere (*L2vm* and *L2d*) **45** right phallomere (*R2*). Scale bars = 1.0 mm (Figs **37–40**), 0.5 mm (Figs **41–45**).

and 6-8 incomplete branches (Figs 92–93). Anterior ventral margin of front femur with 0-4 spines and a small distal spine, hind margin with a large distal spine. Abdominal tergites punctured, and the punctures denser laterally; T4-T7 with holes on the anterolateral corners which are surrounded with fine hairs, the holes on T4 small or absent; lateral margins of T7 feebly crenulate, sometimes the irregularities subobsolete and indistinct, caudal angle oblique (Fig. 38). Abdominal sternites densely punctured, hind margin with a mesial concavity (Fig. 39). Supra-anal plate densely punctate, hind margin with 8–13 subequal teeth (10 in most cases), which are broad basally, triangular, or fused together, lateral angles obtuse and about the same size as the largest tooth between them. Cercus conical, very few or no setae dorsally, ventral surface swollen, densely setose (Fig. 41). Anterior margin of subgenital plate slightly concave, lateral margins sunken (Fig. 42).

Male genitalia. Genital phallomere *L1* reduced or absent (Fig. 43); *L2d* elongate, apically acute and forked, with a small lateral lobe (Fig. 44); *R2* variably reduced and usually not hook-shaped, or absent (Fig. 45).

Female. Essentially similar to male, but larger than male and with hind margin of the seventh sternite rounded (Fig. 40).

Measurements. Male, $3^{th}-5^{th}$ maxillary segments: 0.65–0.75/0.63–0.89/0.86–1.01mm; pronotum: length × width: 4.7–6.2 × 7.7–10.5mm; distance between disc tubercles: 1.8–2.8mm; tegmen: 24.0–27.0mm; body length: 24.0–30.5mm; fore leg: coxae: 2.60–3.19mm, trochanter: 1.61–1.71mm, femur: 2.71–4.07mm, tibia: 1.30–2.33mm, $1^{st}-5^{th}$ tarsus: 0.62–0.67/0.21–0.22/0.19–0.22/0.24–0.32/1.37–1.44mm; mid leg: coxae: 2.76–3.00mm, trochanter: 2.33–2.39mm, femur: 4.35–5.01mm, tibia: 3.81–4.84mm, $1^{st}-5^{th}$ tarsus: 0.80–0.82/0.26–0.28/0.26–0.27/0.28/1.07–1.11mm; hind leg: coxae: 2.44–2.94mm, trochanter: 2.52–2.60mm, femur: 4.71–5.58mm, tibia: 5.67–7.21mm, $1^{st}-5^{th}$ tarsus: 1.06–1.22/0.26–0.35/0.26–0.34/0.28–0.41/1.07–1.33mm; cerci: 0.68–0.79mm.

Female, $3^{th}-5^{th}$ maxillary segments: 0.68–0.85/0.66–0.75/0.59–0.94mm; pronotum: length × width: 4.7–5.8 × 8.0–13.0mm; distance between disc tubercles: 1.8– 2.7mm; tegmen: 24.1–27.5mm; body length: 25.0–29.5mm; fore leg: coxae: 3.30– 3.78mm, trochanter: 1.99–2.01mm, femur: 3.19–3.41mm, tibia: 2.05–2.06mm, $1^{st}-5^{th}$ tarsus: 0.68–0.78/0.23–0.29/0.22–0.27/0.25–0.29/0.77–1.00mm; mid leg: coxae: 2.85–3.39mm, trochanter: 2.29–2.37mm, femur: 4.37–4.39mm, tibia: 3.80– 4.03mm, $1^{st}-5^{th}$ tarsus: 0.79–0.96/0.24–0.30/0.23–0.27/0.28–0.33/1.05–1.14mm; hind leg: coxae: 2.67–3.03mm, trochanter: 2.44–2.45mm, femur: 4.90–5.04mm, tibia: 6.29–6.47mm, $1^{st}-5^{th}$ tarsus: 1.13–1.28/0.28–0.31/0.30–0.32/0.25–0.37/1.11– 1.16mm; cerci: 0.61–0.68mm.

Material examined. One male (holotype of *Panesthia concinna* Feng & Woo, 1990), Fujian Prov., Mt. Wuyishan, 10–17 July 1982, coll. Feng Xia; one male, Fujian Prov., Mt. Wuyishan, 15 July 1984, coll. Sizheng Wang; two males and one female, Jiangxi Prov., Mt. Jiulianshan, Gongtang, 30 April 1986, coll. Jianzhong Zheng; four males and one female, Jiangxi Prov., Mt. Jiulianshan, 4 May 1986, coll. Liu Luo; two females, Fujian Prov., 30 June 1982, coll. Fan Jiang; one female, Guangxi Prov.,

Huaping Nature Preserves, Mt. Tianpingshan, coll. Kun Yang; two females, Guizhou Prov., Ceheng County, 800–950m, 23–27 July 1979, coll. Shaokun Du; one male, Guangdong Prov., Meizhou City, Mt. Wuzhishan, May 2007, coll. Lijun Cai. (SWU)

Remarks. Considering the *Panesthia*-like lateral margin on *T7* and the disappearance of sclerite *R2*, Feng and Woo (1990) treated *Panesthia concinna* (Figs 7–8) as a member of the genus *Panesthia*. But after examining the holotype of *Panesthia concinna* Feng & Woo, 1990, the essentially straight lateral margin of *T7* and the absence of *R2* should be within the intraspecific variation of *S. taiwanensis*. Herein we treat *Panesthia concinna* Feng & Woo, 1990 as a synonym of *Salganea taiwanensis* Roth, 1979.

Distribution. China (Jiangxi, Fujian, Guangxi, Guizhou, Guangdong, Taiwan); Japan; Vietnam.

Salganea guangxiensis (Feng & Woo, 1990), comb. n.

http://species-id.net/wiki/Salganea_guangxiensis Figs 9–10, 21–24, 46–49

Panesthia guangxiensis Feng & Woo, 1990: 214.

Description. Male. Body dark reddish, with the coloration similar to *S. taiwanensis*.

Vertex sparsely punctate, exposed; face densely punctulated; ocelli round and distinct. Anterior margin of pronotum weakly thickened, with a small mesial emargination, a protuberance on the each side of the excision; anterior half of pronotum depressed, the surface sparsely granular; posterior half punctured, with 2 tubercles (Fig. 9). Tegmina and wings mutilated, probably fully developed (Fig. 9). Anterior ventral margin of front femur with 2 spines and a small distal spine, hind margin with a large distal spine. T4-T7 with holes on the anterolateral corners which are surrounded by fine hairs, the holes on T4 are very small; lateral margins of T7 Panesthia-like (Fig. 46). Supra-anal plate densely punctate, hind margin with 10 subequal teeth, obtuse rounded (Fig. 47). The last abdominal sternite and subgenital plate were broken.

Male genitalia. Genital phallomere *L1* lost; *L2d* elongate, apically acute and forked, with a lateral lobe (Fig. 48); *R2* reduced, clavate (Fig. 49).

Measurements. Male, $3^{th}-5^{th}$ maxillary segments: 0.73/0.76/1.05mm; pronotum: length × width: 5.1×9.5 mm; distance between disc tubercles: 2.2mm; body length: 27.4mm; fore leg: coxae: 2.42mm, trochanter: 1.64mm, femur: 3.47mm, tibia: 2.48mm, $1^{st}-5^{th}$ tarsus: 0.70/0.30/0.19/0.26/1.34mm; mid leg: coxae: 3.31mm, trochanter: 2.74mm, femur: 4.33mm, tibia: 3.96mm; hind leg: coxae: 2.57mm, trochanter: 2.72mm, femur: 4.43mm, tibia: 5.92mm; cerci: 0.71mm.

Material examined. One male (holotype of *Panesthia guangxiensis* Feng & Woo, 1990), China: Guangxi Prov., Mt. Jinxiulaoshan, 6 September 1981, collector unknown. (SWU)

Remarks. Although the lateral margin of *T7* is *Panesthia*-like, the characters of the holes in anterolateral corners of *T4-T7* associated with setae, and the ridge along with


Figures 46–49 *Salganea guangxiensis* (Feng *et* Woo, 1990) **46** abdominal tergum 7, dorsal view **47** supra-anal plate and paraprocts, ventral view **48** median phallomere (*L2vm* and *L2d*) **49** right phallomere (*R2*). Scale bars = 0.5 mm.

the lateral margin of *S7* are more typical of the genus *Salganea*. Thus, we place this species in genus *Salganea*. It is very similar to *S. taiwanensis*, only differing in the rounded teeth in the hind margin of supra-anal plate. To be rigorous, the relationship between this two species requires more specimens to provide an absolute determination.

Distribution. China (Guangxi).

Salganea incerta (Brunner von Wattenwyl, 1893)

http://species-id.net/wiki/Salganea_incerta Figs 11–14, 50–60, 85–86, 94–95

Panesthia incerta Brunner von Wattenwyl, 1893: 50. *Salganea incerta*, Roth 1979: 73, type species by lectotype.

Description. Male. Body reddish brown, darker caudally (Fig. 11). Eyes blackish brown; ocelli yellowish. Antennae, upper lip, mandible, labial palpi and maxillary palpomeres reddish brown and only a little paler than body. Legs reddish brown, paler on coxae and trochanter. Abdominal sternites reddish brown with the middle of the former two sternites brown (Fig. 12).

Face sparsely punctate and vertex exposed. Anterior margin of pronotum slightly concave mesially, with a small tubercle on each side of the excision; anterior half slightly

depressed, the floor with sparse pustules; few punctations on posterior half, with a pair of small tubercles (Fig. 50). Tegmina and wings extending beyond the end of abdomen, sometimes mutilated (Fig. 11). Radial vein of tegmen with 1 forked posterior branch at base, or with 2 simple posterior branches; median vein branched before the midline (Figs 85-86). Radial vein of hind wing simple and branched apically, or with 3 small branches which terminate in the anterior apical angle; median vein branched; cubitus with 5 complete branches, which may be forked or not, and 7-8 incomplete branches (Figs 94-95). Anteroventral margin of front femur armed with 1 spine or unarmed, with or without a minute distal spine, hind margin with a distal spine. Abdominal tergites 1-6 sparsely punctate; T7 denser punctulated caudally, lateral margin weakly crenulate, laterocaudal angle slightly produced (Fig. 52); anterolateral corners with small holes in T6 and T7, some minute and indistinct in T5. Abdominal sternites punctulate, the last sternite densely punctuated and hind margin indented (Fig. 53). Supra-anal plate densely punctate, hind margin varied with 9–13 triangular teeth, border of teeth smooth or crenulate (Figs 55-56). Cercus conical, with few setae near the border dorsally and ventral surface setose (Fig. 55). Anterior margin of subgenital plate slightly concave, lateral margins slightly curved (Fig. 57).

Male genitalia. *L1* reduced, only two small lobes remained (Fig. 58); *L2d* forked apically and apex acute (Fig. 59); *R2* hook-shaped, with weak hook portion and the apex not curved upwards (Fig. 60).

Female. Differs from male as follows: anterior margin of pronotum smooth or indented mesially and the tubercles absent or weakly indicated (Fig. 51); hind margin of S7 entire (Fig. 54).

Nymph. Body brown, darker caudally (Figs 13–14), the depression of pronotum punctate.

Measurements. Male, $3^{th}-5^{th}$ maxillary segments: 0.36–0.59/0.64–0.78/0.90–0.94mm; pronotum: length × width: 3.6–5.2 × 6.5–8.7mm; distance between disc tubercles: 1.4–2.2mm; tegmen: 24.0–26.5mm; body length: 17.7–26.2mm; fore leg: coxae: 1.53–2.29mm, trochanter: 1.65–1.86mm, femur: 2.81–3.19mm, tibia: 1.37–1.55mm, 1st–5th tarsus: 0.34–0.63/0.17–0.20/0.19–0.23/0.24–0.29/1.00–1.18mm; mid leg: coxae: 2.22–2.51mm, trochanter: 2.12–2.58mm, femur: 4.48–4.90mm, tibia: 3.73–3.79mm, 1st–5th tarsus: 0.76–0.99/0.22/0.23/0.26–0.30/1.00–1.03mm; hind leg: coxae: 2.02–2.84mm, trochanter: 2.34–2.56mm, femur: 4.43–5.16mm, tibia: 5.43–5.91mm, 1st–5th tarsus: 1.02–1.20/0.25–0.32/0.26–0.28/0.30–0.32/1.12–1.17mm; cerci: 0.73–0.89mm.

