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Rhadinoscelidia lixa sp. nov. (Hymenoptera, Chrysididae, Loboscelidiinae) found on an ant nest in Thailand

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Abstract

Rhadinoscelidia lixa **sp. nov.** is described from Thailand. It is the fifth species of the genus and second species from Thailand. A biological note on the species with its associated ants is provided.

Keywords

Carebara diversa, chrysidid wasp, myrmecophily, taxonomy, Thailand

Introduction

Loboscelidiinae are rare and morphologically peculiar chrysidid wasps. The subfamily contains two genera, *Loboscelidia* Westwood, 1874 and *Rhadinoscelidia* Kimsey, 1988. To date, *Rhadinoscelidia* is known by four species from Hainan Island (China), Thailand, Laos, West Java (Indonesia), and peninsular Malaysia (Kojima and Ubaidillah 2003; Liu et al. 2011; Kimsey 2018). The genus is similar to *Loboscelidia* in some morphological characters; however, *Rhadinoscelidia* can be distinguished from *Loboscelidia* by the following characters: cervical expansion separated from upper gena with reduced patches of ribbon-like setae, reduced wing venation of the forewing, and reduced flanges on the legs (Kimsey 2018). Although nothing is known about their biology, the genus *Loboscelidia* is considered as an egg parasitoid of stick insects, similar to the Amiseginae, and the bizarre structural modification implies their myrmecophily (Riek 1970; Krombein 1983; Kimsey 2012). During the investigation of chrysidid fauna of Southeast Asia, we had a chance to examine an unidentified female of *Rhadinoscelidia* from Thailand. This wasp was found staying at the nest entrance of the ant species *Carebara diversa* (Jerdon, 1851) (Formicidae, Myrmicinae).

In this paper, we describe it as a new species of *Rhadinoscelidia* and provide a key to known species, and a brief discussion on the life history, of the genus.

Materials and methods

The material used in this study is deposited in the Entomological Laboratory, Faculty of Agriculture, Kyushu University, Japan. Images were taken with a Canon EOS Kiss X8i camera and edited using Adobe Photoshop CC. Morphological terminology and measurements mainly follows Kimsey (1988, 2018) and Liu et al. (2011). The following abbreviations and indices were used: maximum length of median ocellus diameter (MOD), minimum length of postocellar line (POL), minimum length of ocello-ocular line (OOL), maximum length of lateral ocellus diameter (LOD), lateral ocellar line (LOL, Masner and Huggert 1989) is the shortest distance between the inner margins of median and lateral ocelli, segment of flagellomere (F), metasomal tergite (T), and metasomal sternite (S).

Taxonomy

Rhadinoscelidia Kimsey, 1988

Diagnosis. Antennal scape distinctly longer than head; vertex sharply declivous behind ocelli; cervical expansion of head with posterior shield-like expansion clearly separate from rest of head; forewing venation highly reduced, restricted to basal sixth or less; all tibiae without flanges.

Distribution. China (Hainan Island), Thailand, Malaysia, and Indonesia.

Host. Unknown.

Rhadinoscelidia lixa Hisasue & Mita, sp. nov.

http://zoobank.org/AF07B6A0-64D8-4C80-A326-0B3F0B163ADC

Figs 1–7

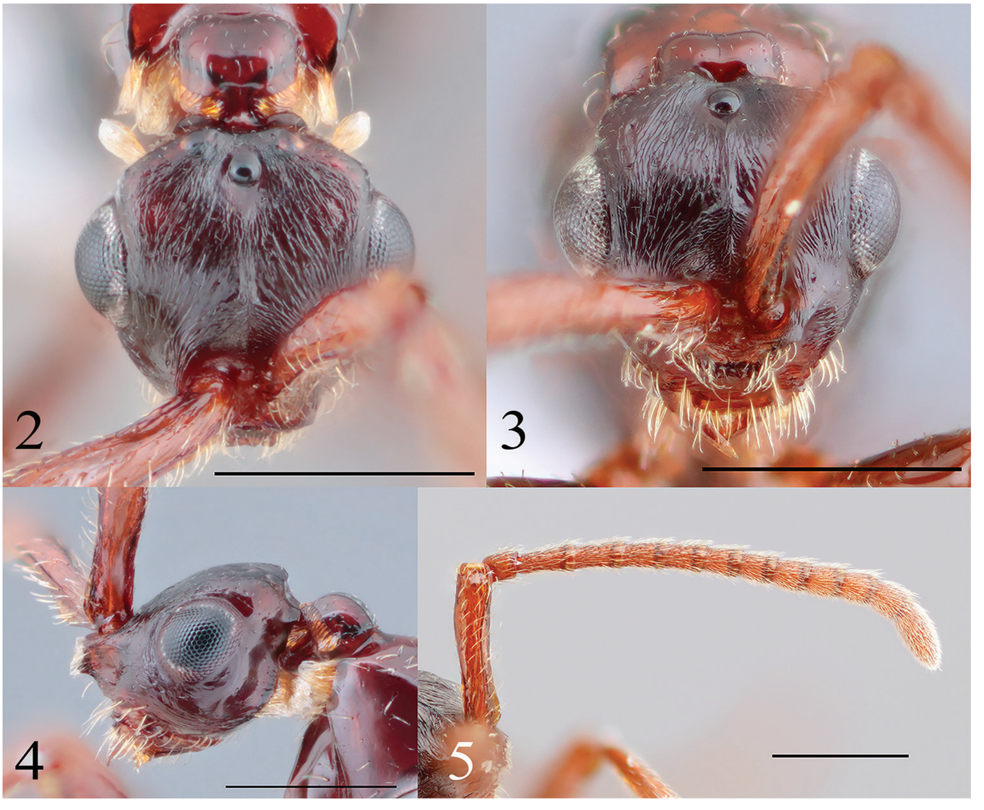
Material examined. ***Holotype,*** ♀, Thailand, Phrae Prov. 153 m, Mang Chin Dist., nr. Wiang Kosai NP, 3. V. 2019, R. Ishikawa leg. (Entomological Laboratory, Faculty of Agriculture, Kyushu University).

Figure 1. Lateral habitus of *Radinoscelidia lixa* sp. nov. (holotype). Scale bar: 1 mm.

Description of holotype. Female (Fig. 1). Body 3.0 mm long.

Head. Head (Figs 2–4) 1.9 times as long as height in lateral view, 1.3 times as long as maximum width; minimum length between compound eyes 0.7 times as long as head width; frontal projection rectangular in frontal view (Fig. 3); apical margin of frontal projection depressed (Fig. 2); malar space striate; frons striate radially except smooth appressed area in front of midocellus (Fig. 2); low ridge present from around posterior part of inner orbit of eye to posterior depression of vertex; vertex without transverse ridge, deeply depressed posteriorly; cervical expansion curved in lateral view (Fig. 4); temple 3.3 times as long as MOD; POL 2.5 times as LOD; OOL 3.0 times as long as LOD; LOL as long as LOD; scape 4.3 times as long as wide, sparsely punctate, slightly curved, 0.8 times as long as head width (Fig. 5); flange of scape 0.3 times as long as scape length; maximum width of flange 0.6 times as wide as tubular part of scape (Fig. 5); pedicel 1.3 times as long as wide, 0.5 times less than F1; F1–F7 tubular; relative length (width) of F1–F11: 2.4 (1.1): 2.0 (1.2): 1.8 (1.2): 1.6 (1.0): 1.4 (1.0): 1.4 (1.0): 1.4 (1.0): 1.4 (1.0): 1.4 (1.1): 1.4 (1.1): 1.4 (1.1): 3.2 (1.2).

Mesosoma. Mesosoma polished (Figs 1, 6); pronotum 0.9 times as long as maximum width; maximum width of pronotum 1.5 times as wide as posterior width; lateral margin of pronotum without distinct ridge (Fig. 6); mesoscutum 1.1 times as long as wide; tegula polished, 1.5 times as long as wide (Fig. 6); mesoscutum with notauli reaching posterior margin; mesoscutellum polished, 1.6 times as long as maximum width, 4.4 times as long as metanotum length (Fig. 7); length between metanotal depressions 1.5 times as long as length of metanotum (Fig. 7); propodeum smooth; projection weakly developed; dorsal margin of propodeum concave above foramen (Figs 1, 7).



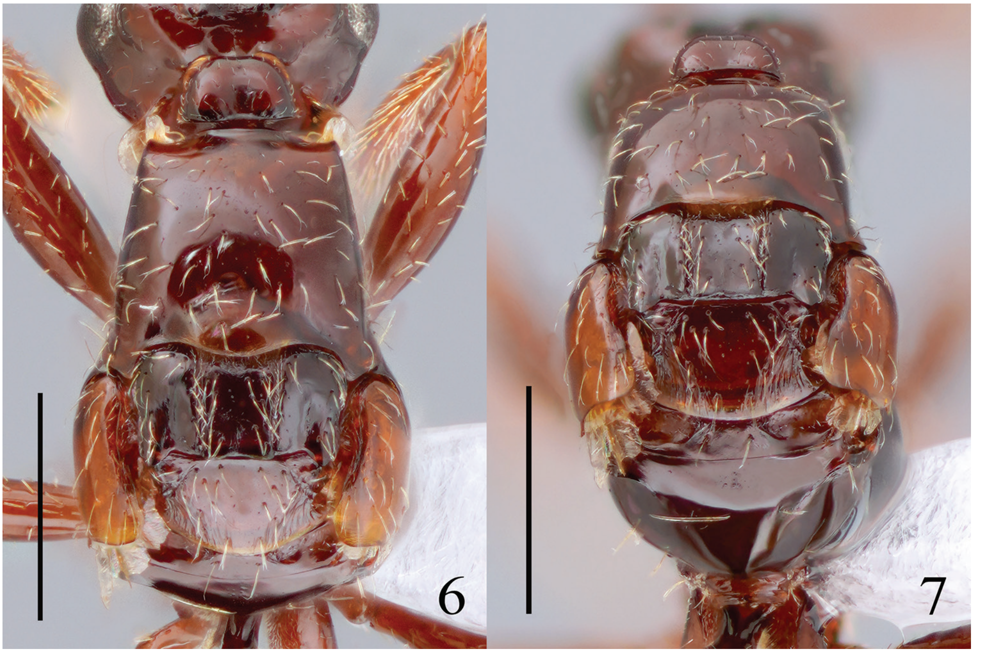
Figures 2–5. Head of *Radinoscelidia lixa* sp. nov. (holotype) **2** dorsal **3** frontal **4** lateral **5** antenna. Scale bars: 0.5 mm.

Legs. Legs polished (Fig. 1); femora cylindrical; tibiae slightly flattened, with longitudinal ridge on lower side; forefemur 4.1 times width; foretibia 5.9 times as long as width; midfemur 4.8 times as long as width; midtibia 6.6 times as long as width; hindcoxa 2.4 times as long as hindtrochanter; hindfemur 5.1 times as long as maximum width, 1.5 times as long as head width; hindtibia nearly straight, 8.1 times as long as maximum width (Fig. 1); hindbasitarsus 0.55 times as long as head width; relative length of hindtarsomeres = 3.5: 1.8: 1.7: 1: 2.3; tarsal claws with median tooth.

Wings. Fore and hindwings broken, missing from basal portion (Figs 6, 7).

Metasoma. Metasoma polished and smooth.

Pilosity. Frons with sparse decumbent needle-like setae; eye without setae; frontal projection with dense erect needle-like or cuneate setae (Fig. 2); clypeus with sparse erect needle-like setae (Fig. 3); maxilla with dense decumbent needle-like setae; labrum with dense decumbent needle-like setae; malar space with sparse suberect cuneate or forked setae (Fig. 4); temple with sparse decumbent needle-like setae; vertex behind ocelli with sparse suberect needle-like setae; vertex with ribbon-like setae, shorter than ribbon-like setae on cervical expansion (Figs 2, 4); cervical expansion with sparse decumbent needle-like setae and ribbon-like setae, longer than ribbon-like setae on vertex; upper gena with ribbon-like setae, as long as ribbon-like setae on pronotum



Figures 6, 7. Mesosoma of *Radinoscelidia lixa* sp. nov. (holotype) **6** dorsal **7** lateral. Scale bars: 0.5 mm.

(Fig. 4); lower gena with sparse suberect needle-like setae along occipital carina; scape with sparse decumbent needle-like setae and sparse suberect forked setae (Fig. 5); pedicel with dense decumbent needle-like setae; F with dense decumbent needle-like setae, shorter than each F length (Fig. 5).

Anterior margin of pronotum with ribbon-like setae (Fig. 6), as long as those on lower gena; pronotum with sparse suberect cuneate or forked setae in dorsal view (Fig. 6); pronotum with sparse decumbent cuneate or forked setae in lateral view; propleuron with sparse decumbent cuneate or forked setae (Fig. 1); mesoscutum with sparse suberect forked setae (Fig. 6); tegula with sparse suberect forked setae (Fig. 6); mesopleuron with sparse decumbent cuneate or forked setae; metanotum with sparse suberect forked setae (Fig. 7); propodeum with sparse suberect cuneate setae in lateral view (Fig. 7).

Apical half of fore and midcoxae with dense suberect needle-like setae (Fig. 1); femora with sparse erect or suberect cuneate setae (Fig. 1); apical part of coxae with dense decumbent cuneate setae; tibiae with dense decumbent needle-like setae; tarsomeres with dense decumbent needle-like setae.

T2–T3 with sparse decumbent setae (Fig. 1), shorter than setae on S3–S4; S3–S4 with sparse suberect needle-like setae (Fig. 1); T5 with sparse suberect needle-like setae; S5 with dense suberect needle-like setae.

Coloration. Body reddish-brown (Fig. 1); labial palpi, maxillary palpi, and ribbon-like setae brownish yellow; other setae white; flange yellowish brown.

Male. Unknown.

Etymology. Named after the Latin 'lixa', meaning camp-follower, referring to the wasp walking near the ant's trail.

Figure 8. Lateral habitus of *Carebara diversa*. Scale bar: 1 mm.

Distribution. Thailand (Phrae).

Associate. *Carebara diversa* (Hymenoptera, Formicidae) (Fig. 8).

Remarks. *Rhadinoscelidia lixa* sp. nov. is easily distinguished from other species by the following characters: scape 4.3 times as long as width (over 5 times as long as width in other species); short erect setae of antenna; wide ribbon-like setae on temple wider than those on pronotum (shorter than those on pronotum in other species); shorter ribbon-like setae on cervical expansion (relatively longer in other species); straight hindtibia (slightly or moderately curved hindtibia in other species).

Key to species of *Rhadinoscelidia* (modified from Kimsey 2018)

1 Eye small and separated by more than half of its diameter from ocelli in lateral view; hindtarsal claw without tooth; vertex rounded and without transverse carina behind hindocelli.. ***R. chaesonensis* Kimsey**

– Eye larger, separated by half its diameter or less from ocelli in lateral view; vertex angulate and with transverse carina behind hindocelli; hindtarsal claw with a median tooth.. **2**

2 Scape shorter, 4.3 times as long as wide; pedicel 0.5 times less than F1; OOL 3.0 times as long as LOD; ribbon-like setae of upper gena as wide as those on pronotum; hindtibia almost straight .... ***R. lixa* sp. nov.**

– Scape longer, more than 5.0 times as long as maximum width; pedicel as long as or slightly shorter than F1; OOL less than 2.0 times as long as LOD; ribbon-like setae of upper gena much shorter than those on pronotum; hindtibia strongly curved... **3**

3 F1 twice as long as broad; frons with Y-shaped carina extending below midocellus.. ***R. halimunensis* Ubaidillah**

– F1 1.3–1.6 times as long as wide; frons with wrinkles or fine carinae diverging from midocellus... **4**

4 Vertex without transverse carina or sharp angle behind ocelli; F11 1.9 times as long as wide .... ***R. delta* Liu, Yao & Xu**

– Vertex with transverse carina or sharp angle behind ocelli; F11 1.6–1.7 times as long as wide .... ***R. malaysiae* Kimsey**

Discussion

Comparing *Rhadinoscelidia lixa* sp. nov. with the other four species of *Rhadinoscelidia*, the morphological characteristics of *R. lixa* sp. nov. are more conservative, rather similar to those of the genus *Loboscelidia*. In *Loboscelidia*, there is one record from the nest of the ant *Rhytidoponera metallica* (Smith, 1858) (Riek 1970). However, no information on the biology of *Rhadinoscelidia* has been reported until now (Kimsey 2018). According to observations by the collector, the holotype of *R. lixa* sp. nov. stayed at the entrance of the nest of *Carebara diversa*, and it was not attacked by ants. However, the wings of *R. lixa* sp. nov. were cut off from the basal portion (Fig. 7), probably by ants. Even though this is a singular observation, this may explain why *Rhadinoscelidia* has rarely been collected by previous trap-based surveys.

Sometimes, ants attack the wings of the ant-associate wasps. For example, *Paralipsis enervis* (Nees) (Braconidae) and *Bruchopria hexatoma* Kieffer (Diapriidae) have fully developed wings, but wings are eventually cut off by ants after entering the nest (Starý 1966; Loiácono et al. 2002). Similarly, Takada and Hashimoto (1985) reported that *Paralipsis eikoae* (Yasumatsu), an associate of *Lasius japonicus* Santschi (*L. niger* (Linnaeus)), had mutilated wings probably caused by ants. These myrmecophilous wasps show strong adaptation to the host ant, including the nutrition change and the mimicry of the cuticular hydrocarbons. As for *C. diversa*, many ant guests have been reported (Kistner 1983; Kistner and Mcnairn 1991; Geiselhardt et al. 2007). Although there is no evidence of the biological relationship between *R. lixa* sp. nov. and *C. diversa*, this observation could be a foothold for further understanding the little-known biology of *Rhadinoscelidia*.

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References

Geiselhardt SF, Peschke K, Nagel P (2007) A review of myrmecophily in ant nest beetles (Coleoptera: Carabidae: Paussinae): linking early observations with recent findings. Naturwissenschaften 94: 871–894. https://doi.org/10.1007/s00114-007-0271-x

Kimsey LS (1988) Loboscelidiinae, new species and a new genus from Malaysia (Hymenoptera: Chrysididae). Psyche 95(1/2): 67–79. https://doi.org/10.1155/1988/16535

Kimsey LS (2012) Review of the odd chrysidid genus *Loboscelidia* Westwood, 1874 (Hymenoptera, Chrysididae, Loboscelidiinae). ZooKeys 213: 1–40. https://doi.org/10.3897/zookeys.213.2985

Kimsey LS (2018) Morphology and review of the odd genus *Rhadinoscelidia* Kimsey, 1988 (Hymenoptera, Chrysididae, Loboscelidiinae). Journal of Hymenoptera Research 62: 45–54. https://doi.org/10.3897/jhr.62.20888

Kistner DH (1983) A new genus and twelve new species of ant mimics associated with *Pheidologeton* (Coleoptera, Staphylinidae; Hymenoptera, Formicidae). Sociobiology 8: 155–198.

Kistner DH, Mcnairn MJ (1991) A new genus and two new species of predacious Staphylinidae associated with *Pheidologeton* in Sulawesi (Coleoptera: Aleocharinae) with notes on their behavior. Sociobiology 18: 305–321.

Kojima J, Ubaidillah R (2003) Two new species of the cryptic chrysidid parasitoid subfamily Loboscelidiinae: the second species in *Rhadinoscelidia* and the first *Loboscelidia* for the Indonesian fauna. Entomological Science 6: 199–207. https://doi.org/10.1046/j.1343-8786.2003.00023.x

Krombein KV (1983) Biosystematic studies of Ceylonese wasps: A monograph of the Amiseginae and Loboscelidiinae (Hymenoptera: Chrysididae). Smithsonian Contributions to Zoology 376: 1–79. https://doi.org/10.5479/si.00810282.376

Liu JX, Yao JM, Xu ZF (2011) A new species of the rare chrysidid subfamily Loboscelidiinae from China: the third species of *Rhadinoscelidia* Kimsey, 1988. ZooKeys 87: 11–17. https://doi.org/10.3897/zookeys.87.1295

Loiácono MS, Margaría CB, Quiran E, Corro Molas B (2002) Revision of the myrmecophilous diapriid genus *Bruchopria* Kieffer (Hymenoptera, Proctotrupoidea, Diapriidae). Revista Brasileira de Entomologia 46(3): 231–235. https://doi.org/10.1590/S0085-56262002000300001

Masner L, Huggert L (1989) World review and keys to genera of the subfamily Inostemmatinae with reassignment of the taxa to the Platygastrinae and Sceliotrachelinae (Hymenoptera:

Platygastridae). Memoirs of the Entomological Society of Canada 147: 1–214. https://doi.org/10.4039/entm121147fv

Riek EF (1970) Loboscelidiidae. Commonwealth Scientific and Industrial Research Organization (Australia). Division of Entomology, The Insects of Australia. Melbourne University Press, Melbourne, 910 pp.

Starý P (1966) Aphid parasites (Hym., Aphidiidae) and their relationship to aphid attending ants, with respect to biological control. Insectes Sociaux 13: 185–202. https://doi.org/10.1007/BF02223024

Takada H, Hashimoto Y (1985) Association of the root aphid parasitoids *Aclitus sappaphis* and *Paralipsis eikoae* (Hymenoptera, Aphidiidae) with the aphid-attending ants *Pheidole fervida* and *Lasius niger* (Hymenoptera, Formicidae). Kontyu 53(1): 150–160.

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The "minute diving beetles" of southern Australia – taxonomic revision of *Gibbidessus* Watts, 1978, with description of six new species (Coleoptera, Dytiscidae, Bidessini)

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Abstract

Morphology and mitochondrial DNA sequence data are used to reassess the taxonomy of Australian diving beetles previously assigned to the genera *Uvarus* Guignot, 1939 and *Gibbidessus* Watts, 1978. *Gibbidessus* was described as a monotypic genus for *Gibbidessus chipi* Watts, 1978. The genus is significantly extended here. Based on molecular systematic evidence, *Uvarus pictipes* (Lea, 1899) is transferred to *Gibbidessus*. *Gibbidessus chipi* and *Gibbidessus pictipes* **comb. nov.** are redescribed, and six new species are described: *Gibbiddessus atomus* **sp. nov.** (SW Australia, Northcliffe area) [the smallest epigean diving beetle in Australia], *G. davidi* **sp. nov.** (SW Australia), *G. drikdrikensis* **sp. nov.** (Victoria), *G. kangarooensis* **sp. nov.** (SA Kangaroo Island), *G. pederzanii* **sp. nov.** (SW Australia, Nannup area), and G. *rottnestensis* **sp. nov.** (SW Australia). Species are delineated using characters such as male genital structure and beetle size, shape and colour pattern. Mitochondrial Cox1 data for 27 individuals, representing five species, were generated, and revealed clusters congruent with the morphological evidence. *Gibbidessus* occur in southern Australia, with the centre of diversification in the isolated peat- and wetlands of SW Australia. All species occur in very shallow water of seasonal, exposed or half-shaded wetlands and flooded meadows.

Keywords

Key, mitochondrial DNA, new species, smallest epigean Australian Dytiscidae species, southern Australia, temporary wetlands, peatlands

Introduction

With 726 described species the Bidessini belong to the most diverse tribes of the Dytiscidae (Nilsson and Hájek 2020). Bidessini genera have to date been justified mainly based on a diagnostic combination of structural features (Biström 1988; Miller and Short 2015), rather than apomorphies. This had to lead to the recognition of genera that render others paraphyletic (Balke and Ribera 2004). Some of these features, such as presence / absence of an elytral plica or occipital line, have been shown to vary within clades of closely related species (Balke et al. 2015). In this context, the use of phylogenetic reconstructions based on DNA sequence data offers a source of information that helps to delineate monophyletic entities (Hendrich and Balke 2009; Balke et al. 2013). In Australia, the situation is currently rather stable. Most Australian genera have been revised or will be revised in the near future (Balke and Ribera 2004; Watts 1978; Watts and Humphreys 2001, 2003, 2004, 2006, 2009; Watts and Leys 2005; Hendrich and Wang 2006; Hendrich and Balke 2009).

In this work we focus on the genus *Gibbidessus* Watts, 1978. These are widespread diving beetles of south-western and south-eastern Australia, but rarely collected, supposedly due to their small size. In fact, some of the species belong to the smallest epigean Australian Dytiscidae. We use molecular systematic evidence to redefine the genus and taxonomically treat all species now assigned to *Gibbidessus*, two known ones and six new species. We provide mitochondrial 3' cox1 sequence data for five species.

Materials and methods

Material: This study is based on the examination of 767 specimens. Types of the two previously known species were examined. Most of the specimens were collected in the past 25 years by LH and CHS Watts. Additional material was collected by Melita Pennifold of the Department of Parks and Wildlife in many parts of south-western Australia, and by Australian Water Quality in South Australia. Furthermore, the authors have studied all available specimens stored in relevant Australian museums.

Descriptions: Beetles were studied with a Leica M205C dissecting microscope at 10–100×. Male genitalia were studied and figured in dry condition. The terminology to denote the orientation of the genitalia follows Miller & Nilsson (2003). Abbreviations used in the text are: **TL** (total length), **TL-H** (total length without head), and **MW** (maximum width). Label data of type material are cited between quotation marks.

Photos and illustrations: Images were taken with a Canon EOS 5DS camera fitted with a Mitutoyo 10× (habitus) or 20× (genital structures) ELWD Plan Apo objective attached to a Carl Zeiss Jena Sonnar 3.5/135 MC as focus lens. Illumination was with two to three LED segments SN-1 from Stonemaster (https://www.stonemaster-onlineshop.de). Image stacks were generated using the Stackmaster macro rail (Stonemaster), and images were then assembled with the computer software Helicon Focus 4.77TM.

Table 1. GenBank accession numbers for *Gibbidessus* cox1 3'end mtDNA sequences.

Species	Voucher	COI-3, accession
Gibbidessus atomus sp. nov.	MB 1729	FR732713
	MB 2780	FR733522
	MB 2781	FR733523
Gibbidessus chipi	N/A	AF484132
Gibbidessus davidi sp. nov.	MB 1730	FR732714
	MB 2782	FR733524
	MB 2783	FR733525
	MB 7243	MT551887
	MB 7244	MT551888
	MB 7245	MT551889
	MB 7246	MT551890
Gibbidessus pictipes	MB 1695	FR732684
	MB 2104	FR733521
	MB 7250	MT551896
	MB 7252	MT551895
	MB 7253	MT551894
	MB 7254	MT551893
	MB 7255	MT551892
	MB 7257	MT551891
	MB 7259	MT551900
	MB 7260	MT551899
	MB 7261	MT551898
	MB 7262	MT551897
Gibbidessus rottnestensis sp. nov.	MB 3921	MT551904
	MB 7247	MT551901
	MB 7248	MT551902
	MB 7249	MT551903

Coordinates are given in decimal notation unless cited verbatim from labels. Besides various Australian road maps, we also used Google Earth (http://earth.google.com) to locate several localities, and their coordinates are given in Degrees, Minutes (DDD° MM'). Our maps are based on "MICROSOFT ENCARTA World-Atlas 2000".

DNA sequencing and data analysis: Our laboratory protocol has been explained in Hendrich et al. (2010). We used the 3' end of the cox1 gene, widely used in diving beetle research. Each of our 27 individual vouchers bears a green cardboard label that indicates the DNA extraction number of M. Balke (e.g., "DNA M. Balke 7247"). This number links the DNA sample to the dry-mounted voucher specimen, deposited in Zoologische Staatssammlung München (**ZSM**). We used a simple approach to calculate a neighbor-joining tree (*p*-distances) in Geneious (11.0.4.) software (Fig. 26), and subsequent visual inspection of the tree to learn whether there was any hidden diversity or haplotype sharing.

GenBank accession numbers are provided in Table 1.

Codens

ANIC Australian National Insect Collection, Canberra, Australia
CFP Collection Fernando Pederzani, Ravenna, Italy
CGC Collection Gilbert L. Challet, Florida, United States

CLH	Collection Lars Hendrich, Berlin, Germany; property of the NMW
DPAW	Department of Parks & Wildlife, Kensington, Australia
NMW	Naturhistorisches Museum Wien, Vienna, Austria
SAMA	South Australian Museum, Adelaide, South Australia, Australia
WAM	Western Australian Museum, Perth, Western Australia, Australia
ZSM	Zoologische Staatssammlung München, Munich, Germany

Collecting procedures

Most of the specimens were collected in the flat transition zones between land and water (1 to 5 cm depth) of seasonal, mainly open swamps, smaller pools, puddles and flooded meadows, using various kinds of aquatic dip nets and plastic strainers with very fine meshes. Mesh diameters varied from 0.1 to 0.5 mm. Most specimens were collected directly from the plastic strainers with forceps and/or an aspirator. According to our knowledge and the label data studied, none of the eight species has ever been obtained via light traps.

Taxonomy

Checklist of *Gibbidessus* species

NSW = New South Wales; SA= South Australia; TAS, = Tasmania; VIC = Victoria; WA = Western Australia.

G. atomus sp. nov.	south-western WA
G. chipi Watts, 1978	SA, VIC, TAS, NSW
G. davidi sp. nov.	south-western WA
G. drikdrikensis sp. nov.	south-western VIC
G. kangarooensis sp. nov.	SA (Kangaroo Island)
G. pederzanii sp. nov.	south-western WA
G. pictipes (Lea, 1899) comb. nov.	south-western WA
G. rottnestensis sp. nov.	south-western WA

Genus *Gibbidessus* Watts, 1978

Gibbidessus Watts, 1978: 29; gender masculine; type species: *Gibbidessus chipi* Watts, 1978: 52 by original designation; Biström (1988: 19); Nilsson & Hájek (2020: 108).

Type species. *Gibbidessus chipi* Watts, 1978.

Diagnosis. Very small diving beetles (1.15–1.9 mm). The smallest epigean dytiscids in Australia can be found in this genus. Body oblong-oval or elongate and fairly compactly built. Head with or without cervical line; frontally not bordered. Palpi rather slender, apically very finely bifid, in one species broad. Pronotum with a pair of basal striae. Elytron with a basal stria but without sutural striae. Punctation of elytra does not form rows. Epipleura lack a basal cavity posteriorly limited by a transverse carina. Prosternal process rather elongate, narrow, laterally distinctly marginated and with ventral surface not medially excavated. Prosternal process reaches metaventrite, which is not distinctly depressed posterior to mesocoxae. Metacoxal lines comparatively short, only slightly longer than distance between them posteriorly. Very fine punctures on either side of midline of metaventrite, not forming distinct rows. Metatrochanters and metafemora not distinctly modified (Biström 1988; Hendrich et al. 2019). Parameres symmetric. Larvae unknown.

Gibbidessus was described as a monotypic genus to accommodate *G. chipi* Watts, 1978. A molecular phylogenetic investigation covering all Australian Bidessini genera (Hendrich et al. 2010) recovered *G. chipi*, the single *Uvarus* species reported from Australia, *Uvarus pictipes* (Lea, 1899), as well as three undescribed species in one clade (Fig. 26). We refer to this clade as genus *Gibbidessus*. Subsequently, we assembled a multigene dataset of global Hydroporinae (Balke, work in progress), where we again recovered *Gibbidessus* species as well as *Uvarus pictipes* in one clade. The non-Australian *Uvarus* included in that preliminary study did form a separate, not closely related clade. Consequently, *Uvarus pictipes* is transferred to *Gibbidessus* here.

***Gibbidessus atomus* sp. nov.**

http://zoobank.org/713DD48F-BA41-4581-A05F-DEECAED51519
Figs 1, 14, 23, 27

Type locality. Western Australia, Windy Harbour Road, 11 km south of Northcliffe, small pool in sedge swamp [34°48'51S, 116°4'8E].

Type material. ***Holotype***, male: "Australia: SW WA, D´Entrecasteaux NP, 11 km S, Northcliffe, 77m, 4.I.2007, 34.44.048S, 116.05.354E [34°44'0S, 116°5'13E], L. & E. Hendrich (WA 162)", "Holotype *Gibbidessus atomus* Hendrich, Watts & Balke des. 2020" [red printed label] (WAM). ***Paratypes* (20 exs.)**. 7 specimens with same data as holotype, three specimens with "DNA M. Balke 1729", "DNA M. Balke 2780", "DNA M. Balke 2781" [green printed labels]; 13 exs., "AUSTRALIA/WA: D´Entrecasteaux N.P., 11 km south of Northcliffe, Windy Harbour Road, 50 m, 3.1.2000, 34°42'S, 116°05'E [34°44'0S, 116°5'13E], Hendrich leg. (loc. WA 10c/156)" (ANIC, CLH, SAMA, ZSM). All paratypes with red printed paratype labels.

Additional material. 1 ex., "Australia, WA, RVDLE03 Riverdale Wetland [32°59'22S, 115°47'7E], 23/09/2008, South West Catchment Council Mon." (DPAW).

Diagnosis. Very small species, externally characterised by widely rounded body, with less pronounced habitus disruption between pronotum and elytron, shiny non-microreticulate dorsal surface and vague ferruginous markings on elytra. Dorsoventrally rather domed. Cervical line present (Fig. 1).

Figures 1–4. Habitus of **1** *Gibbidessus atomus* sp. nov. **2** *G. chipi*, **3** *G. davidi*, male **4** *G. davidi* female. Scale bar: 1.0 mm.

Measurements. Holotype: TL = 1.15 mm, TL-H = 1.05 mm, MW = 0.6 mm. Paratypes: TL = 1.15–1.30 mm, TL-H = 1.0–1.05 mm, MW = 0.6–0.65 mm.

***Head*:** Dark brown, around eyes almost black. Cervical line present. Strongly and coarsely punctate, rather shiny, microsculpture almost absent. Punctures weakly distributed anteriorly, strong posteriorly between eyes. Antennae relatively short, stout. Antennomeres ferruginous, darkened anteriorly.

***Pronotum*:** Ferruginous, anterior and posterior margins darker. Disc of pronotum somewhat darkened, broadest at posterior corners. Punctation very weakly, almost evenly distributed, shiny, microsculpture absent. Sides of pronotum margined and almost evenly rounded. Angle between pronotum and elytra less pronounced, basal pronotal plicae present. Striae moderately defined, on almost 1/2 length of pronotum, moderately incurved.

***Elytra*:** Dark brown with vague basal area ferruginous (Fig. 1). Coarsely and densely punctate, shiny, microsculpture absent. Striae weakly impressed, slightly straighter but shorter than basal pronotal striae.

***Ventral side*:** Ferruginous. Prothorax and apex of abdomen paler than other parts. Metacoxae and metaventrite covered with numerous larger punctures, surface shiny, without microreticulation. Abdominal ventrites with dense and finer punctures, shiny, microreticulation absent. Metacoxal lines almost straight, anteriorly slightly divergent. Epipleuron ferruginous, coarsely punctate, shiny, lacking microsculpture. Legs ferruginous with meta-/mesotibiae and meta-/mesotarsi set in black.

***Male*.** Dorsal surface with coarse punctures but otherwise with shiny surface (Fig. 1). Median lobe of aedeagus as in Fig. 14A, B. Shape of median lobe fairly uniform, bent evenly, apex straight and pointed. Paramere, as in *Limbodessus* Guignot, 1939, with hook or bent finger-like apical part with tiny setae on tip (Fig. 14C).

Affinities. This species is similar to *G. davidi* sp. nov. but readily separated by its smaller size, the different colour pattern and the form of the median lobe and parameres (Figs 14, 16).

Etymology. From Latin *atomus* (smallest particle), as it is the smallest epigean diving beetle in Australia described so far.

Distribution. South-western Australia. Known only from the type locality in the D´Entrecasteaux National Park, south of Northcliffe and the Riverdale Wetland [32°59'22S, 115°47'7E] (Fig. 23).

Habitat. Most specimens were obtained from an exposed, shallow and small roundish puddle without any vegetation, except some algae (Fig. 27B). The remaining specimens were collected in a half-shaded pool in a *Melaleuca* blackwater swamp (Fig. 27A), with few clumps of *Juncus* spp. and extensive beds of macrophytes; depth up to 20 cm; bottom of sedge-filled peat (pH 5.5), twigs and rotten leaves. The heathlands south of Northcliffe are seasonally flooded, with some permanent water bodies in the summer. At Northcliffe the species is syntopic with *G. davidi* sp. nov. (Hendrich 2001a), at the Riverdale Wetland it was collected with *G. davidi* sp. nov. and *G. rottnestensis* sp. nov.

Apart from the *Gibbidessus*, the water beetle coenosis at Northcliffe included the following species: Dytiscidae: *Limbodessus inornatus* (Sharp, 1882), *Antiporus hollingsworthi* Watts, 1997, *A. mcraeae* Watts & Pinder, 2000, *Brancuporus gottwaldi* (Hendrich, 2001), *Sternopriscus minimus* Lea, 1899, *S. eikei* Hendrich & Watts, 2007, *Exocelina ater* (Sharp, 1882); Hydrophilidae: *Enochrus eyrensis* (Blackburn, 1895), *Limnoxenus zealandicus* (Broun, 1880), *Paracymus pygmaeus* (Macleay, 1871).

Gibbidessus chipi Watts, 1978

Figs 2, 15, 22

Gibbidessus chipi Watts, 1978: 33 (original description); Watts (1985: 24, checklist); Lawrence et al. (1987: 335, catalogue); Biström (1988: 19, systematics); Watts (2002: 31, 44, identification key, checklist); Davies et al. (2003: 24, 27, faunistics); Nilsson & Hájek (2020: 108, catalogue).

Type locality. Australia, New South Wales, Collector, old farm dam [34°54'40S, 149°26'24E].

Type material. ***Holotype***, male [with one paratype on the same plate]: "Collector NSW Febr 1961 C.W.", "Holotype" [red printed label], "ANIC Database No. 25 015140" [printed label], "Holotype Gibbidessus chipi Det. C. Watts 1976 [handwritten label by Chris Watts] (ANIC). ***Paratypes*** **(10 exs.)**. 2 males, 4 females: "Collector NSW 2/61" [handwritten label by Chris Watts], "Paratype Gibbidessus chipi Det C. Watts 1976" [white, printed and handwritten label], "ANIC Database No 2515141" (ANIC); 2 males: "Collector NSW 2/61" [handwritten label by Chris Watts], "Paratype Gibbidessus chipi Det C. Watts 1976" [white, printed and handwritten label], "SAMA Database No 25-003994" (SAMA); 1 male, 1 female: "Dartmoor Victoria Jan 59. CW" [handwritten label], "Paratype Gibbidessus chipi Det C. Watts 1976" [white, printed and handwritten label], "SAMA Database No 25-003398" (SAMA).

Additional material studied (17 exs.): **South Australia**. 2 exs., "1 km S, Nangwarry 5.X.2000, C. Watts leg.", "SAMA Database No 25-004002", one specimen "DNA M. Balke 2109 [green printed label] (SAMA, ZSM); 3 exs., "Fleurieu Peninsula, Myponga, A.H. Elston leg.", "SAMA Database No 25-00399" (SAMA); 1 ex., "Mt. Crawford State Forest, Watts Gully, 3.X.1998, C. Watts leg.", "SAMA Database No 25-003996" (SAMA). **Victoria**: 1 ex., "5.3 km S, Drik Drik,14. VIII.2004, C. Watts leg.", "DNA Voucher d" (SAMA); 6 exs., "18 km W Casterton, 25.IX.1998, C. Watts leg.", "SAMA Database No 25-004003" (SAMA); 3 exs., "18 km W Casterton, 25.IX.1998, C. Watts leg." (CLH); 1 ex., "22 km W Casterton, 23.IX.1999, C. Watts leg.", "photographed" [yellow label], "SAMA Database No 25-004004" (SAMA).

Diagnosis. Medium-sized species which externally is characterised by a widely rounded body, shiny non-microreticulate dorsal surface, vague testaceous markings on elytra, and without habitus disruption between pronotum and elytron. Dorsoventrally rather domed. Cervical line present (Fig. 2).

Measurements. TL = 1.5–1.55 mm, TL-H = 1.4–1.45 mm, MW = 0.86–0.98 mm.

Head: Dark brown, around eyes almost black. Cervical line present. Strongly and coarsely punctate, rather shiny, microsculpture almost absent. Punctures weakly anteriorly and strongly posteriorly between eyes. Antennae relatively short, stout. Antennomeres 1-2 ferruginous, 3-11 darkened anteriorly.

Pronotum: Ferruginous, anterior and posterior margins darker. Disc of pronotum somewhat darkened, broadest at posterior corners. Punctation very weakly punctate almost evenly distributed, shiny and microsculpture absent. Sides of pronotum margined and almost evenly rounded. Angle between pronotum and elytra not pronounced, basal pronotal plicae present. Striae well defined, almost 1/2 length of pronotum, strongly incurved.

Elytra: Ferruginous, with vague areas darkened (Fig. 2). Coarsely and densely punctate, shiny, microsculpture absent. Striae strongly impressed, same length as basal pronotal striae but slightly straighter.

Ventral side: Ferruginous. Prothorax and abdomen paler than other parts. Metacoxae and metaventrite covered with numerous larger punctures, surface shiny, without microreticulation. Abdominal ventrites with dense and fine punctures, shiny, microreticulation absent. Metacoxal lines almost straight, anteriorly slightly divergent. Epipleuron testaceous, with few coarse punctures, shiny, lacking microsculpture. Legs ferruginous with meta-/mesotibia and meta-/mesotarsi set in black.

Male. Dorsal surface with coarse punctures but otherwise with shiny surface Fig. 2. Median lobe of aedeagus as in Fig. 15A, B. Shape of median lobe fairly uniform, apex in lateral view straight and pointed, in ventral view very broad and rounded at apex. Parameres bi-segmented and elongated with few setae at apex (Fig. 15C).