Female, $3^{th}-5^{th}$ maxillary segments: 0.70–0.74/0.59–0.66/0.96–0.99mm; pronotum: length × width: 4.4–5.8 × 7.6–9.1mm; body length: 20.0–27.0mm; fore leg: coxae: 2.27–2.54mm, trochanter: 1.68–1.93mm, femur: 3.52–3.54mm, tibia: 1.64–2.00mm, $1^{st}-5^{th}$ tarsus: 0.54–0.56/0.16–0.21/0.20–0.26/0.27–0.30/1.10–1.17mm; mid leg: coxae: 2.34–3.02mm, trochanter: 1.63–1.99mm, femur: 4.67–4.75mm, tibia: 4.25–4.46mm, $1^{st}-5^{th}$ tarsus: 1.08–1.11/0.29–0.30/0.25/0.30–0.31/1.01–1.13mm; hind leg: coxae: 2.11–2.51mm, trochanter: 2.01–2.30mm, femur: 5.02–5.60mm, tibia: 6.04–6.19mm, $1^{st}-5^{th}$ tarsus: 1.02–1.17/0.30–0.34/0.27–0.28/0.32–0.33/1.00–1.13mm; cerci: 0.54–0.94mm.



Figures 50–60. *Salganea incerta* (Brunner von Wattenwyl, 1893) **50** vertex and pronotum, male **51** vertex and pronotum, female **52** abdominal tergum 7, dorsal view **53** abdominal sternite 7 of male, ventral view **54** abdominal sternite 7 of female, ventral view **55** supra-anal plate and paraprocts, ventral view **56** hind margin of supra-anal plate, ventral view **57** subgenital plate, dorsal view **58** left phallomere (*L1*) **59** median phallomere (*L2vm* and *L2d*) **60** right phallomere (*R2*). Scale bars = 1.0 mm (Figs **50–54**), 0.5 mm (Figs **55–60**).

Material examined. Two males, Guangxi Prov., Jinxiu County, Mt. Yangjiaoshan, 25 September 1981, collector unknown; one male and two females, Chongqing, Mt. Simianshan, Dawopu, 11 July 2008, coll. Zongqing Wang; one male and one female, Sichuan Prov., Hongya County, Mt. Wawushan, 30 June 2013, coll. Yang Li and Jinjin Wang; one male, Yunnan Prov., Yingjiang County, 1418m, 24°61'N, 97°62'E, 4–5 June 2008, coll. Weiwei Zhang; two males, Yunnan Prov., Yingjiang County, Xima Township, Menglaihe River 2nd Hydroelectric Power Station, 1470m, 24°78.404'N, 97°67.493'E, 27–29 May 2009, coll. Weiwei Zhang; two males, Yunnan Prov., Yingjiang County, Xima Township, Menglaihe 2nd Hydroelectric Power Station, 1470m, 6–9 June 2008, coll. Weiwei Zhang; two males, Yunnan Prov., Yingjiang Country, Taiping Town, Longpen Village, 30 May-9 June 2009, coll. Weiwei Zhang; one male and one female, Hainan Prov., Mt. Diaoluoshan, 18°43.462'N, 108°52.105'E, 4 May 2013,coll. Yan Shi and Shunhua Gui; one male and one female, China, 4 May 1980, coll. Qiaosheng Yuan; two males, two females and 3 nymphs, Chongqing, Mt. Simianshan, 2 October 2013, coll. Hao Xu and Jianyue Qiu. (SWU)

Distribution. China (Guangxi, Chongqing, Sichuan, Yunnan, Hainan); India; Myanmar; Thailand.

Salganea raggei Roth, 1979

http://species-id.net/wiki/Salganea_raggei Figs 15–18, 61–68, 87–88, 96–97 *Salganea raggei* Roth, 1979: 30.

Description. Male. Body reddish brown, darker caudally, or black (Fig. 15). Eyes black and ocelli yellowish. Antennae, upper lip, mandible, labial palpi and maxillary palpomeres reddish brown. Legs brown, reddish on coxae, trochanter and anterior half of femora. Abdominal sternites reddish brown with the middle of the former several sternites brown (Fig. 16).

Face punctulated and vertex exposed. Ocelli small and round. Anterior margin of pronotum with a V-shaped emargination in the midline, a small recurved tubercle behind the margin on each side of the excision; anterior half depressed, the floor densely granular, lateral area punctate; region behind grooves convex and densely punctate, with one or two pairs of relatively large tubercles on the mounds symmetrically (Fig. 61). Tegmina and wings well developed, sometimes mutilated and remaining an uneven base (Fig. 15). Radius of tegmen with or without 1 long posterior branch which is forked; median vein branched (Figs 87–88). Radial vein of hind wing with one or more branches near the apex, some branches reforked, the posterior branch branched or not; median vein with two branches or simple; cubitus with 7–8 complete and 8–10 incomplete branches (Figs 96-97). Anterior ventral margin of fore femur equipped with 1–3 spines, and with or without a minute distal spine, posterior margin with a large distal spine. Abdominal tergites punctated, the punctures denser laterally and dorsoposteriorly, anterolateral corners usually without holes, rarely with small holes on



Figures 61–68. *Salganea raggei* Roth, 1979 **61** vertex and pronotum **62** abdominal tergum 7, dorsal view **63** abdominal sternite 7, ventral view **64** supra-anal plate and paraprocts, ventral view **65** subgenital plate, dorsal view **66** left phallomere (*L1*) **67** median phallomere (*L2vm* and *L2d*) **68** right phallomere (*R2*). Scale bars = 1.0 mm (Figs **61–64**), 0.5 mm (Figs **65–68**).

T6 and T7 only; lateral angle of T6 produced into a rounded and oblique spine; lateral margin of T7 with 5–6 obtuse teeth, laterocaudal angle stout and subacute (Fig. 62). Abdominal sternites densely punctured, S7 with a depression on the caudal margin (Fig. 63), subgenital plate more or less exposed. Supra-anal plate densely covered with

coarse punctations, sometimes with minute hairs; hind margin with 8-16 subequal teeth, whose apex obtuse; some teeth contiguous. Cerci bulbous, dorsal surface hairless and ventral surface setose (Fig. 64). Subgenital plate with anterior margin concave, lateral margin with a mesal indentation (Fig. 65).

Male genitalia. *L1* developed but slightly sclerotized (Fig. 66); *L2d* not bifurcated, elongate and tapering towards the apex, mostly with a weak concavity in hind margin (Fig. 67); *R2* well developed, hook-shaped, apex subacute and curved upwards (Fig. 68).

Female. Differs only slightly from male in partial specimens as follows: anterior margin of pronotum slightly excised, and the tubercles indistinct behind the indentation.

Nymph. Similar to adult, but body yellowish-brown, anterior margin of the pronotum without excision and protuberance, the tubercles on the floor absent; depression of anterior half densely punctuate; meso- and metanotum with produced laterocaudal angle, the protrusion dark or black (Figs 17-18).

Measurements. Male, $3^{th}-5^{th}$ maxillary segments: 0.86–0.90/0.88–1.29/1.15–1.67mm; pronotum: length × width: 6.3–10.1 × 10.0–16.0 mm; distance between anterior disc tubercles: 5.4–7.7 mm; distance between posterior disc tubercles: 2.4–4.7mm; tegmen: 38.0–51.0mm; body length: 29.0–49.0 mm; fore leg: coxae: 4.26–4.93mm, trochanter: 2.67–3.17mm, femur: 4.98–5.65mm, tibia: 2.65–3.23mm, 1st–5th tarsus: 0.88–0.99/0.27–0.36/0.30–0.35/0.36–0.55/1.51–1.65mm; mid leg: coxae: 4.35–5.04mm, trochanter: 2.87–4.25mm, femur: 6.39–6.84mm, tibia: 5.47–5.87mm, 1st–5th tarsus: 1.18–1.47/0.31–0.40/0.31–0.43/0.40–0.58/1.34–1.98mm; hind leg: coxae: 3.81–5.02mm, trochanter: 3.13–4.39mm, femur: 7.26–7.44mm, tibia: 7.54–9.98mm, 1st–5th tarsus: 1.42–1.47/0.44–0.51/0.37–0.45/0.43–0.66/1.60–2.10mm; cerci: 1.00–1.22mm.

Female, $3^{h}-5^{h}$ maxillary segments: 0.95-1.14/0.73-0.98/1.12-1.37mm; pronotum: length × width: $7.0-12.0 \times 11.0-16.5$ mm; distance between posterior disc tubercles: 2.5-4.7 mm; tegmen: 33.0-50.0mm; body length: 30.5-49.0 mm; fore leg: coxae: 2.29-5.01mm, trochanter: 2.97-3.33mm, femur: 4.62-4.91mm, tibia: 2.39-2.67mm, $1^{st}-5^{th}$ tarsus: 0.89-1.11/0.31-0.32/0.30-0.32/0.31-0.42/1.57-1.85mm; mid leg: coxae: 3.99-4.43mm, trochanter: 4.08-4.29mm, femur: 6.58-6.69mm, tibia: 5.54-5.85mm, $1^{st}-5^{th}$ tarsus: 1.10-1.24/0.29-0.38/0.27-0.39/0.42-0.45/1.30-1.50mm; hind leg: coxae: 3.94-4.56mm, trochanter: 3.66-4.27mm, femur: 6.54-7.44mm, tibia: 7.91-9.35mm, $1^{st}-5^{th}$ tarsus: 1.22-1.64/0.32-0.40/0.32-0.38/0.38-0.52/1.15-2.19mm; cerci: 0.97-1.20mm.

Material examined. One male and two females, Yunnan Prov., Damenglong Town, 650m, 13 April 1958, coll. Chunpei Hong; one male and one female, Yunnan Prov., Damenglong Town, 650m, 16 March 1958, coll. Zhizi Chen; one male, one female and one nymph, Yunnan Prov., Damenglong Town, 650m, 18 April 1958, coll. Fuji Pu; three males, Yunnan Prov., Yingjiang County, Tongbiguan Township, 1418m, 24°61'N, 97°62'E, 4–5 June 2008, coll. Weiwei Zhang; one male, Xizang Prov., Motuo County, 1300m, 10 September 1979, coll. Gentao Jin and Jianyi Wu; one female, Xizang Prov., Motuo County, Gedang Township, 2080m, 15-18 April 1980, coll. Gentao Jin and Jianyi Wu; two males, Hainan Prov., Mt. Jianfengling, 22 February 1982, collector unknown; one female, Hainan Prov., Mt. Jianfengling,

10 May 1964, coll. Sikong Liu; two males and one nymph, Hainan Prov., Mt. Jianfengling, 4 May 2013, coll. Yan Shi and Shunhua Gui; one male, Hainan Prov., Wuzhishan city, shuiman Township, 740m, 18°51'N, 109°40', 28–30 June 2008, coll. Weiwei Zhang; one male, Hainan Prov., Mt. Jianfengling, 15 June 1983, collector unknown; one male, Hainan Prov. Mt. Jianfengling, Tianchi, 25 April 1981, coll. Shaoying Liang. (SWU).

Distribution. China (Yunnan, Xizang, Hainan, Taiwan); Bhutan; India; Laos; Nepal; Vietnam; Sikkim; Thailand.

Salganea flexibilis sp. n.

http://zoobank.org/F372D347-53DE-4495-8E4A-252371FA93B1 http://species-id.net/wiki/Salganea_flexibilis Figs 19–20, 69–76

Description. Male. Body black (Fig. 19). Head black, dark reddish brown between eyes, ocelli and eyes with yellowish border. Antennae, upper lip, mandible, labial palpi and maxillary palpomeres dark brown. Legs black, coxae, trochanter and the former half of femora yellowish brown. Abdominal sternites black with the middle of the former five segments reddish brown, cercus reddish brown (Fig. 20).

Vertex exposed, punctured; face densely punctured; ocelli circular and distinct. Pronotum convex (anterior margin damaged, it is probably a developmental error), anterior and lateral area depressed, densely granular and equally distributed; posterior half with a distinct tubercle on each side of the midline, the floor densely punctured (Fig. 69). Tegmina and wings mutilated, but probably fully developed (Fig. 19). Anterior ventral margin of front femur with 2 spines, and a minute distal spine, posterior margin with a spine. Centre region of abdominal tergites sparsely punctured, more and larger laterally, and with dense setae; lateral angle of T6 produced; T7 hirsute, with large disc pits densely; round holes only present in the anterolateral corners of T6 and T7; lateral margin of T7 with 3 subacute and distinct teeth, sometimes also with subobsolete papulas, caudal angle produced into a strong and oblique spine (Fig. 70). Abdominal sternites densely punctured; S7 densely covered with hairs, hind margin emarginated (Fig. 71), subgenital plate slightly exposed. Supraanal plate convex, hirsute, with large disc pits densely; middle of hind margin with 8 unequal teeth, deflexed, which are triangular or apically truncate; caudal angles tapering, and same length as the largest tooth between them. Cerci conical, dorsal and ventral surfaces densely setose (Fig. 72). Anterior margin of subgenital plate depressed, anterolateral corners subacute, lateral margins straight and not concave (Fig. 73).

Male genitalia. *L1* well developed (Fig.74); *L2d* not bifurcated with acute apex (Fig. 75); *R2* hook-shaped (Fig. 76).

Female. Unknown. Nymph. Unknown.



Figures 69–76. *Salganea flexibilis* sp. n. **69** vertex and pronotum **70** abdominal tergum 7, dorsal view **71** abdominal sternite 7, ventral view **72** supra-anal plate and paraprocts, ventral view **73** subgenital plate, dorsal view **74** left phallomere (*L1*) **75** median phallomere (*L2vm* and *L2d*) **76** right phallomere (*R2*). Scale bars = 1.0 mm (Figs **69–72**), 0.5 mm (Figs **73–76**).

Measurements. Male, $3^{th}-5^{th}$ maxillary segments: 0.90/0.89/0.99mm; pronotum: length × width: 6.9×11.5 mm; distance between disc tubercles: 2.8mm; body length: 32.2mm; fore leg: coxae: 2.99mm, trochanter: 2.54mm, femur:



Figures 77–79. 77 ecotope of Mountain Diaoluoshan, Hainan Province (Photographs by Keliang Wu) **78** nymph of *Salganea quinquedentata* sp. n. **79** *Salganea incerta* (Brunner von Wattenwyl, 1893), in Mountain Simianshan, Chongqing, 2 October 2013 (Photographs by Jianyue Qiu).

4.04mm, tibia: 2.00mm, 1st-5th tarsus: 0.90/0.32/0.32/0.38/1.36mm; mid leg: coxae: 3.50mm, trochanter: 2.88mm, femur: 5.76mm, tibia: 4.34mm, 1st-5th tarsus: 1.09/0.33/0.34/0.42/1.30mm; hind leg: coxae: 3.32mm, trochanter: 3.36mm, femur: 6.77mm, tibia: 6.59mm, 1st-5th tarsus: 1.27/0.42/0.38/0.45/1.46mm; cerci: 0.93mm.

Material examined. *Holotype*, male, China: Yunnan Prov., Nujiang State, Gongshan County, Dulongjiang Township, Kongmu Village, 1391m, 27°44.79'N, 98°20.19'E, 25 May 2013, coll. Hao Xu and Jianyue Qiu (SWU).

Remarks. Owing to *L2d* not being bifurcated, this species should be placed under the *S. raggei* species group. It is superficially similar to *S. aperturifera*, but can be differentiated by the following characteristics: 1) posterior half of pronotum with 1 pair of tubercles, 2 pairs in *S. aperturifera*; 2) abdominal tergites 6 and 7 with holes in the anterolateral corners, T3-T7 with holes in *S. aperturifera*; 3) supra-anal plate convex, hind margin with 8 deflexed and unequal teeth, the teeth but in *S. aperturifera* the number of teeth is 8–10, which are subequal and undeflexed.

Etymology. The specific epithet "*flexibilis*" is derived from Latin, which means that the teeth on the hind margin of the supra-anal plate are deflexed.

Discussion

The members of *Salganea* are known to be burrowers in rotten logs (Figs 78–79), with a hard, rigid, pitted exoskeletion and a thick, scoop-shaped pronotum (Bell et al. 2007). Some macropterous ones shed their wings and only keep the basal region of tegmina and wings intact (Roth 1979; Maekawa et al. 1999b; Bell et al. 2007), *i.e., S. quinquedentata* sp. n., *S. flexibilis* sp. n. and *S. anisodonta* sp. n. as described in this paper, which are all collected by chopping logs and not by light trapping in tropical forests (Fig. 77). Most of them have shed their tegmina and wings and only one specimen of *S. quinquedentata* sp. n. kept these intact; the reason of shedding is maybe the combination of scraping them against gallery walls and the chewing action of conspecifics (Maekawa et al. 2008). The nymphs of *S. quinquedentata* sp. n. are not active and slowly crawl on the scraps of wood; but if frightened by sound and light, they will flee and hide below the scraps (Wang X.D., pers. obser.).



Figures 80–97. 80–88 tegmina: 80–81 left and right tegmina of one specimen (*Salganea quinquedentata* sp. n.), dorsal view 82 *Salganea anisodonta* sp. n. 83–84 *Salganea taiwanensis* Roth, 1979 85–86 *Salganea incerta* (Brunner von Wattenwyl, 1893) 87–88 *Salganea raggei* Roth, 1979 89–97 wings: 89–90 left and right wings of one specimen (*Salganea quinquedentata* sp. n.), dorsal view 91 *Salganea anisodonta* sp. n. 92–93 *Salganea taiwanensis* Roth, 1979 94–95 *Salganea incerta* (Brunner von Wattenwyl, 1893) 96–97 *Salganea raggei* Roth, 1979. Scale bars = 4.0 mm.

Owing to this unique behavior of shedding their tegmina and wings, venation as an important taxonomic character has not been used widely in the classification of Panesthiinae. But a large number of species of Panesthiinae have fully developed tegmina and wings (Roth 1979). Moreover, Rehn (1951) considered that wings of this taxon had a characteristic venation which differed from other families. But after strict examination we find that the veins of the tegmina and wings are unstable. First, we



Figures 98–113. four wings of *S. taiwanensis* Roth, 1979 of one specimen, dorsal view **98** wings with cross-veins **99–113** cross-veins of wings omitted. Scale bars = 4.0 mm.

	Sc	R	Post. + M	Cu	Total
M	1	7	2	7	11
Nin	1;1	6;7	2;2	7;8	11;11
М	1	14	6	12	17
Iviax	1;1	12;14	5;6	12;11	17;17
Madian	1	9	3	9	13
Median	1;1	9;9	3.5;3	9;9	13;13
M. J.	1	9	3	9	13
Nide	1;1	8;9	4;3	9;8	13;14
A	1	9.563	3.344	9.063	13.406
Average	1;1	9.313;9.563	3.313;3.344	8.938;9.188	13.438;13.375
Destation	0	1.590	1.066	1.243	1.500
Deviation	0;0	1.815;1.590	1.250;1.066	1.167;1.243	1.548;1.500
CV := 0/	0	16.631	31.877	13.713	11.186
CV in %	0;0	19.495;16.631	26.224;37.736	14.994;12.705	11.519;11.215

Table 1. Tegmen venation variability of *S. taiwanensis* for 16 specimens The second line numbers are data of left and right tegmina separately. Post. + M – posterior branch of radius + media; Total – total number of veins without radius and anal veins; CV – coefficient of variation. (Liang et al. 2012)

Table 2. Hindwing venation variability of *S. taiwanensis* for 16 specimens. The second line numbers are data of left and right tegmina separately. Total – total number of veins without anal veins; CV – coefficient of variation. (Liang et al. 2012)

	Sc	R	М	Cu	Total
M	1	1	1	4	10
IVIIN	1;1	2;2	1;1	5;4	10;10
M	1	7	3	8	15
Iviax	1;1	5;7	3;2	8;8	15;15
Madian	1	3	1	6	12
Median	1;1	3.5;3	1;1	6.5;6	12;12
	1	3	1	6	11
Niode	1;1	3;3	1;1	7;6	12;11
A	1	3.625	1.188	6.406	12.188
Average	1;1	3.625;3.625	1.188;1.188	6.438;6.375	12.188;12.188
Desident	0	1.157	0.471	0.837	1.355
Deviation	0;0	0.885;1.408	0.544;0.403	0.814;0.885	1.274;1.471
CV := 0/	0	31.918	39.657	13.066	11.114
CV in %	0;0	24.415;38.850	45.803;33.946	12.644;13.883	10.473;12.066

find the venation of the left and right tegmina and wings of one specimen are variable. As in *S. quinquedentata* sp. n., the apical posterior radial vein is branched in the left tegmen (Fig. 80), but has 2 complete and 1 incomplete branches in the right one (Fig. 81); the cubitus has variable branches. The radial vein of the wing bifurcated near the apex, and the median vein is unbranched in the left wing (Fig. 89), but in the right one, the radius is not bifurcated apically, and the median vein branched at the apex (Fig. 90). Second, the intraspecific venation is also variable, as in S. taiwanensis (Figs 83–84, 92–93, 98–113); venations of all left tegmina illustrated here are significantly different, mainly in the numbers of each vein (Figs 83-84, 98-113). But the total number of veins at the margin appears relatively stable, as in S. taiwanensis, the CV_{total} of tegmina is 11.19 (Table 1) and CV_{total} of hindwings is 11.11 (Table 2), which are almost same as in the archaic species. The CV of the total number of veins in all living species were under 5.00 (Vršanský 2000). There are mainly 4 kinds of deformities of veins presented in the drawings (S. taiwanensis of 16 specimens, Figs 98–113), which are expressed as mutual fusion of veins (Cu-Cu, Figs 99-100, 104, 107-113), lost of a branch (Cu, Figs 106-107, 109-110, 112), fusion of vein to another vein (*Cu-Cu*, Figs 99–100, 102–108, 110, 111, 113), or as veins with unfinished growth (Fig. 98) in both right and left tegmina. In hindwings, there are deformities expressed as fusion of radial veins (Figs 100–101, 109–110). Mass insects deformities expressed as fusion of wing veins most probably represent heritable mutations (Vršanský 2005). At the same time he mentioned that enhanced environmental stress might have caused the occurrence of mass mutations. Vršanský (2000) also made the conclusion that the variability of the venation of Blattaria species decrease from the archaic to more recent group. So we speculate that the deformities of *S. taiwanensis* listed above might be the result of adaptation to the environment, that is, their ancestors may be able fliers but now they have no chance to fly or lack ability of flight before entering the log. However, interspecific venation is relatively stable especially in hindwings (Figs 89–97). The subcosta is simple and long; the radial vein does not have more than five branches; the median vein is with one or without a branch on the anterior part.

Overall, we find venation to be of little value as a specific character; but the venation variation is more stable and distinct at higher taxonomic levels. Additional investigation will be required to search for more stable wing characteristics to support our view.

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RESEARCH ARTICLE



The invasion history, distribution and colour pattern forms of the harlequin ladybird beetle Harmonia axyridis (Pall.) (Coleoptera, Coccinellidae) in Slovakia, Central Europe

Ľubomír Panigaj¹, Peter Zach², Alois Honěk³, Oldřich Nedvěd^{4,5}, Ján Kulfan², Zdenka Martinková³, Diana Selyemová⁶, Sandra Viglášová², Helen E. Roy⁷

I Pavol Jozef Šafárik University, Šrobárova 2, Košice, Slovak Republic 2 Institute of Forest Ecology, Slovak Academy of Sciences, E. Štúra 2, 960 53 Zvolen, Slovak Republic 3 Crop Research Institute, Drnovská 507/73, 161 06 Prague 6 – Ruzyně, Czech Republic 4 Faculty of Science, University of South Bohemia, Branišovská 31c, 37005 České Budějovice, Czech Republic 5 Institute of Entomology, Biology Centre AS CR, Branišovská 31a, 37005 České Budějovice, Czech Republic 6 Institute of Zoology, Dúbravská cesta 9, Bratislava, Slovak Republic 7 NERC Centre for Ecology and Hydrology, Wallingford, OX10 8BB United Kingdom

Corresponding author: Peter Zach (zach@savzv.sk)

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Abstract

The harlequin ladybird beetle *Harmonia axyridis* (Coleoptera, Coccinellidae) has invaded and established in Slovakia. Following unintentional introduction in 2008, the spread of the alien coccinellid was very fast. By the end of 2009, it was recorded across the whole country, and by the end of 2012 it was widely distributed and common in various habitats, particularly gardens, orchards and urban areas, where it was most frequent on trees. The rate of eastward spread was approximately 200 km year⁻¹, similar to the overall rate of spread in Europe. Between 2008 and 2012, the coccinellid was recorded in a total of 153 localities, in altitudes ranging from 98 to 1,250 m. Most records of this species were made in lowlands, hilly areas and valleys separating mountain ridges. However, it was only rarely documented in areas above 700 m a.s.l. The non-melanic colour form (f. *succinea*) was dominant along a longitudinal transect including eight urban areas across Slovakia, with the frequency of melanic forms (f. *spectabilis* and f. *conspicua* together) between 6.3 and 19.2% and a median equal to 10.5%. The invasion history and distribution of *H. axyridis* in Slovakia are discussed with regard to the time sequence of records, rate of spread, altitudinal distribution, anthropogenic dispersal, effective recording, proportion of melanic forms and other relevant aspects associated with the spread of this successful invader.