Affinities. This species is similar to *G. drikdrikensis* sp. nov. but readily separated by its smaller size, and the form of the median lobe (Figs 15, 17).

Distribution. South-eastern Australia, from the Lofty Ranges near Adelaide and north-eastern Tasmania to Canberra (Watts 1978). Also recorded from King Island, Bertie Lagoon [39°42'36S, 144°4'24E] (Davies et al. 2003), northwest of Tasmania (Fig. 22).

Habitat. The type specimens were collected in an old farm dam and its flood zone, overgrown by rich vegetation. In Victoria and South Australia most of the specimens were collected in small shallow pools and seasonal wetlands. A single specimen from South Australia (Mount Crawford State Forest, Watts Gully) has been found in a shallow, slow flowing temporary forest creek. At Dri Drik, in Victoria, the species is syntopic with *G. drikdrikensis* sp. nov.

Gibbidessus davidi **sp. nov.**

http://zoobank.org/4D235E7C-F517-4C1D-A3C7-0C87BDA34515
Figs 3, 4, 12, 16, 23, 27, 28

Type locality. Western Australia, Perth, suburb Success, Beeliar Regional Park, shallow peaty puddle [32°8'4S, 115°50'22E].

Type material. ***Holotype***, male: "Australia, WA, Perth, Success, Beeliar RP, shallow peaty puddle 32°8'4.97"S, 115°50'22.78"E 21.-31.10.2015 L. Hendrich (WA 1/15)", "Holotype *Gibbidessus davidi* Hendrich, Watts & Balke des. 2020" (WAM) [red printed label]. ***Paratypes* (370 exs.)**. 354 specimens with same data as holotype (ANIC, CGC, CLH, SAMA, WAM, ZSM); 4 exs, "Australia: SW WA, D´Entrecasteaux NP, 11 km S, Northcliffe, 77m, 4.I.2007, 34.44.048S, 116.05.354E [34°44'0S, 116°5'13E], L. & E. Hendrich (WA 162)" (ZSM); 10 exs., "Australia, WA, Albany Hwy, Muir Lakes Nature Reserve, SW part of Byenup Lagoon, 4.& 5.1.2000, 34°30'4S, 116°44'19E, Hendrich leg. (loc. WA 11/157)" (CLH, ZSM); 1 ex., "Australia, WA, Barlee Brook Dickson Road (A) [34°12'17S, 115°46'18E], DON03, 21/10/2005, South West Forest Monitoring" (DPAW); 1 ex., "Australia, WA, Fish Creek (A) [34°37'29S, 116°26'11E], SHA22, 17/10/2010, South West Forest Monitoring" (DPAW); 4 exs., "Australia, WA, RVDLE03 Riverdale Wetland [32°59'23S, 115°47'23E], 23/09/2008, South West Catchment Council Mon." (DPAW). All paratypes with red printed paratype labels.

Diagnosis. Small species which externally is characterised by a wide rounded body, shiny non-microreticulate dorsal surface, vague testaceous markings on elytra, and without habitus disruption between pronotum and elytron. Dorsoventrally rather domed. Cervical line present (Fig. 3).

Measurements. Holotype: TL = 1.45 mm, TL-H = 1.35 mm, MW = 0.83 mm. Paratypes: TL = 1.35–1.5 mm, TL-H = 1.15–1.4 mm, MW = 0.8–0.9 mm.

***Head*:** Ferruginous, around eyes almost black. Cervical line present (Fig. 12A). Strongly and coarsely punctate, rather shiny, microreticulation present. Punctures weak anteriorly and strongly posteriorly between eyes. Antennae relatively short, stout. Antennomeres 1-8 ferruginous, 9-11 darkened anteriorly.

Pronotum: Ferruginous, anterior and posterior margins darker. Disc of pronotum somewhat darkened, broadest at posterior corners. Punctation of pronotum very weak, almost evenly distributed, shiny and microsculpture absent. Sides of pronotum margined and almost evenly rounded. Angle between pronotum and elytra less pronounced, basal pronotal plicae present. Striae moderately defined, almost 1/2 length of pronotum, strongly incurved.

***Elytra*:** Dark brown with vague basolateral area ferruginous (Fig. 3). Coarsely and densely punctate, shiny, microsculpture absent. Striae deeply impressed, straight but shorter than basal pronotal striae.

***Ventral side*:** Ferruginous. Prothorax and abdomen paler than other parts. Metacoxae and metaventrite covered with larger punctures, surface shiny, without microreticulation. Abdominal ventrites with dense and finer punctures, shiny, microreticulation absent. Metacoxal lines almost straight, anteriorly not divergent. Epipleuron ferruginous, with few coarse punctures, shiny, lacking microsculpture. Legs ferruginous with meta-/mesotibia and meta-/mesotarsi set in black.

***Male*.** Smaller and more elongate than female (Fig. 4). Median lobe of aedeagus as in Fig. 16A, B. Shape of median lobe in lateral view, straight and fairly uniform, in ventral view broad, with a thorn on each side, and rounded at apex. Parameres bisegmented and elongated with few setae at apex (Fig. 16C, D).

Affinities. This species is similar to *G. atomus* sp. nov. but readily separated by its larger size, the different colour pattern and the form of the median lobe and parameres (Figs 14, 16). From *G. pederzanii* sp. nov. it can be distinguished by the less roundish body and the form of the median lobe and parameres (Figs 16, 19).

Etymology. The beetle is named after the son of the first author, David Hendrich. The specific epithet is a substantive in the genitive case.

Distribution. South-western Australia. From Perth in the north to D´Entrecasteaux National Park in the south (Fig. 23).

Habitat. In the Northcliffe area most specimens were obtained from an exposed, shallow and small roundish puddle, without any vegetation, except some algae. The other specimens were collected in a half-shaded pool in a Melaleuca blackwater swamp, with few clumps of *Juncus* spp. and extensive beds of macrophytes; depth up to 20 cm; bottom consisted of sedge-filled peat (pH 5.5), twigs and rotten leaves (Figs 27, 28). The whole area south of Northcliffe is seasonally flooded with some permanent central water bodies in summer. In the D´Entrecasteaux NP the species is syntopic with *G. atomus* sp. nov., and around Perth in the Beeliar Regional Park with *G. rottnestensis* sp. nov. At the Riverdale Wetland Reserve *G. davidi* sp. nov. was syntopic with *G. atomus* sp. nov. and *G. rottnestensis* sp. nov.

Apart from the *Gibbidessus*, the water beetle coenosis at Northcliffe included the following species: Dytiscidae: *Limbodessus inornatus*, *Antiporus hollingsworthi*, *A. mcraeae*, *Brancuporus gottwaldi*, *Sternopriscus minimus*, *S. eikei*, *Exocelina ater*; Hydrophilidae: *Enochrus eyrensis*, *Limnoxenus zealandicus*, *Paracymus pygmaeus* (see Hendrich 2001a). In the Beeliar Park the two *Gibbidessus* species share their habitat with *Limbodessus inornatus*, *Paroster insculptilis* (Clark, 1862), *Exocelina ater*, *Rhantus suturalis* (Macleay, 1825) and *Rhantus simulans* Régimbart, 1908.

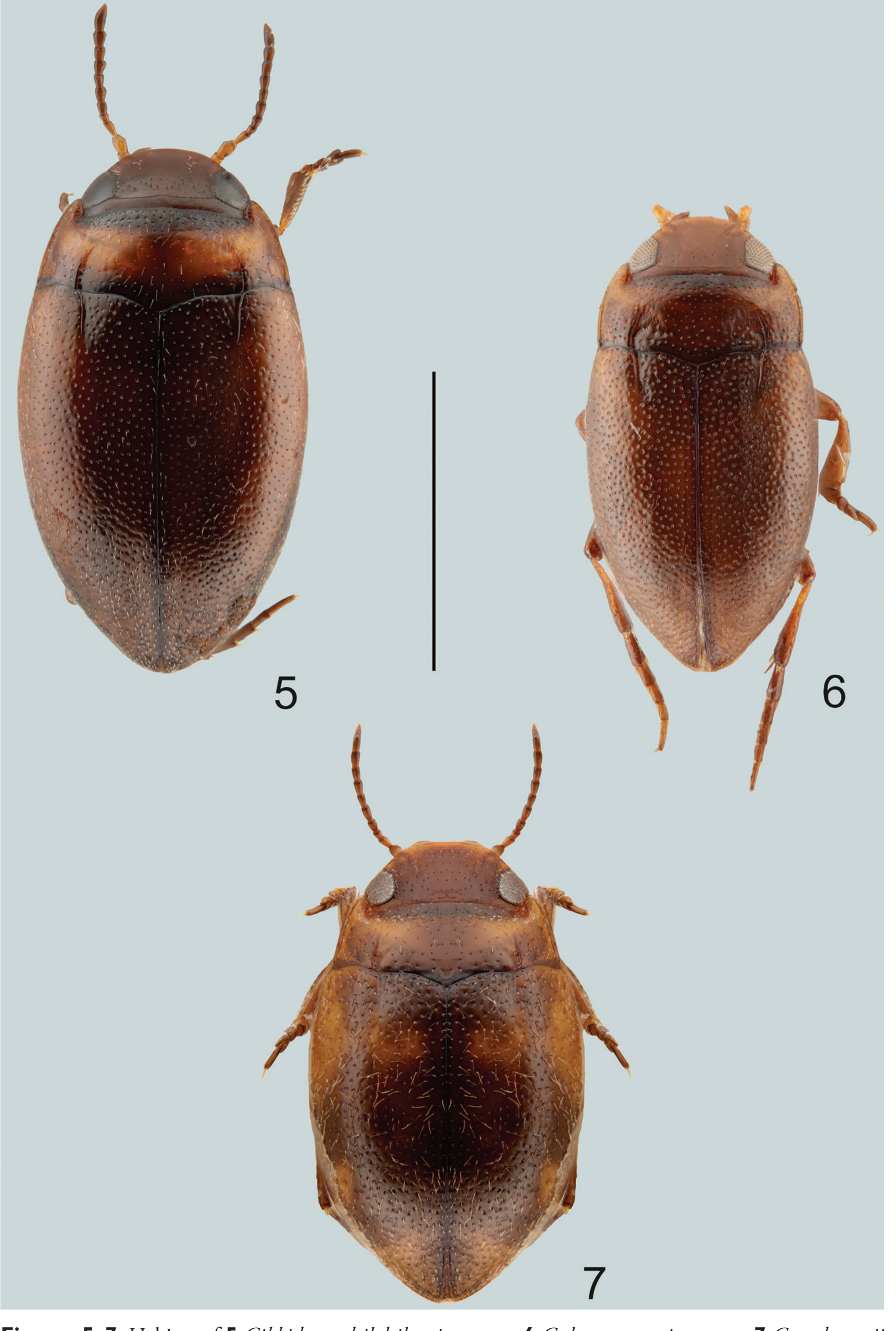
Gibbidessus drikdrikensis sp. nov.

http://zoobank.org/281FB8F4-C366-40CA-9358-6BF75CBCE8DD
Figs 5, 17, 22

Type locality. Australia, Victoria, Drik Drik, old farm dam [37°59'27S, 141°17'18E].

Type material. ***Holotype*:** Male, "1 km S, Drik Drik Vic. 24/9/98 C. Watts", "Photographed", "SAMA Database No 25-004000", "Holotype *Gibbidessus drikdrikensis* sp.nov. Hendrich, Watts & Balke des. 2020" [red printed label] (SAMA). ***Paratypes*** **(6 exs.):** 6 specimens with same data as holotype. Two specimens with "DNA voucher b" and "DNA voucher c" and one with a yellow prointed label "photographed" (CLH, SAMA). All paratypes are provided with printed red paratype labels.

Diagnosis. Medium-sized species which externally is characterised by a wide rounded body, shiny non-microreticulate dorsal surface, vague testaceous markings



Figures 5–7. Habitus of **5** *Gibbidessus drikdrikensis* sp. nov. **6** *G. kangarooensis* sp. nov. **7** *G. pederzanii* sp. nov. Scale bar: 1.0 mm.

on elytra, and without slight habitus disruption between pronotum and elytron. Dorsoventrally rather domed. Cervical line present (Fig. 5).

Measurements. Holotype: TL = 1.7 mm, TL-H = 1.5 mm, MW = 0.98 mm. Paratypes: TL = 1.6–1.7 mm, TL-H = 1.4–1.5 mm, MW = 0.86–0.98 mm.

***Head*:** Dark brown, around eyes almost black. Cervical line present. Strongly and coarsely punctate, rather shiny, microsculpture almost absent. Punctures weakly anteriorly and strongly posteriorly between eyes. Antennae relatively short, stout. Antennomeres 1 and 2 ferruginous, 3-11 darkened anteriorly.

***Pronotum*:** Ferruginous, anterior and posterior margins darker. Disc of pronotum somewhat darkened, broadest at posterior corners. Punctation very weak, almost evenly distributed, shiny and microsculpture absent. Sides of pronotum margined and almost evenly rounded. Angle between pronotum and elytra not pronounced, basal pronotal plicae present. Striae well defined, almost 1/2 length of pronotum, strongly incurved.

***Elytra*:** Ferruginous, with vague areas darkened (Fig. 5). Coarsely and densely punctate, shiny, microsculpture absent. Striae strongly impressed, same length as basal pronotal striae but slightly straighter.

***Ventral side*:** Ferruginous. Prothorax and abdomen paler than other parts. Metacoxae and metaventrite covered with numerous larger punctures, surface shiny, without microreticulation. Abdominal ventrites with dense and finer punctures, shiny, microreticulation absent. Metacoxal lines almost straight, anteriorly slightly divergent. Epipleuron testaceous, with few coarse punctures, shiny, lacking microsculpture. Legs ferruginous meta-/mesotarsi set in black.

***Male*.** Dorsal surface with coarse punctures but otherwise with shiny surface (Fig. 5). Median lobe of aedeagus as in Fig. 17A, B. Shape of median lobe fairly uniform, evenly bent in lateral view, apex straight and pointed at tip in ventral view. Parameres bi-segmented, broad and with few setae at apex (Fig. 17C, D).

Affinities. This species is very similar to *G. chipi* but readily separated by its larger size and the form of the median lobe and parameres (Figs 15, 17).

Etymology. The species is named after the type locality. The specific epithet is a substantive in the genitive case.

Distribution. Only known from the type locality Drik Drik in south-western Victoria (Fig. 22).

Habitat. The few specimens were collected in shallow water at the edge of a large, exposed but shallow farm dam, overgrown with grasses and sedges. The species is syntopic with *G. chipi*.

***Gibbidessus kangarooensis* sp. nov.**

http://zoobank.org/9CD26871-28DA-4A6E-A9FC-DBC0F74A6DC6
Figs 6, 18, 22

Type locality. South Australia, Kangaroo Island, Eleaner River at South Coast [Road] Crossing, edge sample [35°56'S, 137°14'E].

Type material. ***Holotype***: Male, "Eleaner R. S, Coast rd AWQ [Australian Water Quality] survey 8/11/95 site 3714 [35°56'S, 137°14'E]" "Holotype *Gibbidessus kangarooensis* sp. nov. Hendrich, Watts & Balke des. 2020" [red printed label] (SAMA).

Diagnosis. Small species which externally is characterised by a more elongate body, shiny non-microreticulate dorsal surface, and with well pronounced habitus disruption between pronotum and elytron. Dorsoventrally rather flattened. Without cervical line but rather a few punctures instead (Fig. 6).

Measurements. Holotype: TL = 1.55 mm, TL-H = 1.4 mm, MW = 0.88 mm.

Head**:** Ferruginous, without cervical line but rather a few punctures instead. Evenly and coarsely punctate, shiny, microsculpture absent. Punctures weakly anteriorly and strongly posteriorly between eyes. Antennae missing.

Pronotum**:** Ferruginous, anterior and posterior margins darker, broadest at middle. Punctation weak anteriorly but quite strong on posterior half and on lateral sides, almost evenly distributed, shiny and microsculpture absent. Sides of pronotum broadly margined and almost evenly rounded. Angle between pronotum and elytra well pronounced, basal pronotal and elytral plicae present. Striae moderately defined, almost 1/2 length of pronotum, strongly incurved.

Elytra**:** Dark brown with vague basal area ferruginous (Fig. 6). Coarsely and densely punctate, shiny, microsculpture absent. Striae weakly impressed, slightly straighter and of same length as basal pronotal striae.

Ventral side**:** Ferruginous. Prothorax and apex of abdomen paler than other parts. Metacoxae and metaventrite covered with numerous larger punctures, surface shiny, without microreticulation. Abdominal ventrites with finer punctures, shiny, microreticulation absent. Metacoxal lines almost straight, anteriorly slightly divergent. Epipleuron ferruginous, coarsely punctate, shiny, lacking microsculpture. Legs ferruginous with meta-/mesotibia and meta-/mesotarsi somewhat darkened.

Male**.** Dorsal surface with coarse punctures but otherwise with shiny surface (Fig. 6). Median lobe of aedeagus as in Fig. 18A, B. Shape of median lobe, bent evenly and fairly uniform in lateral view, in ventral view pointed at apex. Parameres bi-segmented, elongated, and with few setae at apex (Fig. 18C, D).

Female**.** Unknown.

Affinities. This species is similar to *G. pictipes* but readily separated by the different colour pattern and the more flattened body. Furthermore, both species can be separated by the form of the median lobe and parameres (Figs 18, 20).

Etymology. The species is named after the type locality. The specific epithet is a substantive in the genitive case.

Distribution. A rare species, only known from the type locality on Kangaroo Island, South Australia (Fig. 22).

Habitat. The single specimen was collected at the edge of the Eleaner River in the southern part of Kangaroo Island. Most probably this is not the original habitat of the species. Almost all *Gibbidessus* inhabit more seasonal, open wetlands, overgrown with sedges and rushes.

***Gibbidessus pederzanii* sp. nov.**
http://zoobank.org/9389E4E1-D5E3-4063-A0F3-33C7FAFD045E
Figs 7, 12, 19, 25

Type locality. Australia, Western Australia, creek around Nannup [33°58'S, 115°45'E].

Type material. ***Holotype***: Male, "Australia (WA) Nannup env. roadside creeks 1/12/98 Pederzani", "Holotype *Gibbidessus pederzanii* Hendrich, Watts & Balke des. 2020" [red printed label] (SAMA). ***Paratypes* (13 exs.)**: All specimens with same data as holotype. Two specimens with "SAMA Database No 25-001593" and one with a yellow printed label "photographed" (CFP, CLH, SAMA, ZSM). All paratypes are provided with printed red paratype labels.

Diagnosis. Medium-sized species which externally is characterised by a rounded habitus, without disruption between pronotum and elytron, and shiny, non-microreticulate dorsal surface with testaceous markings on elytra. Dorsoventrally rather arched. Without cervical line but rather a few punctures instead (Fig. 7).

Measurements. Holotype: TL = 1.5 mm, TL-H = 1.3 mm, MW = 0.85 mm. Paratypes: TL = 1.5–1.6 mm, TL-H = 1.3–1.4 mm, MW = 0.85–0.95 mm.

***Head*:** Ferruginous, around eyes almost black, without cervical line but rather a few punctures instead (Fig. 12B). Coarsely punctate, rather shiny, weak microreticulation visible. Punctures weakly anteriorly and strongly posteriorly between eyes. Antennae relatively short, stout. Antennomeres 1 and 2 ferruginous, 3-11 darkened anteriorly.

***Pronotum*:** Ferruginous, anterior and posterior margins, between striae, slightly darker, broadest at posterior corners. Punctation very weak almost evenly distributed, shiny and microsculpture absent. Sides of pronotum margined and almost evenly rounded. Angle between pronotum and elytra less pronounced, basal pronotal plicae present. Striae moderately defined, almost 1/2 length of pronotum, slightly incurved.

***Elytra*:** Dark brown with vague basolateral and apical area ferruginous (Fig. 7). Coarsely and densely punctate, shiny, microsculpture absent. Striae deeply impressed, straight but shorter than basal pronotal striae.

***Ventral side*:** Ferruginous. Prothorax and abdomen paler than other parts. Metacoxae and metaventrite covered with larger punctures, surface shiny, without microreticulation. Abdominal ventrites with dense and finer punctures, shiny, microreticulation absent. Metacoxal lines almost straight, anteriorly not divergent. Epipleuron testaceous, with few coarse punctures, shiny, lacking microsculpture. Legs ferruginous with meta- and mesotarsi somewhat darkened.

***Male*.** Dorsal surface with coarse punctures but otherwise with shiny surface (Fig. 7). Median lobe of aedeagus as in Fig. 19A, B. Shape of median lobe, almost straight and fairly uniform in lateral view, in ventral view rounded at apex. Parameres bi-segmented, elongated, and without setae at apex (Fig. 19C, D).

Affinities. This species is similar to *G. davidi* sp. nov. but readily separated by the different colour pattern, the more roundish body (Figs 4, 7), the larger punctation on elytra, and the form of the median lobe and parameres (Figs 16, 19).

Etymology. The species is named after our colleague, the dytiscid specialist Fernando Pederzani (Ravenna, Italy), who collected the type material. The specific epithet is a substantive in the genitive case.

Distribution. South-western Australia. A rare species, which is only known from the type locality somewhere around Nannup in south-western Australia. Most probably a more inland species and restricted to forested areas and not in heathland or coastal sedge swamps (Fig. 25).

Habitat. All specimens were collected in shallow water at the edge of a small slow flowing forest creek (F. Pederzani in litt.).

Gibbidessus pictipes **(Lea, 1899), comb. nov.**

Figs 8, 9, 13, 20, 30, 31

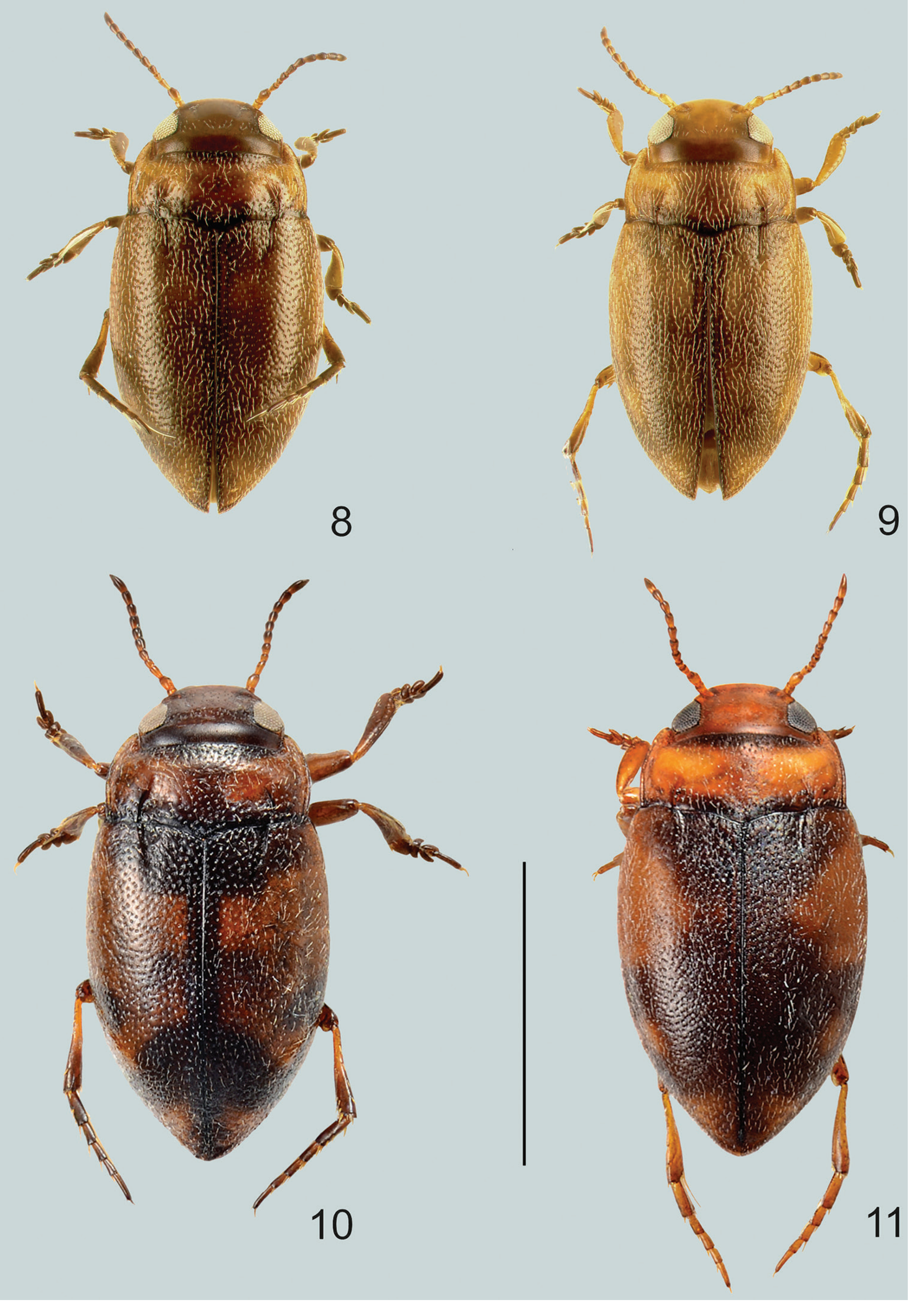
Bidessus pictipes Lea, 1899: 523 (original description).

Uvarus pictipes (Lea, 1899): Watts (1978: 33, comb. nov., redescription); Watts (1985: 24, checklist); Lawrence et al. (1987: 335, catalogue); Biström (1988: 10, systematics); Hendrich (2001a: 302, faunistics, habitat); Hendrich (2001b: 21, faunistics, habitat); Watts (2002: 31, 44, identification key, checklist); Nilsson & Hájek (2020: 128, catalogue).

Type locality. Australia, south-western Australia, Pinjarrah [32°37'56S, 115°51'49E].

Type material. ***Syntype***, female, "pictipes Lea Type Pinjarrah" (handwritten label), "Bidessus pictipes Lea W. Australia TYPE" (handwritten label), "SAMA Database No 25-001599" (SAMA).

Additional material studied (320 exs.). 51 exs., "WA Lake Nalyerin 33 08S, 116 22E CHS, Watts 6/10/03", "SAMA Database 25-009282" (SAMA); 4 exs., "Nalyeen Lake [Nalyerin] WA J. McRae 8/10/97", "SAMA Database No 25-002918" (SAMA); 1 ex., "WA Byenup Lagoon NR 21/9/00 C.H.S. Watts" "SAMA Database No 25-002922" (SAMA). 2 exs., "Australia, WA, SWA31 (A), Helena River, 22/08/2005, South-west Forest Monitoring" (DPAW); 1 ex., "Australia, WA, HAR21 (A), Stirling Dam 2, 7/09/2006, South-west Forest Monitoring" (DPAW); 3 exs., "Australia, WA, SPM011 (B) Kulicup Swamp, 6/11/1998, Salinity Action Plan Wetland Monitoring Programme" (DPAW); 1 ex., "Australia, WA, SPM011 (A) Kulicup Swamp [34°20'1S, 116°47'17E], 23/10/2002, Salinity Action Plan Wetland Monitoring Programme" (DPAW); 1 ex., "Australia, WA, SPM011 (B) Kulicup Swamp [34°20'1S, 116°47'17E], 23/10/2002, Salinity Action Plan Wetland Monitoring Programme" (DPAW); 2 exs., "Australia, WA, SPM011 (A) Kulicup Swamp [34°20'1S, 116°47'17E], 11/10/2000, Salinity Action Plan Wetland Monitoring Programme" (DPAW); 2 exs., "Australia, WA, SPM011 (B) Kulicup Swamp [34°20'1S, 116°47'17E], 11/10/2000, Salinity Action Plan Wetland Monitoring Programme" (DPAW); 1 ex., "Australia, WA, SPM024 (A) Lake Pleasant View [34°49'S, 118°10'E], 24/10/1999, Salinity Action



Figures 8–11. Habitus of **8** *G. pictipes*, male **9** *G. pictipes*, female **10** *G. rottnestensis* sp. nov., male **11** *G. rottnestensis* sp. nov., female. Scale bar: 1.0 mm.

Figure 12. Head of *G. davidi* sp. nov. **A** with cervical line (red arrow), and head of *G. pederzanii* sp. nov. **B** without cervical line but rather a few punctures instead (red arrow).

Plan Wetland Monitoring Programme" (DPAW); 3 exs., "Australia, WA, SPM024 (A) Lake Pleasant View [34°49'S, 118°10'E], 24/10/2003, Salinity Action Plan Wetland Monitoring Programme" (DPAW); 2 ex., "Australia, WA, SPM024 (B) Lake Pleasant View [34°49'S, 118°10'E], 24/10/2001, Salinity Action Plan Wetland Monitoring Programme" (DPAW); 4 exs., "Australia, WA, SPM024 (A) Lake Pleasant View [34°49'S, 118°10'E], 24/10/1999, Salinity Action Plan Wetland Monitoring Programme"

Figure 13. Head of *G. pictipes* **A** without cervical line (red arrows), and of *G. rottnestensis* sp. nov. **B** without cervical line but rather a few punctures instead (red arrows).

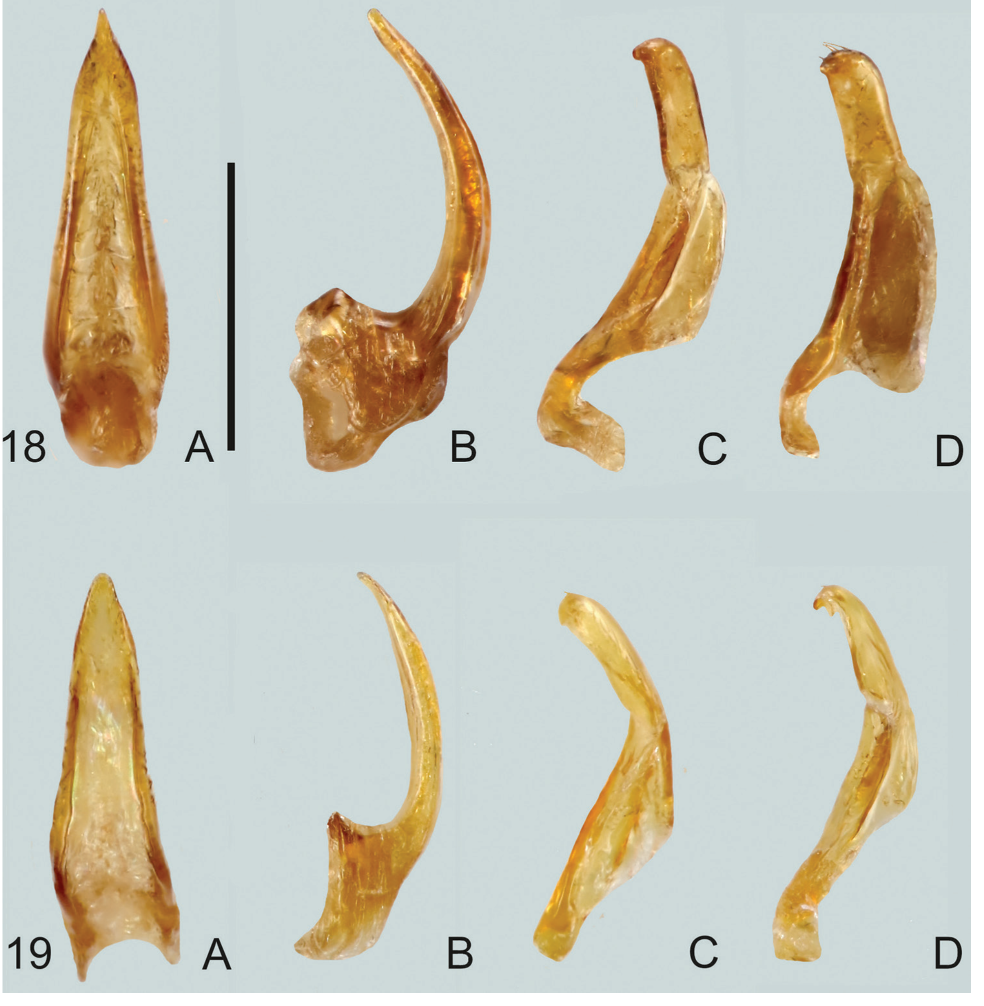
(DPAW); 1 ex., "Australia, WA, RUAB01 (A) Ruabon Road 01 [33°37'S, 115°27'E], 11/10/2007, South-west Catchment Council Wetland monitoring" (DPAW); 1 ex., "Australia, WA, RVDLE03 (A) Riverdale 03 [32°59S, 115°47E], 4/10/2007, South-west Catchment Council Wetland monitoring" (DPAW); 30 exs., "Australia, WA, SPS111 (A), Boyacup Bridge Swamp [34°13'S, 117°15'E], 10/10/1998, Salinity Action Plan Wetland Biological Survey" (DPAW); 1 ex., "Australia, WA, SPS032 (A), Qualeup Lake [33°50'S, 116°45'E], 9/10/1998, Salinity Action Plan Wetland Biologi-

Figures 14, 15. 14 *Gibbidessus atomus* sp. nov. **15** *G. chipi* **A** median lobe in ventral view **B** median lobe in lateral view, left side **C** left paramere in lateral view. Scale bar: 0.2 mm.

cal Survey" (DPAW); 2 exs., "Australia, WA, SPS103 (A), Lake Poorginup [34°32'S, 116°44'E], 2/10/1998, Salinity Action Plan Wetland Biological Survey" (DPAW); 4 exs., "Australia, WA, SPS104 (A), Pindicup Lake [34°25'S, 116°43'E], 2/10/1998, Sa-

Figures 16, 17. 16 *Gibbidessus davidi* sp. nov. **17** *G. drikdrikensis* sp. nov. **A** median lobe in ventral view **B** median lobe in lateral view, left side **C** left paramere in lateral view, **D** right paramere in lateral view. Scale bar: 0.2 mm.

linity Action Plan Wetland Biological Survey", one specimen "M. Balke DNA 7250" [green printed label] (DPAW, ZSM); 1 ex., "Australia, WA, MUB030 (A), Pindicup Lake [34°25'S, 116°43'E], 25.09.2014, Muir-Byenup Survey" (DPAW); 11 exs., "Australia, WA, MUB030 (A), Pindicup Lake, 25.09.2014, Muir-Byenup Survey (DPAW); 4 exs., "Australia, WA, SPS105 (A) Kodjinup Melaleuca Swamp [34°23'S, 116°39'E], 2/10/1998, Salinity Action Plan Wetland Biological Survey" (DPAW); 30 exs, "Australia, WA, SPS108 (A) Pillenorup Swamp, 30/09/1998, Salinity Action Plan Wetland Biological Survey" (DPAW); 7 exs., "Australia, WA, SPS113 (A) Tucker's Road Melaleuca Swamp, 27/08/1998, Salinity Action Plan Wetland Biological Survey" (DPAW); 1 ex., "Australia, WA, LVR003 (A) Lower Vasse River Site 3, 4/10/2001, Lower Vasse River Clean-up Program" (DPAW); 1 ex., "Australia, WA, LVR004 (A), Lower Vasse River Site 4, 5/10/2001, Lower Vasse River Clean-up Program" (DPAW); 1 ex., "Australia,

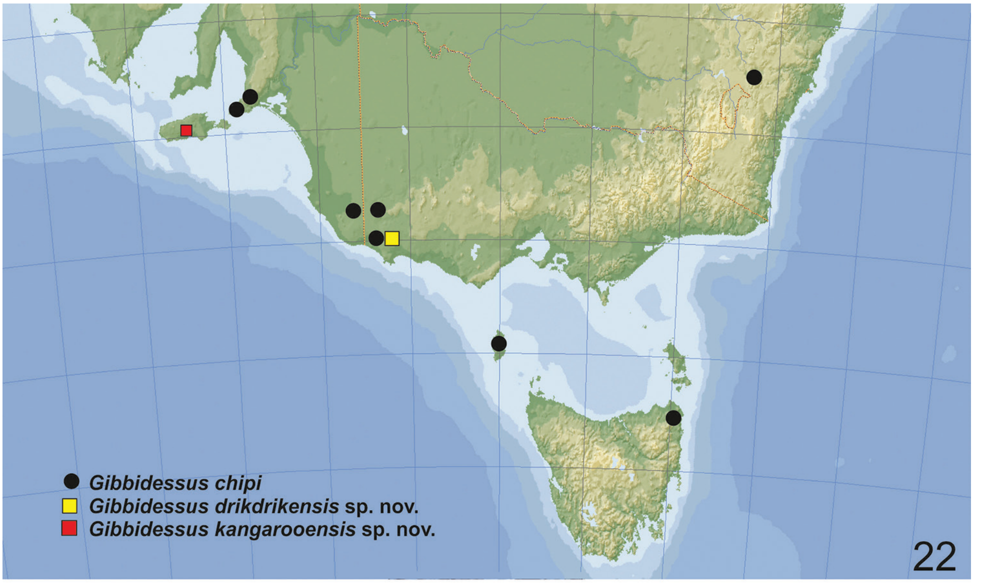


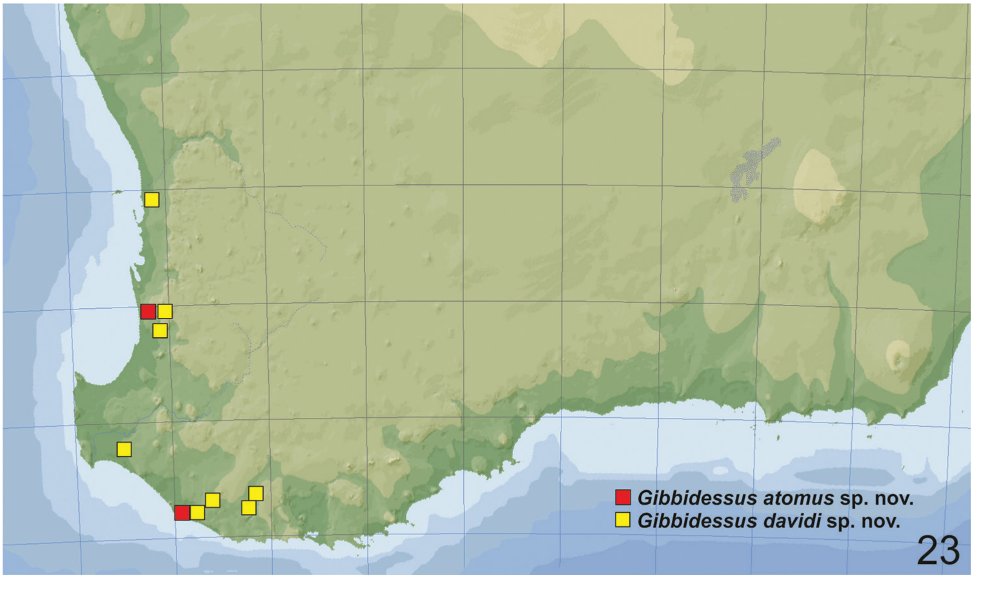
Figures 18, 19. 18 *Gibbidessus kangarooensis* sp. nov. **19** *G. pederzanii* sp. nov. **A** median lobe in ventral view **B** median lobe in lateral view, left side **C** left paramere in lateral view **D** right paramere in lateral view. Scale bar: 0.2 mm.

WA, LVR005 (A), Lower Vasse River Site 5, 5/10/2001, Lower Vasse River Clean-up Program" (DPAW); 6 exs., "Australia, WA, JCS019 (A), Sedge Swamp W of Deadhorse Soak [29°54'7S, 115°1'11E], 21/09/2011, Jurien Coastal Survey" (DPAW); 1 ex., "Australia, WA, Mulgarnup MUB 012, 28.01.2004, Andrew Storey leg." (DPAW); 2 exs., "Australia, WA, Mulgarnup MUB 012, 1.10.2014, M. Pennifold leg.", two specimens "M. Balke DNA 7252", "M. Balke DNA 7253" [green printed labels] (ZSM); 4 exs., "Australia, WA, W Kodjinup #18 [34°23'S, 116°39'E], 28.01.2004, Andrew Storey leg." (DPAW); 1 ex., "Australia, WA, Wimbalup #52 [34°29'S, 116°50'E], 29.11.2003, Andrew Storey leg." (DPAW); 11 exs., "Australia, WA, MUB019 (A), Galamup Swamp [34°26'S, 116°45'E], 30.09.2014, Muir-Byenup Survey", one specimen "M. Balke

Figures 20, 21. 20 *Gibbidessus pictipes* **21** *G. rottnestensis* sp. nov. **A** median lobe in ventral view **B** median lobe in lateral view, left side **C** left paramere in lateral view, **D** right paramere in lateral view. Scale bar: 0.2 mm.