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Keywords

Alien, altitude, colour morphs, spatial occurrence, spread

Introduction

The harlequin ladybird beetle Harmonia axyridis (Pallas, 1773) (Coleoptera, Coccinellidae) is native to eastern and central Asia occurring in Japan, Korea, China, Mongolia, Russian Far East through Siberia to Kazakhstan (Brown et al. 2008). This coccinellid is considered an invasive alien species in many countries (Brown et al. 2011). It was intentionally introduced into North America several times from 1916 (Gordon 1985) for biological control of aphids and coccids but was first detected reproducing in the wild decades later, in 1988 (Koch et al. 2006). It has also been introduced in Europe, South America and Africa (Brown et al. 2011). Early introductions of *H. axyridis* into Europe, from Siberia to western Ukraine, were not successful (Kuznetsov 1987). The first intentional introduction of *H. axyridis* in western Europe (from China) was in southern France in 1982, followed by temporary acclimatization by 1991 (Coutanceau 2006). However, *H. axyridis* was recorded in the border area between Belgium and the Netherlands around 2002, representing the extensive spread of this species throughout Europe. It is now known that the European populations of *H. axyridis* originated from hybrids with the invasive population unintentionally introduced from eastern North America (Lombaert et al. 2010). By 2006, the coccinellid was recorded in all regions of Belgium and western Germany, and since 2006 it was frequent in central eastern Germany (Brown et al. 2008). Its continuing eastward spread was immediately documented by the records in Poland in 2006 (Przewozny et al. 2007), followed by rapid establishment there (Ceryngier 2008). First records of the coccinellid in Austria, also, were made in 2006 (Rabitsch and Schuh 2006). In the same year it was first recorded in the Czech Republic (Brown et al. 2008, Špryňar 2008), and within three years (by 2009) it was detected in most areas across the Czech Republic (Nedvěd 2009). In 2008, the beetle was recorded in Hungary (Merkl 2008) and Slovakia (Majzlan 2008, Brown et al. 2011, Zach et al. 2012). By 2009, it was reported from Ukraine and Romania (Nekrasova and Tytar 2009, Marko and Pozsgai 2009).

The invasion history and distribution of *H. axyridis* in some European countries has been detailed in Brown et al. (2008, 2011). However, detailed consideration of the information on the spread and spatial distribution of the insect was missing from Slovakia until 2012. The topography of Slovakia, characterized by a diverse relief, with lowlands, hills and mountains changing on small spatial scales, has enabled first insights into how *H. axyridis* is distributed with altitude and, consequently, this enabled increased understanding of this beetle's ecological plasticity. Indeed, the altitudinal distribution of coccinellids is only rarely studied (Honěk 1989, Selyemova et al. 2007). Observations of *H. axyridis* from different altitudes, as presented in this study, are unique for Central Europe.

Adult *H. axyridis* exhibit a conspicuous colour pattern polymorphism of the dorsal and ventral side (Blehman 2009), the genetic determination of which has been exten-

sively studied (Sloggett and Honek 2012). In Central Europe, Slovakia included, the species is mostly represented by three forms distinguished by the specific colour pattern of elytra which, in the order of decreasing frequency, are: (1) f. succinea with yellow to red background colouration and up to 19 black spots, (2) f. spectabilis with black background colouration and four red spots, and (3) f. conspicua with black background colouration and two red spots. Also, several rare morphs occur at low frequency such as f. axyridis with black background colouration and 12 red spots on the elytra or f. equicolor (very rare) with the anterior half of elytra red and posterior black (Hosino 1942, Tan 1946). The size of the spots exhibited by f. succinea is determined genetically (Hosino 1942, Tan 1946) and influenced by the temperature during larval and pupal development (Michie et al. 2010). In its native area, there is a conspicuous geographic variation in the proportion of the forms which may correlate with climatic factors (Dobzhansky 1924). The proportion of forms also vary seasonally (Osawa and Nishida 1992, Wang et al. 2009) but not in all geographic areas (Kholin 1990). Despite these advances in our understanding of the colour pattern polymorphism of elytra in H. axyridis, in Central Europe little is known about spatial variability in the frequency (proportion) of non-melanic and melanic forms. Further information on colour pattern polymorphism in *H. axyridis* is essential for detecting similarity (and consequently relationships) among the populations of the coccinellid originating from geographically distant areas and/or along the routes of the spread of this invasive alien insect.

This study aims to document the spread (longitudinal and altitudinal distribution) of *H. axyridis* in Slovakia by summarizing the known records of the species collected over the period 2008–2012. Additionally, we document the spatial variation in proportion of the non-melanic and melanic forms of *H. axyridis* to improve understanding of this globally successful invader.

Methods

Data recording

The occurrence of *H. axyridis* in Slovakia was recorded over the period 2008–2012 by the authors of this study and other contributors from the Czech Republic and Slovakia, including students of the Pavol Jozef Šafárik University in Košice. The original records collated through the study were supplemented by a few published data (Majzlan 2008).

Larvae and adults of *H. axyridis* were recorded by observing them on plants or collecting them from vegetation (various habitats) using a sweep net and/or beating tray. In urban areas, they were also knocked down (by hand) from branches of trees and observed on the bare surfaces of pavements or roads. Species presence was also recorded at overwintering sites, mostly in buildings and, quite uniquely in a man-made stony well, occasionally in sheltered semi-natural habitats such as rock piles covered with dry grass. Sampling effort varied within the study, except for in 2012 when a standardized method (described below) was employed. Most grid squares that have no record

of *H. axyridis* (empty in Fig. 1) were not investigated or were sampled randomly with low effort. An exception exists for a few localities for which there were no observations of the species despite intense standardized sampling effort (described below). These negative results are mentioned in the Suppl. material 1.

The non-melanic (f. *succinea*) and melanic forms of *H. axyridis* (f. *conspicua* and f. *spectabilis* together) were recorded along a 380 km long transect extending from the west to the east of the country between 30th July and 7th August 2012, in the following eight urban areas: Bratislava, Nitra, Levice (western Slovakia), Zvolen, Lučenec (central Slovakia), Rožňava, Košice and Michalovce (eastern Slovakia). Along this longitudinal transect adult *H. axyridis* were collected from lower branches of lime trees (*Tilia* spp.) using a circular beating tray (diameter 1.0 m). A total of 30 samples were obtained in each town where one sample represented the individuals from a total of 20 branches of two to five trees; thus the branches in a total length of 600 m were examined for the presence of the coccinellid in each town. Proportions of colour forms, categorized into the same groups as above, were also estimated independently for eastern Slovakia by pooling the observational records from 2010 and 2011.

Data analysis

The map of distribution of *H. axyridis* in Slovakia was constructed by combining the following data sources: (1) the database of the University of South Bohemia and Institute of Entomology, Biology Centre AS CR (O. Nedvěd et al. 2008–2012), (2) the database of the Pavol Jozef Šafárik University (Ľ. Panigaj et al. 2010–2012) and (3) the database of the Institute of Forest Ecology, Slovak Academy of Sciences (P. Zach et al. 2012). The data (observed presence) were plotted onto the grid map used in the Databank of Fauna of Slovakia ("square" approximately 11 by 12 km). The data from 2008, 2009 and 2010–2012 were plotted separately to demonstrate the temporal sequence of the records.

The distribution of the records of *H. axyridis* by altitude was illustrated by a histogram with breaks (altitude ranges) set to 100 m. Frequencies of non-melanic forms of the coccinellid were compared among particular towns along the longitudinal transect (for each combination of towns possible) using the chi-square test (2×2 contingency table) (Zar 2010). Statistical calculations were made in the program STATISTICA, version 9.0 (Statsoft, Inc. 2008).

Results

A total of 153 records of *H. axyridis* were made across Slovakia over the period 2008–2012, providing evidence of the occurrence of the coccinellid within 109 squares (11 \times 12 km) across Slovakia, i.e. 25.5% of all available squares (Fig. 1, Suppl. material 1).

In 2008, *H. axyridis* was recorded in seven localities in western, central and northern Slovakia. In 2009, it was known from another eight localities, one of them in east-



Figure 1. Distribution of *Harmonia axyridis* across Slovakia with the time sequence of the 153 records. Map of the Databank of the Fauna of Slovakia in which each "square" is approximately 11 by 12 km. White circles = 2008, grey circles = 2009, black circles = 2010–2012.

ern Slovakia. Between 2010 and 2012, it was reported from numerous other localities across the entire country. The coccinellid was observed in lowland and submontane areas along the south of the country, extending northwards into long valleys of Váh, Hron and Hornád rivers (Fig. 1).

The majority of records of *H. axyridis* come from lowlands (up to 200 m a.s.l.) and hilly areas (200–700 m a.s.l.). The records from altitudes above 700 m, and especially those from mountain areas above 1,000 m a.s.l., are much less frequent (6 and 1 respectively) than those from the lowlands and hilly areas (Fig. 2).

Three colour forms (f. *succinea*, f. *spectabilis*, f. *conspicua*) were documented among the 953 adult *H. axyridis* collected in eight urban areas (towns) located along the 380 km long west-east transect, sampled between 30th July–7th August 2012. The proportion of melanics varied from 6.3% to 19.2% (Fig. 3), with a median of 10.5%. The frequency of melanic forms at Lučenec (19.2%) was significantly different from the frequencies at Bratislava (7.8%) (chi-square test, χ^2 =4.999, df=1, p=0.025) and Michalovce (6.3%) (chi-square test, χ^2 =10.846, df=1, p<0.001). Frequencies of melanic forms in the other six towns did not differ significantly from each other (chi-square test, p>0.05). Pooled samples from eastern Slovakia (2010–2011) consisted of a total of 410 specimens, the 59 (14.4%) of which were melanic (f. *spectabilis* only).



Figure 2. Frequency distribution of the records of *Harmonia axyridis* from Slovakia, 2008–2012 (n = 153). Data arranged by altitude (m).

Discussion

Harmonia axyridis has recently been described as the fastest-spreading invasive alien insect in Europe (Brown et al. 2011). In Slovakia, it was first recorded in Malaise traps in Tatra Mountains (Tichá dolina valley and Podbanské area) in 2008 (map grid number 6885, see Fig. 1 and Suppl. material 1; collector O. Majzlan), and in the same year records were reported from Banská Bystrica (7280, V. Franc), Malacky (7568, R. Hergovits), Bratislava (7868, R. Hergovits), Župkov (7477, K. Bucsek) (Majzlan 2008), Sološnica (7569, T. Stacho) and Šikov (7785, O. Pultar). The records reported in this study show that as early as two years after introduction (by the end of 2009) the coccinellid was distributed across the entire country and that it remained abundant through 2012. The time sequence of the records indicates easterly spread of the coccinellid, with introductions most likely from the Czech Republic and/or Austria (Brown et al. 2011, Nedvěd 2009; Rabitsch and Schuh 2006), although the spread from the other neighbouring countries, Hungary and Poland, cannot be excluded. Observations of *H. axyridis* became more frequent between 2010 and 2012 as its distribution got wider and recording effort increased. We are aware that scarcity of records between 2008 and 2009 (Fig. 1) may be due to lower recording effort rather than real absence of the coccinellid in the country at that time. However, we did not observe *H. axyridis*, despite intensive surveys at several localities, in central and eastern Slovakia between 2008 and 2010, but it was subsequently recorded in 2012.

Undoubtedly, *H. axyridis* has spread very quickly across Slovakia since its arrival in 2008 (Brown et al. 2011). Similar rapid spread of the insect was observed in the Czech Republic (Nedvěd 2009), Poland (Ceryngier 2008; with late arrival and relative scarcity in north-eastern Poland (http://www.cbe-pan.pl/harmonia/rozmieszczenie.htm) and Hungary (Markó and Pozsgai 2009). However, we did not observe this species in Estonia in the summer of 2012 (O. Nedvěd, unpublished data). The cold climate there may prevent successful establishment of *H. axyridis*, but it also does not appear to occur in hot climates, except for one record in Kenya (Nedvěd et al. 2011).