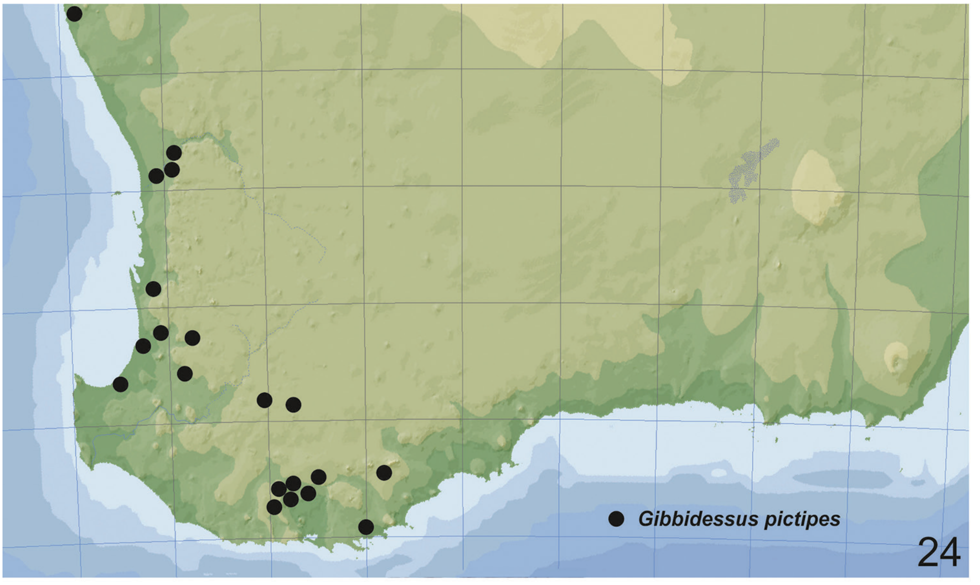
DNA 7262" [green printed label] (DPAW, ZSM); 23 exs., "Australia, WA, MUB035, NE Unicup NR [34°20'S, 116°43'E], 24.09.2014, Muir-Byenup Survey", one specimen "M. Balke DNA 7257" [green printed label] (DPAW, ZSM); 43 exs., "Australia, WA, MUB037 (A) S, Kulunilup NR [34°20'S, 116°47'E], 25.09.2014, Muir-Byenup Survey", three specimens "M. Balke DNA 7259", "M. Balke DNA 7260", "M. Balke DNA 7261" [green printed labels] (DPAW, ZSM); 11 exs., "Australia, WA,

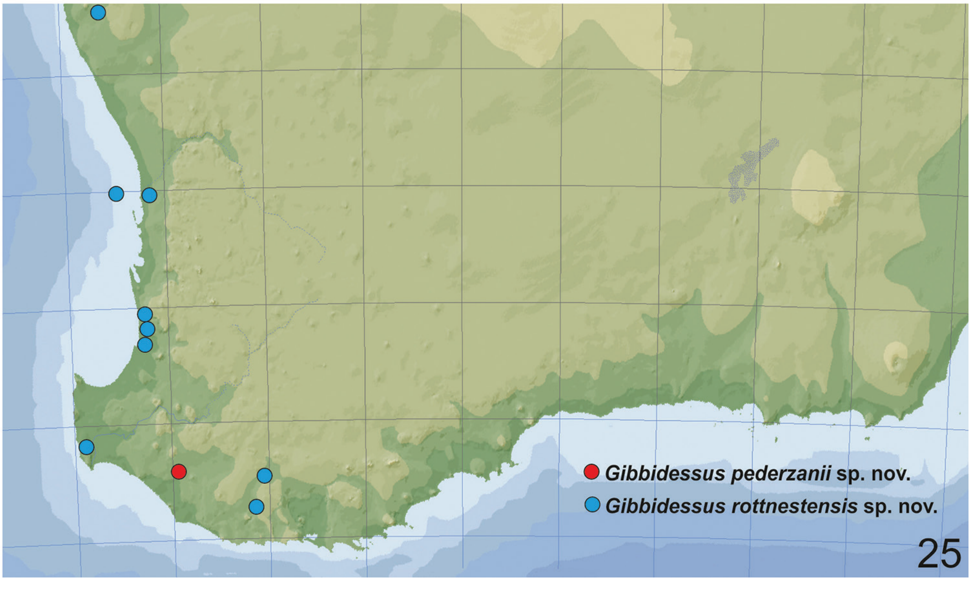




Figures 22, 23. Distribution of **22** *Gibbidessus chipi* (black dots), *G. drikdrikensis* sp. nov. (yellow square), *G. kangarooensis* sp. nov. (red square) **23** *G. atomus* sp. nov. (red square), *G. davidi* sp. nov. (yellow square).

MUB011 (A) Kulunilup Lake [34°20'S, 116°47'E], 25.09.2014, Muir-Byenup Survey" (DPAW); 2 exs., "Australia, WA, MUB008 (B) Noobijup Swamp [34°23'S, 116°47'E], 24.09.2014, Muir-Byenup Survey" two specimens "M.Balke DNA 7254", "M. Balke DNA 7255" [green printed labels] (DPAW, ZSM); 1 ex., "Australia, WA, MUB005 (A), Yarnup Swamp [34°22'26S, 116°52'4E], 22.09.2014, Muir-Byenup Survey" (DPAW); 12 exs., "Australia, WA, MUB012 (A), Mulgarnup Swamp [34°15'1S, 116°41'44E],





Figures 24, 25. Distribution of **24** *Gibbidessus pictipes* (black dots) **25** *G. pederzanii* sp. nov. (red dot), *G. rottnestensis* sp. nov. (blue dots).

01.10.2014, Muir-Byenup Survey" (DPAW); 1 ex., "Australia, WA, Twin Swamps NW [31°43'7S, 116°0'50E], 24/09/1992, Twin Swamps/Ellen Brook Survey" (DPAW); 1 ex., "Australia, WA, SPS031, 08/10/1997, SAP Survey" (DPAW); 1 ex., "Australia, WA, ABP041, 14/09/2007, Avon Baselining Project" (DPAW); 26 exs., "Australia, WA, Albany Hwy, Muir Lakes Nature Reserve, SW part of Byenup Lagoon, 4.& 5.1.2000, 34°29'S, 116°44'E, Hendrich leg. (loc. WA 11/157)" (CLH, ZSM); 18 ex., "Australia,

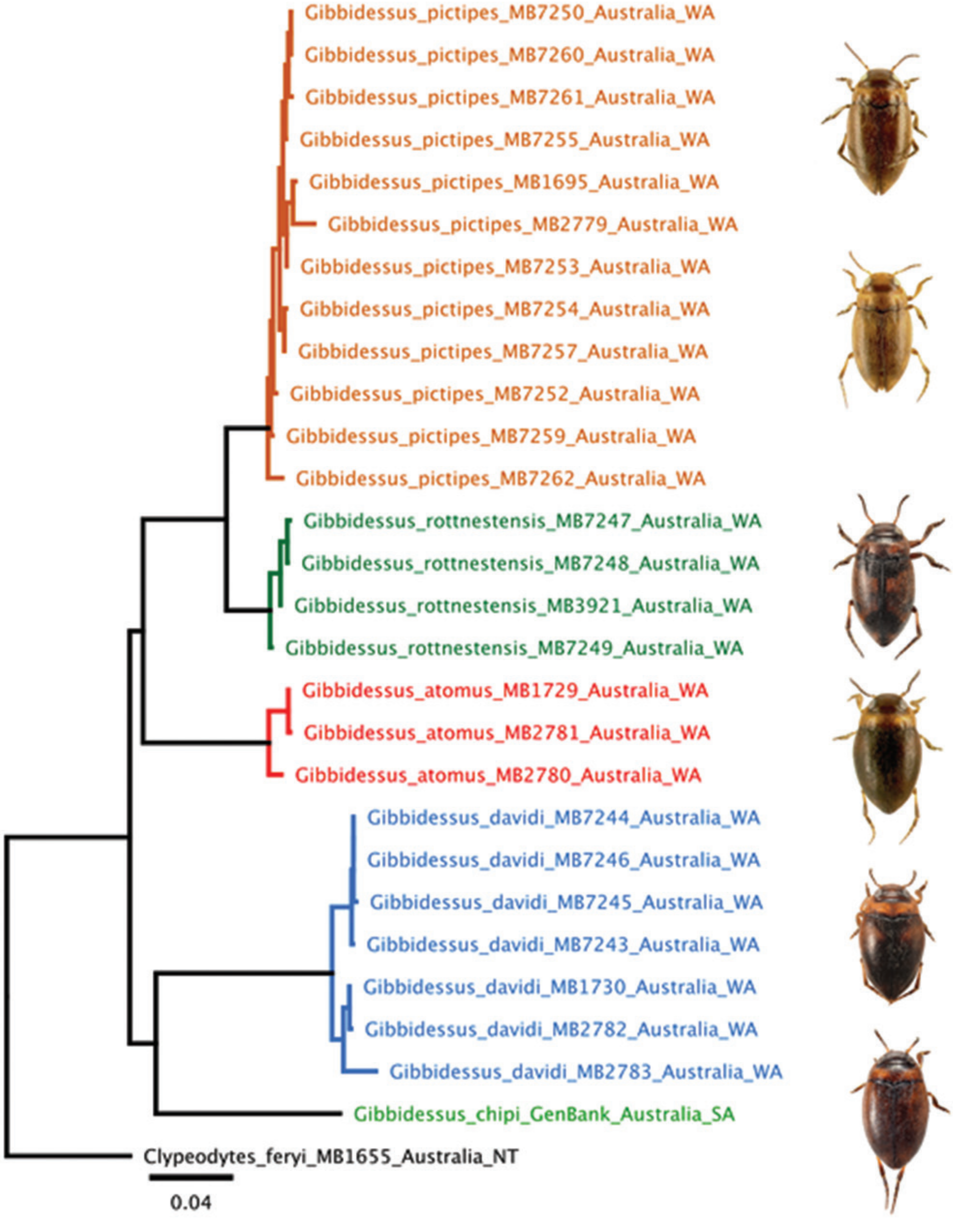


Figure 26. Maximum likelihood tree for Australian *Gibbidessus*. Neighbour joining tree (p-distances) calculated with Geneious (11.0.4.) software.

WA, Albany, 3 km ENE Manypeaks, Lake Pleasant Nature Reserve, 7.1.2000, 34°49'S, 118°10'E, Hendrich leg. (loc. WA 13/159) (CLH, ZSM); 38 exs., "Australia, WA, Darling Range, Lane Poole Conservation Reserve, Nalyerin Lake, 300 m, 29. & 30.12.1999, 33°8.51'S, 116°22.15'E, Hendrich leg. (loc. WA 4/151)" (CGC, CLH, ZSM); 1 ex., "Australia: SW WA, 3 km NE Manypeaks, Lake Pleasant View NR, 91m, 2.I.2007, 34°49'S, 118°10'E, L. & E. Hendrich leg. (WA 160)" (ZSM).

Note. Watts (1978), who moved *Bidessus pictipes* to *Uvarus*, already noticed that this species might not belong to *Uvarus*: "It is with considerable hesitation that I place the following species in this genus. I suspect that it will eventually prove to belong to a genus of its own".

Diagnosis. Small and dark brown species, with vague testaceous markings on elytra, and with habitus disruption between pronotum and elytron. Dorsoventrally rather flattened. Head without cervical line but rather a few punctures instead (punctures not obvious in females) (Fig. 8).

***Measurements*:** Lectotype, female: TL = 1.45 mm, TL-H = 1.25 mm, MW = 0.82 mm. Additional material: TL = 1.45–1.6 mm, TL-H = 1.3–1.4 mm, MW = 0.8–0.83 mm.

***Head*:** Dark brown to ferruginous, without cervical line but rather a few punctures instead (punctures not obvious in females) (Fig. 13A). Evenly and coarsely punctate, shiny but with weak microreticulation. Punctures weakly anteriorly and strongly posteriorly between eyes. Antennae relatively short, stout. Antennomeres 1–3 ferruginous, 4–11 darkened anteriorly.

***Pronotum*:** Ferruginous, anterior and posterior margins darker, broadest at middle. Punctation very weak, almost evenly distributed, shiny and microsculpture absent. Sides of pronotum margined and almost evenly rounded. Angle between pronotum and elytra well pronounced, basal pronotal plicae present. Striae moderately defined, almost 1/2 length of pronotum, strongly incurved.

***Elytra*:** Dark brown with vague basal area ferruginous (Fig. 8). Coarsely and densely punctate, shiny, microsculpture absent. Striae weakly impressed, slightly straighter than in female specimens and of same length as basal pronotal striae.

***Ventral side*:** Ferruginous. Prothorax and apex of abdomen paler than other parts. Metacoxae and metaventrite covered with numerous larger punctures, surface shiny, without microreticulation. Abdominal ventrites with finer punctures, shiny, microreticulation absent. Metacoxal lines almost straight, anteriorly slightly divergent. Epipleuron ferruginous, coarsely punctate, shiny, lacking microsculpture. Legs ferruginous with meta-/mesotibia and meta-/mesotarsi somewhat darkened.

***Male*.** Dorsal surface with coarse punctures but otherwise with shiny surface (Fig. 8). Median lobe of aedeagus as in Fig. 20A, B. Shape of median lobe, bent evenly and fairly uniform in lateral view, in ventral view tapering and pointed at apex. Parameres bi-segmented, elongated, and with setae inside apical hook (Fig. 20C, D).

***Female*.** Dorsal surface almost mat, with coarse punctures and dense microreticulation (Fig. 9).

Affinities. This species is similar to *G. kangarooensis* sp. nov. and the larger *G. rottnestensis* sp. nov. (TL = 1.5–1.7 mm) but readily separated by the different colour pattern. Furthermore, all three species can be separated by the form of their median lobes and parameres (Figs 18, 20, 21).

Figure 27. Habitat of *Gibbidessus atomus* sp. nov. and *Gibbidessus davidi* sp. nov. **A** Seasonally flooded *Melaleuca* sedge swamp **B** small and shallow heathland pool along Windy Harbour Road, south of Northcliffe, south-western Australia.

Figure 28. Habitat of *Gibbidessus davidi* sp. nov. and *Gibbidessus rottnestensis* sp. nov. **A** Shallow peaty pool with mats of floating grasses along Beeliar Swamps in Perth **B** same spot and habitat details with collecting methods.

Distribution. South-western Australia. The most common and widespread species in south-western Australia and a more inland species. South of a line from 230 km north of Perth (Leeman) to Albany (Fig. 24).

Habitat. Permanent and seasonal, very shallow, sun exposed or half-shaded sedge swamps, lakeshores, larger ponds and flooded meadows on sandy bottom, with a thin layer of peat or rotten debris of sedges (Figs 30, 31). A winter and early spring breeder. Most specimens were collected in September and October, with the next generation in December and January. Apart from *G. pictipes*, the water beetle coenosis at Nalyerin Lake (Fig. 31) included the following species: Dytiscidae: *Limbodessus inornatus*, *Antiporus hollingsworthi*, *Sternopriscus minimus*, *Exocelina ater*; Hydrophilidae: *Enochrus eyrensis*, *Limnoxenus zealandicus*, *Paracymus pygmaeus* (see Hendrich 2001b). At Manypeaks (Fig. 30) *G. pictipes* was collected with the Dytiscidae: *Limbodessus inornatus*, *Sternopriscus browni* Sharp, 1882, *S. multimaculatus* (Clark, 1862), *S. storeyi* Hendrich & Watts, 2004, *S. wattsi* Hendrich & Watts, 2004, *Necterosoma darwinii* (Babington, 1841), *Rhantus suturalis* and *Lancetes lanceolatus* (Clark, 1863).

Gibbidessus rottnestensis **sp. nov.**

http://zoobank.org/C19B9505-4465-4C4B-BFD4-1BE35B7E645E
Figs 10, 11, 13, 21, 25, 28, 29

Uvarus pictipes (Lea, 1899): Watts (1978: 33, partim).

Type locality. Australia, south-western Australia, Rottnest Island [32°0'22S, 115°30'26E].

Type material. ***Holotype***: Male, "W AUS, ca. 25 km N Augusta on Rd. 250, shallow pool, 4.11.2013, leg. Wewalka (A4)" "Holotype *Gibbidessus rottnestensis* Hendrich, Watts & Balke des. 2020" [red printed label] (WAM). ***Paratypes* (27 exs.)**: 4 specimens with same data as holotype (CGW, ZSM); 3 males, 1 female "Rottnest Is. [32°0'22S, 115°30'26E] Oct´ 31 W.A.", "Australia, Harvard Exp., Darlington", "Museum of Comparative Zoology", "ANIC Database No. 25013255" (ANIC); 3 specimens with same data, and "SAMA Database No 25-00/596" (SAMA). 2 exs., "Australia, WA, Perth, Success, Beeliar RP, shallow peaty puddle 32°8'4S, 115°50'22E 21.-31.10.2015 L. Hendrich (WA 1/15)", "M. Balke 7248", "M. Balke 7247" [green, printed label] (ZSM); 1 ex., "Australia, WA, Albany Hwy, Muir Lakes Nature Reserve, SW part of Byenup Lagoon, 4. & 5.1.2000, 34°29'S, 116°44'E [34°30'4S, 116°44'19E], Hendrich leg. (loc. WA 11/157)" (CLH); 3 exs., "Australia, WA, 1 km W Kodjinup NP 34°24.03 S, 116°38.37 E [34°24'1S, 116°38'22E] 4.X.2003, CHS, Watts leg.", one specimen "M. Balke 3921" [green, printed label] (CLH, SAMA); 1 ex., "WA Kodjinup N.R. [34°23'10S, 116°39'30E] 21/9/00 C.H.S.Watts", "SAMA Database No 25-00/594" (SAMA); 2 exs., "AUSTRALIA, WA, Midlands, 38 Km ESE Cervantes, Wongonderrah Road, Nambung River Crossing, 9.9.2002, 30°33'21S, 115°21'27E, Hendrich leg. /Loc. 28b/192b" (CLH); 1 ex., "SW Australia/ N Bunbury, Yalgorup N.P. östl. Preston Beach [32°52'35S, 115°40'6E], 0m, 24.11.1996, Hendrich leg./Lok. 30" (CLH); 1 ex., "Australia, WA, RVDLE03 Riverdale Wetland [32°59'22S, 115°47'7E], 23/09/2008,

Figure 29. Habitat of *Gibbidessus rottnestensis* sp. nov. **A** and **B** seasonally flooded wetlands at Wongonderrah Road, Nambung River Crossing, 38 Km ESE Cervantes.

South West Catchment Council Mon." (DPAW); 1 ex., "Australia, WA, Pindicup Lake [34°24'35S, 116°43'20E], MUB030, 29.09.2014, Muir-Byenup Survey, M. Pennifold leg." (DPAW); 1 ex., "Australia, WA, Pindicup Lake [34°24'35S, 116°43'20E], MUB030,

Figure 30. Habitat of *Gibbidessus pictipes*. **A, B** Seasonally flooded and exposed wetland with *Baumea* and sedges 3 km ENE Manypeaks, Lake Pleasant Nature Reserve.

Figure 31. Habitat of *Gibbidessus pictipes*. **A, B** Seasonally flooded sedge swamp around lake Nalyerin **C** deeper and more permanent part of the lake, with stands of *Baumea*.

25.09.2014, Muir-Byenup Survey, M. Pennifold leg." (DPAW); 2 ex., "Australia, WA, wetland north of Mialla Lagoon [33°10'04S, 115°44'01E], MIAL01, 8/10/2007, South-west Catchment Council Wetland Monitoring" (DPAW). All paratypes are provided with red printed paratype labels.

Note. Watts (1978: 33) reports *Uvarus pictipes* from Rottnest Island (housed in Museum of Comparative Zoology and SAMA); these specimens belong to *Gibbidessus rottnestensis* sp. nov.

Diagnosis. Larger species which externally is characterised by a more elongate body, shiny non-microreticulate dorsal surface, testaceous markings on elytra, and with distinct habitus disruption between pronotum and elytron. Dorsoventrally slightly flattened. Without cervical line but rather a few punctures instead (Fig. 10).

Measurements. Holotype: TL = 1.85 mm, TL-H = 1.65 mm, MW = 0.95 mm. Paratypes: TL = 1.7–1.9 mm, TL-H = 1.5–1.7 mm, MW = 0.85–1.0 mm.

***Head*:** Black to ferruginous, without cervical line but rather a few punctures instead (punctures not obvious in females) (Fig. 13B). Evenly and coarsely punctate, shiny but with weak microreticulation. Punctures weak anteriorly and stronger posteriorly between eyes. Antennae relatively short, stout. Antennomeres 1-3 ferruginous, 4-11 darkened anteriorly.

***Pronotum*:** Ferruginous, anterior and posterior margins darker. Broadest at middle. Punctation very strong, almost evenly distributed, shiny and microsculpture absent. Sides of pronotum broadly margined and almost evenly rounded. Angle between pronotum and elytra well pronounced, basal pronotal plicae present. Striae moderately defined, almost 1/2 length of pronotum, strongly incurved.

***Elytra*:** Dark brown to black, with distinct basal and subapical testaceous markings (Fig. 10). Coarsely and densely punctate, shiny, microsculpture absent. Striae weakly impressed, slightly incurved and of same length as basal pronotal striae.

***Ventral side*:** Ferruginous. Prothorax and apex of abdomen paler than other parts. Metacoxae and metaventrite covered with numerous larger punctures, surface shiny, without microreticulation. Abdominal ventrites with finer punctures, shiny, microreticulation absent. Metacoxal lines almost straight, anteriorly slightly divergent. Epipleuron ferruginous, coarsely punctate, shiny, lacking microsculpture. Legs ferruginous with meta-/mesotibia and meta-/mesotarsae somewhat darkened.

***Male*.** Dorsal surface with coarse punctures but otherwise with shiny surface (Fig. 10). Median lobe of aedeagus as in Fig. 21A, B. Shape of median lobe, bent evenly and fairly uniform in lateral view, in ventral view strongly tapering and rounded at apex. Parameres bi-segmented, elongated, without setae inside apical hook (Fig. 21C, D).

***Female*.** Dorsal surface almost mat, with coarse punctures and dense microreticulation (Fig. 11).

Affinities. This species is similar to the smaller *G. pictipes* (TL = 1.45–1.6 mm) but readily separated by the different colour pattern on elytra. Furthermore, both species can be separated by the form of their median lobes and parameres (Figs 20, 21).

Etymology. The species is named after the type locality. The specific epithet is a substantive in the genitive case.

Distribution. South-western Australia. Widespread but always rare and in low population densities. A more coastal species, from around 100 km north of Perth to south of Augusta and eastwards to the Muir Lakes (Fig. 25).

Habitat. Seasonal, very shallow and exposed sedge swamps, pool and puddles on sandy bottom, with a thin layer of peat and rotten debris of sedges (Figs 28, 29). *Gibbidessus rottnestensis* sp. nov. tolerates slightly saline water as it was found at Preston Beach in a shallow lagoon near the coast. According to the data it is an early spring breeder. Most specimens were collected in September and October. In the Riverdale Wetland the species was syntopic with *Gibbidessus atomus* sp. nov. and *G. davidi* sp. nov. For the rich water beetle coenosis in Beeliar Regional Park near Perth see under *Gibbidessus davidi* sp. nov. In the seasonal swamps at Wongonderrah Road, near Nambung River Crossing, the species was collected with several hundred specimens of an undescribed *Exocelina* species and *Hyderodes crassus* Sharp, 1882; at Preston Beach north of Bunbury it was collected with *Hyphydrus elegans* (Montrouzier, 1860), *Necterosoma darwinii*, and *Platynectes aenescens* Sharp, 1882.

Key to *Gibbidessus* Watts, 1978

1 Head with cervical line (Fig. 12A). Body roundish and without habitus disruption between pronotum and elytron. Dorsoventrally rather domed **2**

– Head without cervical line (Figs 12B, 13). Body roundish or elongate, with or without habitus disruption between pronotum and elytron. Dorsoventrally domed or flattened....... **5**

2 Species distributed in south-eastern Australia....... **3**

– Species distributed in south-western Australia....... **4**

3 Smaller, TL = 1.5–1.55 mm. Median lobe and paramere as in Fig. 15. South Australia, Victoria, New South Wales, Tasmania .... ***chipi***

– Larger, TL = 1.6–1.7 mm. Median lobe and parameres as in Fig.17. Victoria..... .... ***drikdrikensis* sp. nov.**

4 Smaller, TL = 1.15–1.3 mm. Median lobe and paramere as in Fig. 12. From Perth area south to Northcliffe....... ***atomus* sp. nov.**

– Larger, TL = 1.35–1.5 mm. Median lobe and parameres as in Fig. 16. From Perth area south to Northcliffe....... ***davidi* sp. nov.**

5 Species distributed in south-eastern Australia. Body elongate, with pronounced habitus disruption between pronotum and elytron. Dorsoventrally rather flattened, TL = 1.55 mm. Median lobe and parameres as in Fig. 18. Kangaroo Island, South Australia....... ***kangarooensis* sp. nov.**

– Species distributed in south-western Australia....... **6**

6 Body elongate, with pronounced habitus disruption between pronotum and elytron. 7

– Body roundish and without habitus disruption between pronotum and elytron. Dorsoventrally rather domed, with more widely separated punctation on elytra. TL = 1.5–1.6 mm. Median lobe and parameres as in Fig. 19. Nannup and Pemberton area .... ***pederzanii* sp. nov.**

7 Elytron dark brown without distinct testaceous basal marking (Figs 8, 9). Smaller, TL = 1.45–1.6 mm. Median lobe and parameres as in Fig. 20. Occurs more inland, south of a line from Perth to Albany .... ***pictipes*** **comb. nov.**
– Elytron with a broad testaceous basal marking (Figs 10, 11). Larger, TL = 1.7–1.9 mm. Median lobe and parameres as in Fig. 21. A more coastal species, from around 100 km north of Perth to south of Augusta and eastward to the Muir Lakes... ***rottnestensis*** **sp. nov.**

Discussion

South-western Australia has long been recognised as a hotspot of aquatic macroinvertebrate and microfaunal diversity (Horwitz 1997; Segers and Shiel 2003). Four of the six described species of *Gibbidessus* are elements of this endemic freshwater fauna, and constitute a significant qualitative contribution to the biodiversity of the region. Three species are distributed in the southeast, including one endemic species from Kangaroo Island. Most probably more intensive studies will reveal further species occurring along the lowland coastal areas of south-western and south-eastern Australia.

Seven species of the genus are strictly lentic, appearing to be restricted to shallow and temporary pools, puddles, flooded meadows and seasonal sedge swamps in peatland areas or to very shallow waters at the edges of peaty lakes. One species, *G. pederzanii* sp. nov. was collected only at the edge of a shallow and slow-flowing forest creek. Occasionally, single specimens of *G. pictipes* and *G. chipi* have been found in slowly flowing or intermittent creeks. All species can be found in spring and early summer, and the majority of specimens have been collected between September and October. In the southern and more humid parts of south-western Australia, specimens of the new generation can be collected from November until January. Within any of their habitats, up to three species of the genus can be found (e.g., Riverdale Wetland); aggregations of several hundred specimens of at least one species are possible (e.g., Beeliar Regional Park in Perth and Lake Nalyerin). According to our experience, the occurrence of any *Gibbidessus* species indicates a high conservation value of the sampled water body or wetland.

The larvae of all species are still undescribed. The adults of all species seem to be capable of flight, but no specimens of any species have been obtained by operating light traps.

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References

Balke M, Ribera I (2004) Jumping across Wallace´s line: *Allodessus* and *Limbodessus* revisited (Coleoptera: Dytiscidae, Bidessini) based on molecular-phylogenetic and morphological data. Australian Journal of Entomology 43: 114–128. https://doi.org/10.1111/j.1440-6055.2004.00415.x

Balke M, Warikar E, Toussaint EFA, Hendrich L (2013) *Papuadessus baueri* sp. nov. from Biak Island, Papua (Coleoptera: Dytiscidae: Hydroporinae). Spixiana 36(2): 283–288.

Balke M, Ruthensteiner B, Warikar E, Neven K, Hendrich L (2015) Two new species of *Limbodessus* diving beetles from New Guinea – short verbal descriptions flanked by online content (digital photography, μCT scans, drawings and DNA sequence data). Biodiversity Data Journal 3: e7096. https://doi.org/10.3897/BDJ.3.e7096

Biström O (1988) Generic review of the Bidessini (Coleoptera, Dytiscidae). Acta Zoologica Fennica 184: 1–41.

Davies PE, Brown K, Walker R, Cook L (2003) The aquatic fauna of King Island´s streams and wetlands. In: Donaghey R (Ed.) The Fauna of King Island. A Guide to Identification and Conservation Management. Natural Heritage Trust, Australia, 152 pp.

Hendrich L (2001a) A new species of *Antiporus* Sharp, 1882 from peatland swamps of south-western Australia (Coleoptera: Dytiscidae). Linzer biologische Beiträge 33(1): 299–308.

Hendrich L (2001b) A new species of *Hygrobia* Latreille, from peatlands of south-western Australia (Coleoptera: Hygrobiidae). Koleopterologische Rundschau 71: 17–25.

Hendrich L, Balke M (2009) *Kakadudessus tomweiri*, a new genus and species of diving beetle from tropical northern Australia, based on molecular phylogenetic and morphological data (Coleoptera, Dytiscidae, Bidessini). Zootaxa 2134: 49–59. https://doi.org/10.11646/zootaxa.2134.1.4

Hendrich L, Wang LJ (2006) Taxonomic revision of Australian *Clypeodytes* (Coleoptera: Dytiscidae, Bidessini). Entomological Problems 37(2): 1–11.

Hendrich L, Pons J, Ribera I, Balke M (2010) Mitochondrial Cox1 Sequence Data Reliably Uncover Patterns of Insect Diversity but Suffer from High Lineage-Idiosyncratic Error Rates. PloS ONE 5(12): e14448. https://doi.org/10.1371/journal.pone.0014448

Hendrich L, Lemann C, Weir TA (2019) 11. Dytiscidae LEACH, 1815. In: Slipinski A, Lawrence J (Eds) Australian Beetles, Volume 2 – Archostemata, Myxophaga, Adephaga, Polyphaga (part). CSIRO Publishing, 34–60.

Horwitz P (1997) Comparative endemism and richness of the aquatic invertebrate fauna in peatlands and shrublands of far south-western Australia. Memoirs of the Museum of Victoria 56(2): 313–321. https://doi.org/10.24199/j.mmv.1997.56.19

Lawrence JF, Weir TA, Pyke JE (1987) Haliplidae, Hygrobiidae, Noteridae, Dytiscidae and Gyrinidae. In: Walton DW (Ed.) Zoological Catalogue of Australia. 4. Coleoptera: Archostemata, Myxophaga and Adephaga edited by the Bureau of Flora and Fauna. Canberra: Australian Government Publishing Service, 444 pp.

Lea AM (1899) Descriptions of new species of Australian Coleoptera. Part V. Proceedings of the Linnean Society of New South Wales 23: 512–645.

Miller KB, Nilsson AN (2003) Homology and terminology: Communicating information about rotated structures in water beetles. Latissimus 17: 1–4.

Miller KB, Short AEZ (2015) *Belladessus* Miller & Short (Coleoptera: Dytiscidae: Hydroporinae: Bidessini), new genus for two new species from northern South America: Parthenogenetic diving beetles? The Coleopterists Bulletin 69: 498–503. https://doi.org/10.1649/0010-065X-69.3.498

Nilsson AN, Hájek J (2020) A World Catalogue of the Family Dytiscidae, or the Diving Beetles (Coleoptera, Adephaga). Version 1.I.2020. Distributed as a PDF file via Internet. http://www.waterbeetles.eu [accessed 08 February 2020]

Segers H, Shiel RJ (2003) Microfaunal Diversity in a Biodiversity Hotspot: New Rotifers from Southwestern Australia. Zoological Studies 42(4): 516–521.

Watts CHS (1978) A revision of the Australian Dytiscidae (Coleoptera). Australian Journal of Zoology Supplement Series 57: 1–166. https://doi.org/10.1071/AJZS057

Watts CHS, (1985) A faunal assessment of Australian Hydradephaga. Proceedings of the Academy of Natural Sciences of Philadelphia 137(1): 22–28.

Watts CHS, (2002) Checklist and guides to the identification, to genus, of adults and larval Australian water beetles of the families Dytiscidae, Noteridae, Hygrobiidae, Haliplidae, Gyrinidae, Hydraenidae and the superfamily Hydrophiloidea (Insecta – Coleoptera). Cooperative Research Centre for Freshwater Ecology (Australia). Identification and Ecology Guide 43: 1–110.

Watts CHS, Humphreys WF (2001) A new genus and six new species of Dytiscidae (Coleoptera) from underground waters in the Yilgarn palaeodrainage system of Western Australia. Records of the South Australian Museum 34(2): 99–114.

Watts, CHS, Humphreys WF (2003) Twenty-five new Dytiscidae (Coleoptera) of the genera *Tjirtudessus* Watts & Humphreys, *Nirripirti* Watts & Humphreys and *Bidessodes* Régimbart from underground waters in Australia. Records of the South Australian Museum 36(2): 135–187.

Watts CHS, Humphreys WF (2004) Thirteen new Dytiscidae (Coleoptera) of the genera *Boongurrus* Larson, *Tjirtudessus* Watts & Humphreys and *Nirripirti* Watts & Humphreys, from underground waters in Australia. Transactions of the Royal Society of South Australia 128(2): 99–129.

Watts CHS, Humphreys WF (2006) Twenty-six new Dytiscidae (Coleoptera) of the genera *Limbodessus* Guignot and *Nirripirti* Watts & Humphreys, from underground waters in Australia. Transactions of the Royal Society of South Australia 130(1): 123–185. https://doi.org/10.1080/3721426.2006.10887055

Watts CHS, Humphreys WF (2009) Fourteen new Dytiscidae (Coleoptera) of the genera *Limbodessus* Guignot, *Paroster* Sharp, and *Exocelina* Broun from underground waters in Australia. Transactions of the Royal Society of South Australia 133(1): 62–107. https://doi.org/10.1080/03721426.2009.10887112

Watts CHS, Leys R (2005) Review of the epigean species of Australian *Limbodessus* Guignot (Insecta: Coleoptera: Dytiscidae). Transactions of the Royal Society of South Australia 129: 1–13.

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RESEARCH ARTICLE

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Four new species and two new records of genus *Zeugophora* (Coleoptera, Megalopodidae, Zeugophorinae) from China

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Abstract

Four new species of the subgenus *Pedrillia* Westwood, 1864 are described from southwest and central China: *Zeugophora* (*Pedrillia*) *euonymorum* **sp. nov.**, *Zeugophora* (*Pedrillia*) *flavithorax* **sp. nov.**, *Zeugophora* (*Pedrillia*) *trifasciata* **sp. nov.** and *Zeugophora* (*Pedrillia*) *yuae* **sp. nov.** Two species are recorded for the first time in China and redescribed: *Zeugophora* (*Zeugophora*) *turneri* Power, 1863 and *Zeugophora* (*Pedrillia*) *nigricollis* Jacoby, 1885. To date, a total of 35 Zeugophorinae species has been recognized in China.

Keywords

Celastraceae, new record, new species, *Pedrillia*, *Zeugophora*, Zeugophorinae

Introduction

The genus *Zeugophora* Kunze, 1818 belongs to the subfamily Zeugophorinae in the family Megalopodidae. A total of 29 species of the subfamily Zeugophorinae has been recorded in China (Lee and Cheng 2007; Li and Liang 2018). The Chinese fauna consists of *Zeugophora* with two subgenera *Pedrillia* Westwood, 1864 and *Zeugophora* Kunze, 1818. However, the status of *Pedrillia* Westwood is controversial, and it has been treated as a distinct genus by some authors (Baly 1873; Jacoby 1908; Chûjô 1935, 1937; Tan et al. 1980; Yu and Yang 1997), or as a subgenus of *Zeugophora* (Crowson 1946; Monrós 1959; Gressitt and Kimoto 1961; Chen and Pu 1962; Kimoto and Gressitt 1979; Medvedev 1985, 1997; Reid 1989, 1992, 1995; Schöller 2009; Warchałowski 2010), or even a synonym of *Zeugophora* (Bryant 1943; Sekerka and Vives 2013). In the present paper, we treat *Pedrillia* as a subgenus as we did previously (Li and Liang 2018).

In recent years, a number of expeditions have been made for collecting specimens of *Zeugophora*. On Songshan Mountain near Beijing City, a quite large number of *Zeugophora* were collected using Malaise traps, a tool which was originally used to collect wasps and flies. In Ningxia and Guizhou, *Zeugophora* specimens were collected by beating plants in the family Celastraceae. In the museum of the Kunming Institute of Zoology, two specimens of *Zeugophora* were sorted out from samples collected for ecological monitoring. After carefully comparison with types and named specimens, we found four species new to science and two records new to China from said specimens. Their descriptions are given below.

Materials and methods

Abbreviations:

KIZ	Kunming Natural History Museum of Zoology, Kunming Institute of Zoology, Chinese Academy of Sciences, Kunming, China.
IZCAS	National Zoological Museum of China, Institute of Zoology, Chinese Academy of Sciences, Beijing, China.
NHMUK	The Natural History Museum, London, UK.

Species studied

Thirteen species belonging to one genus and two subgenera of Zeugophorinae were studied and examined (Table 1). All specimens studied in this paper are deposited in KIZ unless otherwise stated.

Methods

Dry specimens were soaked in boiled water for 1–2 hours. The lateral margin of the abdomen was opened and the genitalia were pulled out of the abdomen with fine forceps, or the whole abdomen was removed from the specimen. The genitalia or abdomen were soaked in a warm solution of 10% KOH or NaOH for 10–20 minutes

Table 1. Species of Zeugophorinae studied and examined.

Genus (Subgenus)	Species	Number of specimens	Depository
Zeugophora (*Zeugophora*)	*turneri* Power, 1863	61	IZCAS, KIZ
	cribrata Chen, 1974	8	IZCAS
	cyanea Chen, 1974	16	IZCAS
	scutellaris Suffrian, 1840	15	IZCAS
Zeugophora (*Pedrillia*) bbe	*annulata* Baly, 1873	25	IZCAS, KIZ
	bicolor Kraatz, 1879	6	IZCAS
	euonymorum Li & Liang, sp. nov.	24	IZCAS, KIZ
	flavithorax Li & Liang, sp. nov.	3	KIZ
	maculata (Chûjô, 1941)	8	KIZ
	nigricollis Jacoby, 1885	2	KIZ
	tricolor Chen & Pu, 1962	5	IZCAS, KIZ
	trifasciata Li & Liang, sp. nov.	2	KIZ
	yuae Li & Liang, sp. nov.	8	IZCAS, KIZ

as a treatment. The treatment time depended upon the degree of sclerotization of the genitalia in different species. After treatment, these organs were washed with water, then dyed with Chlorazol Black E for one second. The genitalia were then detached and transferred to glycerin for observation, photography, and preservation.

All measurements were made using a Nikon SMZ1500 or a Nikon SMZ18 stereoscopic microscope with the aid of an ocular micrometer. Body length (BL) = the linear distance along the midline from the anterior margin of the labrum to the apex of the elytra; body width (BW) = elytra width (EW) = the maximum linear distance across the elytra; pronotum length (PL) = the linear distance along the median line of the pronotum; pronotum width (PW) = the linear distance across the widest part of the pronotum; pronotum width at the apex (PAW) = the linear distance across the apex of the pronotum; pronotum width at the base (PBW) = the linear distance across the base of the pronotum; elytra length (EL) = the linear distance from the base of the elytra to the apex of the sutural angle; median lobe length = the linear distance from the base to the apex; median struts length = the linear distance from the base to the apex. Ratios cited in descriptions are based on these measurements.

Photographs of male genitalia were taken using a Nikon SMZ-1500 stereoscopic dissecting microscope fitted with a Cannon 450D digital camera or Nikon SMZ18 stereoscopic dissecting microscope fitted with a Nikon D610 digital camera. For each final image, several photographs were taken using different focal planes, combined with Helicon Focus software to obtain one synthesized photograph, and finally edited with Adobe Photoshop software.

Morphological terminology for male genitalia follows Snodgrass (1935), Verma (1996), Chûjô (1952, 1953), Kasap and Crowson (1985), Li and Liang (2018), and Li et al. (2013).

Taxonomy

Genus *Zeugophora* Kunze, 1818
Subgenus *Zeugophora* Kunze, 1818

***Zeugophora* (*Zeugophora*) *turneri* Power, 1863, new record**
Figures 1–11

Zeugophora turneri Power, 1863: 8735.
Zeugophora rufotestacea Kraatz, 1871: 162.

Specimens examined. Sixty-one males and females (IZCAS, KIZ), China, Beijing, Songshan, Haituoshan, Xiaohunpo, 1100 m, 2013.ix.14, Bo Liu coll.

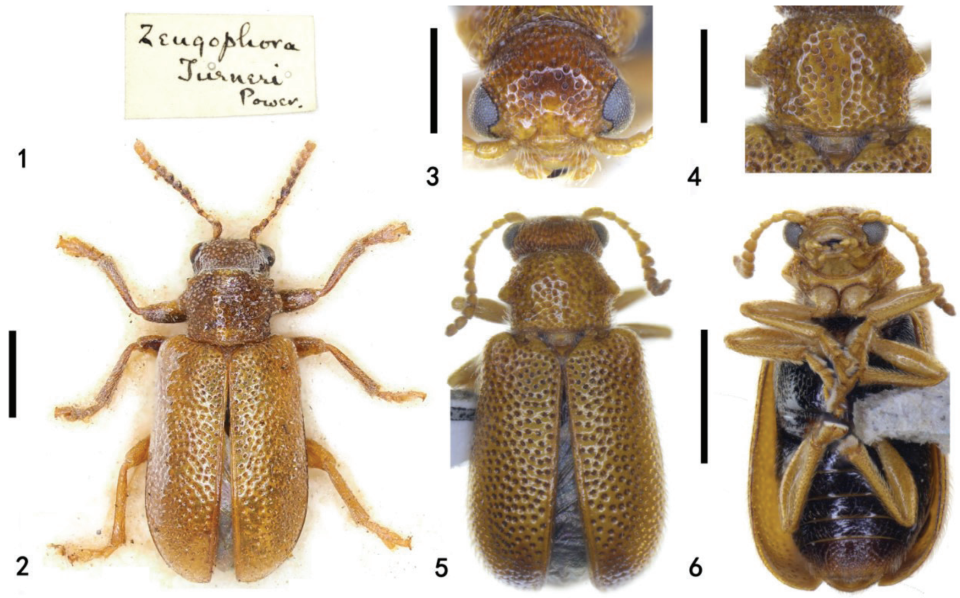
Diagnosis. Antennae, head, pronotum, scutellum, elytra, prosternum and legs yellowish brown; apex of mandible black, mesoventrite, metaventrite and abdominal ventrites black; dorso-central portion of median lobe with a slender sclerite, apex of median lobe gradually narrowed.