H. axyridis is considered a successful invader (Koch et al. 2006, Brown et al. 2011) and is known to spread at rates between 100 and 500 km year⁻¹, depending on area and/or whether its introduction was assisted by anthropogenic means (Brown et al. 2011). According to McCorquodale (1998) the rate of *H. axyridis* range expansion in eastern North America was as fast as 442 km year⁻¹, reflecting both the innate dispersal capability and human mediated movement of the coccinellid (Koch et al. 2006). Brown et al. (2011), taking Europe as a whole, have calculated the maximum rate of the spread of *H. axyridis* to be approximately 200 km year⁻¹. Taking this rate and the eastward direction of spread into consideration, the insect was predicted to colonize much of Slovakia (distance between western and easternmost part of the country is approximately 400 km) within two years. The distribution and time sequence of the records reported here (Fig. 1), together with many negative observations in the eastern part before 2010, support this prediction.

The spread of *H. axyridis* may be assisted and, indeed, accelerated by human movement. For example, an adult specimen of the beetle was unintentionally transported in a coach from Prague (western Czech Republic) to Žarnovica (central Slovakia), travelling over the direct distance of 355 km in 7 hours (P. Zach, personal observation). Human-assisted long-distance dispersal, deliberate and inadvertent, has been well-documented in the case of *H. axyridis* (Harmon et al. 2007) and such transportation has clearly played a dominant role in the fast spread of this coccinellid throughout the world (Lombaert et al. 2011). The strong preference of H. axyridis for urban environments (the species is frequently found in buildings and/or on ornamental trees in built up areas) increases the probability of being dispersed by humans. The outlying (spatially separated) record of the coccinellid in Ukraine (Kyiv) from 2009 (Nekrasova and Tytar 2009) suggests an anthropogenic origin. Passive transportation by anthropogenic means is the mechanism resulting in rapid spread of the beetle (Koch et al. 2006). H. axyridis is known to exhibit high fecundity and long lasting fertility and, therefore, a single fertilized female may establish a new large colony without additional access to a male (Awad et al. 2013).

The success in recording *H. axyridis* strongly depends on the establishment and abundance of the beetle in a certain habitat or area. In Slovakia, this semi-arboreal coccinellid (Hodek and Honek 1996) was reported as established immediately after the introduction in 2008 (O. Nedvěd and M. Marko in Brown et al. 2011). Based on the data from the U.S.A. and England, *H. axyridis* may become a dominant species of coccinellid communities within four to five years following introduction (Majerus et al. 2006). In 2012, five years after the introduction of *H. axyridis* in Slovakia, the relative abundance of the beetle in coccinellid communities of lime trees in eight towns along the longitidinal transect of southern Slovakia was in the range from 47.9 (Levice) to 92.2% (Michalovce) with the median 71.7% (P. Zach, A. Honek, J. Kulfan, Z. Martinková, D. Selyemová, unpublished data, 30th July–7th August 2012). In central Europe, a combination of lime trees and urban areas enables very efficient recording of *H. axyridis*. In late summer 2012, the beetle was found in all the urban areas surveyed and always on lime trees. Even a solitary lime tree present at a rural site enabled collecting of *H. axyridis* with minimal effort (by knocking one to five branches only) (e.g. in Tatranská Štrba, Z. Martinková, A. Honěk, D. Selyemová, J. Kulfan, P. Zach, personal observation).

In Slovakia, as well as in the Czech Republic (Honek et al. 2013), *H. axyridis* was documented in various habitats and on many plant species (Zach et al. 2013). This habitat generalist (Brown et al. 2011) was often recorded in urban areas with deciduous trees and in gardens or orchards with fruit trees. These habitats harbour essential (aphids and coccids) and alternative food (fruits) of the beetle (Hodek and Evans 2012). The local topography, also, is known to play a crucial role in the spread and distribution of the coccinellid (Honek 2012). The records reported here indicate spatial heterogeneity with most records from within the catchment area of the central flow of the river Váh in the west or within the catchment area of the river Hornád in the east of the country. There are also scattered records from non-urban habitats along the middle flow of the river Hron (Fig. 1). Valleys of greater rivers in Slovakia are densely populated locally, with abundant road and rail traffic. These open corridors in fragmented landscapes are crucial for the spread and establishment of *H. axyridis*.

During field surveys, H. axyridis was recorded in altitudes ranging from 98 m in the south-east to 1,000 m in the north (foothills of High Tatra Mountains), or as high as 1,250 m in the central part of the country (Polana Mountains). Most often, however, it was reported from lowlands, hilly areas and valleys separating mountain ridges, in altitudes bellow 700 m. The low number of records of the coccinellid below 100 m is a consequence of the relief - the lowest point in Slovakia being 94.3 m a.s.l. In contrast, few records were obtained from altitudes above 700 m. This might be a consequence of the possible scarcity of the beetle in higher altitudes and/or difficulty to detect it, especially in inaccessible and not frequently surveyed mountain areas - the highest point in Slovakia being 2,654 m. It is unclear at the moment as to whether fragmented habitats in mountain ranges dominated by Norway spruce [Picea abies (L.) Karst.] play any role in the active spread of the coccinellid, as documented for native species of coccinellids (Selvemová et al. 2007). The uppermost record of five individuals of H. axyridis in a trailer (Polana Mountains, 1,250 m) requires special consideration as it might result from anthropogenic dispersal. The regions with occurrence of the beetle are determined by the density of occupied neighbouring squares. The differences

in sampling effort is thus averaged and compensated. There are other examples of studies on the distribution of *H. axyridis* based on grid mapping using "citizen science" approaches with unknown sampling effort (Roy et al. 2012).

Coccinellids in Central Europe overwinter as adults, often in large aggregations (Honěk 1989), which is also the case for *H. axyridis* (Zach et al. 2013). The aggregations of overwintering specimens of *H. axyridis* were commonly found in anthropogenic habitats in western, central and eastern Slovakia, mostly in buildings (clusters of 2 to 42 individuals, n = 12) or outer splits in building walls (5 and 7 individuals) (P. Zach personal observation) and a human-made stony well (more than 846 individuals) (Svidník, D. Jurina, personal observation). Very occasionally records were obtained from sheltered semi-natural habitats like rock piles covered with dry grass (7, 15 and 18 aggregated individuals). Since H. axyridis is considered as a nuisance species to humans, specifically in built up areas (Koch and Galvan 2008), the clusters of aggregated specimens in buildings, often, are unstable due to removal by man (e.g. at Sliač spa - frequent complains of spa visitors in October 2011 and 2012; P. Zach, unpublished data). European populations of H. axyridis have weak diapause (Raak-van den Berg et al. 2012). Individuals leave aggregations in warm (heated) buildings between January and March, starve and die because of the lack of food (M. Mikuš, O. Nedvěd, P. Zach, personal observations). Aggregations in semi-natural habitats with cool microclimates seem more stable than those associated with heated buildings with regard to artificial removal and mortality (Raak-van den Berg et al. 2012; O. Nedvěd, P. Zach, personal observations). Aggregating behaviour plays an important role in the anthropogenic spread of *H. axyridis* (Labrie et al. 2008). Indeed, 200 individuals of the species in Åndalsnes, Norway, in 2007, were found on timber imported from North America (Lombaert et al. 2010). Nevertheless, no evidence of human-assisted transportations of aggregated individuals of the coccinellid has been obtained during our surveys.

The proportion (percentage) of melanic and non-melanic individuals in urban populations of *H. axyridis*, sampled along the longitudinal transect over a short time period in the summer of 2012, were reasonably consistent, although some spatial variability was evident: the range was 6.3-19.2% and median was 10.5%. The estimate of the percentage of melanic individuals made for eastern Slovakia (14.4%) was within this range. The proportion of melanic forms detected along this transect was somewhat lower than that in Belgium, England and Luxembourg but it was similar to those observed in the Czech Republic (Brown et al. 2008, Nedvědová et al. 2013). Nevertheless, deviations from the rather consistent pattern of colour form frequency across Europe (Brown et al. 2008), detected in the study (Fig. 3), are not excessive. This perhaps indicates (in a broader sense) genetic similarity of individuals spreading from few points of origin in western Europe but genetical analysis is needed (Zakharov et al. 2011) to clarify this in detail. Proportions of the two melanic forms were not recorded separately during the survey. In Slovakia, f. spectabilis is more frequent than f. conspicua, which is also the case in the Czech Republic (Nedvědová et al. 2013).



Figure 3. Percentage of melanic f. *spectabilis* and f. *conspicua* (combined) and a non-melanic f. *succinea* among adult *H. axyridis* (n = 953) in eight urban areas along the 380 km long west-east transect across Slovakia. BA – Bratislava, NR – Nitra, LV – Levice, ZV – Zvolen, LC – Lučenec, RV – Rožňava, KE – Košice, MI – Michalovce. 30th July–7th August 2012

Conclusions

The detailed observations documented here provide further evidence of invasion by *H. axyridis* within Europe. The ability of *H. axyridis* to exploit a range of altitudes provides further insights into the spatial spread of this species. Indeed, the spectacular spread of *H. axyridis* around the world is testament to the success of this invader. The threat to biodiversity posed by this generalist beetle has been widely recognised (Roy et al. 2012). Additionally characteristics of this species which have ensured its success as an invader have been given consideration (Roy and Wajnberg 2008; Soares et al. 2008; Comont et al. 2012). The opportunity to increase our understanding of the ecology of *H. axyridis* is critical for ensuring lessons are learnt from this invasion process.

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Supplementary material I

Records of Harmonia axyridis in Slovakia

- Ľubomír Panigaj, Peter Zach, Alois Honěk, Oldřich Nedvěd, Ján Kulfan, Zdenka Martinková, Diana Selyemová, Sandra Viglášová, Helen Roy
- Data type: occurence
- Explanation note: There are records from 2008 to 2012; years 2008 and 2009 marked in bold. The localities (sites of collection) are arranged in alphabetical order. Indicated are the numeric code of the mapping square (see Fig. 1), year of the first record and name of observer. Data on absence of the species are indicated by subsequent records of the species in the same squares or near squares from which it had not previously been recorded (e.g. 2008 – no record, 2009 – first record).
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RESEARCH ARTICLE



A new species of the genus *Diplocentrus* Peters, 1861 (Scorpiones, Diplocentridae) from Oaxaca, Mexico

Carlos Eduardo Santibáñez-López^{1,†}

Colección Nacional de Arácnidos, Instituto de Biología, Circuito exterior s/n, Ciudad Universitaria, Copilco, Coyoacán A.P. 70-233, Distrito Federal, C.P. 04510, México

thtp://zoobank.org/B16E16D8-80AC-4CA7-9AB6-A86825457643

Corresponding author: Carlos Eduardo Santibáñez-López (ironc81@hotmail.com)

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Abstract

A new species of the genus *Diplocentrus* Peters, 1861 is described, based on several specimens collected in the Mexican state of Oaxaca. It is characterized by a high telotarsal spiniform setae count (4-5/5:5/6:6/6:6/6-7), and the pectinal tooth counts of 12–15, mode = 13 (male) or 11–13, mode = 12 (female). With the description of this species, the diversity of the genus is increased to 51 species in Mexico.

Keywords

Scorpions, diversity, mexicanus group

Introduction

The genus *Diplocentrus* Peters, 1861 comprises nearly 60 species, 51 of them are distributed in Mexico, is the most diverse genus in the family Diplocentridae Karsch, 1880 (Santibáñez-López et al. 2013a). The Mexican species were divided in two groups by Hoffmann (1931), based on size and coloration. Francke (1977) redefined the groups in a key to identification of the *Diplocentrus* species occur-

ring in the Mexican state of Oaxaca, based on cheliceral and pedipalp femur ratios, and renamed the *whitei* group to *mexicanus* group because it included type species (*Diplocentrus mexicanus* Peters, 1861). Nevertheless, Francke (1978) realized that the distinction of both groups was problematic because the diagnostic characters of the pedipalp femur were also used to separate other genera in the family. Recently, Santibáñez-López et al. (2013a) presented an operational diagnosis for the *keyserlingii* group; but did not assume that it was monophyletic, pending further investigation of *Diplocentrus* phylogeny. Fifteen species are reported for the Mexican state of Oaxaca, nine of them belong to the *keyserlingii* group, and six to the *mexicanus* group. In the present contribution, *Diplocentrus franckei*, sp. n. from the *mexicanus* group is described from Oaxaca, Mexico; it is compared to its most morphological similar species.

Materials and methods

Scorpion higher classification follows Prendini and Wheeler (2005). Nomenclature and measurements follow Stahnke (1970), except for trichobotria (Vachon 1974), carination of the metasoma (Francke 1977), and pedipalps (Prendini 2000), and carapace surfaces (Prendini et al. 2003). Basitarsi spiniform macrosetae counts as explained in Santibáñez-López et al. (2013b)

Observations were made using a Nikon SMZ-800 stereomicroscope. Measurements, given in millimeters, were obtained with an ocular micrometer calibrated at 10X. Digital images were taken under visible and UV light with a Microptics ML-1000 digital imaging system, equipped with a Nikon DS80 camera, or a Nikon SMZ-800 with Nikon Coolpix S10 VR camera attachment. The focal planes of image stacks were fused with CombineZM (Hadley 2008) and composite images edited with ADOBE PHOTOSHOP CS6. Distribution maps were generated in ARCVIEW Ver. 3.2 (ESRI), using the locality coordinates, a base map from CONABIO (2011) digital database, and a digital elevation model from the CGIAR Consortium for Spatial Information (Jarvis et al. 2008). Geographical coordinates of collection localities were recorded in the field with a GARMIN eTREX H GPS device. Localities without geographical coordinates were retroactively georeferenced using the INEGI (2011) Archivo Histórico de Localidades dataset.

Abbreviations for depositories: AMNH – American Museum of Natural History, New York, USA; CNAN – Colección Nacional de Arácnidos, Instituto de Biología, Universidad Nacional Autónoma de México, DF, Mexico; CALA – Colección Institucional "Luis de Armas", Instituto Tecnológico del Valle de Oaxaca, Oaxaca. CAIMSc. Colección de Artrópodos con importancia médica (CAIM) Laboratorio de Entomología, Instituto de Diagnóstico y Referencia Epidemiológicos (InDRE), Mexico.

Taxonomic account

Family DIPLOCENTRIDAE Karsch, 1880 Genus *Diplocentrus* Peters, 1861

Diplocentrus franckei sp. n.

http://zoobank.org/B219152E-7FEA-4EDC-985C-592C5C5B0422 http://species-id.net/wiki/Diplocentrus_franckei Figures 1–6

Type material. Holotype: Male from MEXICO. OAXACA. Distrito de Villa Alta. Municipio de San Melchor Betaza (CNAN-T0668), km 101 road to Villa Alta 17°13.463'N, 96°09.124'W, 992 m., 21 June 2007, C. Santibáñez and A. Valdez. Paratypes one adult female, one subadult male, one juvenil male and one juvenil female (CNAN- T0669) (same data as holotype). One adult male, three adult females (CNAN-T0670) from San Melchor Betaza 17°15.061'N, 96°09.188'W, 1415 m., 1 June 2007, C. Santibáñez and H. Jara. One adult female, one adult male (AMNH), two adult males, six juvenil male, three adult females and six juvenile female (CNAN) from Municipio de San Andrés Zoolaga, 6 km south 17°15.4722'N 96°14.3928'W, 1119 m., 21 June 2007, O. Francke, A. Ballesteros, H. Montaño, C. Santibáñez and A. Valdez.

Additional material. MEXICO. OAXACA. Distrito de VILLA ALTA: Municipio de San Juan Tabaa, one adult female (CALA) [17°18.292'N, 96°12.390'W, 1280 m.], 10 June 2004, T. Martínez. One adult female (CALA) same data, 12 June 2004, T. Martínez.



Figure 1. *Diplocentrus franckei* sp. n., A Carapace, dorsal aspect B sternum, genital operculum and pectines, ventral aspect.



Figure 2. *Diplocentrus franckei* sp. n., **A** dextral pedipalp femur, dorsal aspect **B** dextral pedipalp patella, external aspect.

One adult male (CALA) from Municipio de San Francisco Yovego [17°33.4848'N, 96°13.551'W, 589 m.], 1 April 2005, T. Martínez. Two adult males (CNAN) from Municipio de San Melchor Betaza [17°15.061'N, 96°09.188'W, 1415 m.], June 2008, R. Mejía. One adult female (CNAN) from 9 km from San Andres Yaa on the road to San Juan Tabaa 17°20.1312'N, 96°11.2188'W, 787 m., 3. April 2007, C. Santibáñez and H. Jara. One adult female (CAIMsc-01136) from Municipio San Juan Yaeé, Santiago Yagallo [17°25.4166'N, 96°17.833'W, 1200 m.], 12 March 1997, P. Ruiz Figueroa.

Diagnosis. The following character combination is diagnostic for *D. franckei*, sp. n. Total length (adult), 55 to 60 mm. Base coloration (adult) brown to dark brown. Carapace anteromedian notch moderately deep, U-shaped (Fig. 1A). Pedipalp femur, dorsal surface sparsely and finely granular (Fig. 2A). Pedipalp patella, dorsomedian carina moderately developed, crenulate to feebly granular (male); externome-



Figure 3. *Diplocentrus franckei* sp. n., dextral pedipalp chela, dorsoexternal aspect. **A** Holotype $\stackrel{\circ}{\supset}$ (CNAN) **B** Paratype $\stackrel{\circ}{\subsetneq}$ (CNAN). Scale bar = 1 mm.

dian carina moderately developed, crenulate (male; Fig. 2B); ventromedian carina weakly developed to faint, granular (male, female). Pedipalp chela manus, dorsal surface markedly reticulate (male, Fig. 3A) or weakly reticulate (female, Fig. 3B); digital carina strongly developed, smooth to crenulate (male) or weakly to moderately developed, smooth (female); dorsal secondary carina weakly developed to faint, coarsely granular (male) or faint, smooth (female); dorsal external carina weakly developed to faint, smooth to crenulate (male), or faint, smooth (female). Legs I-IV telotarsi, counts of spiniform macrosetae in pro- and retroventral rows, 4-5/5:5/6:6/6:6/6-7 (variation in Table 1); basitarsi spiniform macrosetae pattern: leg I pst, rst, pm, rm; leg II pt, rt, pst, rst, pm, rm, Rm; legs III-IV pt, rt, vt, rst, vst, vm (variation in Table 2). Pectinal tooth count, 12-15, mode = 13 (male) or 11-13, mode = 12 (female) (variation in Table 3).

Table 1. Telotarsal spiniform macrosetal count (number of macrosetae in pro- and retroventral rows of telotarsi on legs I–IV) in *Diplocentrus franckei* sp. n., given as number of legs observed with corresponding proventral (p) and retroventral (r) setal count.

	Leg I			Leg II			Leg III					Leg IV						
	р		R		1	p 1		r	р		r				р		r	
	4	5	4	5	5	6	5	6	5	6	5	6	7	5	6	7	6	7
D. franckei sp. n.	26	42	4	63	66	2	18	49	5	63	3	60	6	3	63	1	46	21

Table 2. Basitarsal spiniform macrosetal count (number of macrosetae of basitarsi on legs I-IV) in *Diplocentrus franckei* sp. n., given as numbers of legs observed with corresponding setae count.

Leg	n	pt	rt	vt	pst	rst	vst	pm	rm	vm	Rm
Ι	41	1	1		41	41		41	41		5
II	42	42	42		42	42		42	42		42
III	42	42	42	42		42	42			42	
IV	36	36	36	36		36	36			36	

Table 3. Pectinal tooth count (number of teeth per pecten) in *Diplocentrus franckei* sp. n., given as number of male and female pectines observed with corresponding tooth count.

		11	12	13	14	15	16
<i>D. franckei</i> sp. n.	male	3	14	7	2		
	female	6	26	5	1		

Diplocentrus franckei sp. n. resembles D. mexicanus Peters, 1861, D. melici Armas et al., 2004 and D. jaca Armas and Martín-Frías, 2000 in adult size and coloration, but can be distinguished as follows. The leg III telotarsi counts of spiniform macrosetae is higher in D. mexicanus (7/8), while is lower in D. franckei, sp. n. (6/6). The carapace and mesosoma surfaces are strongly granular (male) in D. mexicanus, but weakly granulose to shagreened in D. franckei (male). Metasomal and pedipalp carination is slightly granular to crenulate in D. mexicanus (male), and crenulate to smooth in D. franckei (male). The rt spiniform macroseta in leg I is present in D. mexicanus, while it is absent in D. franckei; also rsm in leg II is present in D. mexicanus and absent in D. franckei.

Pedipalp surfaces in *D. melici* are punctuate, and minutely granular or smooth in *D. franckei*. Carapace anteromargin notch U-shaped in *D. franckei*, while in *D. melici* is V-shaped. Pedipalp patella dorsoexternal and externomedian carinae are strongly developed in *D. franckei* (male), but both are obsolete in *D. melici* (male).

Adults of *D. franckei* (55–60 mm) are smaller than adults of *D. jaca* (75–90 mm). Metasomal segment V ventral carinae are strongly serrate in *D. jaca*, while in *D. franckei* are granular. Carapace anteromargin notch is strongly deep (reaching the second pair of lateral ocelli level) in *D. jaca*, while it is moderately deep (reaching the
first pair of lateral ocelli level) in *D. franckei*. Pedipalp chela is slender in *D. jaca* (male, chela length:ratio= 4.97), and rounded in *D. franckei* (male, chela length:ratio= 2.32).

Description. Based on holotype (male) and paratype (male) (Fig. 4A, B) with differences in paratype (female) (Figs 4C, D) noted. Measurements in Table 4.

Coloration: Carapace brown (male) or darker brown (female), moderately infuscate throughout, uniformly around median ocelli, variegated elsewhere. Coxosternum pale yellow to light brown. Pedipalps brown to dark brown, carinae darker. Legs brown to reddish brown, uniformly and faintly infuscate. Mesosoma brown (male) to dark brown (female), tergites moderately (male) to weakly (female) infuscate; sternites pale brown to pale yellow. Metasoma reddish brown (male) to dark brown (female). Telson brown, uniformly infuscate.

Carapace: Anterior margin weakly setose; anteromedian notch weakly to moderately deep, U-shaped (Fig. 1A). Frontal lobes and interocular surface moderately granular; surfaces around median ocular tubercle shagreened; other surfaces minutely, sparsely and finely granular. Three pairs of subequal lateral ocelli.

Pedipalps: Orthobothriotaxic, Type C. Femur width greater than height (Fig. 2A); dorsal intercarinal surface flat, sparsely granular; external intercarinal surface smooth; ventral intercarinal surface flat, shagreened to minutely, finely granular; internal intercarinal surface coarsely and densely granular; dorsointernal carina strongly developed, comprising several large granules; dorsoexternal carina moderately to weakly developed, comprising few large granules; ventroexternal carina obsolete; ventrointernal carina moderately developed, comprising large granules. Patella, dorsal and external intercarinal surfaces slightly, minutely and finely granular-reticulate (Fig. 2B); ventral intercarinal surface flat, minutely granular between ventrointernal and ventromedian carinae, smooth to slightly reticulate between ventromedian and ventroexternal carinae (male) or smooth (female); internal intercarinal surface sparsely granular; proximal tubercle strongly developed, comprising two large granules; dorsointernal carina obsolete; dorsomedian carina moderately developed, crenulate to feebly granular; dorsoexternal carina strongly developed, crenuate to feebly granular (male) or weakly developed to faint, smooth (female); externomedian and ventroexternal carinae moderately developed, smooth to slightly crenulate; ventromedian carina weakly to moderately developed, granular (male) or weakly developed, smooth to slightly granular (female); ventrointernal carina weakly to moderately developed, granular. Chela manus rounded (male, female) height greater than width, moderately (male) to sparsely setose (female); dorsal intercarinal surface granular-reticulate (male, female); external intercarinal surface granular-reticulate (male) or reticulate (female) (Fig. 3A, B); dorsal margin strongly developed, granular; digital carina strongly developed, crenulate to smooth (male, female); dorsal secondary carina weakly developed, granular; external secondary carina weakly developed, smooth to slightly granular (male) or weakly developed, smooth (female); ventroexternal carina weakly developed, crenulate; ventromedian carina moderately to strongly developed, coarsely granular to crenulate (male) or crenulate to smooth (female), directed towards midpoint of movable finger articulation; ventrointernal



Figure 4. *Diplocentrus franckei* sp. n., habitus, dorsal (**A**, **C**) and ventral (**B**, **D**) aspect. **A**, **B**. Holotype \Diamond (CNAN) **C**, **D** Paratype \Diamond (CNAN). Scale bars = 5 mm.