Description. BL = 3.0–3.2 mm, BW = 1.4–1.5 mm. Antennae, head, pronotum, scutellum, elytra, prosternum and legs yellowish brown; apex of mandible black, mesoventrite, metaventrite and abdominal ventrites black.

Head: eyes prominent, inner margin with shallow canthus; center of vertex without puncture and pubescence, sides of vertex coarsely punctate and pubescent; occiput constricted, densely punctate and pubescent; frons coarsely punctate and pubescent, center concave; clypeus trapezoid, anterior margin and lateral sides with punctures and pubescence; fronto-clypeal suture prominently backwards in the center; labrum rectangular, 3 × as long as wide; antennae short, extending to the humeri, antennomere 1 swollen, antennomere 2 slightly shorter than antennomere 1, antennomere 3 as long as antennomere 1, antennomere 4 as long as antennomere 3, antennomeres 5–11 short and broad, equal in length, as long as antennomere 2, apex of antennomere 11 acute.

Thorax: PW/PL = 1.3–1.5; anterior margin slightly flattened, posterior margin arching backwards in the center, length of anterior margin nearly equal to posterior margin; anterior margin indistinct; posterior margin backwards medially; anterior and posterior groove indistinct; lateral margins subparallel at anterior portions, lateral tubercle prominent laterally, blunt at apex; disc slightly convex, coarsely punctate and pubescent; base slightly depressed. Scutellum triangular, apical margin slightly emarginate, finely punctate and pubescent.

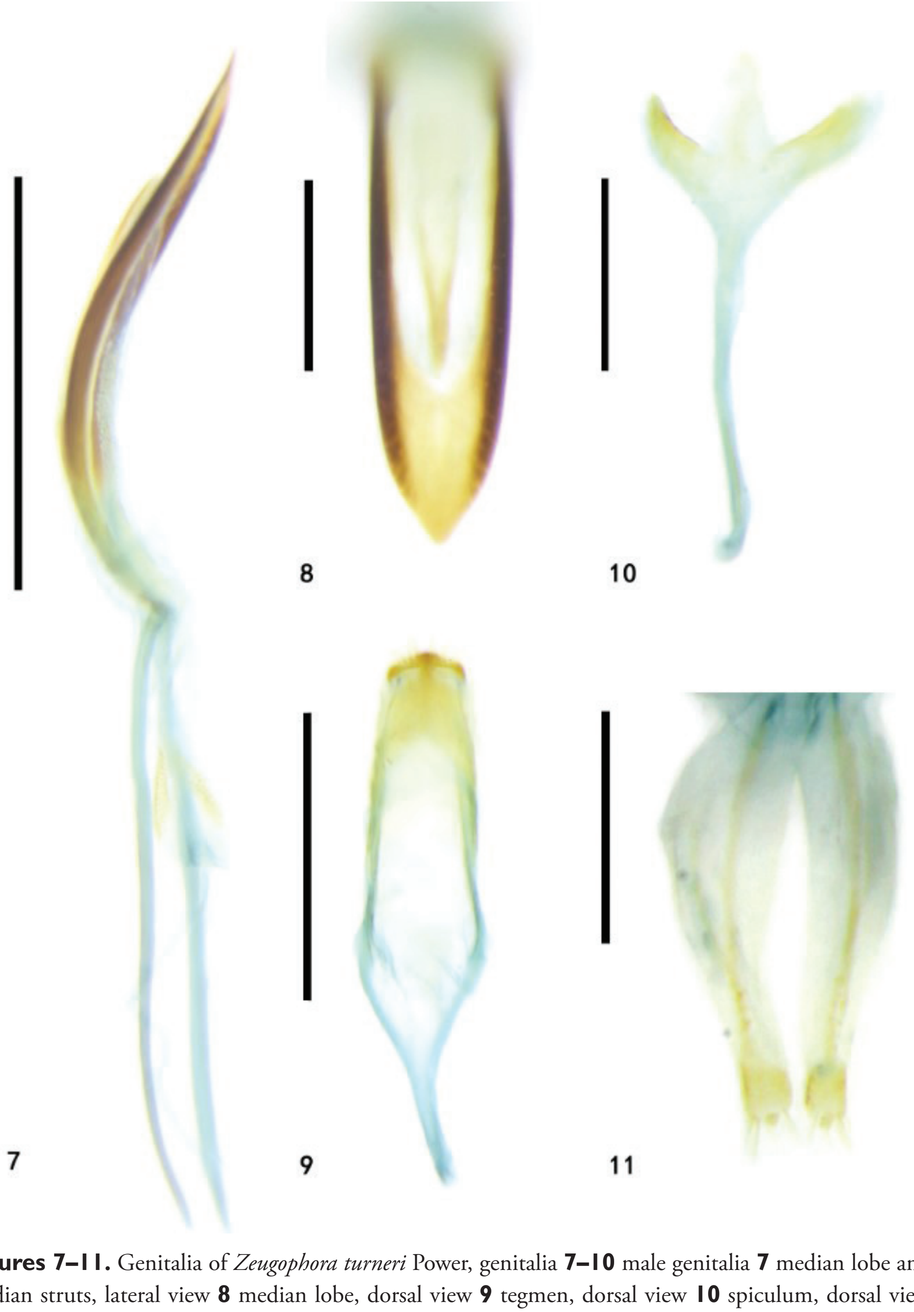
Elytra: EL/EW = 1.4–1.6; elytral humeri slightly projecting antero-laterally, humeral groove shallow; lateral margin gradually expanding from anterior to posterior, the elytra widest behind the middle, apex rounded; disc slightly convex, coarsely punctate and pubescent; elytral base coarsely punctate and pubescent; suture with one row of punctures and pubescence; epipleura narrow, with two rows of punctures and pubescence at base and one row at apex.



Figures 1–6. *Zeugophora turneri* Power. **1, 2** specimen identified by Power **1** label **2** dorsal view **3, 4** common specimen from Beijing **3** head, anterior view **4** pronotum, dorsal view **5** dorsal view **6** ventral view. Scale bars: 1.0 mm (**1, 5, 6**); 0.5 mm (**3, 4**).

Abdomen and legs: underside sparsely punctate and pubescent. Legs moderately long, femora robust. Pygidium moderately long, apical portion exposed, punctate, and pubescent. Apical margin of last abdominal ventrite slightly concave in female, slightly prominent in male. Median lobe strongly sclerotized, slender, dorso-central portion membranous with a tongue-shaped sclerite, curved in lateral view, lateral sides thin, subparallel, apex narrower than base, apical portion tongue-shaped, apex upward, sharp; median struts rod-shaped, widely separated from each other, 1.1 × as long as median lobe; basal piece rod-like, short, basal portion of tegmen Y-shaped, tegminal ring with base broad and gradually narrowed to apical portion, paramere sub-square, apical margin of paramere with dense setae; endophallus membranous, with paired granulated and sclerotized areas. Spiculum long, Y-shaped, apical portion tongue-shaped, weakly sclerotized. Ovipositor moderately long, sub-triangular, base broad, apex slightly narrowed, divided into two vaginal palpi, each side with two baculi, one baculus extending from the base of the ovipositor backwards, base slightly broad, apex slightly narrowed, length of two baculi proximal to each other at base; another baculus extended from the coxite to the middle of the ovipositor; the two baculi of each side proximal to each other but not fused; coxite strongly sclerotized, cylindrical, lateral margin apex with long setae; stylus short, small, distinct.

Distribution. China (Beijing), Belarus, Czech Republic, Denmark, Estonia, Finland, the United Kingdom, Germany, Latvia, Lithuania, Norway, Poland, Sweden, Russia, Mongolia.



Figures 7–11. Genitalia of *Zeugophora turneri* Power, genitalia **7–10** male genitalia **7** median lobe and median struts, lateral view **8** median lobe, dorsal view **9** tegmen, dorsal view **10** spiculum, dorsal view **11** ovipositor, dorsal view. Scale bars: 0.5 mm (**7, 9**); 0.2 mm (**8, 10, 11**).

Host plant. *Populus tremula* (Salicaceae).

Remarks. A large number of this species was caught by Malaise trips set in Songshan for approximately four months. This species is similar to *Zeugophora cribrata*

Chen, 1974, but differs in having a brown head and pronotum; the lateral tubercle of the pronotum is more prominent; the pronotum and elytra are sparsely punctate; with the apex of the median lobe gradually narrowed (head black, pronotum brown, slightly black; lateral tubercle of the pronotum less prominent; pronotum and elytra densely punctate; and the apex of the median lobe strongly constricted in *Z. cribrata*).

This species is also similar to *Zeugophora scutellaris* Suffrian, 1840 with regards to the shape of the lateral tubercle on the pronotum, but differs in having the head, pronotum, elytra and antennae yellowish brown; the pronotal disc is finely punctate while the elytra is sparsely punctate; the dorso-central portion of the median lobe has a slender sclerite, and the apex of the median lobe is slightly broad and blunt (head and pronotum reddish brown, elytra black, antennomeres 1–4 brown, antennomeres 5–11 black; pronotal disc coarsely punctate and elytra densely punctate; the dorso-central portion of the median lobe without a sclerite, and the apex slightly narrowed and sharp in *Z. scutellaris*).

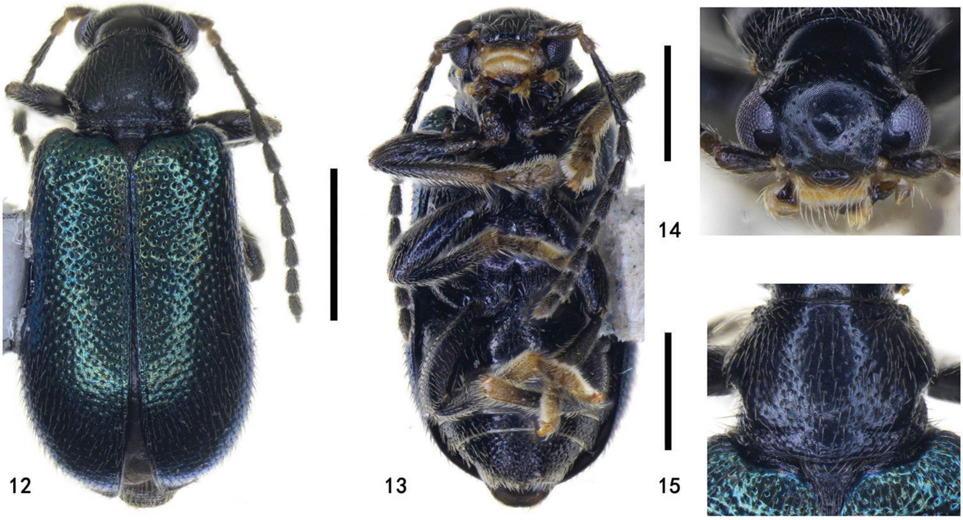
Subgenus *Pedrillia* Westwood, 1864

Zeugophora (*Pedrillia*) *euonymorum* sp. nov.

http://zoobank.org/A9A6AB06-C0DE-45A2-B64F-5CE8D598820C
Figures 12–28

Specimens examined. ***Holotype:*** male, China, Ningxia, Jingyuan, Liupan Shan National Nature Reserve, Erlonghe Forest Farm, 35.33041N, 106.35110E / 2088 m, 2018.vii.29, Kaiqin Li coll., Kunming Institute of Zoology, Chinese Acad. Sci. / Holotype, *Zeugophora* (*Pedrillia*) *euonymorum* sp. nov., des. by K.Q. Li & H.B. Liang, 2020 [red label]. ***Paratypes*** (11 males and 12 females): 4 males and 7 females (1 male and 1 female in IZCAS), same data as holotype except Paratype *Zeugophora* (*Pedrillia*) *euonymorum* sp. nov., des. by K.Q. Li & H.B. Liang, 2020 / [yellow label]; 1 female, China, Ningxia, Jingyuan, Liupan Shan National Nature Reserve, Xiaonanchuan, 35.35788N, 106.31659E / 2021 m, 2018.vii.27, Xinpu Wang coll. Ningxia University / Paratype *Zeugophora* (*Pedrillia*) *euonymorum* sp. nov., des. by K.Q. Li & H.B. Liang, 2020 / [yellow label]; 3 males, 1 female, China, Ningxia, Jingyuan, Liupan Shan National Nature Reserve, Danangou, 35.48659N, 106.27045E / 2130 m, 2018.vii.28, Kaiqin Li coll. / Paratype *Zeugophora* (*Pedrillia*) *euonymorum* sp. nov., des. by K.Q. Li & H.B. Liang, 2020 / [yellow label]; 4 males and 3 females (1 male and 1 female in IZCAS) / China, Guizhou, Leishan, Leigong Shan National Nature Reserve, 26.38470N, 108.20681E / 2158 m, 2019.vii.16, Kaiqin Li coll. / Paratype *Zeugophora* (*Pedrillia*) *euonymorum* sp. nov., des. by K.Q. Li & H.B. Liang, 2020 / [yellow label].

Diagnosis. Head, pronotum, scutellum, underside black; elytra with dark blue or dark green metallic luster; antennae slender, exceeding half the length of body; lateral tubercle of pronotum gradually expanding from anterior to the middle and then constricted; median lobe with basal one third tubular, slightly flattened and curved in lateral view, apex triangular and blunt.



Figures 12–15. Holotype of *Zeugophora* (*Pedrillia*) *euonymorum* sp. nov., male **12** dorsal view **13** ventral view **14** head, anterior view **15** pronotum, dorsal view. Scale bars: 1.0 mm (**12, 13**); 0.5 mm (**14, 15**).

Description. BL = 2.8–4.0 mm, BW = 1.3–2.0 mm. Head, pronotum, scutellum, underside black; elytra with dark blue or dark green metallic luster; mouthparts yellowish brown except mandible brown; antennae black or with antennomere 1 dark brown; legs black, sometimes basal portion of femora, apex of tibiae and most of tarsi yellow, or legs yellow.

Head: eyes prominent, inner margin with distinct canthus; vertex densely punctate and pubescent; occiput strongly constricted; frons sparsely punctate and pubescent, center with a shallow concave, lateral sides slightly depressed; clypeus rectangular, width 2 × length, punctate and pubescent laterally, separated from frons by deep fronto-clypeal suture; labrum rectangular, narrower than clypeus, anterior margin with punctures and pubescence; antennae slender, exceeding half the length of body, antennomere 1 long and swollen, antennomere 2 short, half as long as antennomere 1, antennomere 3 as long as 4, slightly longer than antennomere 1, antennomeres 5–10 as long as antennomere 1, antennomere 11 acute at apex; antennomeres 1–4 sparsely punctate and pubescent, antennomeres 5–11 densely punctate and pubescent.

Thorax: PW/PL = 1.3–1.5; anterior margin slightly flattened; posterior margin backwards medially; length of anterior margin nearly equal to posterior margin; anterior groove distinct laterally, obsolete medially; posterior groove deep laterally, shallow medially; anterior portion of lateral margin subparallel, then gradually expanding from anterior portion to middle, strongly constricted behind middle; lateral tubercle rounded; behind the lateral tubercle, an oblique groove extending to base portion; disc convex with punctures and pubescence, basal portion slightly depressed; basal portion of each side slightly prominent. Scutellum triangular, slightly emarginate at apex, densely punctate and pubescent.

Elytra: EL/EW = 1.4–1.6; elytral humeri projecting antero-laterally, humeral groove shallow, lateral of humeri densely punctate and pubescent; lateral margins

Figures 16–20. Types of *Zeugophora* (*Pedrillia*) *euonymorum* sp. nov. **16–19** male genitalia of holotype **16** median lobe and median struts, lateral view **17** median lobe, dorsal view **18** tegmen, dorsal view **19** spiculum, dorsal view **20** ovipositor of paratype, dorsal view. Scale bars: 0.5 mm (**16, 18**); 0.2 mm (**17, 19, 20**).

slightly expanding from the base to the middle, widest behind the middle, apex rounded; disc slightly flattened, coarsely punctate and pubescent; suture with two rows of punctures and pubescence; epipleura narrow, two rows of punctures and pubescence at base and one row at apex.

Abdomen and legs: underside sparsely punctate and pubescent. Legs moderately long, femora robust, mid- and hind-tibiae slightly curved. Pygidium moderately long, apical portion exposed. Apical margin of last abdominal ventrite slightly prominent in male (apical margin of last abdominal ventrite nearly straight in female). Median lobe sclerotized, short and broad, slightly curved in lateral view, dorso-central portion membranous, basal one

Figures 21–24. 21 Habitat of *Zeugophora* (*Pedrillia*) *euonymorum* sp. nov. (Ningxia, Liupan Shan) **22, 23** host plant of *Zeugophora* (*Pedrillia*) *euonymorum* (*Euonymus elatus*) **24** copulation.

third tubular, lateral sides thick and parallel, apex triangular and blunt; median struts rod-shaped, widely separated from each other, approximately 2.1–2.3 × as long as median lobe; basal portion of tegmen Y-shaped, tegminal ring oval-shaped, paramere tongue-shaped, apical margin of paramere with setae; endophallus membranous, with paired granulated and weakly sclerotized area. Spiculum spoon-shaped, apical margin slightly emarginate. Ovipositor moderately long, sub-rectangular, base broad, apex slightly narrowed, divided into two vaginal palpi, each side with one baculus, extending from the base of the ovipositor backwards to the coxite, baculus sclerotized, base slightly broad, apex slightly narrowed, two baculi proximal to each other at base; coxite strongly sclerotized, cylindrical, lateral margin of apex with long setae; stylus, cylindrical, short, small and distinct.

Distribution. China (Ningxia, Guizhou).

Host plant. *Euonymus elatus*, *Euonymus hamiltonianus* (Celastraceae).

Etymology. The specific name *euonymorum* refers to the host plant genus *Euonymus* (Family Celastraceae).

Remarks. This species is similar to *Zeugophora cyanea* Chen, 1974 in color, but differs in having longer antennae, the lateral tubercle of the pronotum gradually expanding from the anterior to the middle and then constricted, the lateral tubercle broader and bigger, the ratio of median struts / median lobe approximately 2.1–2.3, basal third of median lobe tubular with the apex of the median lobe broader and blunt, the tegminal ring oval-shaped, the paramere tongue-shaped, the spiculum long and Y-shaped and with the apex prominent (shorter antennae, lateral tubercle prominent on lateral middle of pronotum, anterior margin of pronotum slightly subparallel, lateral tubercle narrow and smaller, the ratio of median struts / median lobe approximately 1.1, median lobe dorso-central portion membranous and apical portion with a slender

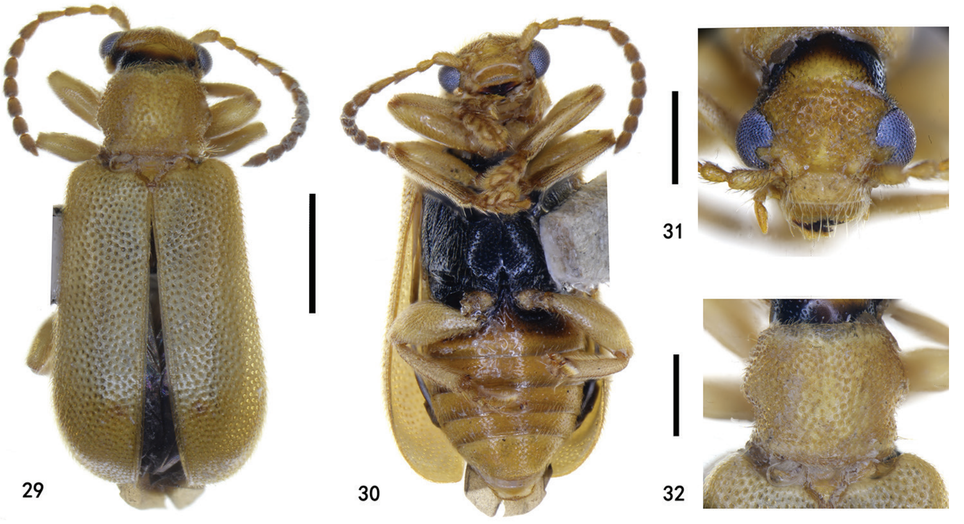
Figures 25–28. 25 Habitat of *Zeugophora* (*Pedrillia*) *euonymorum* sp. nov. (Guizhou, Leigong Shan) **26, 27** host plant of *euonymorum* sp. nov. (*Euonymus hamiltonianus*) **28** copulation.

and weakly sclerotized sclerite, apex of median lobe narrower and sharper, tegminal ring gradually narrowed from base to apical portion, paramere sub-square, spiculum long and Y-shaped, and apex trifid in *Z. cyanea*).

The external male genitalia of this species are similar to those of *Zeugophora* (*Pedrillia*) *annulata* Baly, 1873, *Zeugophora* (*Pedrillia*) *bicolor* Kraatz, 1879, *Zeugophora* (*Pedrillia*) *tricolor* Chen & Pu, 1962, but differs from them in having a slightly flattened and less curved median lobe in the lateral view, with the apex of the median lobe shorter and slightly broader.

***Zeugophora* (*Pedrillia*) *flavithorax* sp. nov.**
http://zoobank.org/E25DF81C-67EF-410A-9855-AE2002ECE2B2
Figures 29–37, 46–47

Specimens ecamined. ***Holotype:*** male, China, Guizhou, Leishan, Leigong Shan National Nature Reserve, 26.36966N, 108.18724E / 1367 m, 2019.vii.14, Kaiqin Li coll. / Holotype, *Zeugophora* (*Pedrillia*) *flavithorax* sp. nov., des. by K.Q. Li & H.B.



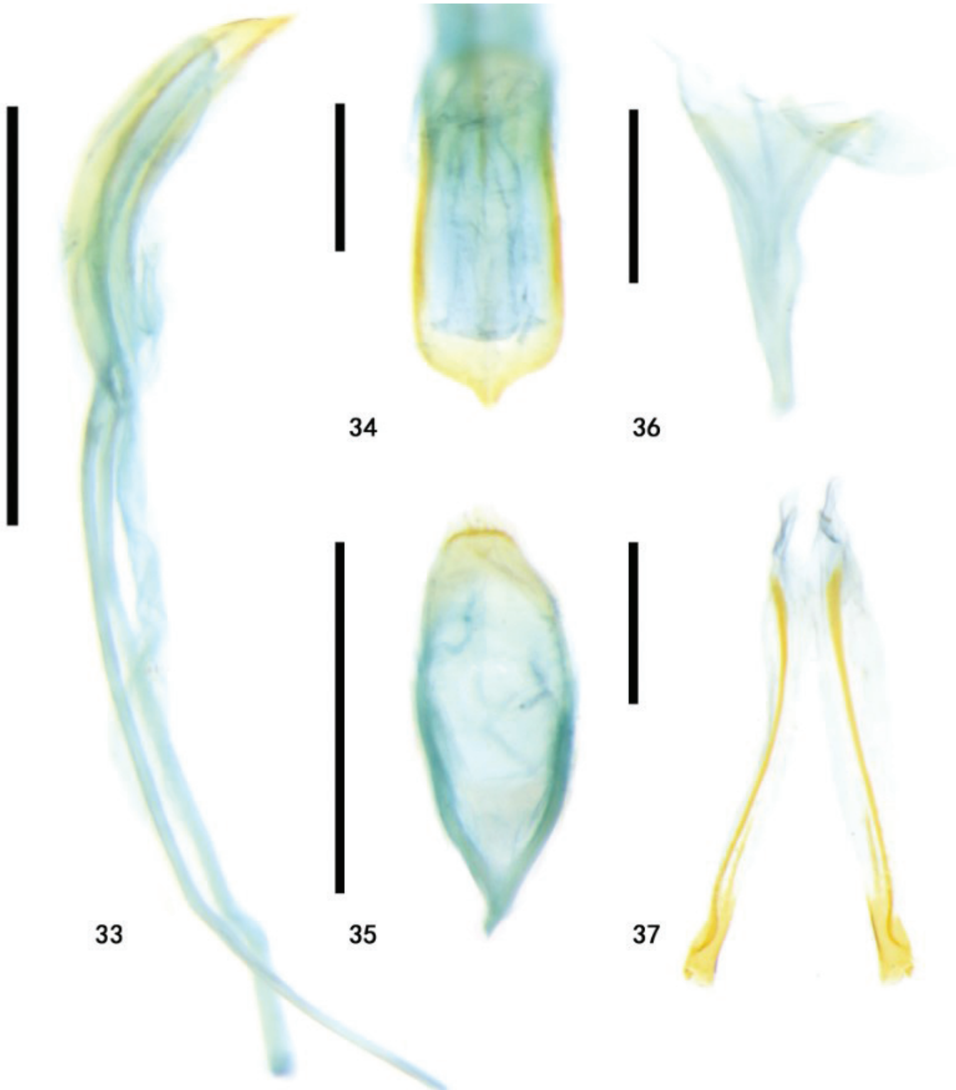
Figures 29–32. Holotype of *Zeugophora* (*Pedrillia*) *flavithorax* sp. nov., male **29** dorsal view **30** ventral view **31** head, anterior view **32** pronotum, dorsal view. Scale bars: 1.0 mm (**29, 30**); 0.5 mm (**31, 32**).

Liang, 2020 [red label]. ***Paratypes*** (1 male and 1 female): 1 female, same data as holotype but paratype *Zeugophora* (*Pedrillia*) *flavithorax* sp. nov., des. by K.Q. Li & H.B. Liang, 2020 [yellow label]; 1 male (IZCAS), China, Guizhou, Leishan, Leigong Shan National Nature Reserve, 26.36966N, 108.18724E / 1367 m, 2019.vii.15, Kaiqin Li coll. / Paratype *Zeugophora* (*Pedrillia*) *flavithorax* sp. nov., des. by K.Q. Li & H.B. Liang, 2020 [yellow label].

Diagnosis. Head brown except occiput black, antennae, pronotum, elytra, prosternum, abdominal ventrites and legs brown, mesoventrite and metaventrite black, the pubescence of surfaces slightly yellow and transparent; median lobe short and broad, slightly curved in lateral view, lateral sides thin, apex slightly broad, middle of apical margin projecting and sharp; base of coxite with one elongate sclerotized area.

Description. BL = 4.0–4.2 mm, BW = 1.6–1.8 mm. Head brown except occiput black, antennae, pronotum, elytra, prosternum, abdominal ventrites, and legs brown, mesoventrite and metaventrite black.

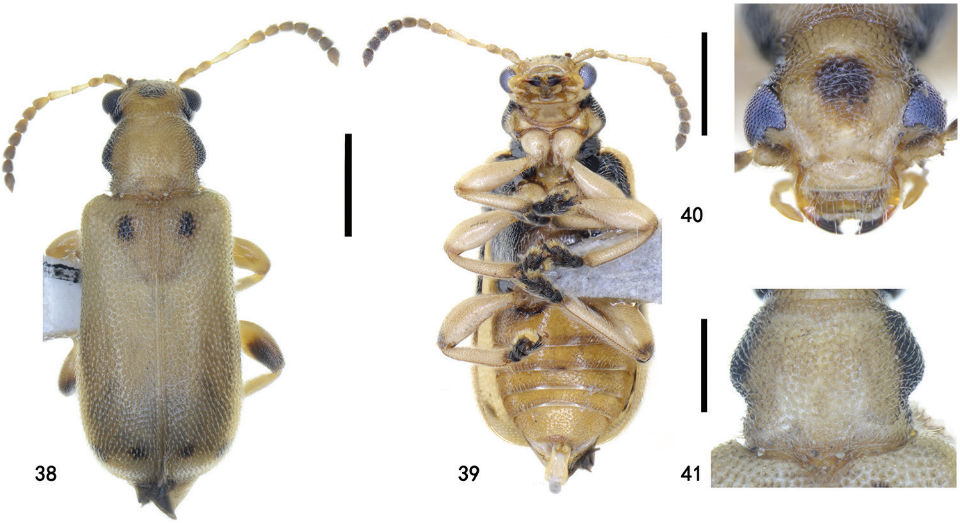
Head: eyes prominent, inner margin with distinct canthus; vertex coarsely and densely punctate and pubescent; occiput strongly constricted; frons finely punctate and pubescent; fronto-clypeal suture arching backwards centrally; clypeus rectangular, width 2.1 × that of length, anterior margin and lateral with punctures and pubescence; labrum rectangular, narrower than clypeus, center of anterior portion emarginate, anterior and lateral portion with punctures and pubescence; antennae extended to exceed the humeri, antennomere 1 long, anterior portion slightly swollen, antennomere 2 short, half-length of antennomere 1, antennomere 3 slightly shorter than antennomere 1, antennomere 4 as long as antennomere 1, antennomeres 5–11 slightly thick, antennomere 5 shorter than antennomere 4, antennomere 6 slightly shorter than an-



Figures 33–37. Types of *Zeugophora* (*Pedrillia*) *flavithorax* sp. nov., genitalia **33–36** male genitalia of holotype **33** median lobe and median struts, lateral view **34** median lobe, dorsal view **35** tegmen, dorsal view **36** spiculum, dorsal **37** ovipositor of paratype, dorsal view. Scale bars: 0.5 mm (**33, 35**); 0.2 mm (**34, 36, 37**).

tennomere 5, antennomeres 7–10 slightly shorter than antennomere 6, antennomere 11 as long as antennomere 6, acute at apex, antennomeres 1–4 sparely punctate and pubescent, antennomeres 5–11 densely punctate and pubescent.

Thorax: PW/PL = 1.2–1.3; anterior margin slightly flattened; posterior margin arching backwards in the center; length of anterior margin nearly equal to posterior margin; anterior and posterior groove shallow; lateral margin gradually expanding

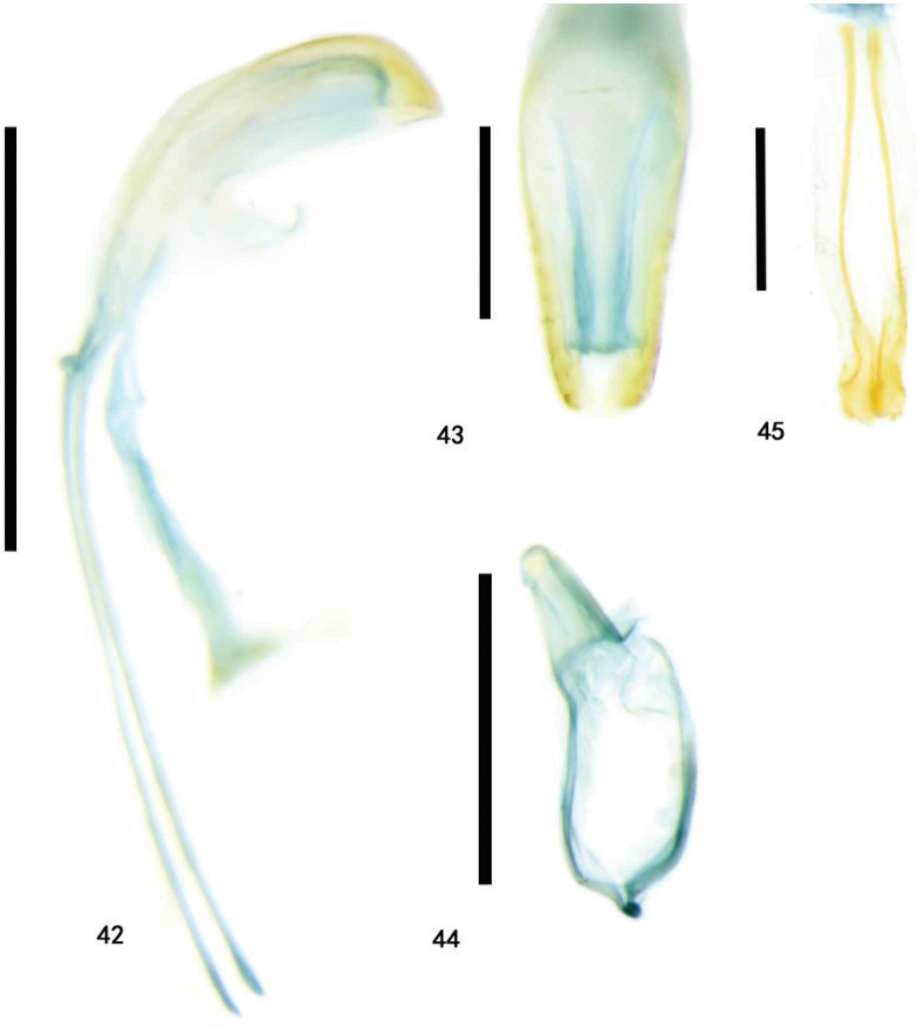


Figures 38–41. *Zeugophora* (*Pedrillia*) *maculata* (Chûjô) from Guizhou, female **38** dorsal view **39** ventral view **40** head, anterior view **41** pronotum, dorsal view. Scale bars: 1.0 mm (**38, 39**); 0.5 mm (**40, 41**).

from anterior angle to the middle, then constricted, lateral tubercle projecting, narrow and blunt; disc slightly convex, coarsely punctate and pubescent. Scutellum triangular, apical margin slightly emarginate, sparsely punctate and pubescent.

Elytra: EL/EW = 1.5–1.7; elytral humeri slightly projecting antero-laterally, humeral groove shallow; lateral margin gradually expanding from anterior to posterior, the elytra widest behind the middle, apex rounded; disc slightly convex, weakly depressed at basal one third, coarsely punctate and pubescent; elytra base finely punctate and pubescent; suture with one or two rows of punctures and pubescence; epipleura narrow, two rows of punctures and pubescence at base and one row at apex.

Abdomen and legs: underside sparsely punctate and pubescent. Legs moderately long, femora robust. Pygidium moderately long, punctate, and pubescent, apical portion exposed; apical margin of last abdominal ventrite slightly prominent in male (slightly emarginate in female). Median lobe weakly sclerotized, short and broad, slightly curved in lateral view, dorso-central portion entirely membranous, lateral sides thin, apex slightly broad, middle of apical margin projecting and sharp; median struts rod-shaped, widely separated from each other, approximately 1.8 × as long as median lobe; base of tegmen V-shaped, tegminal ring sub-oval, paramere sub-trapezoid and apical margin slightly rounded, apical margin with long setae; endophallus membranous, with paired granulated and weakly sclerotized area. Spiculum long Y-shaped, apical margin slightly flattened. Ovipositor long, sub-rectangular, base slightly broader than apex, divided into two vaginal palpi, each side with one baculus, extending from the base of the ovipositor backwards to the coxite, baculus base slightly broad, apex slightly narrowed, sclerotized, two baculi proximal to each other at base; coxite strongly sclerotized, sub-rectangular, apical margin with setae, lateral sides of apical margin with stylus; stylus, cylindrical, small and distinct.



Figures 42–45. Genitalia of *Zeugophora* (*Pedrillia*) *maculata* (Chûjô) from Guizhou, genitalia **42–44** male genitalia **42** median lobe and median struts, lateral view **43** median lobe, dorsal view **44** tegmen, dorsal view **45** ovipositor, dorsal view. Scale bars: 0.5 mm (**42, 44**); 0.2 mm (**43, 45**).

Distribution. China (Guizhou).

Host plant. Symplocaceae.

Etymology. The specific name *flavithorax* refers to the yellow color of the prothorax.

Remarks. This species is most similar to *Zeugophora* (*Pedrillia*) *maculata* (Chûjô, 1941) (Figs 38–41) in the shape of the external morphology and color, but differs in having the pronotum and elytra without a black spot, the pubescence of surfaces slightly yellow and transparent, the median lobe apex slightly broad and the apical margin projecting and sharp, paramere of tegmen sub-trapezoid, and the base of the coxite with one elongate sclerotized area (pronotum and elytra with a black

Figures 46–47. Habitat of *Zeugophora* (*Pedrillia*) *flavithorax* sp. nov. (Guizhou, Leigong Shan).

spot, the pubescence of surfaces pale yellow, median lobe apex slightly narrowed and downward, apical margin slightly round without projecting, paramere of tegmen tongue-shaped, base of coxite without elongate sclerotized area in *Z.* (*P.*) *maculata* (Figs 38–45)).

Zeugophora (*Pedrillia*) *nigricollis* (Jacoby, 1885), new record

Figures 48–57

Pedrillia nigricollis Jacoby, 1885: 195. Type locality: Japan, Wada-tôge. Type depository: NHMUK. Synonymized as *Pedrillia bicolor* Kraatz, 1879 by Kimoto 1986: 309.

Zeugophora (*Pedrillia*) *nigricollis*: Crowson, 1946: 95 [Japan]; Gressitt and Kimoto 1961: 24, 27; Chûjô 1954: 51; Chûjô and Kimoto 1961: 119; Kimoto 1964: 108.

Zeugophora (*Pedrillia*) *bicolor*: Kimoto, 1986: 309; Jolivet 1957: 12; Kimoto and Takizawa 1994: 6, 99, 267; An and Kwon 2002: 272; Silfverberg 2010: 334; Li and Liang 2018: 133.

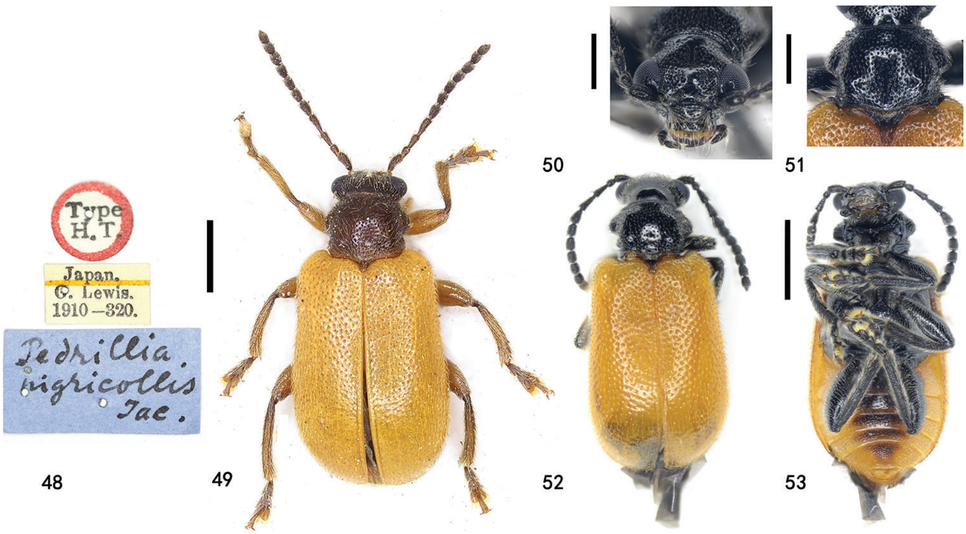
Zeugophora bicolor: Gressitt, 1945: 139; An and Kwon 1995: 91–92; Takizawa 2006: 2; Rodríguez-Mirón 2018: 291.

Zeugophora nigricollis (Jacoby, 1885). Restored as a valid species by Takemoto 2019: 15–19.

Specimens examined. Type: H. T. / Japan. G. Lewis. 1910–320. / *Pedrillia nigricollis* Jac.

Non-types (KIZ). Two males, China, Ningxia, Jingyuan, Liupan Shan National Nature Reserve, Erlonghe Forest Farm, 35.33041N, 106.35110E, 2088 m, 2018.vii.27, Kaiqin Li coll.

Diagnosis. Elytra brown, head, antennae, pronotum, scutellum, legs, and underside black (except lateral sides of abdominal ventrites brown); median lobe slender, curved in lateral view, apex of median lobe triangular and blunt.