	6	Ŷ
	Holotype	Paratype
Total L	57.8	57.2
Carapace L	7.1	7.7
Carapace W	6.8	7.5
Mesosoma L	18.5	21.9
Pedipalp L	27.2	24.6
Femur L	6.1	5.5
W	2.2	2.4
D	2.0	2.0
Patella L	6.8	6.0
W	2.0	2.0
D	2.8	2.7
Chela L	14.3	13.1
W	3.0	3.7
D	6.2	6.1
Movable finger L	9.3	7.4
Fixed finger L	6.0	4.9
Chelicera L	3.2	3.2
W	1.4	1.6
Movable finger L	2.0	2.1
Fixed finger L	1.2	1.1
Metasoma L	27.0	22.5
Segment IV L	5.5	4.8
W	3.0	3.0
Segment V L	8.0	6.0
W	2.5	2.6
D	2.5	2.5
Telson L	5.2	5.1
Vesicle L	5.2	5.1
W	2.5	3.0
D	2.4	2.5

Table 4. Measurements (mm) of male and female type specimens of *Diplocentrus franckei*, sp. n., in the CNAN.

carina weakly developed, smooth to slightly crenulate; internoventral, internomedian and internodorsal carinae weakly developed, slightly granular; internal surface with shallow longitudinal depression where chela rest against patella. Chela fixed finger slightly curved, length equals femur length; dorsal surface smooth and densely setose proximally, external surface flat, internal surface shallowly concave.

Legs: Legs I-IV femora and tibiae, prolateral surfaces shagreened; telotarsi, counts of spiniform macrosetae in pro- and retroventral rows (dextral/sinistral): 4/5 5/5:5/5



Figure 5. *Diplocentrus franckei* sp. n., paratype ♂ (CNAN) sinistral hemispermatophore. **A** dorsal aspect **B** ental view **C** Capsular region. Scale bars = 1 mm.

5/6:6/6 6/6:6/6 6/6 (holotype); basitarsi, spiniform macrosetae pattern: Leg I pst. rst, pm, rm; leg II pt, rt, pst, rst, pm, rm, Rm; legs III-IV pt, rt, vt, rst, vst, vm (holotype).

Pectines: Tooth count: 13-14 (male; Fig. 1B) or 11-11 (female)

Mesosoma: Tergites I-VI, pre-tergites smooth, post-tergites minutely granular; VII granular. Sternites smooth; dorsosubmedian and dorsolateral carinae weakly to moderately developed, crenulate.

Metasoma: Metasomal segments I-V, dorsal intercarinal surfaces shagreened on segments I-IV, smooth on V; lateral intercarinal surfaces shagreened on segments I-IV, smooth on V; ventral intercarinal surfaces smooth on I-V. Segments I-IV, dorsolateral carinae weakly developed, granular; lateral surpamedian carinae moderately developed, granular on I, moderately developed, granular to crenulate on II-III; moderately developed, granular to serrate on IV; lateral inframedian carinae strongly developed, crenu-



Figure 6. *Diplocentrus franckei* sp. n., known records in Oaxaca (in circles). *Diplocentrus mexicanus* (type locality in triangle). *Diplocentrus jaca* (type locality in square).

lae on I, moderately developed, crenulate to granular on II-IV; ventrolateral carinae strongly developed, crenulate on I, moderately developed, crenulate to slightly granular on II-IV; ventrosubmedian carinae strongly developed, smooth to crenulate on I, moderately developed, smooth to crenulate on II-IV. Segment V length: pedipalp femur length ratio, 1.31 (male), 1.09 (female); dorsolateral carinae strongly developed, crenulate to feebly granular; lateral inframedian carinae moderately to weakly developed, feebly granular on I-III, weakly developed, sparsely granular on IV; ventrolateral carinae

moderately developed, granular to feebly serrate, with subspiniform granules; ventromedian carina moderately to strongly developed, granular, with subspiniform granules; ventral transverse carina moderately developed, comprising four subspiniform granules posteriorly; anal arch semicircular; anal subterminal carina moderately developed, comprising twelve subspiniform granules; anal terminal carina vestigial, weakly granular.

Telson: Telson, width: length ratio, 0.46 (male), 0.58 (female). Vesicle, lateral surface smooth; ventral surface granular anteriorly. Subaculear tubercle stout, subconical. Aculeus length 1.5.

Hemispermatophore: Lamelliform, weakly sclerotized (Fig. 5); total length 8.9 mm; distal lamella, length 4.8 mm, capsular region width, 1.8 mm; median lobe narrow, margin with small crenulations.

Etymology. This species is dedicated to Dr. Oscar Francke, for his enormous contribution to the taxonomy and systematics of the genus *Diplocentrus*, and his guidance through the years in my education.

Distribution. *Diplocentrus franckei*, sp. n. is known from the Villa Alta district within the Northern mountain range in Oaxaca; in the municipalities of San Andres Yaa, San Andres Zoolaga, San Juan Tabaa, San Melchor Betaza (Fig. 6).

Ecology. This species was observed first on the soil surface, walking at night with UV detection; later it was collected inside houses, under stones and also in the crevices of rock walls. It was also found doorkeeping at burrow entrances in walls of road cuts. The burrows were constructed at an angle of ca. 30° to the wall, ca. 40–50 cm long and mostly straight with some turns around stones in the soil matrix. The dominant vegetation was the transition between dry tropical forest and pine-oak forest at 1500 m. *Centruroides serrano* Santibáñez-López & Ponce-Saavedra, 2009 was collected in sympatry. The habitat and habitus of *D. franckei*, sp. n. are consistent with the pelophilous ecomorphotype (Prendini 2001).

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Taxonomic notes on Cryptamorpha sculptifrons Reitter (Coleoptera, Silvanidae), with description of its larval morphology

Takahiro Yoshida¹, Toshiya Hirowatari²

I Entomological Laboratory, Graduate School of Bioresource and Bioenvironmental Sciences, Kyushu University, Fukuoka, 812–8581 Japan 2 Entomological Laboratory, Faculty of Agriculture, Kyushu University, Fukuoka, 812–8581 Japan

Corresponding author: Takahiro Yoshida (yoshida_toritoma@yahoo.co.jp)

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Abstract

Cryptamorpha sculptifrons Reitter, 1889 is redescribed and a lectotype and paralectotype are designated. The mature larva of *C. sculptifrons* is described. It is hypothesized that a variety described by Grouvelle (1908), *C. sculptifrons* var. *punctifrons* from India, might not be conspecific with Japanese *C. sculptifrons*. It is also suggested that larvae of *Cryptamorpha* can be distinguished from larvae of the tribe Brontini by the relatively thick antennae and the 3rd antennomere which is less than 3/4 of the length of the 2nd.

Keywords

Taxonomy, redescription, lectotype, variety, urogomphi

Introduction

The family Silvanidae Kirby, 1837 (Coleoptera, Cucujoidea) includes two subfamilies, about 58 genera and approximately 500 species (Thomas and Leschen 2010) throughout the world, of which 43 species have been recorded from Japan (Hirano 2009, 2010 and Yoshida and Hirowatari 2013, 2014). Silvanidae are considered to be fairly

primitive among the Cucujoidea, and most of its members seem to be fungivorous (Thomas 2002).

The genus *Cryptamorpha* Wollaston, 1854 (Brontinae, Telephanini) includes 27 described species globally (Thomas and Leschen 2010; Brown et al. 2012). In Japan, two species and one undetermined species were recorded by Hirano (2009, 2010). *Cryptamorpha desjardinsi* (Guérin-Méneville, 1844) is the only species of the subfamily Brontinae listed in the provisional list of alien species naturalized in Japan (Murakami and Washitani 2002). There is little biological information on other *Cryptamorpha* species. *Cryptamorpha sculptifrons* Reitter, 1889 was described on the basis of specimens collected by George Lewis from Japan. This species was listed in the taxonomic key of the genus *Cryptamorpha* by Grouvelle (1919), and two varieties were described by Grouvelle (1908). However, there was no figure of the male genital structure and no redescription of this species based on the type specimens.

While larval morphology can provide useful information for phylogenetic studies (e.g. Lawrence et al. 2011; Leschen et al. 2005), there is little information on the larval morphology of this family, and the larvae of *Cryptamorpha* species are poorly known.

In this paper, we redescribe *C. sculptifrons* and designate a lectotype and paralectotype. In addition, we describe the larval morphology of this species for the first time.

Materials and methods

Observation of morphology and dissection and photographic technique

External characters were observed under a stereoscopic microscope (Olympus SZX10). Genital structures were placed on a cavity slide glass with 50% glycerol solution and observed with an optical microscope (Nikon Eclipse E400). The genitalia slide was prepared in the following steps: The removed abdomen was placed in a 200 µl PCR tube filled with 10% solution of potassium hydroxide (KOH) and kept in heated water for about seven minutes. After rinsing in 70% ethanol solution, the abdomen was dissected by cutting its lateral side using fine insect pins. The genitalia were transferred to a cavity slide glass with 50% glycerol solution for observation. After the observation, the genitalia and abdomen were mounted in Euparal on cover glasses each glued to a piece of cardboard, and pinned with the specimens.

Photographs of adults were taken with digital camera (Canon EOS 7D), and composite images were produced using automontage software Combine ZM. These images were retouched using Photoshop 6.0 (Adobe Systems Inc.).

The larvae were preserved in 70% ethanol (Stehr 1987), and the dissected specimens were mounted in Euparal. Two larval specimens were dehydrated with absolute ethanol and sputter-coated with gold-palladium with a JEOL Ion Sputter JFC-1100 for examination with a scanning electron microscope (SEM). SEM photographs were taken using JSM-5600LV.

Terminology, abbreviations and specimen deposition

Technical terms of genital structures follow Halstead (1980) and Lawrence et al. (2011) and larval morphology follows Stehr (1991), Thomas and Leschen (2010) and Lawrence et al. (2010).

The lectotype and the paralectotype designated herein are deposited in the Natural History Museum, London (BMNH). The other specimens examined in this paper are deposited in the Ehime University Museum, Matsuyama (EUMJ) and the Entomological Laboratory, Kyushu University, Fukuoka (ELKU).

Results

Description

Cryptamorpha sculptifrons Reitter, 1889

http://species-id.net/wiki/Cryptamorpha_sculptifrons Japanese name: Semaru-hoso-hiratamushi Figs 1–5

Cryptamorpha sculptifrons Reitter, 1889: 320. – Grouvelle 1908: 474–476. – Gouvelle 1919: 46. – Hetschko 1930: 89. (catalogue) – Hisamatsu 1961: 2–3. – Kamiya 1961: 18, pl. 5. – Sasaji 1985: 205, fig. 36 in pl. 32. – Pal and Sen Gupta 1979: 77, 79, fig. 7. – Satô 1989: 377. – Halstead et al. 2007: 497. (catalogue) – Hirano 2009: 62. – Hirano 2010: 9–10.

Adults. Body length from anterior margin of clypeus to apex of elytra measured along the median line: 3.69–4.14 mm (n=14).

Coloration (Fig. 1A). Surface brown, yellowish-brown in some lighter colored specimens. Elytra brown, sometimes slightly lighter than head and pronotum, with a variable round dark macula at each posterior half; elytra of lectotype with dark maculae. Antennae unicolorous, brown, as in head and pronotum.

Head (Fig. 1B, C and D). Triangular, width across eyes 0.76-0.86 mm. Temples immediately narrowed behind eyes, slightly incised at bases, with short setae except around eyes. Eyes relatively small, somewhat prominent, diameter less than half of length of head. Ventral surface with rough irregular punctuation except posterior half; dorsal surface with sparser punctuation. Antennal length 2.07-2.09 mm, 2nd antennomere short; 9th and 10th widened distally; covered with medium length semi-erect pubescence on each antennomere in lectotype as follows: 2.2 : 1.0 : 1.4 : 1.7 : 1.8 : 1.7 : 1.5 : 1.2 : 1.2 : 1.8 (Fig. 1B).

Prothorax (Fig. 1C and D). Rectangular, longer than wide, maximum width near middle, length 0.84–1.01 mm, width 0.89–0.95 mm in male (n=8) and 0.91–0.82 mm in fe-



Figure 1. *Cryptamorpha sculptifrons* Reitter, 1889, lectotype, male. **A** Habitus, dorsal view **B** left antenna **C** head and pronotum, dorsal view **D** head and pronotum, ventral view **E** metaventrite **F** right elytron **G** right foreleg, ventral view. Scale: 2.0 mm for **A** and 1.0 mm for **B–G**.

male (n=5). Dorsal surface punctuated moderately densely except around posterior margin. Pubescence composed of many medium length setae on the dorsal side, and several relatively short setae on the ventral side. Each anterior angle with a few very small protuberances, with depressions around posterior angles of ventral surface. Procoxae without punctuation.

Elytra (Fig. 1F). Elongate, length 2.38–2.62 mm, combined width 1.22–1.43 mm. Punctures a little wider than interstices, scutellary striole composed of seven or eight punctures. Pubescence composed of semi-erect medium length setae.

Legs (Fig. 1E and G). Trochanter with a tooth on apical angle of inner margin. Profemora stout, maximum width near middle. Mesotibia curved inwards around apical 1/4.

Eighth and 9th sternites (Fig. 2A and B). Eighth sternite (Fig. 2A) triangular, furcated near middle, each posterior half semicircular, covered with many medium length



Figure 2. Male genital organs of *Cryptamorpha sculptifrons* Reitter, 1889, lectotype, male. **A** 8th sternite, ventral view **B** 9th sternite **C** phallobase, dorsal view **D** parameres, ventral view **E** penis, dorsal view **F** internal sac, dorsal view. Scale: 0.5 mm for **A**, **D** and 1.0 mm for **B**, **C**, **E**, **F**.

and some short setae, membranous around anterior portions. Ninth sternite (Fig. 2B) composed of two curved elements forming a ring: a short posterior semicircular strut strongly curved inwards at each end, connected to a long anterior element by a membrane; the long element strongly curved at middle, with a short dorsally orientated subapical process on each end, and the anterior half broadened.

Aedeagus (Fig. 2C–F). Parameres (Fig. 2C and D) L-shaped, relatively long, basal portions strongly curved inwards, inner dorsal margin of basal portion with several punctures, several medium length setae sparsely grouped around half of ventral surface,



Figure 3. Sexual dimorphism of *Cryptamorpha sculptifrons* Reitter, 1889. **A**, **B** male **C**, **D** female. **A**, **C** Head and pronotum, dorsal view; **B**, **D** 7th sternite, ventral view. Scale: 1.0 mm.

one or two long, a few medium length and a few short setae on each apex. Phallobase (Fig. 2C) rectangular, longer than wide, membranous around posterior angles, anterior margin of dorsal portion curled up at posterior 2/7, anterior angles protruding anterolaterally; each lateral portion strongly extended posteriorly, exposed from anterior margin of dorsal portion, connecting at posterior 1/3, membranous around anterior margin. Penis (Fig. 2E) elongate, posterior half relatively wide, somewhat flat, moderately punctuated on posterior 1/5, with blunt apex, and dorsal portion thinly extended posteriorly.

Sexual dimorphism (Fig. 3). Males and females are very similar. However, males can be distinguished from females by the wider pronotum which is comparatively expanded (Fig. 3A) and the strongly impressed central area of the 7th sternite with a small protrusion around middle of posterior margin (Fig. 3B).

Type series. Lectotype here designated: male, Chûzenji, Nikkô City, Tochigi Prefecture, Japan, 19–24–VIII–1881, G. Lewis leg. (BMNH). Paralectotype: 1 male, same data as lectotype (BMNH).



Figure 4. Mature larval morphology of *Cryptamorpha sculptifrons* Reitter, 1889. **A** Habitus, dorsal view **B** head, dorsal view; **C** right antenna, dorsal view **D** right mandible, ventral view **E** left mandible, ventral view **F** right maxilla, dorsal view **G** labium, ventral view **H** 8th to 10th abdominal segments, dorsal view **I** right foreleg, dorsal view. Abbreviations: cl–claw; fa–frontal arm; fe–femur; ma–mala; mo–mola; mp–maxillary palpus; pr–prostheca; sp–stipe; st–stemmata; ti–tibiotarsus; tr–trochanter; ur–urogomphus; 1a–1st antennomere; 2a–2nd antennomere; 3a–3rd antennomere; 8as–8th abdominal segment; 10as–10th abdominal segment. Scale: a for **A–H**, 2.0 mm for **A**, 1.0 mm for **B**, **H**, 0.5 mm for **C–F** and 0.3 mm for **G**; b for **I**, 0.5 mm.

Specimens examined. JAPAN: [Gunma Pref.] 2 females, Hatomachi-Pass, Katashina Village, 29–VIII–1978, Y. Hori leg. (EUMJ). [Nagano Pref.] 1 female, Mt. Kisokomagatake, 6–VII–1960, Y. Kimura leg. (EUMJ). [Yamanashi Pref.] 1 male, Takizawa-Rindô, Narusawa Village, 1–VIII–2005, T. Kurihara leg. (EUMJ). [Gifu Pref.] 2 female, 5 male & 1 ex., Nigorigo-Onsen, Gero City, 14–15–VIII–2013, N. Tsuji leg. (ELKU).

Distribution. JAPAN: Honshu; China, Bhutan, India (Pal and Sen Gupta 1979).

Remarks. Syntypes of this species consisted of two specimens. We designate a brownish male specimen as lectotype, and another male yellowish-brown specimen as paralectotype, because the original description expressed their color as "testacea", which means reddish brown color (Reitter 1889). Type specimens were collected from Chûzenji, Nikkô City, Tochigi. This species was collected from relatively high altitudes, and there is no specimen collected from western Japan.



Figure 5. Mature larval morphology of *Cryptamorpha sculptifrons* Reitter, 1889. **A** Head, dorsal view **B** right antenna, dorsal view **C** 8th to 10th abdominal segments, dorsal view **D** left foreleg, dorsolateral view **E**, **F** urogomphi, dorsal view, basal portion (E) and middle portion (F). Scale: 0.5 mm for **A–D** and 0.1 mm for **E**, **F**.

Mature larva. Head capsule width of mature larvae: 0.90–0.96 mm (n=27).

Coloration. Body white to yellowish white. First antennomere, posterior 4/5 of 2nd and anterior half of 3rd somewhat darkened. Frontal arm white. Most setae, base and posterior 2/7 of urogomphi brownish white.

Head (Figs 4A–G, 5A and B). Rectangular, covered with medium length and long setae and several short setae. Frontal arm U-shaped (Figs 4B and 5A). Antenna (Figs 4C

and 5B) moderately long; 1st antennomere stout but relatively long, apical half covered with relatively short setae; 2nd subparallel, relatively thick, twice as long as 1st, covered with many variable length setae, a short and thick conical sensorium present near apex of inner margin; 3rd less than 1.5 times as long as 1st, covered with many short and a few long setae, a stout and short seta present on apex. Mandibles (Fig. 4D and E) triangular with two acute and one blunt teeth around each apex; a prostheca on anterior 1/3 of each inner margin, anterior angles strongly pointed; molae on bases of inner margins enlarged in anterolateral direction with many minute spines; several fine spines around inner margins of posterior half; a few medium length setae and a long seta on each outer margin. Maxilla (Fig. 4F) oblong; mala diverging at apex, with several short setae on outer margin near apex, inner margin with relatively thick and long setae in a row of which the most apical seta spiniform; stipes with many moderately dense minute spines around inner margin of central dorsal areas; maxillary palpus 3-segmented; 1st spherical and short; 2nd more than twice as long as 1st, with a few long setae on apical portion; 3rd almost as long as 2nd with a few minute spines on apex and some short setae. Labium (Fig. 4G) round, covered with several short setae and a pair of relatively long setae; palpus two segmented, covered with a few short setae, a few very short spines on each apex. Six stemmata on each lateral portion (Fig. 5A).

Thorax and abdomen (Figs 4A, H, 5C, E and F). The shape easily deformed according to their posture. Thoraxes covered with short and medium length setae, a pair of relatively long setae on middle lateral margins, two relatively long setae on anterior angles of prothorax. Abdomen 10-segmented; 1st abdominal segment short, 2nd to 8th rectangular, wider than long, posterior angles of 8th strongly protruding, covered with some variably sized setae on each segment, a long seta on apex of each posterior angle of 8th (Fig. 4H), 9th concealed but urogomphi exposed from under posterior margin of 8th abdominal tergite, less than twice as long as 10th, deeply emarginate around base, a few medium length setae around base and a relatively short seta on middle of each branch, anterior half of each branch scaly (Figs 4H, 5C, E and F), 10th longer than wide, covered with relatively short setae.

Legs (Figs 4I and 5D). Elongate. Trochanter triangular, covered with a few medium length setae; femur relatively thick, covered with short and medium length setae and one or two long setae around inner margin; tibiotarsus elongate, curved strongly inwards around base, covered with many medium length setae and a relatively stout seta around apex; claw elongate, weakly curved inwards, apex pointed, with two short setae.

Specimens examined. 27 exs. (two specimens were examined with slide preparation, and two specimens with a SEM), Nigorigo-Onsen, Gero City, Gifu Prefecture, Japan, 14–15–VIII–2013, N. Tsuji leg. (ELKU).

Biology. According to Mr. Tsuji (pers. comm.), the mature larvae were collected from dead leaves of Southern Japanese hemlock *Tsuga sieboldii* with their adults.

Identification. The examined larvae were collected with adult individuals of *C. sculptifrons.* They were identified as a member of the subfamily Brontinae from the generic key to the known larvae of some cucujoid families (Thomas 1988). The larvae of the genus *Cryptamorpha* can be distinguished from those of the genus *Psammoecus*

by the presence of urogomphi on the 9th abdominal segment (Pal 1985 and Hayashi 1992). In addition, *C. sculptifrons* is the only *Cryptamorpha* species distributed in mainland Japan. On the basis of this data, we identified the collected larvae as *C. sculptifrons*.

Discussion

Distribution of C. sculptifrons

Grouvelle (1908) described two varieties, *C. sculptifrons* var. *punctifrons* from India and *C. sculptifrons* var. *opacifrons* from China (Yun-nan) and India. He noted that these varieties differed from Japanese *C. sculptifrons* by their body shape and the shapes of the 1st to 3rd antennomeres, and suggested that reexamination of more numerous individuals of var. *punctifrons* might justify the separation of this variety from Japanese *C. sculptifrons*. Pal and Sen Gupta (1979) recorded this species based on specimens from Bhutan similar to var. *punctifrons* with an illustration of their male genitalia. However, the male genital structure of the Japanese species (Fig. 2C-E) differs from these by the longer setae on the apex of the parameres and the shape of the penis, which has a roundly prominent apex in Bhutanese specimens. Thus, var. *punctifrons* in India and Bhutan are considered unreliable. Further examination of the specimens studied by Grouvelle (1908) and specimens of the genus *Cryptamorpha* collected in South East Asia are required.

Taxonomic importance of larval morphology

Silvanid classification is in its infancy, and there is only one preliminary phylogenetic analysis for this family, treating 20 genera, based on 15 characters, by Thomas and Nearns (2008). In the analysis of Thomas and Nearns (2008), no more than three larval characters were used, and they were known in about half of the species treated. In the genus *Cryptamorpha*, larval morphology is known only for two species, *C. desjardinsi* and *C. brevicornis* (White, 1846). The former was included in a taxonomic key of some Cucujoid families and the latter was described by Hudson (1924) without describing the mouth parts. Thus, our paper provides the first description of the mouth parts of a *Cryptamorpha* larva.

In the key to known larvae of America North of Mexico by Thomas (1988), the genus *Cryptamorpha* was distinguished from members of the tribe Brontini by the presence of urogomphi that are shorter than the 10th abdominal segment and the absence of strongly protruded posterior angles of the 8th abdominal segment. However, *C. sculptifrons* (not occurring in the New World) possesses urogomphi that are longer than the 10th abdominal segment and strongly protruding posterior angles of

the 8th abdominal segment, though they are not protruding as strongly as those of the Brontini (Figs 4H, 5C). Including further information on the morphology of this species, larvae of *Cryptamorpha* can be distinguished from members of the tribe Brontini by having relatively thick antennae and the 3rd antennomere which is less than 3/4 of the length of the 2nd in the larval morphology.

Accumulation of detailed descriptions of the immature stages of more Silvanid taxa would be required for more accurate inferences on phylogenetic relationships and the completion of a more correct taxonomic key to larvae.

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