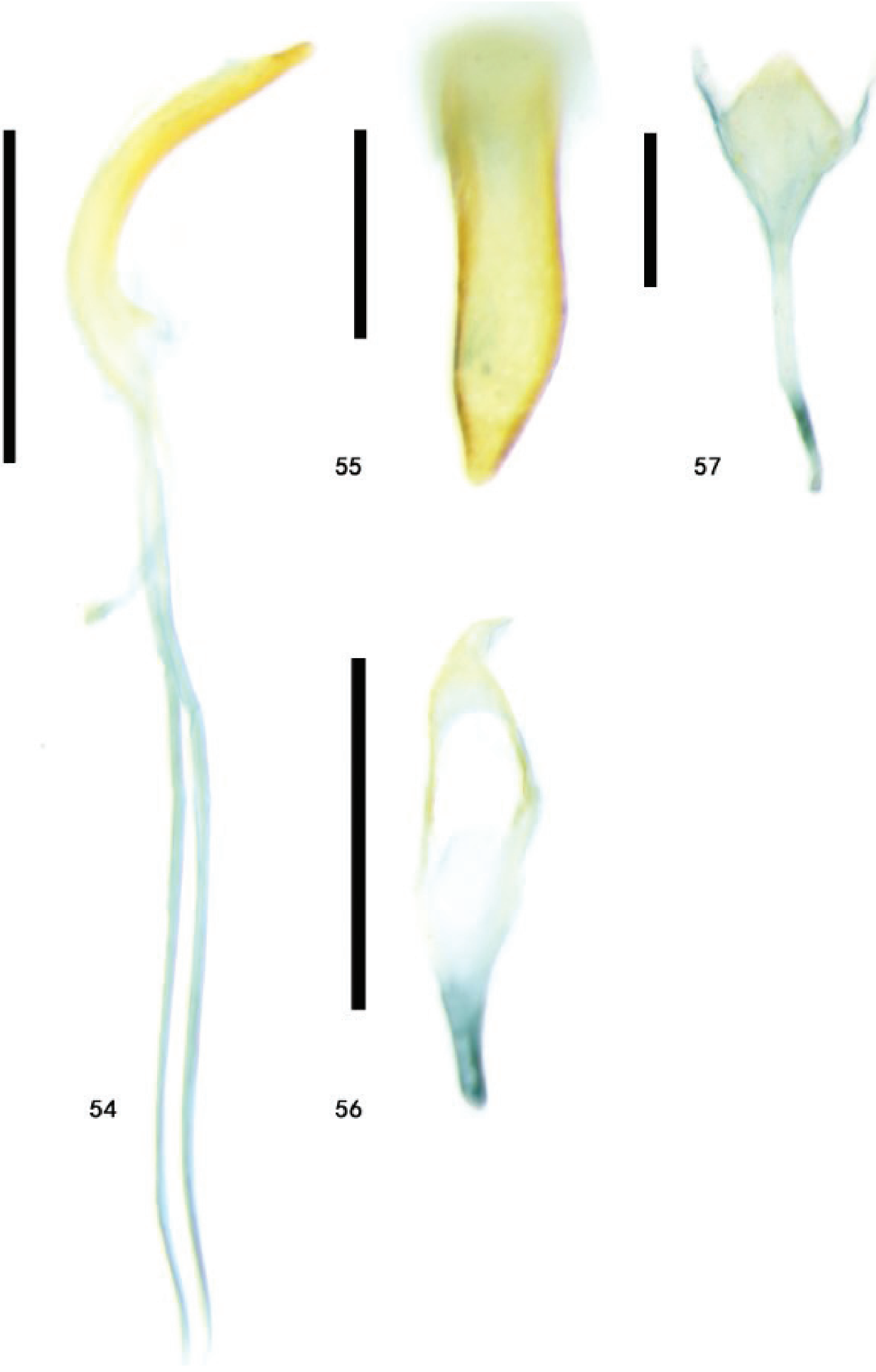


Figures 48–53. *Zeugophora nigricollis* Jacoby **48** holotype label **49** holotype dorsal view **50–53** specimens from Ningxia, male **50** head, anterior view **51** pronotum, dorsal view **52** dorsal view **53** ventral view. Scale bars: 1.0 mm (**49, 52, 53**); 0.5 mm (**50, 51**).

Description. BL = 3.8–4.5 mm, BW = 1.9–2.2 mm. Elytra brown, head, antennae, pronotum, scutellum, legs, and underside black (except lateral sides of abdominal ventrites brown).

Head: eyes prominent, inner margin with distinct canthus; vertex coarsely and densely punctate and pubescent, the middle slightly smooth without puncture; occiput strongly constricted; frons densely punctate and pubescent; fronto-clypeal suture slightly arching backwards centrally; clypeus rectangular, width 2.1 × that of length, anterior and lateral margin densely punctate and pubescent; labrum rectangular, narrower than clypeus, center of anterior portion emarginate, anterior and lateral with punctures and pubescence; antennae extended to exceed the humeri, antennomere 1 long, anterior portion slightly swollen, antennomere 2 short, half-length of antennomere 1, antennomere 3 slightly shorter than antennomere 1, antennomere 4 as long as antennomere 1, antennomeres 5–11 slightly thick, antennomere 5 shorter than antennomere 3, antennomeres 6–10 slightly shorter than antennomere 5, antennomere 11 as long as antennomere 5, acute at apex, antennomeres 1–4 sparsely punctate and pubescent, antennomeres 5–11 densely punctate and pubescent.

Thorax: PW/PL = 1.5–1.6; anterior margin slightly flattened; length of anterior margin nearly equal to posterior margin; posterior margin arching backwards in the center; anterior groove distinct laterally, shallow medially; posterior groove shallow; lateral margin gradually expanding from anterior angle to the middle, then constricted, lateral tubercle broad and round; disc convex, densely punctate and pubescent, basal portion of each side slightly prominent; each anterior and posterior angle with two or three long setae. Scutellum triangular, apical margin flattened, sparsely punctate and pubescent.



Figures 54–57. Genitalia of *Zeugophora* (*Pedrillia*) *nigricollis* Jacoby from Ningxia, male genitalia **54** median lobe and median struts, lateral view **55** median lobe, dorsal view **56** tegmen, dorsal view **57** spiculum, dorsal view. Scale bars: 0.5 mm (**54, 56**); 0.2 mm (**55, 57**).

Elytra: EL/EW = 1.3–1.5; elytral humeri projecting antero-laterally, humeral groove shallow; lateral margin gradually expanding from anterior to posterior, the elytra widest behind the middle, apex round; disc flattened, weakly depressed at basal one third, coarsely punctate and pubescent; elytra base densely punctate and pubescent; suture with one row of punctures and pubescence; epipleura narrow, with one row of punctures and pubescence.

Abdomen and legs: underside sparsely punctate and pubescent. Legs moderately long, femora robust, meso- and meta-tibia slightly curved. Pygidium moderately long, punctate, and pubescent; apical margin of last abdominal ventrite slightly prominent. Median lobe sclerotized, slender, curved in lateral view, lateral sides thick and parallel, dorso-central portion membranous with basal one third tubular, apex triangular and blunt, apex slightly leftward; median struts rod-shaped, widely separated from each other, approximately 2.6 × as long as median lobe; base of tegmen V-shaped, tegminal ring sub-oval, paramere long and triangular with apical margin with long setae; endophallus membranous, with paired granulated and weakly sclerotized area. Spiculum long and Y-shaped, with apical margin projecting.

Distribution. China (Ningxia).

Host plant. *Euonymus elatus* (Celastraceae) (Figs 22, 23).

Remarks. Takemoto (2019) restored *Zeugophora* (*Pedrillia*) *nigricollis* Jacoby, 1885 to a valid species from the synonymy of Z. (*P.*) *bicolor* (Kraatz, 1879). This species is most similar to *Zeugophora* (*Pedrillia*) *bicolor* Kraatz, 1879 in having the black and brown color, but differs in having the pronotum entirely black, the median lobe less curved in the lateral view, the median lobe slender, with the apex of the median lobe triangular and blunt (the base of the pronotum is slightly brown, median lobe is more curved in the lateral view, median lobe slightly broader, and apex of median lobe narrower and sharper in *Z.* (*P.*) *bicolor*).

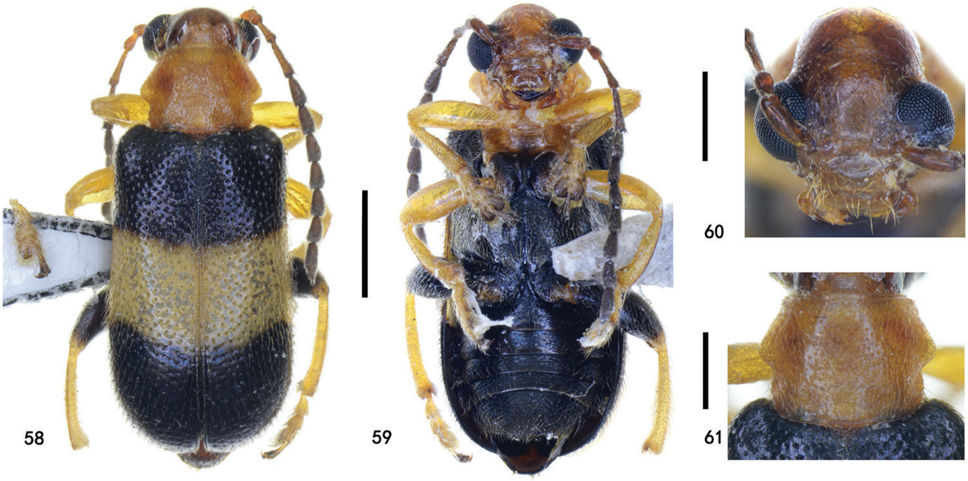
***Zeugophora* (*Pedrillia*) *trifasciata* sp. nov.**

http://zoobank.org/04D8AB26-4E47-45C3-8D75-3228A5E6A641

Figures 58–66

Specimens examined. ***Holotype:*** male, China, Yunnan, Ailaoshan, Xujiaba, 1986.viii.21 / Holotype, *Zeugophora* (*Pedrillia*) *trifasciata* sp. nov., des. by K.Q. Li & H.B. Liang, 2020 [red label]. ***Paratype***, 1 male, same data as holotype but 1986.x.31 / Paratype *Zeugophora* (*Pedrillia*) *trifasciata* sp. nov., des. by K.Q. Li & H.B. Liang, 2020 [yellow label].

Diagnosis. Head brown; antennae black, with basal four antennomeres brown; pronotum yellowish brown; scutellum dark brown; elytra dark blue with a pale yellow transverse band from epipleura to suture on the center; underside dark blue except prosternum and mesoventrite yellowish brown; legs yellowish brown except hind femur dark blue; antennae elongate, lateral sides of elytra sub-paralleled; dorso-central portion of the median lobe with one sclerite from base to apical portion.

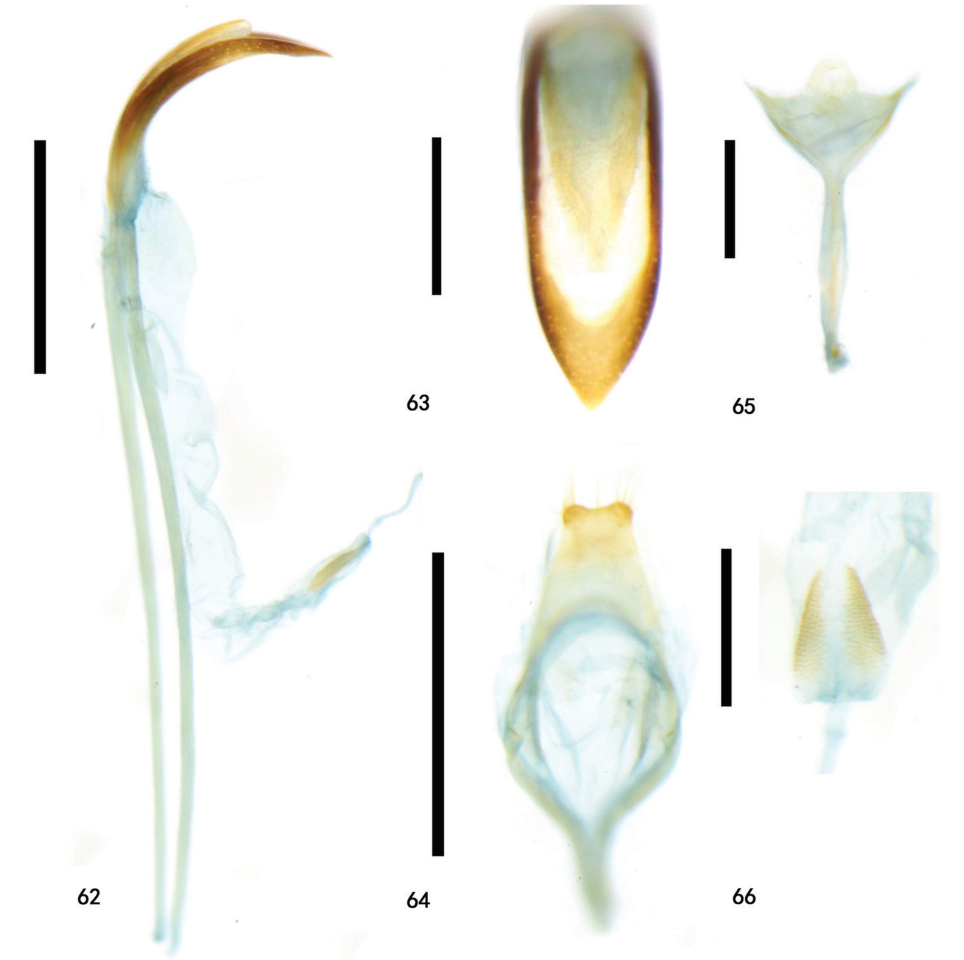


Figures 58–61. Holotype of *Zeugophora* (*Pedrillia*) *trifasciata* sp. nov., male **58** dorsal view **59** ventral view **60** head, anterior view **61** pronotum, dorsal view. Scale bars: 1.0 mm (**58, 59**); 0.5 mm (**60, 61**).

Description. BL = 4.3–4.4 mm, BW = 1.7–1.9 mm. Head brown; antennae black, with basal four antennomeres brown; pronotum yellowish brown; scutellum dark brown; elytra dark blue with a pale yellow transverse band from epipleura to suture on the center; underside dark blue except prosternum and mesoventrite yellowish brown; legs yellowish brown except hind femur dark blue.

Head: eyes prominent, inner margin with distinct canthus; center of vertex sparsely punctate and pubescent, lateral sides densely punctate and pubescent; occiput strongly constricted; frons finely punctate and pubescent, center slightly concave; clypeus rectangular, width 2.4 × that of length, central portion slightly prominent, punctate and pubescent laterally, separated from frons by deep fronto-clypeal suture; shallow oblique groove from inner margin of upper portion of eye to fronto-clypeal suture; labrum rectangular, slightly narrower than clypeus, anterior margin with punctures and pubescence; antennae slender, exceeding half the length of body, antennomere 1 long and swollen, antennomere 2 short, shorter than half the length of antennomere 1, antennomere 3 slightly shorter than antennomere 1, antennomere 4 subequal to antennomere 1, antennomere 5 equal to 6 in length, and two-thirds as long as antennomere 4, antennomeres 7–10 equal to each other in length and slightly shorter than antennomere 5, antennomere 11 slightly longer than antennomere 5 and apex acute, antennomeres 1–4 sparsely punctate and pubescent, antennomeres 5–11 densely punctate and pubescent.

Thorax: PW/PL = 1.5–1.6; anterior margin slightly flattened; posterior margin arching backwards medially; length of anterior margin nearly equal to posterior margin; anterior and posterior groove indistinct; lateral sides subparallel at anterior portion, then gradually expanding in the middle, strongly constricted posterior to the middle; lateral tubercle prominent and blunt; with a shallow oblique groove behind the lateral tubercle to basal portion; disc convex, with fine punctures and pubescence,



Figures 62–66. Holotype of *Zeugophora* (*Pedrillia*) *trifasciata* sp. nov., male genitalia **62** median lobe and median struts, lateral view **63** median lobe, dorsal view **64** tegmen, dorsal view **65** spiculum, dorsal view **66** sclerotized area of endophallus. Scale bars: 0.5 mm (**62, 64**); 0.2 mm (**63, 65, 66**).

basal portion slightly depressed; basal portion of each side slightly prominent. Scutellum trapezoid, slightly emarginate at apex, densely punctate and pubescent.

Elytra: EL/EW = 1.6–1.7; elongate, elytral humeri projecting antero-laterally, humeral groove somewhat deep; lateral sides subparallel; disc slightly flattened, base slightly prominent and posterior slightly depressed, base densely punctate and pubescent, apex coarsely punctate and pubescent; suture with one row of punctures and pubescence; epipleura narrow, base with two rows of punctures and pubescence, apex with one row of punctures and pubescence.

Abdomen and legs: underside sparsely punctate and pubescent. Legs moderately long, femora robust, mid- and hind-tibiae slightly curved. Pygidium moderately long, apex portion exposed. Last abdominal ventrite with apical margin slightly prominent. Median lobe flattened, slightly curved in lateral view, sides and apex sclerotized, dorso-central portion with one sclerite from base to apical portion, sides moderately thick, apical portion tongue-shaped, apex sharp; median struts rod-shaped, widely separated from each other, approximately 2.8 × as long as median lobe; basal portion of tegmen Y-shaped, tegminal ring sub-round, paramere trapezoid, apical margin of paramere slightly emarginate in middle, lateral sides with setae; endophallus membranous, with paired granulated and sclerotized area. Spiculum Y-shaped, apical margin trifid.

Distribution. China (Yunnan).

Host plant. Unknown.

Etymology. The specific name *trifasciata* refers to the transverse bands on the elytra.

Remarks. This species is similar to *Zeugophora* (*Pedrillia*) *formosana* Gressitt, 1945 in having the transverse bands on the elytra, but differs in having the antennae elongate, the lateral sides of the elytra subparallel, the base of the pronotum without a distinct transverse groove (antennae shorter, lateral sides of elytra gradually expanding posteriorly from the base, broadest behind the middle, and the base of the pronotum with a transverse groove in *Z.* (*P.*) *formosana*).

This species is also similar to *Zeugophora* (*Pedrillia*) *pallidicinata* Gressitt, 1945 in color, but differs in having the elytra elongate and the lateral sides subparallel (elytra broad and short, the lateral sides expanding posteriorly from the base, widest behind the middle in *Z.* (*P.*) *pallidicinata*).

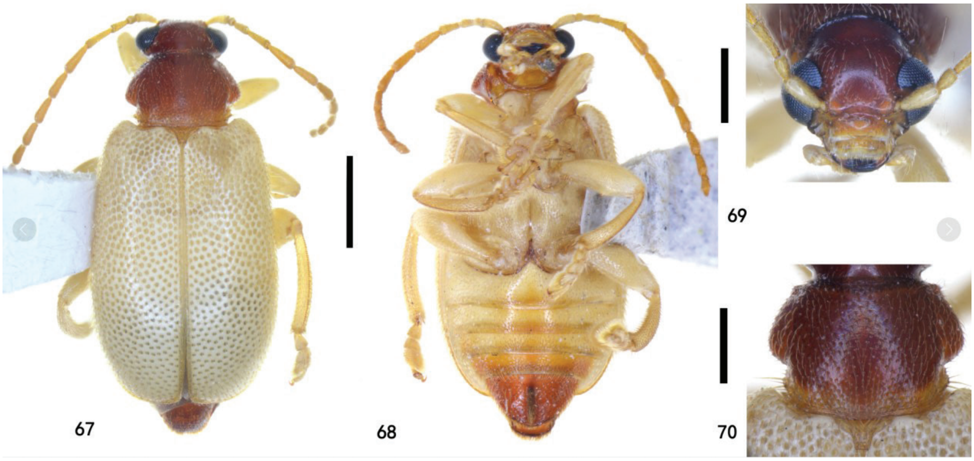
The median lobe of this species is distinct with the dorsal portion of the median lobe having a long triangular sclerite (Figs 62, 63).

***Zeugophora* (*Pedrillia*) *yuae* sp. nov.**

http://zoobank.org/92BC423A-5713-4D74-856B-F08CA4B0C047
Figures 67–79

Specimens examined. ***Holotype*:** male, China, Yunnan, Xishuangbanna, Nabanhe National Nature Reserve, Dayangdi, 22.24610N, 100.60303E / 911 m, 2019.v.10, Kaiqin Li coll. / Holotype, *Zeugophora* (*Pedrillia*) *yuae* sp. nov., des. by K.Q. Li & H.B. Liang, 2020 [red label]. ***Paratypes*** (4 males and 3 females): 1 male and 1 female (1 male in IZCAS), same data as holotype but paratype *Zeugophora* (*Pedrillia*) *yuae* sp. nov., des. by K.Q. Li & H.B. Liang, 2020 / [yellow label]; 3 males and 2 females (1 female in IZCAS), China, Yunnan, Xishuangbanna, Nabanhe National Nature Reserve, Dayangdi, 22.24610N, 100.60303E / 911 m, 2019.v.11, Kaiqin Li coll. / Paratype *Zeugophora* (*Pedrillia*) *yuae* sp. nov., des. by K.Q. Li & H.B. Liang, 2020 / [yellow label].

Diagnosis. Head, prothorax, pygidium, last abdominal ventrite reddish brown; antennae and scutellum brown; elytra, mesoventrite, metaventrite, most portion of abdominal ventrites, legs pale brown; pubescence pale brown; antennae slender, extended to half the length of body; median lobe slender, slightly curved in lateral view, dorso-central portion membranous with basal one half tubular and other portion flattened, apex triangular, blunt.



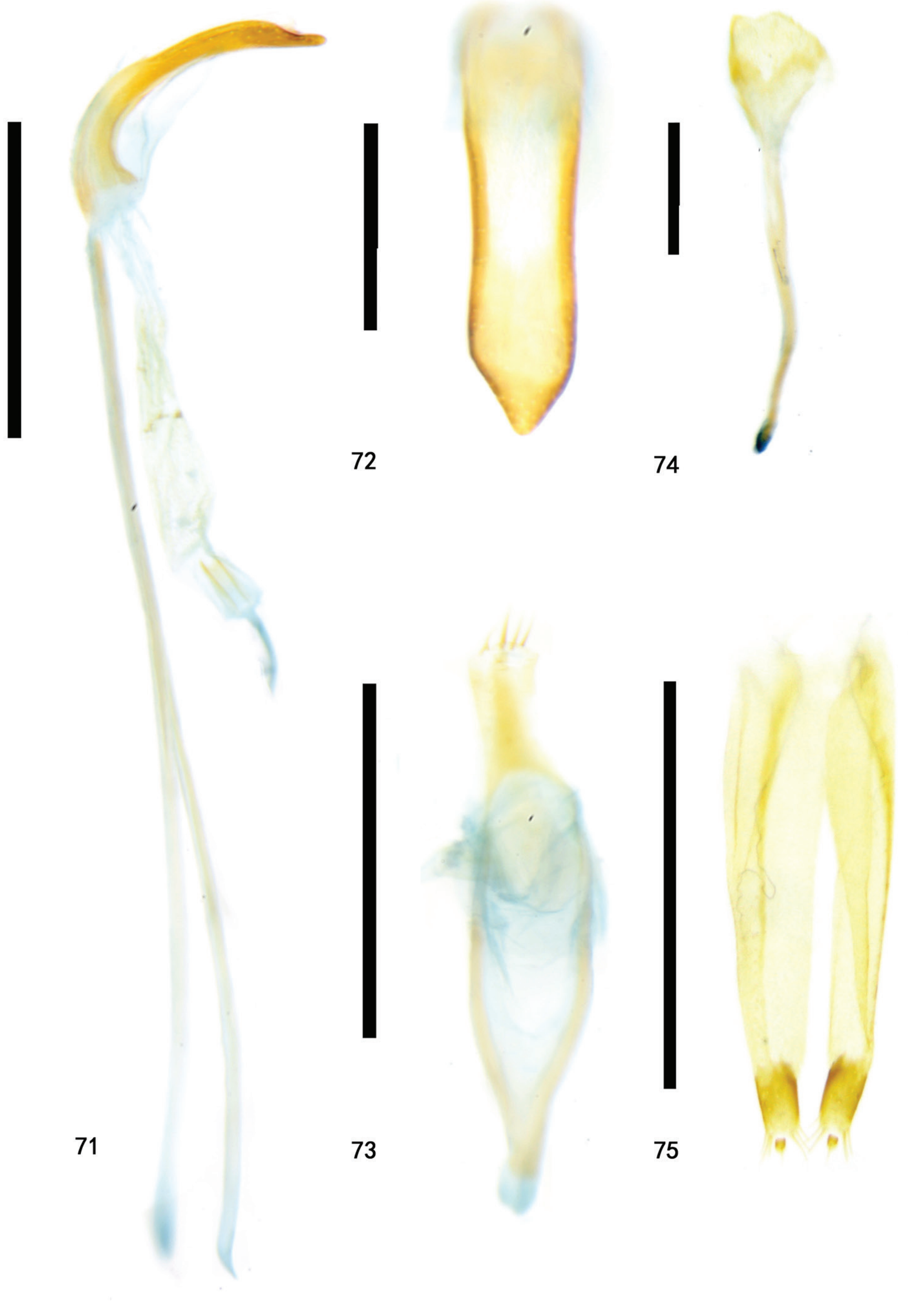
Figures 67–70. Holotype of *Zeugophora* (*Pedrillia*) *yuae* sp. nov., male **67** dorsal view **68** ventral view **69** head, anterior view **70** pronotum, dorsal view. Scale bars: 1.0 mm (**67, 68**); 0.5 mm (**69, 70**).

Description. BL = 3.3–4.7 mm, BW = 1.6–2.2 mm. Head, prothorax, pygidium, last abdominal ventrite reddish brown; antennae and scutellum brown; elytra, mesoventrite, metaventrite, most portion of abdominal ventrites, legs pale brown; pubescence pale brown.

Head: eyes prominent, inner margin with distinct canthus; vertex smooth, lateral sides near eyes finely and sparsely punctate and pubescent; occiput strongly constricted; frons finely punctate and pubescent; fronto-clypeal suture slightly arching backwards; clypeus rectangular, width 2.2 × that of length, anterior and lateral margin with punctures and pubescence; labrum rectangular, slightly narrower than clypeus, center of anterior portion emarginate, anterior and lateral portion with punctures and pubescence; antennae slender, extending to half the length of body, antennomere 1 long, anterior portion slightly swollen, antennomere 2 short, less than half the length of antennomere 1, antennomere 3 slightly shorter than antennomere 1, antennomere 4 as long as antennomere 1, antennomeres 5–11 slightly thick, antennomere 5 as long as antennomere 4, antennomeres 6–8 slightly shorter than antennomere 5, antennomere 9 as long as antennomere 10 and slightly shorter than antennomere 8, antennomere 11 as long as antennomere 10, acute at apex, antennomeres 1–4 sparsely punctate and pubescent, antennomeres 5–11 densely punctate and pubescent.

Thorax: PW/PL = 1.5–1.7; anterior margin slightly flattened; posterior margin arching backwards centrally; length of anterior margin nearly equal to posterior margin; anterior groove shallow laterally, indistinct medially; posterior groove deep laterally, shallow medially; lateral margin gradually expanding from anterior angle to beyond the middle, then constricted, lateral tubercle broad and round; disc slightly convex, sparsely punctate and pubescent, each side of the basal portion slightly depressed. Scutellum trapezoid, apical margin slightly flattened, sparsely punctate and pubescent.

Elytra: EL/EW = 1.3–1.5; elytral humeri projecting antero-laterally, humeral groove shallow; lateral margin gradually expanding from anterior to posterior, the



71 72 73 74 75

Figures 71–75. Types of *Zeugophora* (*Pedrillia*) *yuae* sp. nov., genitalia **71–74** male genitalia of holotype **71** median lobe and median struts, lateral view **72** median lobe, dorsal view **73** tegmen, dorsal view **74** spiculum, dorsal **75** ovipositor of paratype, dorsal view. Scale bars: 0.5 mm (**71, 73**); 0.2 mm (**72, 74, 75**).

Figures 76–79. Habitat, host plant and adult of *Zeugophora* (*Pedrillia*) *yuae* sp. nov. **76** habitat (Yunnan, Nabanhe) **77–78** host plant (*Vitex quinata*) **79** dorsal view.

elytra widest behind the middle, apex rounded; disc slightly convex, weakly depressed at basal one third, coarsely punctate and pubescent; base of elytra finely punctate and pubescent; suture with one row of punctures and pubescence; epipleura narrow, two rows of punctures and pubescence at base and one row at apex.

Abdomen and legs: underside sparsely punctate and pubescent. Legs moderately long, femora robust, mid- and hind-tibiae slightly curved; the mid-femur with a small ventral tooth in the male (without a small ventral tooth in the female). Pygidium long, with punctures and pubescence, most exposed, apical margin slightly truncated; last abdominal ventrite center with one ridge, apical margin slightly prominent in male (last abdominal ventrite center without ridge, apical margin slightly straight in female). Median lobe sclerotized, slender, slightly curved in lateral view, dorso-central portion membranous with basal half tubular and other half flattened, apex triangular, blunt; median struts rod-shaped, widely separated from each other, approximately 3.5 × as long as median lobe; base of tegmen V-shaped, tegminal ring slightly sub-parallel, parameres tongue-shaped, apical margin with long setae; endophallus membranous, with paired granulated and weakly sclerotized area. Spiculum long, spoon-shaped. Ovipositor long, sub-rectangular, base broad, apex slightly narrowed, divided into two vaginal palpi, each side with one baculus, extending from the base of the ovipositor backwards to the coxite, baculus base slightly broad, apex slightly narrowed, base sclerotized and gradually less sclerotized from base to apex, two baculi proximal to each other at base; coxite strongly sclerotized, cylindrical, apical margin with long setae; stylus, cylindrical, small and distinct.

Distribution. China (Yunnan).

Host plant. *Vitex quinata* (Lamiaceae) (Figs 77, 78).

Etymology. The specific name *yuae* is proposed in memory of Professor Peiyu Yu, who has greatly contributed to the taxonomy of the Chinese Megalopodidae.

Remarks. This species is similar to *Zeugophora* (*Pedrillia*) *tricolor* Chen & Pu, 1962 in having a reddish-brown pronotum and pale brown elytra, but can differ from it in having the head reddish brown, antennae brown and slender, the base of the pronotum without a distinct tubercle, the median lobe less curved in the lateral view, the apex of the median lobe slightly broader and blunt, and the ratio of median struts / median lobe approximately 3.5 (head black, antennomeres 1–4 pale brown, antennomeres 5–11 black, antennae shorter and slightly robust, the base of the pronotum with a slight tubercle, the median lobe more curved in the lateral view, the apex of the median lobe slightly narrower and sharper, and the ratio of median struts / median lobe approximately 2.2 in *Z. tricolor*).

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References

Baly JS (1873) Catalogue of the phytophagous Coleoptera of Japan, with descriptions of the species new to science. The Transactions of the Royal Entomological Society of London 1873: 69–99. https://doi.org/10.1111/j.1365-2311.1873.tb00637.x

Bryant GE (1943) New species of African Zeugophora (Orsodacninae, Col.) and synonymy. Annals and Magazine of Natural History Series 11, 10(64): 245–248. https://doi.org/10.1080/03745481.1943.9728014

Chen SX, Pu FJ (1962) Notes on Chinese Megalopodinae. Acta Entomologica Sinica 11(Suppl.): 114–118.

Chûjô M (1935) Chrysomelidae of Loo-Choo Archipelago (I). Transactions of the Natural History Society of Formosa Taihoku 25: 136–139.

Chûjô M (1937) Descriptions of four new species of the genus *Pedrillia* Westwood, with a list of the species known from the world (Col. Chrysomelidae). Transactions of the Natural History Society of Formosa Taihoku 27: 146–151.

Chûjô MA (1952) Taxonomic study on the Chrysomelidae (Insecta-Coleoptera) from Formosa. Part IV Subfamily Zeugophorinae. The Technical Bulletin of the Kagawa Agricultural College 3(3): 166–183.

Chûjô MA (1953) A taxonomic study on the Chrysomelidae with special reference to the fauna of Formosa. The Technical Bulletin of the Kagawa Agricultural College 5(2): 121–136.

Gressitt JL, Kimoto S (1961) The Chrysomelidae (Coleopt.) of China and Korea, Part 1. Pacific Insects Monograph 1A: 1–299.

Crowson RA (1946) A revision of the genera of the chrysomelid group Sagrinae (Coleoptera). The Transactions of the Royal Entomological Society of London 97(4), 75–115. https://doi.org/10.1111/j.1365-2311.1946.tb00276.x

Jacoby M (1885) Descriptions of the phytophagous Coleoptera of Japan, obtained by Mr. George Lewis during his second journey, from February 1880 to September 1881. Part I. Proceedings of the Scientific Meetings of the Zoological Society of London 1885: 190–211. [pl. XI] https://doi.org/10.1111/j.1096-3642.1885.tb02894.x

Jacoby M (1908) The fauna of British India, including Ceylon and Burma. Coleoptera, Chrysomelidae. Vol. 1. Taylor & Francis, London, 534 pp. [2 pls]

Kasap H, Crowson RA (1985) The studies on the ovipositors and 8th abdominal segments of species of Bruchidae and Chrysomelidae (Coleoptera). Türkiye Bitki Koruma Dergisi 9(3): 131–145.

Kimoto S, Gressitt J (1979) Chrysomelidae (Coleoptera) of Thailand, Cambodia, Laos and Vietnam. 1. Sagrinae, Donaciinae, Zeugphorinae, Megalopodinae and Criocerinae. Pacific Insects 20(2–3): 191–256.

Kraatz G (1871) Eine neue deutsche Criocerinen-Art. Berliner Entomologische Zeitschrift 15: 162. https://doi.org/10.1002/mmnd.18710150212

Lee CF, Cheng HT (2007) The Chrysomelidae of Taiwan 1. Sishou-Hills Insect Observation Network Press, Taipei, 199 pp. [In Chinese]

Li KQ, Liang HB, (2018) A check list of the Chinese Zeugophorinae (Coleoptera: Megalopodidae), with new synonym, new record and two new species of subgenus *Pedrillia* from China. Zootaxa 4455(1): 127–149. https://doi.org/10.11646/zootaxa.4455.1.5

Li KQ, Liang ZL, Liang HB (2013) Two new species of the genus *Temnaspis* Lacordaire, 1845, (Coleoptera: Chrysomeloidea: Megalopodidae) from China and Myanmar, with notes on the biology of the genus. Zootaxa 3737(4): 379–398. https://doi.org/10.11646/zootaxa.3737.4.3

Li KQ, Wang YZ, Dong DZ, Zhang LK (2015) Catalog of insect type specimens preserved at the Kunming Institute of Zoology, Chinese Academy of Science with corrections of some specimens. Zoological Research 36(5): 263–284.

Medvedev LN (1985) Zeugophorinae and Megalopodinae (Coleoptera, Chrysomelidae) fauna of Vietnam. Insects of Vietnam 1985: 59–63.

Medvedev LN (1997) To the knowledge of Zeugophorinae (Chrysomelidae) of the Old World. Russian Entomological Journal 6(3–4): 65–69.

Monrós F (1959) Notas sobre Chrysomelidae. Acta Zoologica Lilloana 17: 1–24.

Power JA (1863) Description of a new British *Zeugophora*. The Zoologist 21: 8735.

Reid CAM (1989) The Australian species of the tribe Zeugophorini (Coleoptera: Chrysomelidae: Megalopodinae). General and Applied Entomology 21: 39–48.

Reid CAM (1992) A new species of *Zeugophora* Kunze from Java (Coleoptera: Chrysomelidae: Megalopodinae). Treubia 30: 403–408.

Reid CAM (1995) A cladistic analysis of subfamilial relationships in the Chrysomelidae senus lato (Chrysomeloidea). In: Pakaluk J, Slipinski SA (Eds) Biology, phylogeny, and classification of Coleoptera papers celebrating the 80th Birthday of Roy A. Crowson. Muzeum i Instytut Zoologii PAN, Warsaw, 559–631.

Schöller M (2009) First records of Zeugophorinae from New Caledonia with description of two new species (Coleoptera: Megalopodidae, Zeugophorinae). Entomologische Zeitschrift Stuttgart 119(5): 195–198.

Sekerka L, Vives E (2013) Review of Zeugophorinae of New Guinea, with description of Zeugophorella gen. nov. and new synonyms of *Zeugophora* (Coleoptera: Megalopodidae). Acta Entomologica Musei Nationalis Pragae 53(2): 747–762.

Snodgrass RE (1935) Principles of insect morphology. McGraw-Hill Book Company, New York, 667 pp.

Takemoto T (2019) Revision of the genus *Zeugophora* (Coleoptera, Megalopodidae, Zeugophorinae) in Japan. Zootaxa 4644(1): 001–062. https://doi.org/10.11646/zootaxa.4644.1.1

Tan JJ, Yu PY, Li HX, Wang SY, Jiang SQ (1980) Economic insect fauna of China, Coleoptera: Chrysomeloidea (I). Science Press, Beijing, 213 pp. [In Chinese].

Verma KK (1996) Inter-subfamily relations among Chrysomelidae (Coleoptera) as suggested by organization of the male genital system. In: Jolivet P, Cox ML (Eds) Chrysomelidae Biology, vol. 1, Classification, Phylogeny and Genetics. Academic Publishing, Amsterdam, 317–351.

Warchałowski A (2010) The Palaearctic Chrysomelidae: identification keys. Volume 1. Natura optima dux Foundation, Warsaw, 629 pp.

Yu PY, Yang XK (1994) Biological studies on *Temnaspis nankinea* (Pic) (Chrysomelidae: Megalopodinae). In: Jolivet, PH, Cox ML, Petitpierre E (Eds) Novel Aspects of the Biology of Chrysomelidae, Series Entomologica, Vol. 50. Kluwer Academic Publishers, Dordrecht, 527–531. https://doi.org/10.1007/978-94-011-1781-4_39

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RESEARCH ARTICLE

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Species delimitation and life stage association of *Propsilocerus* Kieffer, 1923 (Diptera, Chironomidae) using DNA barcodes

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Abstract

The utility of COI DNA barcodes in species delimitation is explored as well as life stage associations of five closely related *Propsilocerus* species: *Propsilocerus akamusi* (Tokunaga, 1938), *Propsilocerus paradoxus* (Lundström, 1915), *Propsilocerus saetheri* Wang, Liu et Paasivirta, 2007, *Propsilocerus sinicus* Sæther et Wang, 1996, and *Propsilocerus taihuensis* (Wen, Zhou et Rong, 1994). Results revealed distinctly larger interspecific than intraspecific divergences and indicated a clear "barcode gap". In total, 42 COI barcode sequences including 16 newly generated DNA barcodes were applied to seven Barcode Index Numbers (BINs). A neighbor-joining (NJ) tree comprises five well-separated clusters representing five morphospecies. Comments on how to distinguish the larvae of *P. akamusi* and *P. taihuensis* are provided.

Keywords

barcode gap, bioindicator, chironomid, COI, genetic distance, larval association, *Propsilocerus taihuensis*

Introduction

The genus *Propsilocerus* Kieffer, 1923 (Fig. 1) was erected with the type species *Propsilocerus lacustris* Kieffer, 1923. At present, there are nine *Propsilocerus* species described in the Palaearctic and Oriental regions (Sæther and Wang 1996; Zelentsov 2000; Tang et al. 2004; Wang et al. 2007; Makarchenko and Makarchenko 2009) and one unnamed species from the Nearctic region (Cranston et al. 2011). Larvae of *Propsilocerus* usually inhabit eutrophic rivers and lakes. Because of their great densities and ability to adapt to different freshwater bodies, they are important food items for fishes and birds, and also bioindicators in monitoring of the freshwater ecosystem. However, the high morphological similarity between closely related species within *Propsilocerus* and intraspecific morphological variation have likely led to misidentifications, particularly in larvae. The morphological diagnosis (e.g., AR, LR_1) of closely related morphospecies needs to be evaluated to verify the identity of each *Propsilocerus* species.

All four common species, *Propsilocerus akamusi* (Tokunaga, 1938), *Propsilocerus paradoxus* (Lundström, 1915), *Propsilocerus sinicus* Sæther et Wang, 1996, and *Propsilocerus taihuensis* (Wen, Zhou et Rong, 1994) are present in Yuqiao Reservoir, Jizhou Distinct, Tianjin, China during the spring and autumn. As a result, larvae of these four species usually have been misidentified as *Propsilocerus akamusi* by ecologists in China.

DNA barcodes (Hebert et al. 2003a, b) have proven successful in species delimitation and recognition of cryptic species diversity in chironomids (Anderson et al. 2013; Lin et al. 2015; Lin et al. 2018; Song et al. 2018). However, only one named (*P. akamusi*) and one unidentified species (*Propsilocerus* sp. JC-2015) have registered public DNA barcodes in the Barcode of Life Data systems (BOLD) (Ratnasingham and Hebert 2007). Thus, it is necessary to barcode more *Propsilocerus* species, which are common species in polluted rivers and lakes.

Here we explore the utility of DNA barcodes in species delimitation and in associating life stage in *Propsilocerus*. Registering new barcodes of *Propsilocerus* species will improve the reference library of Chironomidae (Ekrem et al. 2007) for DNA metabarcoding in biodiversity assessment in monitoring freshwater ecosystems.

Materials and methods

In this study, 42 specimens of five *Propsilocerus* species (*P. akamusi*, *P. paradoxus*, *P. saetheri*, *P. sinicus*, and *P. taihuensis*) from China, Japan, Norway, and South Korea with COI barcodes were included. Twenty-six specimens with public COI barcodes were retrieved from BOLD and GenBank, and an additional 16 individuals of four *Propsilocerus* species were collected from the eutrophic lakes and reservoirs from Hebei Province, Shanghai and Tianjin, China, using D-nets, sweep nets, and light traps.

Larvae were preserved in 95% ethanol, adults in 85% ethanol, and stored at 4 °C in the dark before morphological and molecular studies. Photographs of all intact specimens were taken before dissection using a ZEISS camera mounted on a ZEISS stereomicroscope using the software AxioVision Rel. 4.8. at the College of Life Sciences,

Figure 1. Larva of *Propsilocerus taihuensis* (Wen, Zhou & Rong, 1994).

Nankai University, Tianjin, China. Digital photographs of slide specimens were taken at 300-dpi resolution using a Nikon Digital Sight DS-Fi1 camera mounted on a Nikon Eclipse 80i compound microscope.

Extraction of genomic DNA was done following the standard protocol of the Qiagen DNeasy Blood & Tissue Kit, except the volume of DNA template was 110 μl in the final step. Morphological terminology used in this work is according to Sæther (1980). The cleared exoskeleton of adults was mounted in Euparal on microscope slides together with the corresponding wings, legs, and antennae after DNA extraction. Voucher specimens from China were deposited in the College of Life Sciences, Nankai University, Tianjin, China.

DNA amplifications of COI barcode sequences with the universal primers LCO1490 and HCO2198 (Folmer et al. 1994) were carried out at the College of Fishery, Tianjin Agricultural University. Polymerase chain reaction (PCR) was set up using12.5 μl 2× Es Taq MasterMix (CoWin Biotech Co., Beijing, China), 0.625 μl of each primer, 2.5 μl template DNA, and 8.75 μl ddH_2O to make a total of 25 μl for each sample. PCR was performed on a MasterCycler Gradient (Biometra GmbH, Göttingen, Germany), with an initial denaturation step of 95 °C for 4 min followed by 40 cycles at 94 °C for 45 s, 52 °C for 45 s, 72 °C for 1 min, and one final extension at 72 °C for 10 min. PCR products were electrophoresed in 1.5% agarose gel, purified and sequenced with ABI 3730 (BGI TechSolutions Co., Lit. Beijing, China).

Raw sequences were edited and assembled in SeqMan version 7.1.0 (in the LaserGene package, DNASTAR, Madison, USA), aligned using the Muscle algorithm (Edgar 2004), and checked for stop codons on the amino acids in MEGA version 7.0 (Kumar et al. 2016). Sequences were uploaded on BOLD with collateral information and images. A public dataset including all 42 specimens, "DNA barcodes of Propsilocerus [DS-

PROPSIL]", can be found in BOLD. The neighbor-joining (NJ) trees were constructed in MEGA using Kimura 2-Parameter (K2P) substitution model, 1000 bootstrap replicates and the "pairwise deletion" option for missing data. The pairwise distances of five *Propsilocerus* species were calculated using K2P model in MEGA. To detect the "barcode gap", the aligned sequence dataset was subject to Automatic Barcode Gap Discovery (ABGD) (Puillandre et al. 2012) with the K2P model, following the default setting.

Results

DNA barcode analyses

In general, the data showed distinctly larger interspecific than intraspecific divergence, and there was a clear "barcode gap" in the pairwise K2P distances (Fig. 2). The minimum interspecific genetic distance between the closely related morphospecies *P. akamusi* and *P. taihuensis* is 13.4%. The maximum intraspecific distance of *P. akamusi* is 5.2%, 3.0% in *P. taihuensis*, 0.8% in *P. paradoxus*, and 0.5% in *P. saetheri* (*P. sinicus* is a singleton). Examining the present dataset in BOLD, 42 COI barcodes from five morphospecies of *Propsilocerus* were assigned into seven barcode index numbers (BINs). There are two BINs in each species *P. akamusi* (BOLD:ACB4994, BOLD:ACQ5058) and *P. taihuensis* (BOLD:ADX1391, BOLD:ADK5547), and a unique BIN in *P. paradoxus* (BOLD:ADX2356), *P. saetheri* (BOLD:AAM7072), and *P. sinicus* (BOLD:ADX6952).

The neighbor-joining tree (Fig. 3) based on 42 COI barcodes of *Propsilocerus* species revealed five distinct genetic clusters, corresponding to five morphospecies. The unidentified species (*Propsilocerus* sp. JC-2015) grouped into *P. taihuensis* (Fig. 3). Lar-

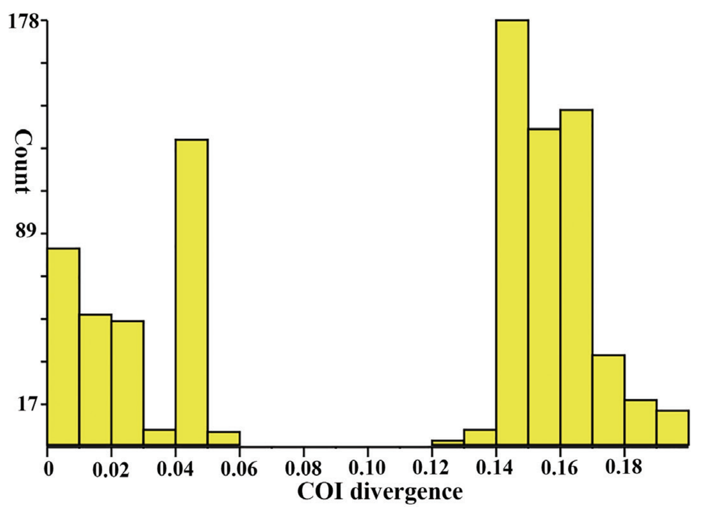

Figure 2. Histogram of pairwise K2P distances of 42 aligned sequences of five *Propsilocerus* morphospecies. The figure was a result of analysis with ABGD using the K2P model. The horizontal axis shows the pairwise K2P-distance, and the vertical axis shows the number of pairwise sequence comparisons.

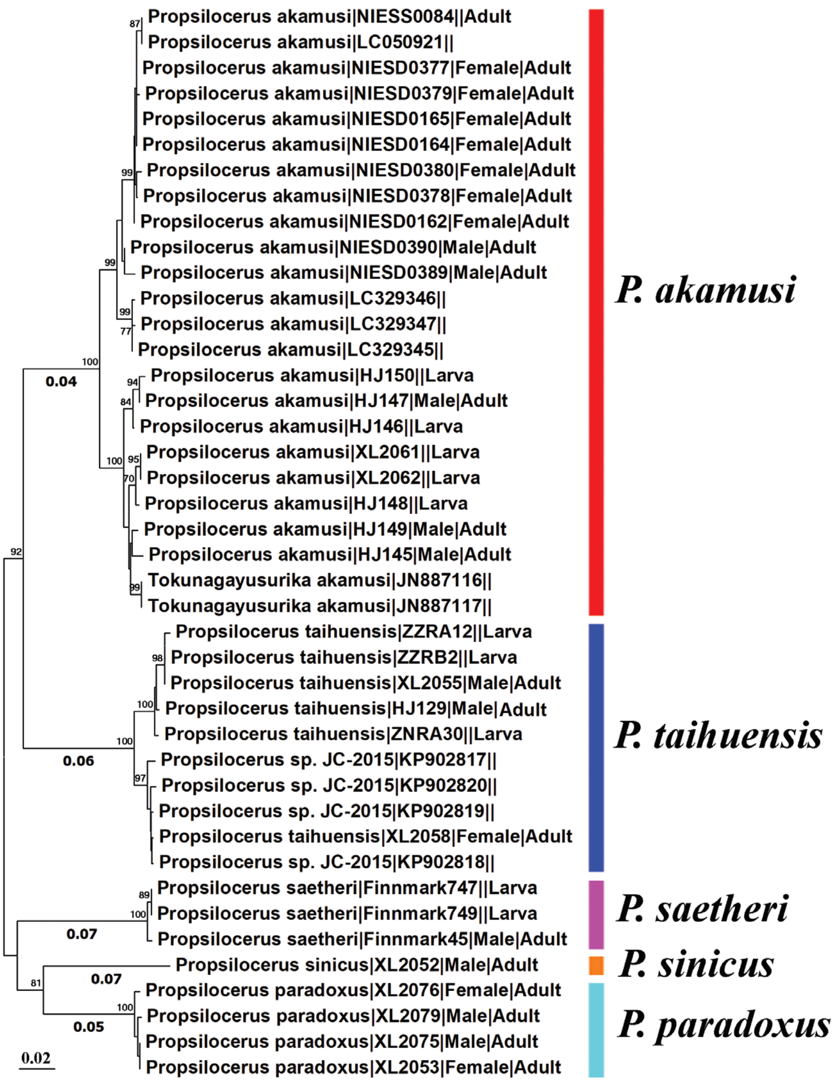

Figure 3. Neighbor-joining tree based on the 42 COI barcode sequences of *Propsilocerus*. Bootstrap support (1000 replicates) > 70% are labelled.

vae of *P. akamusi*, *P. saetheri*, and *P. taihuensis* can now be associated with adults based on DNA barcodes.

Morphology

Although it is feasible to distinguish species of *Propsilocerus* by referring to the works of Makarchenko and Makarchenko (2009), Sæther and Wang (1996), and Wang et al. (2007), misidentification of the larvae of *Propsilocerus* often occurs due to high morphological similarities. Currently, larvae of six *Propsilocerus* named species have been described. Tang et al. (2004) provided a key to the larvae of known species, and described the larvae of *P. taihuensis* based on the material from the type locality, Wuli Lake, Taihu Lake, Jiangsu Province, China. However, these larvae of *P. taihuensis* were not reared, and their identification could be uncertain. In this study, the larvae of *P. taihuensis* have been associated with adults using DNA barcodes. After reexamining the voucher and type specimens, we confirm that the description of the larvae of *P. taihuensis* by Tang et al. (2004) is correct, and *P. akamusi* can be separated from *P. taihuensis* by the relative lengths of the third and fourth antennal segments and the numbers of lateral teeth (Fig. 4) on the mentum (Tang et al. 2004). However, this is difficult in practice because larvae of *P. akamusi* and *P. taihuensis* both have dark head capsules, and 9–10 lateral teeth (often not easy to count) on the mentum, and short third and fourth antennal segments (Fig. 4). These two species can be more ef-

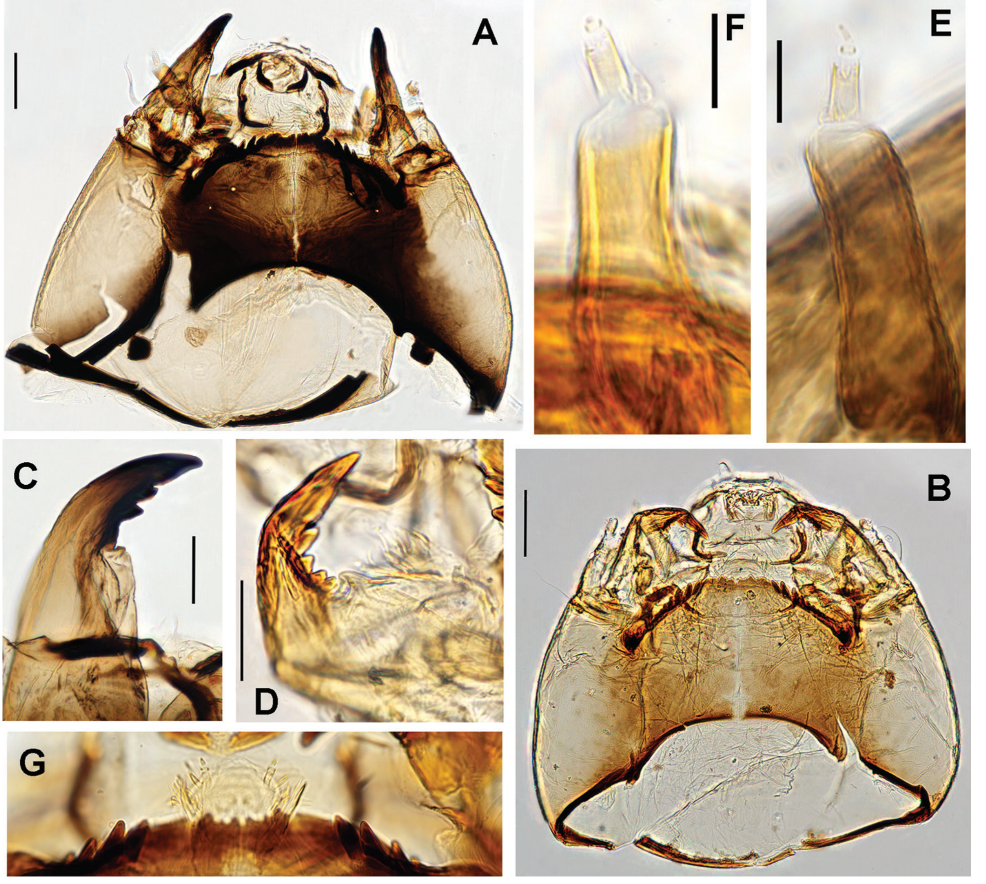

Figure 4. Head capsules of *Propsilocerus akamusi* (Tokunaga, 1938) and *Propsilocerus taihuensis* (Wen, Zhou & Rong, 1994) **A** head capsule of *P. akamusi*, ventral view **B** head capsule of *P. taihuensis*, ventral view **C** mandible of *P. akamusi* **D** mandible of *P. taihuensis* **E** antenna of *P. akamusi* **F** antenna of *P. taihuensis* **G** prementohypopharyngeal complex of *P. taihuensis*. Scale bar: 100 μm (**A, B**), 50 μm (**C, D**), 25 μm (**E, F**).

fectively distinguished by observing the premandible and mentum. In *P. akamusi*, the premandible is bifid, and the median portion of the mentum with one median notch and is subdivided into small teeth; whereas in *P. taihuensis*, the premandible is simple, and the median portion of the mentum has four teeth and one median notch.

It was also discovered that the undescribed Nearctic larva (Cranston et al. 2011) is closely related to *P. taihuensis* (Fig. 4B) in having a well-developed premento-hypopharyngeal complex (Fig. 4G) and the apical tooth longer and pointed, longer than the combined width of four teeth.

Conclusions

Our study has revealed strong concordance between morphospecies and DNA barcodes of *Propsilocerus*. Distinct "barcode gaps" were discovered among *Propsilocerus* species. DNA barcodes have been used to associate different life stages, and the unidentified species (*Propsilocerus* sp. JC-2015) was confidently assigned to *P. taihuensis*. Comments on how to distinguish this species from congeners on the larvae of *P. taihuensis* are given.

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References

Anderson AM, Stur E, Ekrem T (2013) Molecular and morphological methods reveal cryptic diversity and three new species of Nearctic *Micropsectra* (Diptera: Chironomidae). Freshwater Science 32: 892–921. https://doi.org/10.1899/12-026.1

Cranston PS, Barley E, Langley GE, Dieffenbacher-Krall A, Longmuir A, Zloty J (2011) *Propsilocerus* Kieffer (Diptera: Chironomidae) from the Nearctic. Aquatic Insects 33: 343–350. https://doi.org/10.1080/01650424.2011.639306

Edgar RC (2004) MUSCLE: multiple sequence alignment with high accuracy and high throughput. Nucleic Acids Research 32: 1792–1797. https://doi.org/10.1093/nar/gkh340

Ekrem T, Willassen E, Stur E (2007) A comprehensive DNA sequence library is essential for identification with DNA barcodes. Molecular Phylogenetics and Evolution 43: 530–542. https://doi.org/10.1016/j.ympev.2006.11.021

Folmer O, Black M, Hoeh W, Lutz R, Vrijenhoek R (1994) DNA primers for amplification of mitochondrial cytochrome *c* oxidase subunit I from diverse metazoan invertebrates. Molecular Marine Biology and Biotechnology 3: 294–299.

Hebert PDN, Cywinska A, Ball SL (2003a) Biological identifications through DNA barcodes. Proceedings of the Royal Society of London B: Biological Sciences 270: 313–321. https://doi.org/10.1098/rspb.2002.2218

Hebert PDN, Ratnasingham S, de Waard JR (2003b) Barcoding animal life: cytochrome *c* oxidase subunit 1 divergences among closely related species. Proceedings of the Royal Society of London B: Biological Sciences 270: S96–S99. https://doi.org/10.1098/rsbl.2003.0025

Kumar S, Stecher G, Tamura K (2016) MEGA7: Molecular Evolutionary Genetics Analysis version 7.0 for bigger datasets. Molecular Biology and Evolution 33: 1870–1874. https://doi.org/10.1093/molbev/msw054

Lin X-L, Stur E, Ekrem T (2015) Exploring genetic divergence in a species-rich insect genus using 2790 DNA Barcodes. PloS ONE 10: e0138993. https://doi.org/10.1371/journal.pone.0138993

Lin X-L, Stur E, Ekrem T (2018) DNA barcodes and morphology reveal unrecognized species of Chironomidae (Diptera). Insect Systematics & Evolution 49: 329–398. https://doi.org/10.1163/1876312X-00002172

Makarchenko E, Makarchenko M (2009) *Propsilocerus amurensis* sp. n. (Diptera, Chironomidae, Orthocladiinae) from Amur River basin (Russian Far East). Evraziatskii entomologicheskii zhurnal (Euroasian entomological journal) 8: 261–263.

Puillandre N, Lambert A, Brouillet S, Achaz G (2012) ABGD, Automatic Barcode Gap Discovery for primary species delimitation. Molecular Ecology Notes 21: 1864–1877. https://doi.org/10.1111/j.1365-294X.2011.05239.x

Ratnasingham S, Hebert PDN (2007) BOLD: The Barcode of Life Data System (www.barcodinglife.org). Molecular Ecology Notes 7: 355–364. https://doi.org/10.1111/j.1471-8286.2007.01678.x

Sæther OA (1980) Glossary of chironomid morphology terminology (Diptera: Chironomidae). Entomologica Scandinavica Supplement 14: 1–51.

Sæther OA, Wang XH (1996) Revision of the orthoclad genus *Propsilocerus* Kieffer (equals Tokunagayusurika Sasa) (Diptera: Chironomidae). Entomologica Scandinavica 27: 441–479. https://doi.org/10.1163/187631296X00151

Song C, Lin X-L, Wang Q, Wang X-H (2018) DNA barcodes successfully delimit morphospecies in a superdiverse insect genus. Zoological Scripta 47: 311–324. https://doi.org/10.1111/zsc.12284

Tang HQ, Guo YH, Wang XH, Saether OA (2004) The pupa and larva of *Propsilocerus taihuensis* (Wen, Zhou & Rong) (Diptera: Chironomidae), with complete keys to all immatures of the genus *Propsilocerus*. Aquatic Insects 26: 265–272. https://doi.org/10.1080/0165-0420400000585

Wang XH, Liu YD, Paasivirta L (2007) A new species of *Propsilocerus* Kieffer from Finland (Diptera: Chironomidae, Orthocladiinae). In: Andersen T (Ed.) Contributions to the Systematics and Ecology of Aquatic Diptera – A tribute to Ole A Sæther. The Caddis Press, Columbus, Ohio, 309–313.

Zelentsov NI (2000) A new Orthocladiin species of the genus *Propsilocerus* (Diptera, Chironomidae) from Taimyr Peninsula. Zoologichesky Zhurnal 79: 1242–1246.

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The position of the Azeliinae in the Muscidae (Diptera) based on musculature of the male terminalia

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Abstract

The male genital and pregenital skeleton and musculature were studied in males of the following species of the Muscidae subfamily Azeliinae: *Drymeia firthiana* (Huckett, 1965), *Drymeia longiseta* Sorokina & Pont, 2015, *Drymeia segnis* (Holmgren, 1883), *Thricops nigritellus* (Zetterstedt, 1838), *Thricops hirtulus* (Zetterstedt, 1838), *Hydrotaea dentipes* (Fabricius, 1805), *Muscina stabulans* (Fallén, 1817), and *Muscina levida* (Harris, 1780). Descriptions and figures of the genital sclerites and muscles of *D. firthiana* and *M. stabulans* are given. A comparison was made between the genital segments and muscles of previously studied species of Mydaeinae and Muscinae and those of the Azeliinae. Based on the structure of the skeleton and muscles of syntergosternite VII + VIII and the phallapodeme muscles, significant differences were found between the subfamily Azeliinae and the subfamilies Mydaeinae and Muscinae. The basal position of the Azeliinae within the family Muscidae was confirmed. A comparison of the genital segments and muscles of the Muscidae with those of the Scathophagidae (*Scathophaga stercoraria* (Linnaeus, 1758)) and Anthomyiidae (*Delia platura* (Meigen, 1826)) was made. Tendencies in reduction of the pregenital segments and musculature, as well as of the phallapodeme muscles in the evolution of the Muscoidea have been revealed. The complete set of phallapodeme muscles in the Scathophagidae and Anthomyiidae corresponds to the basal state, and therefore the structure of the genital sclerites and muscles in the Muscidae shows a certain degree of reduction. The progressive changes in the Muscidae from the Azeliinae through the Mydaeinae to the Muscinae were traced.

Keywords

abdominal segments, Calyptratae, flies, male genitalia, muscles, Muscoidea, pregenital segments, sclerites

Introduction

The Muscidae is one of the largest family of the Calyptratae (Diptera) and the largest of the Muscoidea. The world fauna includes approximately 5000 species in 180 genera (Pape et al. 2011). Despite the use of various modern methods of phylogenetic analysis, the classification of the family is still unstable and changeable, and sometimes controversial (Carvalho 1989; Carvalho et al. 2005; Schuehli et al. 2007; Fan 2008; Kutty et al. 2010, 2014, 2019; Haseyama et al. 2015; Grzywacz et al. 2017). The monophyly of the family and of some of its subfamilies (i.e., Azeliinae, Muscinae, and Coenosiinae) has been established beyond doubt, based on morphological characters and molecular data. However, the monophyly of some subfamilies (i.e., Mydaeinae and Phaoniinae) has not been supported and the traditional tribal classification has been rejected (Kutty et al. 2014, 2019; Haseyama et al. 2015).

Among the morphological characters used in phylogenetic reconstructions and classification systems, the characters describing the morphology of the muscles of the genital and pregenital structures are usually more stable than those of the sclerites (Matsuda 1976; Ovtshinnikova 1989; Friedrich and Beutel 2008). Moreover, study of the muscles helps to clarify function and homology and reveals parallelisms in the pregenital and genital sclerites (Ovtshinnikova 1989, 1994; Ovtshinnikova and Yeates 1998; Galinskaya and Ovtshinnikova 2015; Galinskaya et al. 2018; Ovtshinnikova et al. 2019).

Very few papers have dealt with the study of the male genital muscles of the Muscoidea. Hennig (1976) produced the first work on the Anthomyiidae, describing in detail the male genital muscles of *Delia platura* (Meigen, 1826) and *Fucellia tergina* (Zetterstedt, 1845), while the musculature of the pregenital sclerites was not studied. Later Ovtshinnikova (1989, 1994) studied the muscles in *Musca domestica* Linnaeus, 1758 and *Scathophaga stercoraria* (Linnaeus, 1758). Most recently, studies of the musculature of the male terminalia of the Muscoidea, and in particular that of the Muscidae, have continued with Ovtshinnikova et al. (2018, 2019) detailing the muscles of the genital and pregenital structures in some members of the Muscinae (*Musca autumnalis* De Geer, 1763, *Pyrellia rapax* (Harris, 1780)) and the Mydaeinae (*Mydaea urbana* (Meigen, 1826), *Graphomya maculata* (Scopoli, 1763)).

This paper continues the series of publications devoted to the structure of the sclerites and muscles of the abdominal segments and male terminalia in Muscidae and presents the results of our study of another subfamily, the Azeliinae. The Azeliinae was recognized as a subfamily following cladistic analyses by Carvalho (1989, 2002) and Carvalho et al. (2005). Previously, according the Hennig's classification, the Azeliini was treated as a tribe within the subfamily Muscinae and this was followed by many authors (e.g., Hennig 1965; Pont 1986; Gregor at al. 2002). However, Skidmore (1985) maintained the Azeliinae and Reinwardtiinae as separate subfamilies mainly because the larvae of Azeliinae are trimorphic or dimorphic, facultative or obligate carnivores, or parasites, unlike the larvae of other Muscinae (Skidmore 1985). Before this study, Lobanov (1979, 1984) had written about a branch of the Azeliinae ("Hydrotaeinae" in Lobanov) on the basis of his studies of the female ovipositor. Savage and Wheeler (2004) conducted a genus-level phylogenetic analysis of the tribe Azeliini within the composition of the subfamily Azeliinae.

The subfamily Azeliinae is currently divided into two tribes: Azeliini and Reinwardtiini. Most of the members of the subfamily are known as anthophilous insects, but others are known as sweat flies or synanthropic flies. The larvae are mainly carnivores and can develop in humus soil, or are saprophages developing in various decomposing substrates including human and animal feces, or are even parasites of birds. The subfamily is cosmopolitan, but with a much higher diversity in the northern hemisphere for the Azeliini (389 species in 12 genera) and in the southern hemisphere for the Reinwardtiini (128 species in 17 genera) (A. C. Pont, pers. comm.).

The monophyly of the subfamily Azeliinae is still a matter for discussion. Only the monophyly of the tribe Azeliini has been established, based on morphological characters, molecular data and also the structure and lifestyle of the larval stage (Savage and Wheeler 2004; Schuehli et al. 2007; Kutty et al. 2014; Haseyama et al. 2015). The Azeliinae are paraphyletic in all molecular analyses because Muscinae is sister-group to the Azeliini while the Reinwardtiini are polyphyletic. There are no morphological synapomorphies to support monophyly of the current Azeliinae (Azeliini + Reinwardtiini), nor do the Reinwardtiini emerge as sister-group of the Azeliini, though according to other classifications the tribe Reinwardtiini has also been shown to be the sister-group of the Azeliini (Carvalho 2002; Savage and Wheeler 2004; Carvalho et al. 2005; Savage 2009). It has even been suggested that the Reinwardtiini should be treated as a separate subfamily (Skidmore 1985; Couri and Carvalho 2003). The monophyly of the Azeliinae has been confirmed in the recent paper by Kutty et al. (2019). However, only one species (*Muscina stabulans* Fallén, 1817) was used in this analysis.

This paper presents the results of our study of the sclerites and muscles of the male abdominal segments and terminalia in members of the subfamily Azeliinae belonging to the genera *Drymeia* Meigen, 1826, *Thricops* Rondani, 1856, *Hydrotaea* Robineau-Desvoidy, 1830 (Azeliini), and *Muscina* Robineau-Desvoidy, 1830 (Reinwardtiini).

Materials and methods

The muscid material used in this paper is deposited in the collection of the Institute of Systematics and Ecology of Animals, Russian Academy of Sciences, Siberian Branch, Novosibirsk, Russia (**SZMN**).

To study the genital sclerites, dry specimens were softened in a hydration chamber; the abdomen was then detached, treated with 10% KOH solution, and dissected. The sclerites are designated here following the terminology of Sinclair (2000). The male abdomen consists of five segments; the pregenital segments VI–VIII are strongly modified as a result of the clockwise rotation of the male genitalia by 360°; the genital segments IX–XI are strongly modified.

The muscles of the male genitalia were studied by manual dissection of specimens preserved in 70% ethanol, using microknives, under a Leica MZ9^5 stereomicroscope. The illustrations were made in Photoshop CS6 and CorelDRAW X6, based on digital images of muscles and sclerites captured with a Canon EOS 77D camera mounted on the Leica MZ9^5 trinocular head. The genital muscles are classified into the following groups: abdominal, pregenital and genital muscles (tergosternal muscles, muscles of the hypandrial complex, and muscles of the epandrial complex). The muscles are numbered according to the classification of Ovtshinnikova (1989, 2000) and grouped by the sites of their origin.

The following abbreviations are used in the text: **c** – cercus; **dph** – distiphallus; **ej –** ejaculatory apodeme; **ep** – epandrium; **eph –** epiphallus; **hyp –** hypandrium; **l –** left muscle; **r –** right muscle; **pgt –** postgonite; **phap –** phallapodeme; **prgt –** pregonite; **sbeps** – subepandrial sclerite; **sp –** spiracle; **st –** sternite; **stgst –** syntergosternite; **sur –** surstylus; **tg –** tergite; **ISM –** abdominal and pregenital intersegmental sternal muscles; **ITM –** abdominal and pregenital intersegmental tergal muscles; **M1–M26 –** pregenital and genital muscles; **TSM –** abdominal and pregenital tergosternal muscles.

The muscle **M18** includes asymmetric muscles which are designated in this paper as **M18 r** and **M18 l**. This corresponds to the previously accepted designations **M18**^{1} and **M18**^{2} in *Scathophaga* (Ovtshinnikova 1994).

Because of genital rotation, sclerites of the pregenital segments do not always lie in the usual position. For this reason, characteristics such as “wide” or “narrow” in the descriptions describe only the geometric shape of the sclerites, regardless of their orientation relative to the body axis.

Results

Muscidae, Azeliinae

The structure of the sclerites of the male terminalia has been previously studied and illustrated in 26 species of *Drymeia* (Sorokina and Pont 2015), in one species of *Hydrotaea* (Sorokina and Pont 2011), and in one species of *Thricops* (Vikhrev and Sorokina 2009). The structure of the sclerites of the male genitalia of most of the known *Thricops* have been studied and clearly illustrated by Savage (2003). In addition to this, genital structures have been studied but not illustrated for many other species of these genera.

In this paper, the structure of the sclerites and muscles of the male terminalia were studied in the following species of the subfamily Azeliinae: *Drymeia firthiana* (Huckett, 1965), *D. longiseta* Sorokina & Pont, 2015, *D. segnis* (Holmgren, 1883), *Hydrotaea dentipes* (Fabricius, 1805), *Thricops hirtulus* (Zetterstedt, 1838), *T. nigritellus* (Zetterstedt, 1838), *Muscina stabulans*, and *M. levida* (Harris, 1780).

Sclerites and musculature of the male terminalia of Azeliinae

Azeliini

Since the genital skeleton and musculature in the examined species of *Drymeia*, *Thricops*, and *Hydrotaea* are very similar, the sclerites and muscles of only one species are described and illustrated here.

Drymeia firthiana **(Huckett, 1965)**
Figures 1–4, 9

Material examined. 10 males, Russia, Altai Republic, Kosh-Agach district, 8 km NE Maitobe Mt., 2420 m, 49°34'N, 87°43'E, pan traps, 7–10.vii.2006, leg. V. Sorokina.

Description. ***Abdominal segments.*** Sternite I reduced to narrow band, tergites I and II fused. Segments III and IV and tergite V not modified; sternite V enlarged, with wide median notch.

Pregenital segments (Fig. 1). Tergite VI reduced to long narrow sclerotized band. Sternite VI positioned under sternite V, reduced in size, represented by short, narrow, wavy sclerite; remainder of sternite VI desclerotized. Sternite VII long, narrow, positioned on left side of body, dilated at articulation with syntergosternite VII + VIII; ventrally connected to desclerotized left margins of sternite VI; laterally connected to syntergosternite VII + VIII. Syntergosternite relatively wide, positioned dorsally; left end wider than right end and connected to sternite VII, right end free; posterior margin extended to epandrium.

Genitalia. Hypandrium in form of concave plate, V-shaped (Fig. 2A); lateral arms of hypandrium articulated with surstyli and epandrium. Pregonites and postgonites present; pregonites larger than postgonites, tapered apically, and longer phallapodeme (Figs 2B, 9B). Phallus comprises epiphallus and distiphallus, basiphallus inconspicuous, either absent or fused with distiphallus. Phallapodeme long, articulated with phallus. Epiphallus well-developed, shaped as long and distally rounded plate. Distiphallus large, as long as pregonite, expanded distally, broadly articulated with epiphallus. Ejaculatory apodeme concave-shaped plate. Epandrium hemispherical, with large posteromedian notch (Fig. 3). Cerci large, wide, fused for a considerable length; each cercus with distal semicircular apical notch and well-formed process (Fig. 3B). Surstylus well-developed, wide, expanded and rounded apically, bent inward, with small process. Cercus approximately as long as surstylus. Subepandrial sclerite present as two long, quite wide, medially not connected plates, as long as length of surstyli and merging with them (Figs 4, 9F).

Thoracic muscles. Paired symmetrical conical muscles extend from thorax to lateromedian parts of tergite I + II, and also straight muscles extend from thorax to basal parts of sternite II.

Abdominal muscles (Fig. 1): ITM 2–ITM 4, ITM 5a, ITM 5b, ISM 2–ISM 5, TSM 1–TSM 5. Flat, very short muscles ITM 2–ITM 4 extend from distal parts of tergites II–IV along their entire width to basal margins of tergites III–V. Paired symmetrical muscles ITM 5a extend from median parts of tergite V to median parts of basal margin of tergite VI. Long, paired, almost symmetrical conical muscles ITM 5b extend from laterobasal parts of tergite V to membrane at lateral parts of tergite VI.

Paired symmetrical muscles ISM 2–ISM 4 extend along the entire basal margin of sternites II–IV to basal margins of sternites III–V, respectively. Very powerful, paired, symmetrical, fan-shaped muscles ISM 5 extend in two layers from basal margin of sternite V to sclerotized plate of sternite VI and to sternite VII at connection with

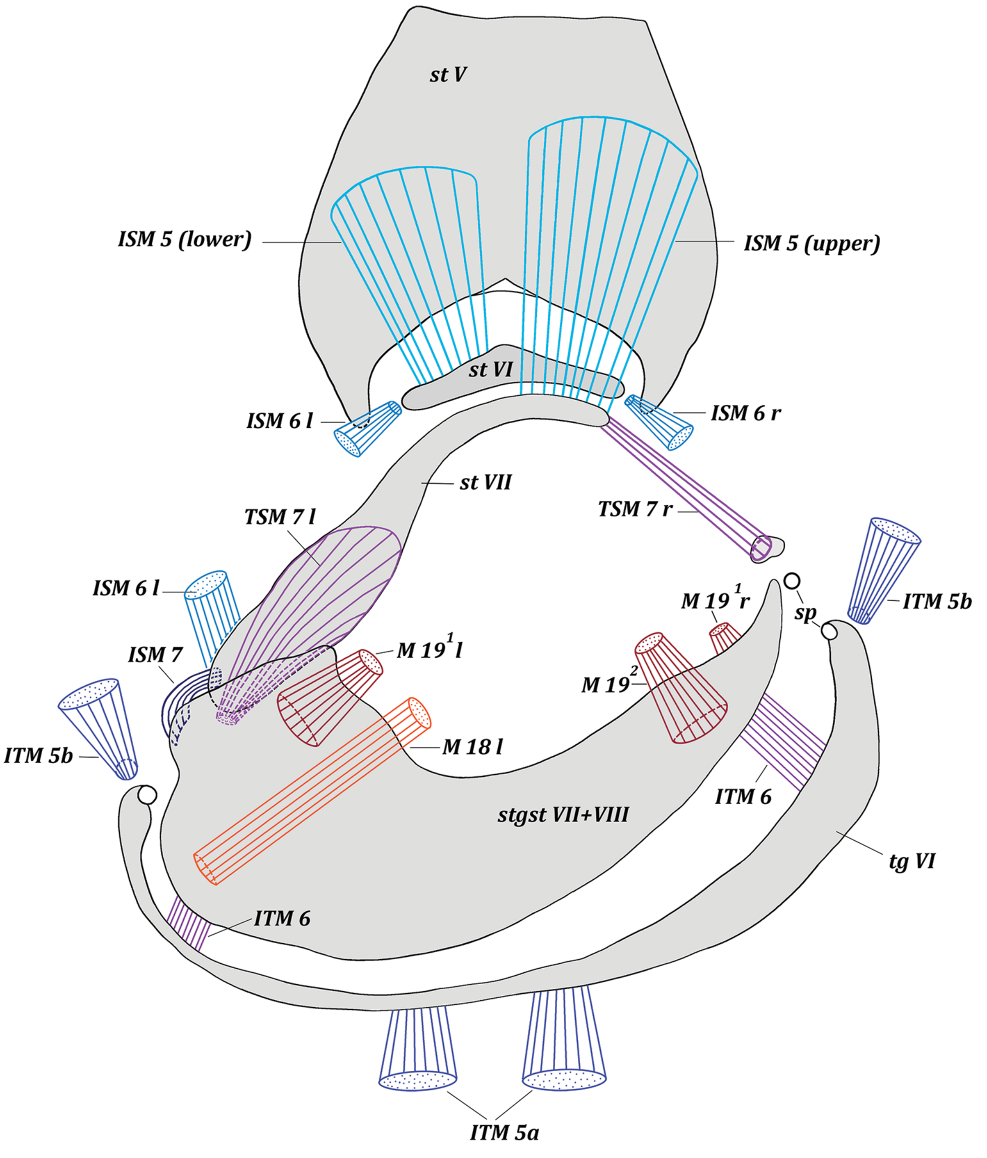

Figure 1. *Drymeia firthiana* (Huckett, 1965). Male pregenital segments, inner view. Upper muscles ISM 5 removed left and lower muscles ISM 5 removed right.

membrane of sternite VI. Muscles extending to sternite VI connected with middle part of sternite V, but muscles extending to sternite VII connected with basal part of sternite V. Wide and flat pleural abdominal muscles TSM 1–TSM 5 easily discernible on corresponding segments.

Pregenital muscles (Figs 1, 2A, 3A, 4): ITM 6, ISM 6, ISM 7, TSM 7, M 18, M 19^1, M 19^2. Small and short, paired, slightly asymmetrical muscles ITM 6 extend from lateral parts of tergite VI to lateral parts of syntergosternite VII + VIII.

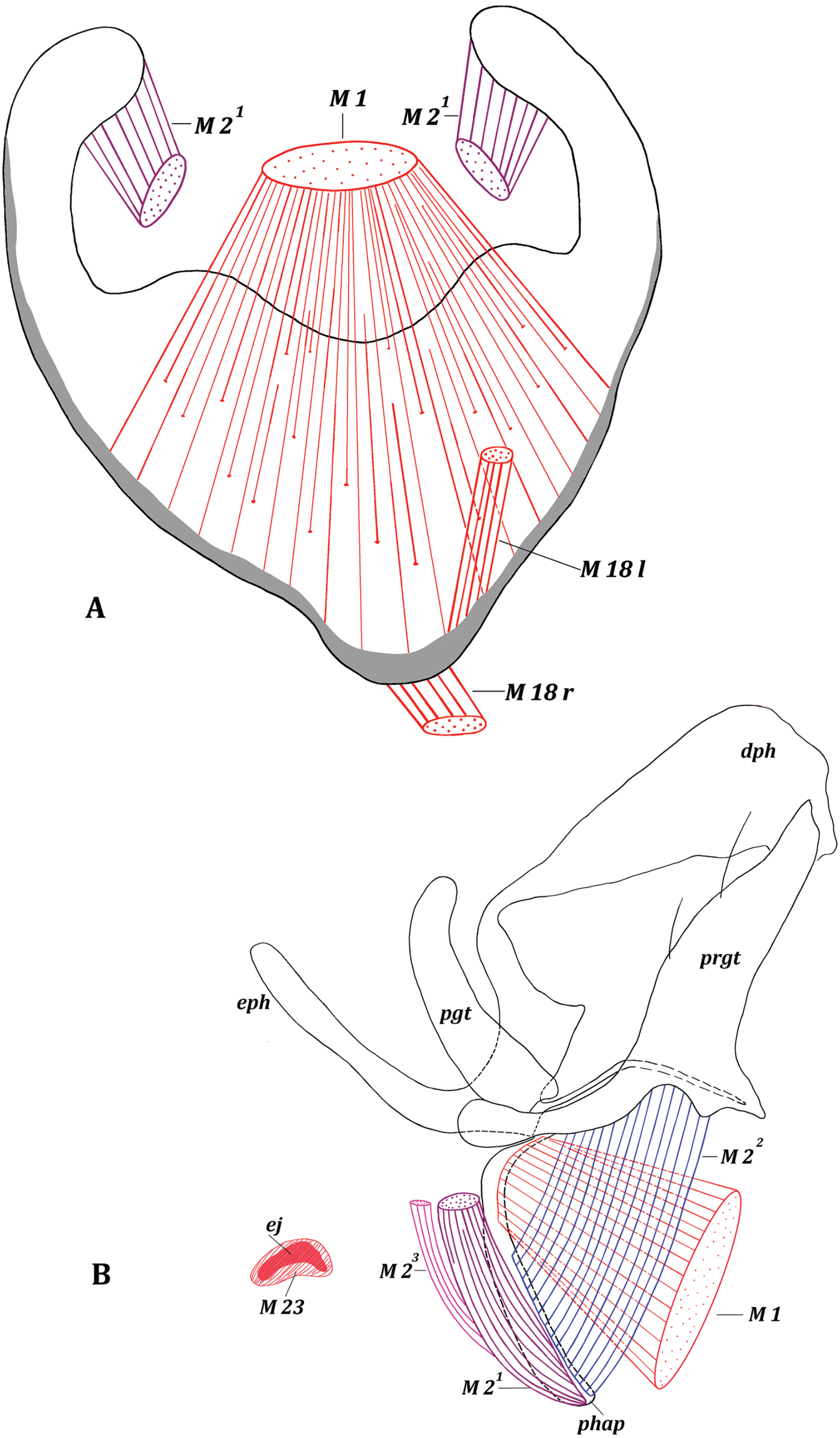

Figure 2. Male genitalia of *Drymeia firthiana* (Huckett, 1965) **A** hypandrium, inner view **B** aedeagal complex, lateral view.

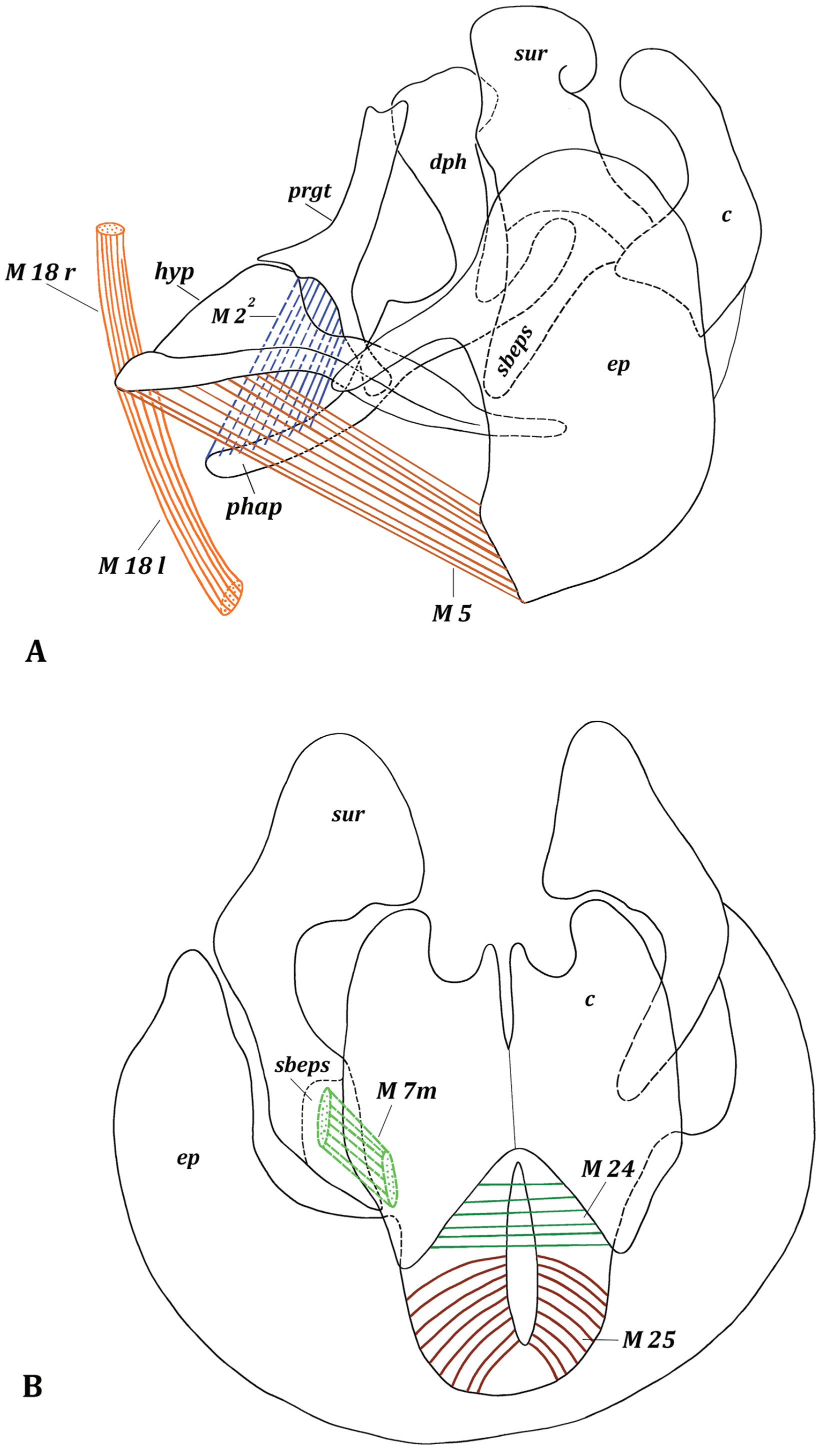

Figure 3. Male genitalia of *Drymeia firthiana* (Huckett, 1965) **A** genitalia, lateral view **B** epandrial complex, dorsal view.

Paired muscles ISM 6: left ISM 6 extends from left membranous parts of sternite VI to lateral margin of inner surface of sternite VII, articulated with syntergosternite VII + VIII; right muscle ISM 6 extends from right membranous parts of sternite VI to membrane near right laterobasal margin of syntergosternite VII + VIII; left ISM 6 larger than right muscle ISM 6. Unpaired left muscle ISM 7 short but powerful, extending from lateral margin of outer surface of sternite VII to outgrowth on lateral part of basal margin of syntergosternite VII + VIII. Paired asymmetrical muscles TSM 7: left muscle TSM 7 wide, short, fan-shaped, extending from lateral part of inner surface of sternite VII to small outgrowth on lateral margin of syntergosternite VII + VIII; right muscle TSM 7 long, fan-shaped, extending from right basal margin of sternite VII to small, sclerotized part of membrane adjacent to syntergosternite VII + VIII.

Paired asymmetrical muscles M 18: right muscle M 18 r wide and flat (homologous with left M 18 in Mydaeinae), extending from membrane covering genital cavity near syntergosternite VII + VIII to middle of basal margin of hypandrium (Figs 2A, 3A, 9C); left muscle M 18 l long (homologous with right M 18 in Mydaeinae), extending from left part of syntergosternite VII + VIII to inner surface of left laterobasal part of hypandrium. Paired asymmetrical muscles M 19^1 (Fig. 4): left muscle M 19^1 l short but powerful, extending from inner surface of small area on left lateral part of syntergosternite VII + VIII (close to connection with sternite VII) to small area on left laterobasal margin of epandrium; right muscle M 19^1 r longer but weaker than M 19^1 l, extending from right part of syntergosternite VII + VIII to right laterobasal margin of epandrium. Unpaired asymmetrical muscle M 19^2 powerful, fan-shaped, and oblique, extending from right lateral part of syntergosternite VII + VIII to slightly to right from middle of basal margin of epandrium.

Genital muscles. *Tergosternal muscles* (Figs 3A, 9C): M 5. Paired, symmetrical powerful muscles M 5 extend from lateral parts of basal margin of hypandrium to median parts of basal margin of epandrium.

Muscles of hypandrial complex (Figs 2, 9A): M 1, M 2^1, M 2^2, M 2^3, M 23. Wide and powerful, paired, symmetrical muscles M 1 extend from hypandrium, occupying considerable part of inner surface, to curve of mediobasal part of phallapodeme in front of pregonites. Long paired symmetrical muscles M 2^1 extend from arms of hypandrium to laterodistal parts of phallapodeme. Powerful paired symmetrical muscles M 2^2 extend from entire laterobasal part of pregonites to distal half of phallapodeme. Symmetrical muscles M 2^3 long and close to each other, extending from membrane of basal margin of epiphallus between lateral ends of hypandrial arms to distal part of phallapodeme, opposite epandrium; muscles M 2^3 very close to muscles M 2^1 and both look like one muscle. Constrictors of ejaculatory apodeme small; muscles M 23 surrounding ejaculatory apodeme, contraction pumps seminal fluid into phallus.

Muscles of epandrial complex (Figs 3B, 4, 9E): M 3, M 4, M 7, M 24–M 26. Powerful paired symmetrical muscles M 3 extend from inner surface of basal parts of epandrium to inner surface of basal parts of subepandrial sclerite. Powerful paired symmetrical muscles M 4 extend from lateral parts of inner surface of epandrium to inner surface of basal parts of surstyli. Paired symmetrical thin cercal muscles M 7 extend

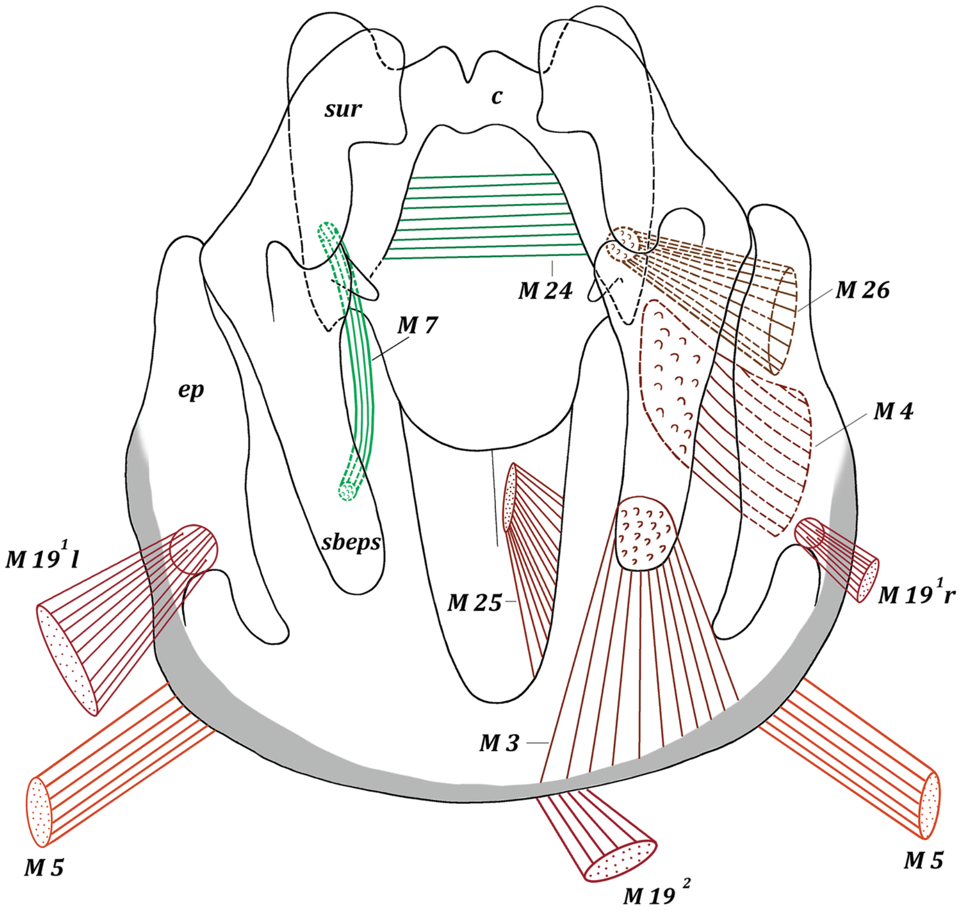

Figure 4. Male genitalia of *Drymeia firthiana* (Huckett, 1965). Epandrial complex, inner view.

from inner part of subepandrial sclerite to laterobasal parts of cerci. Broad powerful muscle M 24 passes inside cerci connecting lateral parts of two halves of cerci. Broad paired muscles M 25 extend from median parts of distal margin of epandrium to integument of anus. Powerful paired symmetrical, fan-shaped muscles M 26 extend from distolateral parts of epandrium to laterobasal margins of small cercal outgrowths.

Drymeia longiseta Sorokina & Pont, 2015

Material examined. 8 males, Russia, Altai Republic, Kosh-Agach district, 8 km NE Maitobe Mt., 2420 m, 49°34'N, 87°43'E, pan traps, 7–10.vii.2006, leg. V. Sorokina.

Comment. The muscles of this species are the same as *D. firthiana*.

Drymeia segnis (Holmgren, 1883)

Material examined. 2 males, Russia, Krasnoyarsk Krai, Taymyr Peninsula, bank of River Zakharova Rassokha, 72°42'N, 101°06'E, in yellow pan traps, 11–20.vii.2011, leg. A. Barkalov.

Comment. The muscles of this species and *D. firthiana* are the same.

Hydrotaea dentipes (Fabricius, 1805)

Material examined. 3 males, Russia, Chukotka AO, 73 km W Anadyr, lower part of Anadyr River, 64°50'N, 175°58'E, 18–24.vii.2013, leg. A. Barkalov.

Comment. The muscles of this speices and *D. firthiana* are the same.

Thricops hirtulus (Zetterstedt, 1838)

Material examined. 2 males, Russia, Altai Republic, Kosh-Agach district, 8 km NE Maitobe Mt., 2420 m, 49°34'N, 87°43'E, pan traps, 7–10.vii.2006, leg. V. Sorokina.

Comment. The muscles of this species and *D. firthiana* are the same.

Thricops nigritellus (Zetterstedt, 1838)

Material examined. 5 males, Russia, Nenetz AO, Bolvanskaya Bay, pan traps, 68°05'N, 54°47'E, 18–25.vii.2015, leg. O. Makarova and M. Bizin.

Comment. The muscles of this species and *D. firthiana* are the same.

Reinwardtiini

Among the Reinwardtiini, only *Muscina* is cosmopolitan, whilst the other 16 genera mostly occur in one or all of the tropical regions: Neotropical, Oriental, Australasian, and Afrotropical regions. One species each from *Passeromyia* Rodhain & Villeneuve, 1915 and *Synthesiomyia* Brauer & Bergenstamm, 1893 have also been found in the Palaearctic Region.

Muscina stabulans (Fallén, 1817)

Figures 5–8

Material examined. 2 males, Russia, Kurgan region, Lebyazh'e district, environs of Lisje village, 55°08'N, 66°47'E, gardens, 15.vii.2019, leg. V. Sorokina. 4 males, Leningrad region, Vyborg district, Gorkovskoe railway station, Skiph, 60°17'N, 29°31'E, 1–7.viii.2018, leg. V. Sorokina.

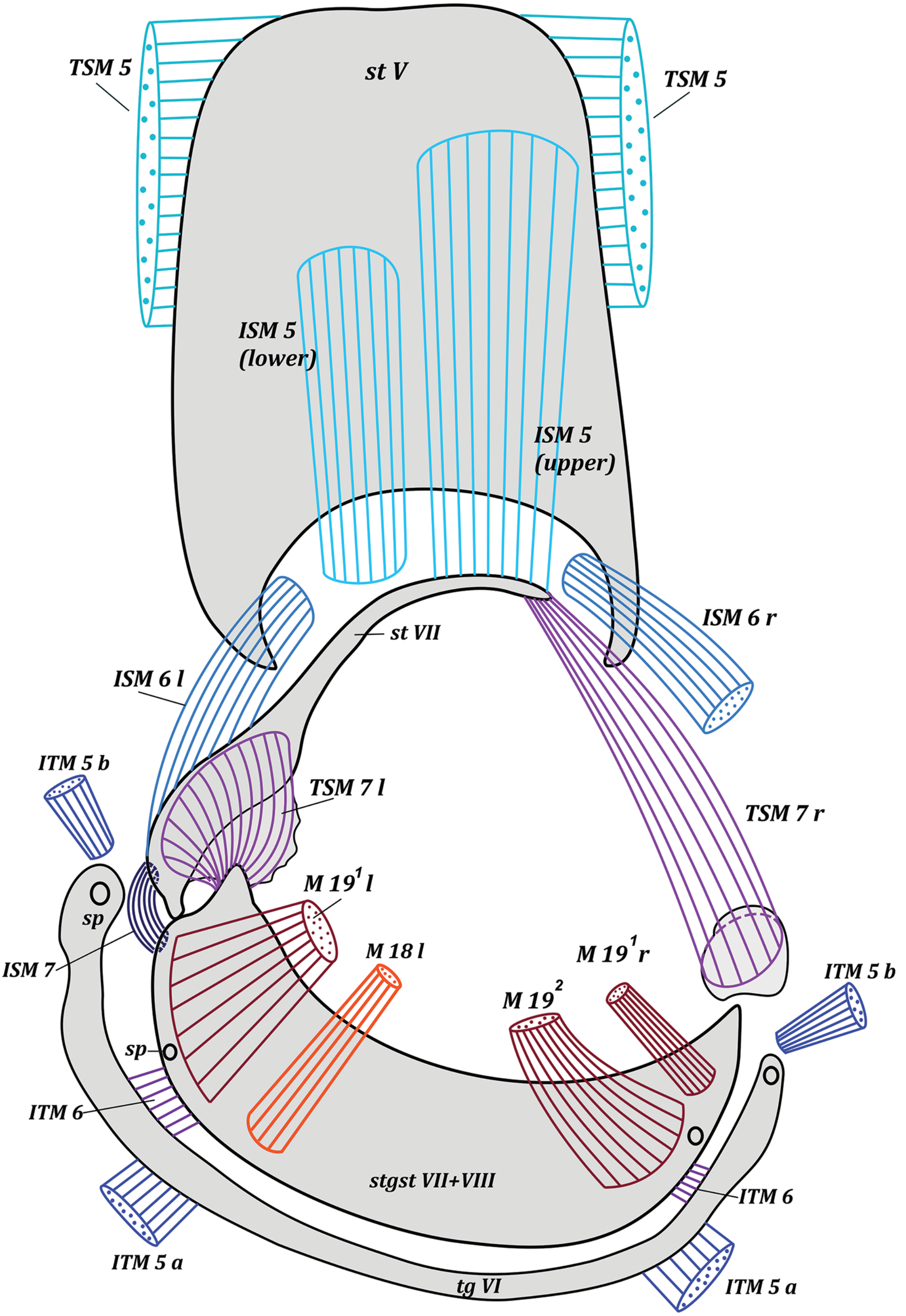

Figure 5. *Muscina stabulans* (Fallén, 1817). Male pregenital segments, inner view. Upper muscles ISM 5 removed left and lower muscles ISM 5 removed right.

Description. ***Abdominal segments.*** Sternite I reduced to narrow band, tergites I and II fused. Segments III and IV and tergite V not modified; sternite V enlarged, with wide median notch.

Pregenital segments (Fig. 5). Tergite VI reduced to long narrow sclerotized band. Sternite VI completely membranous. Sternite VII long, narrow, positioned on left side of body, dilated at articulation with syntergosternite VII + VIII; ventrally terminates on membrane between sternites V and VII (desclerotized sternite VI), laterally connected to syntergosternite VII + VIII. Syntergosternite VII + VIII relatively wide, positioned dorsally; left end wider than right end and connected to sternite VII, right end free; posterior margin extending to epandrium.

Genitalia. Hypandrium in form of concave plate, elongated, V-shaped (Fig. 6A); lateral arms of hypandrium articulated with surstyli and epandrium (Fig. 7A). Pregonites and postgonites of same size and both shorter than phallapodeme; pregonites tapered distally (Fig. 6B). Phallus containing epiphallus and distiphallus; basiphallus inconspicuous, either absent or fused with distiphallus. Phallapodeme long, articulated with phallus. Epiphallus well-developed, shaped as long, distally rounded plate. Distiphallus not large, as long as epiphallus, little expanded distally. Ejaculatory apodeme very large, sclerotized, plate-like, rounded apically (Fig. 6B). Epandrium semispherical, with large posteromedian notch (Figs 7B, 8). Cerci large, wide, fused distally (Fig. 7B). Surstylus well developed, wide, expanded and rounded apically, bent inwards, with small process. Subepandrial sclerite present as two short, quite wide, not medially connected plates, merging with surstyli (Fig. 8).

Thoracic muscles. Paired symmetrical conical muscles extend from thorax to lateromedian parts of tergite I + II, and also straight muscles extend from thorax to basal parts of sternite II.

Abdominal muscles (Fig. 5): ITM 2–ITM 4, ITM 5a, ITM 5b, ISM 2–ISM 5, TSM 1–TSM 5. Flat, very short muscles ITM 2–ITM 4 extend from distal parts of tergites II–IV along their entire width to basal margins of tergites III–V. Paired and slightly asymmetrical muscles ITM 5a extend from median parts of tergite V to lateromedian parts of basal margin of tergite VI. Long, paired, slightly asymmetrical conical muscles ITM 5b extend from laterobasal parts of tergite V to membrane at lateral parts of tergite VI.

Paired symmetrical muscles ISM 2–ISM 4 extend along entire basal margin of sternites II–IV to basal margins of sternites III–V, respectively. Paired symmetrical muscles ISM 5 extend in two layers from sternite V to membrane between sternite V and sternite VII (membranous sternite VI), spread along this membrane, and extend to sternite VII at connection with membrane of sternite VI (powerful, fan-shaped muscles). Muscles extending along membrane of sternite VI (lower layer) connected with distal part of sternite V, but muscles extending to sternite VII (upper layer) connected with basal part of sternite V. Wide and flat pleural abdominal muscles TSM 1–TSM 5 easily discernible on corresponding segments.

Pregenital muscles (Figs 5, 6A, 7A, 8): ITM 6, ISM 6, ISM 7, TSM 7, M 18, M 19^1, M 19^2. Small and short, paired, slightly asymmetrical muscles ITM 6 extend from lateral parts of tergite VI to lateral parts of syntergosternite VII + VIII.

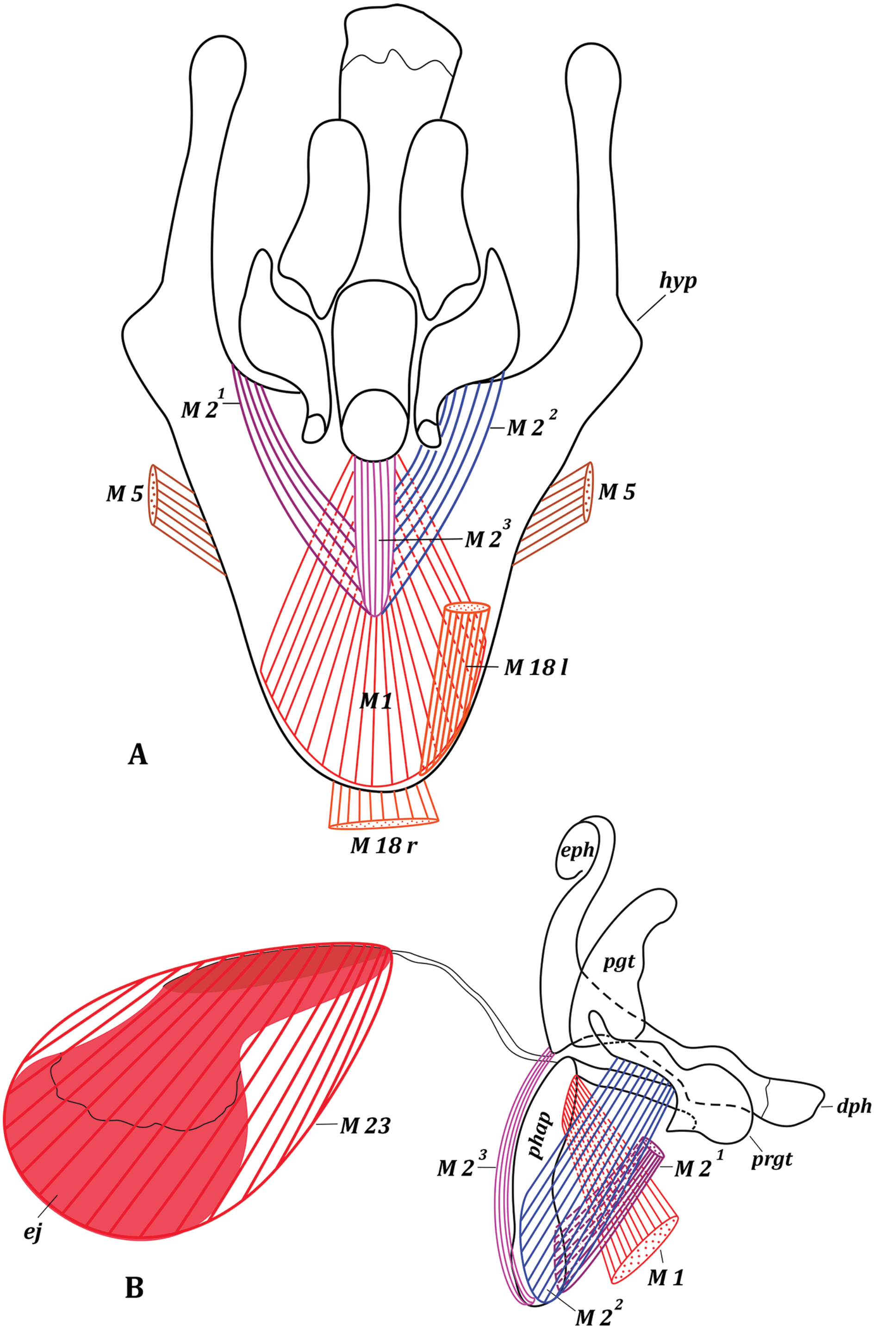

Figure 6. Male genitalia of *Muscina stabulans* (Fallén, 1817) **A** hypandrium, inner view **B** aedeagal complex, lateral view.

Paired muscles ISM 6: left ISM 6 extends from left part of membrane of sternite VI to lateral margin of inner surface of sternite VII close to articulation with syntergosternite VII + VIII; right muscle ISM 6 extends from right parts of membrane of sternite VI to membrane near right laterobasal margin of syntergosternite VII + VIII; left ISM 6 larger than right muscle ISM 6. Unpaired left muscle ISM 7 short, powerful, extending from lateral margin of outer surface of sternite VII to outgrowth on lateral part of basal margin of syntergosternite VII + VIII. Paired asymmetrical muscles TSM 7: left muscle TSM 7 wide, short, fan-shaped, extending from lateral part of inner surface of sternite VII to small outgrowth on lateral margin of syntergosternite VII + VIII; right muscle TSM 7 fan-shaped, extending from right basal margin of sternite VII to small sclerite adjacent to syntergosternite VII + VIII.

Paired asymmetrical muscles M 18: right muscle M 18 r wide and flat, extending from membrane covering genital cavity near syntergosternite VII + VIII to middle of basal margin of hypandrium (Figs 6A, 7A); left muscle M 18 l long, extending from lateromedian left part of syntergosternite VII + VIII to inner surface of left laterobasal part of hypandrium. Paired asymmetrical muscles M 19^1 (Fig. 8): left muscle M 19^1 l powerful, extending from inner surface of left lateral part of syntergosternite VII + VIII (close to connection with sternite VII) to small area of left lateral margin of epandrium at connection with hypandrium; right muscle M 19^1 r weaker than M 19^1 l, extending from right part of syntergosternite VII + VIII to right lateral margin of epandrium at connection with hypandrium. Unpaired muscle M 19^2 powerful, fan-shaped, and oblique, extending from right lateral part of syntergosternite VII + VIII to slightly to right from middle of basal margin of epandrium.

Genital muscles. *Tergosternal muscles* (Fig. 7A): M 5. Paired, symmetrical, powerful muscles M 5 extend from lateral parts of basal margin of hypandrium to lateral parts of basal margin of epandrium.

Muscles of hypandrial complex (Fig. 6): M 1, M 2^1, M 2^2, M 2^3, M 23. Wide and powerful, paired, symmetrical muscles M 1 extend from hypandrium, occupying considerable part of inner surface, to basal part of phallapodeme in front of pregonites. Paired symmetrical muscles M 2^1 extend from base of hypandrial arms to laterodistal parts of phallapodeme, opposite hypandrium. Long paired symmetrical muscles M 2^2 extend almost from entire basal part of pregonites to distal half of phallapodeme, opposite hypandrium. Symmetrical muscles M 2^3 long and close to each other, extending from membranous basal margin of epiphallus to distal part of phallapodeme, opposite epandrium.

Constrictors of ejaculatory apodeme wide and powerful; muscles M 23 surrounding ejaculatory apodeme and extending from rounded wide margin to tapered margin, contraction pumps seminal fluid into phallus.

Muscles of epandrial complex (Figs 7, 8): M 3, M 4, M 7, M 24–M 26. Powerful paired symmetrical muscles M 3 extend from inner surface of basal parts of epandrium to inner surface of subepandrial sclerite. Powerful paired symmetrical muscles M 4 extend from lateral parts of inner surface of epandrium to inner surface of basal parts of surstyli. Paired symmetrical short and thin cercal muscles M 7 extend from inner part of basal part of subepandrial sclerite to laterobasal parts of cerci. Broad powerful

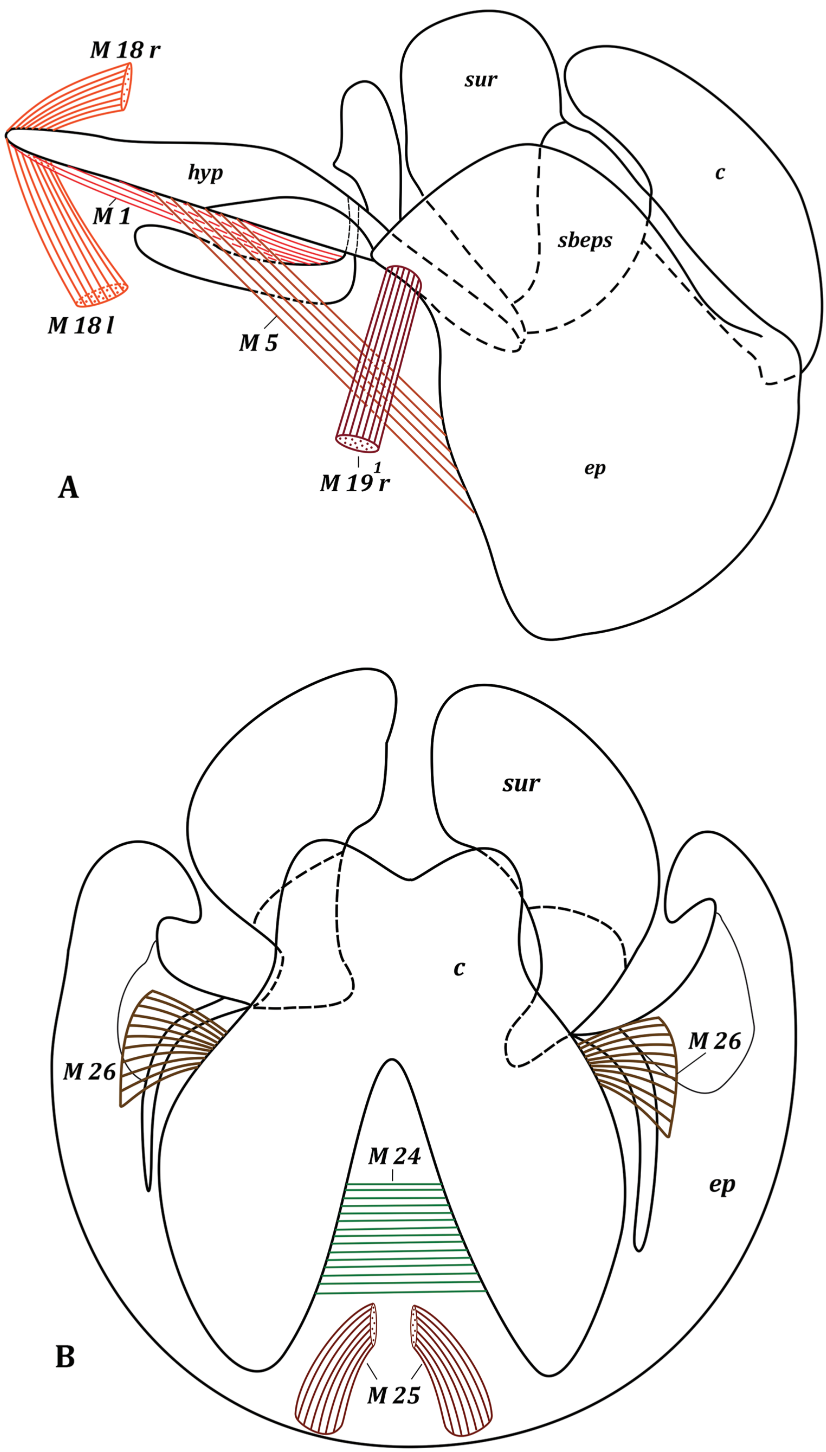

Figure 7. Male genitalia of *Muscina stabulans* (Fallén, 1817) **A** genitalia, lateral view **B** epandrial complex, dorsal view.

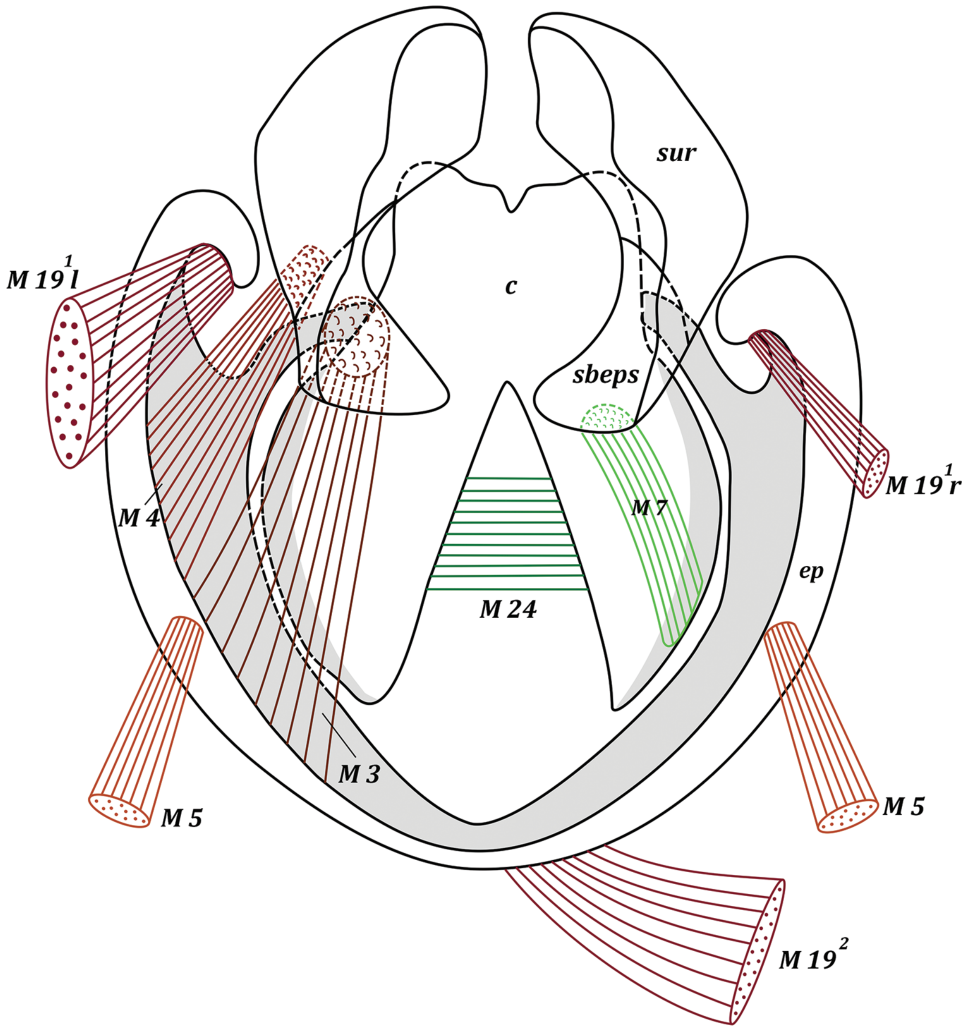

Figure 8. Male genitalia of *Muscina stabulans* (Fallén, 1817). Epandrial complex, inner view.

muscle M 24 passes inside cerci, connecting lateral parts of two halves of cerci. Broad paired muscles M 25 extend from median parts of epandrium to integument of anus. Powerful, fan-shaped, paired symmetrical muscles M 26 extend from distolateral parts of epandrium (more medially than M 4) to lateral cercal outgrowths.

Muscina levida (Harris, 1780)

Material examined. 4 males, Russia, Leningrad region, Vyborg district, Gorkovskoe railway station, Skiph, 60°17'N, 29°31'E, 1–7.viii.2018, leg. V. Sorokina.

Comment. The muscles of this species and *M. stabulans* are the same.

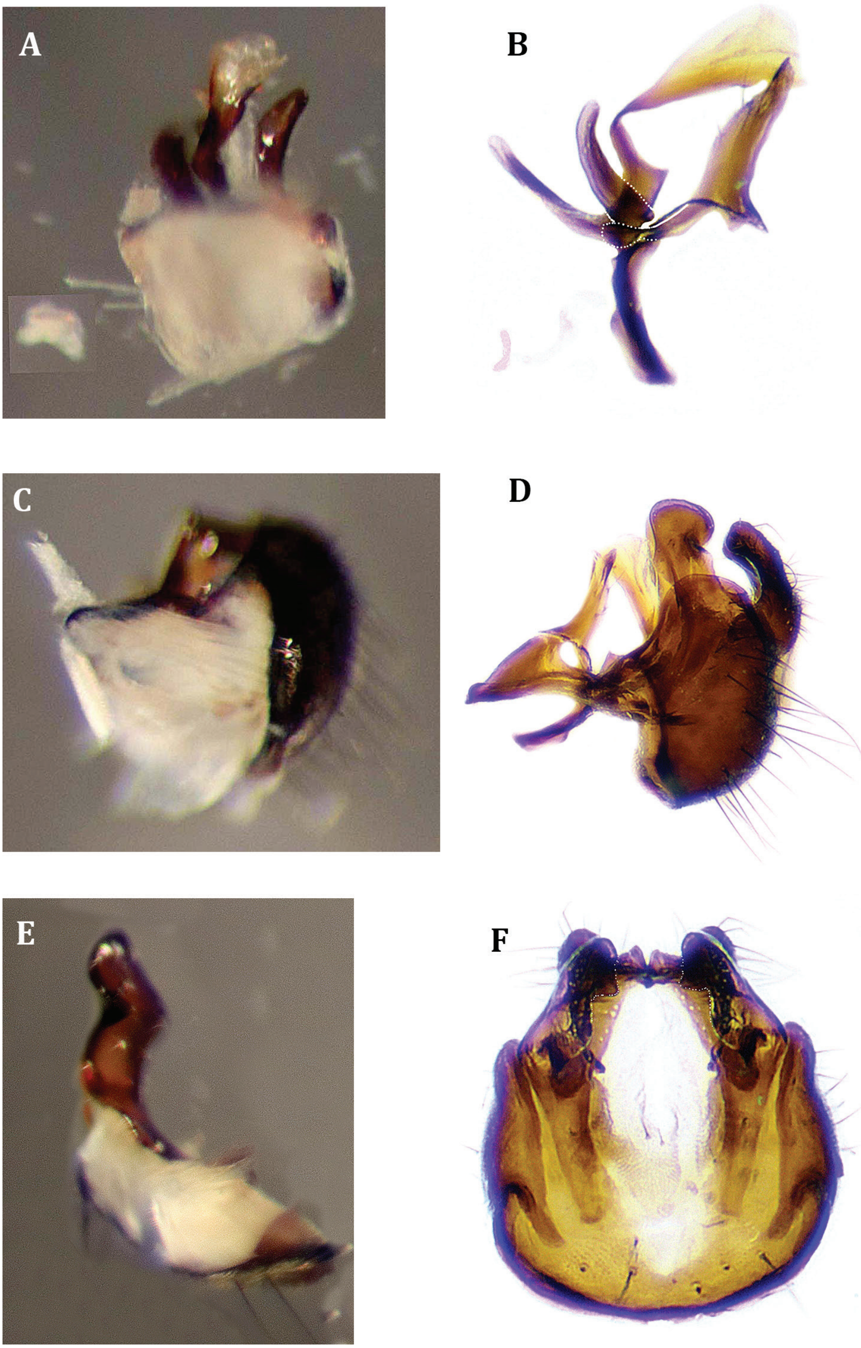

Figure 9. Male genitalia of *Drymeia firthiana* (Huckett, 1965) **A** aedeagal complex, lateral view, with muscles M 1, M 2^1, M 2^2, M 2^3, M 23 and part of hypandrium, epiphallus removed **B** aedeagal complex, lateral view, sclerites **C** genitalia, lateral view, with muscles M 18 r, M 18 l and M 5 **D** genitalia, lateral view, sclerites **E** surstyli and subepandrial sclerite, inner view, with muscles M 4, M 3 **F** epandrial complex, inner view, sclerites.

Discussion and conclusions

In the Muscidae as well as in other Cyclorrhapha, both the sclerites and the muscles of abdominal segments VI–VIII and partly IX are asymmetrical as a result of the clockwise rotation of the male genitalia by 360°. The pregenital sclerites of segments VI–VIII are partly reduced, modified, and fused. In our previous studies we used the characteristic features of the musculature to clarify the homologies of some male pregenital sclerites in the Muscidae. The homologies of the pregenital sclerites in members of different subfamilies of the Muscidae, in particular the nature of tergite VI, sternites VI and VII, syntergosternite VII + VIII, and of the hypandrial appendages, was confirmed by analysis of the muscle connections (Ovtshinnikova et al. 2018, 2019). It was confirmed that syntergosternite VII + VIII in the Muscidae consists of tergites VII and VIII, and at least part of sternite VIII.

The results on the muscles of the Azeliinae and their connections with the sclerites support our previous conclusions about the presence and the order of certain genital sclerites: tergite VI – syntergosternite VII + VIII – epandrium (tergite IX); sternite VI – sternite VII – syntergosternite VII + VIII – hypandrium (sternite IX).

The structure of the sclerites of the terminal segments in the examined species of Azeliini (*Drymeia*, *Thricops*, and *Hydrotaea*) is very similar. The main differences are the shape and the degree of development of some sclerites, for example the extent of sclerotization of the connection point of the muscle TSM 7 r. Unlike other examined species of Azeliini, both *Hydrotaea ignava* (Harris, 1780) and *H. aenescens* (Wiedemann, 1830) have a very strongly sclerotized distiphallus, very small ejaculatory apodeme, and tergite VI divided into two sclerites.

The pregenital and genital musculature in all the examined Azeliini is also very similar. The main differences are in some features of the connection points of the muscles and in their development. In members of different genera, the muscle ISM 6 extending to sternite VII can connect with the lateral margin of sternite VI or the adjacent membrane with sternite VI (desclerotized part of sternite VI). In *H. dentipes*, the muscles of phallapodeme M 2^1 extending from the hypandrial arms are much more developed than in *Drymeia* and *Thricops*.

The study of the sclerites and muscles of the terminal segments of the Reinwardtiini (*Muscina stabulans*, *M. levida*) has shown some differences from the Azeliini. Sternite VI is completely membranous. Nevertheless, as in the Azeliini, muscles ISM 5 in *Muscina* extend in two layers, one above the other, from sternite V to the membrane between sternite V and sternite VII (membranous sternite VI) and to sternite VII at its connection with the membrane of sternite VI. However, muscles of the lower layer of the Reinwardtiini are less powerful and spread along the membrane. The joints of the phallapodeme muscles M 2^1 are different between the Azeliini and the Reinwardtiini. In particular, in the Azeliini these muscles extend from the hypandrial arms close to the base of the epiphallus and they are opposite the epandrium, whereas in the Reinwardtiini M 2^1 extend from the hypandrium, i.e. are on the other side of the phallapodeme. In addition, unlike the large pregonites and postgonites of the Azeliini these structures are smaller in the Reinwardtiini. Compared with other Muscidae previously examined by us, the ejaculatory apodeme in *M. stabulans* and *M. levida* is a very large sclerotized plate located inside syntergosternite VII + VIII and the wide and powerful constrictors of ejaculatory apodeme M 23 extend from one margin of this plate to the other. The same genitalic structures of the Reinwardtiini, in particular the small pregonites and postgonites, and the very large ejaculatory apodeme were described in the Neotropical genus *Callainireinwardtia* by Savage (2009). However, in the genus *Passeromyia* of the Reinwardtiini the ejaculatory apodeme is small, not enlarged, but pregonites and postgonites are also small (Pont 1974). Since the structures of the male genitalia in this tribe were studied in fragments and not for all genera, it is currently difficult to say how much the ejaculatory apodeme size is an important feature of the tribe. Some molecular data demonstrated the differences between the Azeliini and the Reinwardtiini where the Reinwardtiini is not sister-group of the Azeliini (Schuehli et al. 2007; Kutty et al. 2014; Haseyama et al. 2015). In these analyses the affinity between most genera of the Reinwardtiini and Cyrtoneurininae has been shown and only *Reinwardtia* has been related with the Azeliini. The authors of these works suggested that the Reinwardtiini are polyphyletic, but we cannot confirm or refute it in present work because only one genus was studied by us. Thus, further study of these structures as well as the genital and pregenital muscles of different genera of the current Reinwardtiini can confirm polyphyly of the Reinwardtiini and change the position of some genera in the Muscidae and probably this tribe itself.

In our earlier papers on the study of muscles in the subfamilies Muscinae and Mydaeinae, we suggested that the features of the genital musculature in Scathophagidae were basal (plesiomorphic) (Ovtshinnikova et al. 2018, 2019). In these papers, the reduction tendencies in the structure of the sclerites and the genital and pregenital musculature in the Muscinae as compared with the Mydaeinae, basically the pregenital sclerites and phallapodeme, were also found. In the Muscinae syntergosternite VII + VIII is narrow, while it is wider (less strongly reduced and membranous) in the Mydaeinae. Correspondingly, the pregenital muscles are paired and better developed in the Mydaeinae. In the Azeliinae as compared with the Muscinae and Mydaeinae, the pregenital sclerites as well as the pregenital muscles extending from syntergosternite VII + VIII to the epandrium (M 19) and to the hypandrium (M 18) are very well developed. In particular, members of the Azeliinae have three well-developed muscles M 19 and a long M 18, whereas in members of the other subfamilies only one pair of M 19 and a small M 18 were found. Since the set of the pregenital muscles is a stable feature compared with the sclerotization of sternite VI, the complete set of pregenital muscles, in addition to the presence of non-membranous sclerites (joint of the muscle TSM 7 r) close to syntergosternite VII + VIII (a demonstration of a lesser reduction of the pregenital sclerites), indicates the basal position of the Azeliinae in the Muscidae.

In the Muscidae, differences in the development of hypandrial appendages, parts of the phallus (epiphallus, distiphallus, basiphallus) and their musculature as a result of the reduction processes, as well as their homologies, were noted earlier (Ovtshinnikova et al. 2018, 2019). These appendages are of great importance in copulation. In the studied genera of the Azeliinae, the pregonites, postgonites, and epiphallus are well developed.

The main difference in the genital musculature of the Azeliinae (Reinwardtiini and Azeliini) compared with other subfamilies of the Muscidae previously examined by us is the presence of the same large set of the phallapodeme muscles, specifically four pairs of phallapodeme muscles: M 1, M 2^1, M 2^2, M 2^3 (from the hypandrium, pregonites and the epiphallus). The set of the phallapodeme muscles in different subfamilies of the Muscidae is different, but in the Mydaeinae and Muscinae there are only two pairs of the muscle M 2: in the Muscinae M 2^1, M 2^2 (from the hypandrium and pregonites) and in the Mydaeinae M 2^2, M 2^3 (from pregonites and epiphallus). Since the set of phallapodeme muscles is a stable feature, the complete set of phallapodeme muscles (M 1, M 2^1, M 2^2, M 2^3) in the Azeliinae (as in *Scathophaga*) is considered to be the basal state and confirms the basal position of the subfamily Azeliinae within the entire family Muscidae. Moreover, our results confirms well separated subfamily Azeliinae (Carvalho 1989; Carvalho et al. 2005; Savage and Wheeler 2004; Kutty et al. 2014) but refuted newly proposed classification with only three subfamilies (Haseyama et al. 2015) because the Azeliinae and the Muscinae have different set of genital and pregenital muscles and the structure of genital and pregenital segments and they cannot be in one subfamilies as authors suggested.

Comparison of the genital skeleton and muscles in the studied species of Muscidae with those of *Scathophaga stercoraria* has shown that males of most Muscidae as well as *S. stercoraria* possess well-developed pregonites, postgonites and epiphallus. However *Scathophaga* has a larger set of muscles of the hypandrial complex: 4 pairs of phallapodeme muscles M 1, M 2^1, M 2^2, M 2^3 and the ejaculatory apodeme muscle M 23, muscles M 41 extending from the hypandrium to the basiphallus processes, muscles M 42 extending from the pregonites to the hypandrium and 2 pairs of tergosternal muscles M 5. Within the Muscidae, the set of phallapodeme muscles varies among the subfamilies, but members of all the genera we have studied possess only 1 pair of tergosternal muscles M 5, and lack muscles M 41 and M 42.

Comparison of the phallapodeme muscles of *Scathophaga* with those of *Delia platura* by Hennig (1976) has shown that *D. platura* has the same phallapodeme muscles as in *Scathophaga* (in Hennig: M 35 – 37, M 38, M 40, M 41) and one extra pair of muscles extending from the postgonites to the phallapodeme (in Hennig: M 39). In our opinion, the complete set of phallapodeme muscles in Scathophagidae and Anthomyiidae corresponds to the basal state, and the structure of the genital sclerites and muscles in Muscidae therefore reveals a certain degree of reduction. Our results about the relationships among studied families of the Calyptratae are congruent with the previous molecular hypotheses by Kutty et al. (2010, 2019).

The genital and pregenital modifications that we have detected in the Muscidae, in particular the reduction of pregenital sclerites and musculature, as well as the phallapodeme muscles, have thus allowed us to trace the progressive changes from the Azeliinae through the Mydaeinae to the Muscinae.

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References

Carvalho CJB de (1989) Classificação de Muscidae (Diptera): uma proposta através da análise cladística. Revista Brasileira de Zoologia 6(4): 627–648. https://doi.org/10.1590/S0101-81751989000400009

Carvalho CJB de [Ed.] (2002) Muscidae (Diptera) of the Neotropical Region: taxonomy. Editora Universidade Federal do Paraná, Curitiba, 287 pp.

Carvalho CJB de, Couri MS, Pont AC, Pamplona D, Lopes SM (2005) A catalogue of the Muscidae (Diptera) of the Neotropical Region. Zootaxa 860: 1–282. https://doi.org/10.11646/zootaxa.860.1.1

Couri MS, Carvalho CJB de (2003) Systematic relations among *Philornis* Meinert, *Passeromyia* Rodhain and Villeneuve and allied genera (Diptera, Muscidae). Brazilian Journal of Biology 63: 223–232. https://doi.org/10.1590/S1519-69842003000200007

Fan Z (2008) Fauna Sinica Insecta. Diptera Muscidae (1) (Vol. 49). Science Press, Beijing, 1180 pp.

Friedrich F, Beutel RG (2008) The thorax of *Zorotypus* (Hexapoda, Zoraptera) and a new nomenclature for the musculature of Neoptera. Arthropod Structure & Development 37: 29–54. https://doi.org/10.1016/j.asd.2007.04.003

Galinskaya TV, Ovtshinnikova OG (2015) Musculature of the male genitalia in *Rivellia* (Diptera: Platystomatidae). ZooKeys 545: 149–158. https://doi.org/10.3897/zookeys.545.6702

Galinskaya TV, Gafurova D, Ovtshinnikova OG (2018) X-ray microtomography (microCT) of male genitalia of *Nothybus kuznetsovorum* (Nothybidae) and *Cothornobata* sp. (Micropezidae). ZooKeys 744: 139–147. https://doi.org/10.3897/zookeys.744.22347

Gregor F, Rozkošný R, Barták M, Vaňhara J (2002) The Muscidae (Diptera) of Central Europe. Folia Facultatis Scientiarum Naturalium Universitatis Masarykianae Brunensis, Biologia 107: 1–280.

Grzywacz A, Wallman JF, Piwczyński M (2017) To be or not to be a valid genus: the systematic position of *Ophyra* R.-D. revised (Diptera: Muscidae). Systematic Entomology 42: 714–723. https://doi.org/10.1111/syen.12240

Haseyama KLF, Wiegmann BM, Almeida EAB, Carvalho CJB de (2015) Say goodbye to tribes in the new house fly classification: a new molecular phylogenetic analysis and an updated biogeographical narrative for the Muscidae (Diptera). Molecular Phylogenetics and Evolution 89: 1–12. https://doi.org/10.1016/j.ympev.2015.04.006

Hennig W (1965) Vorarbeiten zu einem phylogenetischen System der Muscidae (Diptera: Cyclorrhapha). Stuttgarter Beiträge zur Naturkunde 141: 1–100.

Hennig W (1976) 63a. Anthomyiidae [part]. In: Lindner E (Eds) Die Fliegen der Palaearktischen Region 7(1). Schweizerbart, Stuttgart, 78 pp.

Kutty SN, Pape T, Wiegmann BM, Meier R (2010) Molecular phylogeny of the Calyptratae (Diptera: Cyclorrhapha) with an emphasis on the superfamily Oestroidea and the position of Mystacinobiidae and McAlpine's fly. Systematic Entomology 35: 614–635. https://doi.org/10.1111/j.1365-3113.2010.00536.x

Kutty SN, Pont AC, Meier R, Pape T (2014) Complete tribal sampling reveals basal split in Muscidae (Diptera), confirms saprophagy as ancestral feeding mode, and reveals an evolutionary correlation between instar numbers and carnivory. Molecular Phylogenetics and Evolution 78: 349–364. https://doi.org/10.1016/j.ympev.2014.05.027

Kutty SN, Meusemann K, Bayless KM, Marinho MAT, Pont AC, Zhou X, Misof B, Wiegmann BM, Yeates D, Cerretti P, Meier R, Pape T (2019) Phylogenomic analysis of Calyptratae: resolving a major radiation of Diptera. Cladistics 35(6): 605–622. https://doi.org/10.1111/cla.12375

Lobanov AM (1979) Morphology, systematics and ecology of the family Muscidae (Diptera, Calyptrata). PhD thesis, Leningrad: Zoological Institute, Academy of Sciences of USSR.

Lobanov AM (1984) To the problem of the Muscidae phylogeny. Problems of Diptera evolution and phylogeny. Moscow, 5–17. [In Russian]

Matsuda R (1976) Morphology and Evolution of the Insect Abdomen. Headington Hill Hall Oxford England, Pergamon Press Ltd, 534 pp.

Ovtshinnikova OG (1989) Muscles of the male genitalia of Brachycera-Orthorrhapha (Diptera). Trudy Zoologicheskogo Instituta Akademii Nauk SSSR 190: 1–166.

Ovtshinnikova OG (1994) On the homology of male genital sclerites of Brachycera Orthorrhapha and Cyclorrhapha (Diptera) based on musculature. Dipterological Research 5(4): 263–269.

Ovtshinnikova OG (2000) Muscles of the Male Genitalia of Syrphidae (Diptera). NA Kholodkovsky Memorial Lectures: a Report to the 52nd Annual Meeting, April 1, 1999. St. Petersburg, 70 pp. [in Russian]

Ovtshinnikova OG, Galinskaya TV, Sorokina VS (2018) Musculature of the male abdominal segments and terminalia in *Musca autumnalis* De Geer, 1776 and *Pyrellia rapax* (Harris, 1780) (Diptera, Muscidae: Muscini). Entomological Review 98(6): 678–689. https://doi.org/10.1134/S0013873818060040

Ovtshinnikova OG, Sorokina VS, Galinskaya TV (2019) Musculature of the male abdominal segments and terminalia of *Mydaea urbana* (Meigen, 1826) and *Graphomya maculata*

(Scopoli, 1763) (Diptera, Muscidae: Mydaeinae). Entomological Review 99(5): 628–638. https://doi.org/10.1134/S0013873819050063

Ovtshinnikova OG, Yeates DK (1998) Male genital musculature of Therevidae and Scenopinidae (Diptera: Asiloidea): structure, homology and phylogenetic implications. Australian Journal of Entomology 37(1): 27–33. https://doi.org/10.1111/j.1440-6055.1998.tb01539.x

Pape T, Blagoderov V, Mostovski MB (2011) Order Diptera Linnaeus, 1758. In: Zhang Z-Q (Eds) Animal biodiversity. An outline of higher-level classification and survey of taxonomic richness. Zootaxa 3148: 222–229. https://doi.org/10.11646/zootaxa.3148.1.42

Pont AC (1974) Revision of the genus Passeromyia Rodhain and Villeneuve (Diptera: Muscidae). Bulletin of British Museum Natural History Entomology 30: 339–372. https://doi.org/10.5962/bhl.part.24943

Pont AC (1986) Family Muscidae. In: Soós A, Papp L (Eds) Catalogue of the Palearctic Diptera (Vol. 11). Budapest, Akadémiai Kiadó, 57–215.

Savage J (2003) Revision of the genus *Thricops* Rondani (Diptera: Muscidae). Insect Systematics and Evolution Supplement 61: 1–143.

Savage J (2009) A new genus and new species of Neotropical Reinwardtiini (Diptera: Muscidae). Annals of the Entomological Society of America 102(3): 354–359. https://doi.org/10.1603/008.102.0302

Savage J, Wheeler TA (2004). Phylogeny of the Azeliini (Diptera: Muscidae). Studia Dipterologica 11(1): 259–299.

Schuehli GS, Carvalho CJB de, Wiegmann BM (2007) Molecular phylogenetics of the Muscidae (Diptera: Calyptratae): new ideas in a congruence context. Invertebrate Systematics 21: 263–278. https://doi.org/10.1071/IS06026

Sinclair BJ (2000) 1.2. Morphology and terminology of Diptera male terminalia. In: Papp L, Darvas B (Eds) Contributions to a Manual of Palaearctic Diptera (Vol. 1). Science Herald, Budapest, 53–74.

Skidmore P (1985) The biology of the Muscidae of the world. Series Entomologica 29: 1–550.

Sorokina VS, Pont AC (2011) Fanniidae and Muscidae (Insecta, Diptera) associated with burrows of the Altai Mountains Marmot (*Marmota baibacina baibacina* Kastschenko, 1899) in Siberia, with the description of new species. Zootaxa 3118: 31–44. https://doi.org/10.11646/zootaxa.3118.1.2

Sorokina VS, Pont AC (2015) A review of the genus *Drymeia* Meigen, 1826 (Diptera: Muscidae) in Russia. Zootaxa 4000(2): 151–206. https://doi.org/10.11646/zootaxa.4000.2.1

Vikhrev NE, Sorokina VS (2009) Faunistic records of *Thricops* Rondani (Diptera, Muscidae) from Russia with description of two new species. Euroasian Entomological Journal 8(3): 341–350.

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A new species of *Pima* Hulst, 1888 from China (Lepidoptera, Pyralidae, Phycitinae), with a key to Holarctic species

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Abstract
Pima tristriata **sp. nov.** is described as new to science based on specimens collected from the Ningxia Hui Autonomous Region, China, and *P. boisduvaliella* (Guenée, 1845) is also treated here for comparison. DNA barcodes of the two species are provided, together with a neighbor-joining tree for species delimitation. A key to the Holarctic species and a distribution map of the Chinese species are presented.

Keywords
COI, key, new species, *Pima boisduvaliella*, *Pima tristriata*, snout moths, taxonomy

Introduction

The genus *Pima* was established by Hulst (1888) with *Pima fosterella* Hulst as the type species. Ragonot (1889, 1893) referred *P. fosterella* and the other congeneric American species to *Epischnia* Hübner, 1825. Heinrich (1956) revised the genus *Pima* from America, pointing out that *Epischnia* as defined by Ragonot was a composite of several disparate species and that none of them agreed with the type species of *Epischnia*, and transferred eight species to *Pima*. Neunzig (2003) treated nine species of *Pima* from North America, described one new species and proposed two synonyms. Leraut (2014) treated five species from Europe, including one new species and two new combinations. Tsvetkov (2016) described *P. transfusor* Tsvetkov from the South Urals. Moreno and Gastón (2017) transferred four species to *Pima*. Falck et al. (2019) described *P. tricolorella* Falck, Karsholt & Slamka from the Canary Islands of Spain. Slamka (2019) reviewed the genus in Europe, synonymized *Palloria* Amsel with *Pima* and *Pima leucomixtella* (Ragonot) with *Pima christophori* (Ragonot), transferred *Epiepischnia keredjella* Amsel and *Epischnia trifidella* Zerny to *Pima*, and described three new species. Twenty-four species have hitherto been assigned to *Pima* worldwide, mainly distributed in North America and Europe.

Two species, *Pima boisduvaliella* (Guenée) and *P. trifidella* (Zerny) were reported from China before this study. We herein describe one new species, *Pima tristriata* sp. nov., provide DNA barcodes of the new species and *P. boisduvaliella* (Guenée), and a neighbor-joining tree covering seven species for species delimitation. A key to the known Holarctic species of the genus *Pima* is also provided.

Materials and methods

The examined specimens in this study were collected by light traps in the Ningxia Hui Autonomous Region, China. Morphological terminology follows Heinrich (1956). Genitalia and wings were dissected and mounted according to the methods introduced by Li (2002). Illustrations were prepared using a Leica DM750 microscope, and refined in Photoshop® CS4 software. Photographs of adults were taken with a Leica M205A stereo microscope. The cartographic illustration was made using DIVA-GIS 7.5 (Hijmans et al. 2005). All specimens examined, including the holotype of the new species, are deposited in the Insect Collection of Nankai University, Tianjin, China (**NKU**).

DNA was extracted from dry adult specimens using Qiagen® DNeasy Blood & Tissue Kit, with the genitalia mounted on slides as vouchers. Samples were amplified using the primers LCO1490 and HCO2198 (Folmer et al. 1994) in 25 µl reaction volume: 0.75 µl of each primer (10 mM; Sangon Biotech), 2 µl DNA template, 12.5 µl mixture (KOD One PCR Master Mix; TOYOBO), and 9 µl ddH_2O. PCR reaction conditions used were as follows: 35 cycles of 98 °C for 10 s, 55 °C for 5 s, 68 °C for 1 s; then a 4 °C hold. A weak electrophoretic band of the new species was obtained, and the PCR product was recovered (SanPrep Column DNA Gel Extraction Kit; Sangon Biotech) and cloned (Hieff CloneTM Zero TOPO-TA Cloning Kit; Sangon Biotech). Positive plasmids were sent to Sangon Biotech (Shanghai, China) for sequencing.

Genetic distance estimation and neighbor-joining analysis were conducted in MEGA X using the Kimura 2-Parameter model. Thirty-eight sequences were used in the analyses: one new sequence from a paratype of *P. tristriata* sp. nov. (GenBank accession number MT749678) and three new ones from Chinese specimens of *P. boisduvaliella* (GenBank accession numbers MT734539, MT734540, MT734541), the others from BOLD (Ratnasingham and Hebert 2007). The extreme values of the interspecific and intraspecific distances were presented in Table 2, and the NJ tree was shown in Fig. 8.

Taxonomy

Pima Hulst, 1888

Pima Hulst, 1888: 114. Type species: *Pima fosterella* Hulst, 1888, by original designation and monotypy

Palloria Amsel, 1961: 362. Type species: *Palloria bicornutella* Amsel, 1961

Diagnostic characters. *Pima* is characterized by the male basal few flagellomeres shallowly incurved and containing a row of minute, tooth-like spines (Figs 1a, 2a), third segment of the labial palpus projected forward (Figs 1b, 2b); the forewing usually having a white subcostal streak (absent in *P. keredjella*, *P. milka*, *P. parkerella*, *P. pempeliella*, *P. transfusor* and *P. tristriata* sp. nov.), with 11 veins (Figs 1c, 2c), R_2 approximate to the stalk of R_{3+4} + R_5, R_{3+4} stalked with R_5 of less than half their lengths, M_2, M_3 and CuA_1 free; the hindwing with 10 veins (Figs 1c, 2c), Rs and M_1 shortly stalked, M_2 and M_3 stalked for over half their length, CuA_1 and M_2+ M_3 shortly stalked; apical process of gnathos short and stout, transtilla absent, the broad costa of the narrowed valva with a blunt, slightly forked apex (more pointed and not forked in *P. christophori*, *P. leucoloma*, *P. pempeliella*, and *P. trifidella*), the uncus with a broad base and a short pair of lateral lobes, the aedeagus with two stout cornuti (one cornutus in *P. trifidella*) in male genitalia (Figs 3, 4); the ductus bursae ribbon-like, the stout corpus bursae scobinate-granulate and usually with sclerotized patches or folds in female genitalia (Figs 5, 6).

Pima resembles *Epischnia* Hübner, but they can be separated by the following characters: in *Pima*, the male flagellum with a row of tooth-like spines near the base, the labial palpus with terminal two segments approximately of equal length; male genitalia with a broad, apically slightly forked costa, and two stout cornuti in the aedeagus; female genitalia with a strongly sclerotized, funnel-shaped antrum, the corpus bursae scobinate-granulate throughout and with sclerotized patches or folds. Whereas, in *Epischnia*, the male flagellum lacks a tooth-like spine, the third of the labial palpus is less than half the length of the second; the costa is weak and not forked at the apex, and the aedeagus has a bunch of spinules in the male genitalia; the antrum is weak or represented by a band-shaped plate, the corpus bursae is smooth on the inner surface except for one big sclerotized plate or a line of small thorns and one bunch of spinules in the female genitalia.

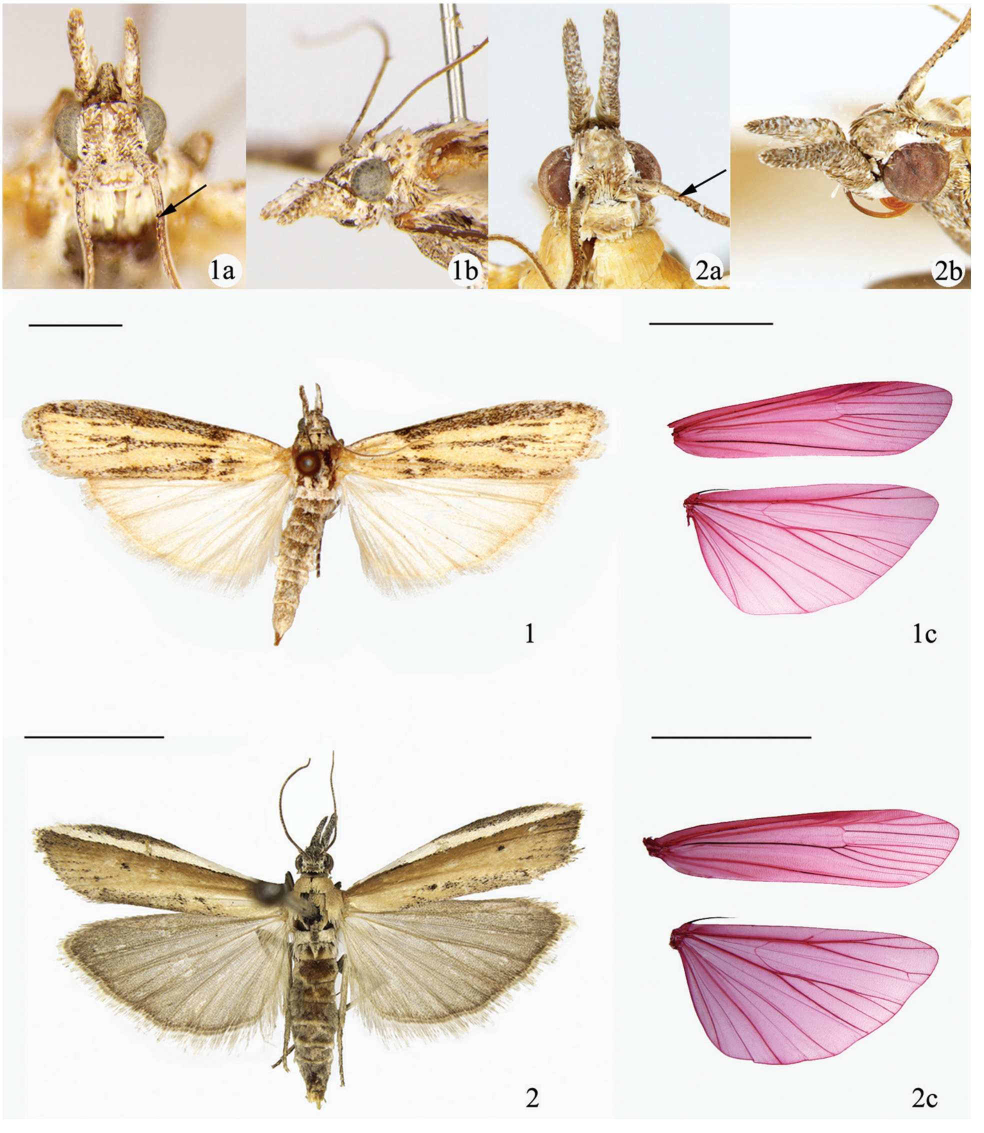
Key to Holarctic species of the genus *Pima*

1	Forewing with distinct white subcostal streak	**2**
–	Forewing with obscure white subcostal streak or absent	**17**
2	Forewing ground color creamy-whitish, with a distinct longitudinal brown streak under white subcostal streak (Amsel 1961: pl. 3, fig. 181; Slamka 2019: pl. 22, fig. 152)	***P. keredjella***
–	Forewing ground color yellowish, grayish or brown, without distinct streak under white subcostal streak	**3**
3	White subcostal streak conspicuously developed only form base of costa to the antemedial line (Falck, Karsholt and Slamka 2019: figs 5, 6)	***P. tricolorella***
–	White subcostal streak well developed along whole length of forewing	**4**
4	Costa of valva has a more pointed and not forked apex	**5**
–	Costa of valva has a blunt, slightly forked apex	**7**
5	Aedoeagus has a single cornutus (Slamka 2019: pl. 78, fig. 156)	***P. trifidella***
–	Aedoeagus has two cornuti	**6**
6	Forewing ground color grayish, with faint postmedial line (Vives Moreno and Gastón 2017: fig. 19; Slamka 2019: pl. 22, figs 154a–e)	***P. leucoloma***
–	Forewing ground color pale yellow, without transverse line (Leraut 2014: pl. 41 fig. 8; Slamka 2019: pl. 22, figs 155a–d)	***P. christophori***
7	Corpus bursae with a slug-shaped sclerotization	**8**
–	Corpus bursae without the above sclerotization	**13**
8	Two cornuti ca equal thickness	**9**
–	Shorter cornutus broader than the longer one	**10**
9	Corpus bursae heart-shaped (Fig. 6)	***P. boisduvaliella***
–	Corpus bursae oblong (Heinrich 1956: fig. 777)	***P. albiplagiatella***
10	Shorter cornutus significantly shorter than the longer one (Leraut 2014: text fig. 121c; Slamka 2019: pl. 73, fig. 146a, pl. 74, fig. 146b–d); Corpus bursae ca 1.5× length of its medial width (Leraut 2014: fig. 122a; Slamka 2019: pl. 154, fig. 146)	***P. tabulella***
–	Shorter cornutus slightly shorter than the longer one; Corpus bursae more than double length of its medial width	**11**
11	Shorter cornutus broad at base, abruptly tapered to apex (Slamka 2019: pl. 74, figs 148)	***P. marocana***
–	Shorter cornutus gradually tapered to apex	**12**
12	Gnathos-arms stouter (Slamka 2019: pl. 74, fig. 147); Corpus bursae sclerotized in posterior three-quarters (Leraut 2014: text fig. 122c; Slamka 2019: pl. 155, figs 147a, b)	***P. aureliae***
–	Gnathos-arms narrower (Slamka 2019: pl. 75, fig. 149); Corpus bursae sclerotized in posterior three-quarters (Slamka 2019: pl. 155, fig. 149a, pl. 156, fig. 149b–c)	***P. yllai***
13	Corpus bursae oblong	**14**
–	Corpus bursae nearly rounded	**15**

14 Corpus bursae without hump-shaped protuberance (Neunzig 2003: text fig. 3) . ... ***P. occidentalis***
– Corpus bursae with a sclerotized hump (Slamka 2019: pl. 156, figs 150a, b)...... .... ***P. vilhelmseni***
15 Forewing pale (Neunzig 2003: pl. 1, fig. 1); corpus bursae not sclerotized anteriorly (Heinrich 1956: fig. 783; Neunzig 2003: fig. 2c) .... ***P. fosterella***
– Forewing darker; corpus bursae sclerotized anteriorly **16**
16 Forewing salmon pink below white subcostal streak (Neunzig 2003: pl. 1, fig. 6); antrum subovate (Heinrich 1956: fig. 780) .... ***P. fulvirugella***
– Forewing dark gray to blackish brown below white subcostal streak (Neunzig 2003: pl. 1, fig. 7; Leraut 2014: pl. 41, fig. 11); antrum funnel-shaped (Heinrich 1956: figs 778, 779) .... ***P. albocostalialis***
17 Forewing with faint antemedial and postmedial lines **18**
– Forewing without transverse lines... **22**
18 Costa of valva not forked at apex.. **19**
– Costa of valva slightly forked at apex **20**
19 Juxta V-shaped, aedeagus significantly shorter than the valva, clasper present (Roesler 1990: fig. 9); apophyses posteriores slightly shorter than anteriores (Roesler 1990: fig. 10).. ***P. milka***
– Juxta U-shaped, aedeagus as long as the valva, clasper absent (Roesler 1990: fig. 11; Slamka 2019: pl. 76, fig. 153); apophyses posteriores significantly shorter than anteriores (Roesler 1990: fig. 12; Slamka 2019: pl. 157, fig. 153).... ***P. pempeliella***
20 Forewing with longitudinal grayish black streaks along costa and dorsum **21**
– Forewing without longitudinal fuscous streaks (Tsvetkov 2016: fig. 1) .... ***P. transfusor***
21 Forewing with a longitudinal grayish black streaks along lower margin of cell (Fig. 1); costa projected beyond apex of valva (Fig. 3); corpus bursae heart-shaped (Fig. 5) .... ***P. tristriata* sp. nov.**
– Forewing without longitudinal streaks along lower margin of cell (Neunzig 2003: pl. 1, fig. 10); costa not projected beyond apex of valva (Heinrich 1956: fig. 306); corpus bursae more rounded, with a projecting shield at junction with ductus bursae (Heinrich 1956: fig. 782) .... ***P. parkerella***
22 Forewing more nearly uniform, without contrasting longitudinal lines (Neunzig 2003: pl. 1, figs 11, 12) .... ***P. fergusoni***
– Forewing more black along veins (Neunzig 2003: pl. 1, figs 8, 9).... ***P. granitella***

***Pima tristriata* sp. nov.**
http://zoobank.org/06B4BDCD-1419-4541-9BAA-D42E2FAA01DC
Figures 1, 3, 5

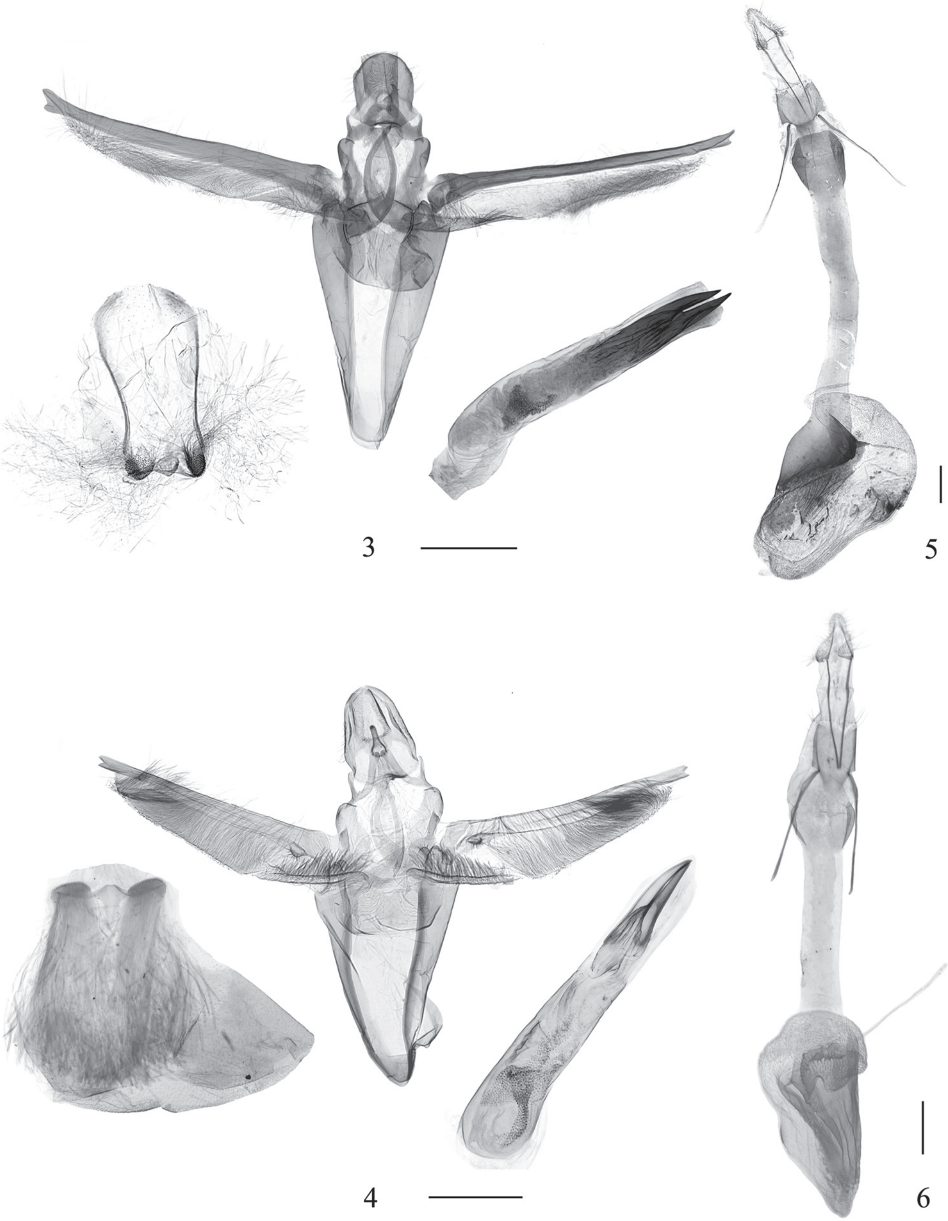
Type material. ***Holotype***: China: • ♂; Shapotou (37°31'N, 105°10'E), Zhongwei, Ningxia Hui Autonomous Region; alt. 1140 m; [?]-v-1985; Guo-Dong Ren leg.



Figures 1, 2. Adult *Pima* species. **1** *P. tristriata* sp. nov., holotype, male **1a** dorsal view of head, holotype, male **1b** lateral view of head, holotype, male **1c** wing venation, paratype, female, DYL01090 **2** *P. boisduvaliella*, female **2a** dorsal view of head, male **2b** lateral view of head, male **2c** wing venation, female, WYQ13200. Scale bars: 5.0 mm.

***Paratypes*:** China: • 7♂; same data as the holotype; genitalia nos. DYL01079, DYL01080, RYD04466 • 3♂, 2♀; same data as the holotype except dated 23-iv-1987; genitalia nos. YLL18042♂, YLL18044♂ • 2 ♀; Gantang (37°27'N, 105°32'E), Zhongwei, Ningxia; 23-v-1987; Guo-Dong Ren leg.; genitalia no. DYL01090.

Diagnosis. The new species can be easily distinguished from its congeners in having one longitudinal grayish black streak along the costa, dorsum, and lower margin of



Figures 3–6. Genitalia of *Pima* species. **3, 4** Male genitalia **3** *P. tristriata* sp. nov., paratype, YLL18044 **4** *P. boisduvaliella*, DYL01090 **5, 6** Female genitalia **5** *P. tristriata* sp. nov., paratype, LJY10110 **6** *P. boisduvaliella*, DYL00331. Scale bars: 0.5 mm.

cell respectively, whereas, most of the other congeners have a white subcostal streak. It is superficially similar to *P. parkerella* (Schaus), but with differences in genitalia: juxta with globular lateral lobes, costa projected beyond apex of valva, and corpus bursae heart-shaped in the new species; juxta with short finger-like lateral lobes, costa terminated at end of valva, and corpus bursae rounded in *P. parkerella*. It resembles *Pima boisduvaliella* (Guenée) in genitalia except for some slight differences: lateral lobes the juxta is globular, the vinculum is ca 2× length of its greatest width, the aedeagus is approximately equal to valva in length in the male genitalia, and the corpus bursae has an irregular sclerotized plate in the female genitalia. In *P. boisduvaliella*, lateral lobes the juxta is slender, finger-like, the vinculum is ca 1.5× length of its greatest width, and the aedeagus is 1.2× length of valva in the male genitalia; the corpus bursae has a couple of tortuous, sclerotized plates in the female genitalia.

Description. ***Adult*** (Fig. 1). Wingspan 25.5–31.0 mm. Head (Fig. 1a, b) grayish white. Antenna grayish white, scape ca 1.5× as long as wide, flagellum of male with short cilia, of female pubescent. Labial palpus of male grayish white mixed with a few brown scales, of female brown mixed with a few grayish white scales; first and second segments obliquely upturned, third second projected forward; third segment as long as second, twice as long as first. Maxillary palpus minute, grayish brown, in form of an aigrette. Patagium, tegula and thorax pale yellow, mottled a few brown scales. Forewing yellow, costa dorsum and lower margin of cell overlaid with a longitudinal grayish black streak respectively, more or less peppering of whitish scales; some scattered black dotting along veins and termen; antemedial line white, arched, white, from costal 1/5 slightly oblique to dorsum 1/4, inner bordering ashy black on lower half, outer edging of grayish brown; postmedial line indistinct; discal spots brown, separated; postmedial line black, obscure; cilia yellowish write. Hindwing pale gray, cilia grayish white.

Male genitalia (Fig. 3). Uncus oval, lateral margins enfolded at distal half. Apical process of gnathos conical, ca 1/3 length of uncus. Transtilla absent. Valva narrow, 5× as long as wide; clasper a narrowed triangular process, with a globular, haired base; costa stout, slightly longer than and ca 2/3 width of valva, its apex blunt, slightly forked; sacculus ca 2/5 length of valva, broader at base, tapering toward pointed apex, bearing dense, spine-like hairs along ventral margin. Juxta a broad, semicircular plate, with a pair of short, globular lateral lobes. Vinculum twice as long as its greatest width, narrowly rounded anteriorly. Aedeagus nearly as long as valva, slightly curved towards base, with a tuft of granulations near base; Cornuti two stout thorns, longer one slightly less than half length of aedeagus. Culcita one pair of long hair tufts, 2/3 length of valva.

Female genitalia (Fig. 5). Ovipositor triangular, 3× as long as wide. Apophyses posteriores slender, 3/4 length of apophyses anteriores. Eighth tergite 2/3 length of its width. Antrum strongly sclerotized, funnel-shaped, broader than eighth segment. Ductus bursae sclerotized, 1.2× as long as corpus bursae, of nearly equal width throughout, slightly broader at junction with corpus bursae. Corpus bursae heart-shaped, scobinate-granulate on inner surface, with two sclerotized patches: one oval sclerotized plate near middle; one irregular large plate from junction with ductus bursae to anterior 1/3, its posterior half smooth, forming a shallow fold along its edge, anterior half granulated and wrinkled. Ductus seminalis from posterior margin of corpus bursae.

DNA barcode. One DNA barcode from a female paratype was obtained and deposited in GenBank (accession numbers: MT749678), DNA voucher slide no. DNAYLL18119.

Etymology. The specific name is derived from the Latin prefix *tri-*, meaning three, and the Latin word *striatus*, meaning streak, referring to three grayish black streaks on the forewing.

Distribution. China (Ningxia).

Host plant. Unknown.

Pima boisduvaliella (Guenée, 1845)

Figures 2, 4, 6

Epischnia boisduvaliella Guenée, 1845: 319.
Anerastia farrella Curtis, 1850: 114.
Myelois lafauryella Constant, 1865: 189.
Pima boisduvaliella (Guenée): Hannemann 1964: 180.

Diagnosis. Adults (Fig. 2) with wingspan 15.0–22.0 mm. *Pima boisduvaliella* is characterized by the yellowish brown forewing with a white subcostal streak; the elongate valva with a well-developed costa that produced and weakly notched apically, the broad semicircular juxta with a pair of short, finger-like lateral lobes, the V-shaped vinculum ca 1.5× length of its greatest width, and the aedeagus with two thorns that slightly less than half the length of the aedeagus in the male genitalia (Fig. 4); the rounded antrum, the heart-shaped corpus bursae with dense microtrichia in anterior 1/3, with a small oval sclerotized plate and a couple of tortuous, sclerotized plates in the female genitalia (Fig. 6).

Three DNA barcodes were obtained and deposited in GenBank: a male collected on August 19, 2007 at alt. 2178 m in Mt. Xinglong, Yuzhong County, Gansu Province, accession no. MT734539, DNA voucher slide no. DNAYLL18043; a male collected on July 24, 2013 at alt. 1461 m in Habahu, Yanchi County, Ningxia Hui Autonomous Region, accession no. MT734540, DNA voucher slide no. DNAYLL18076; a male collected on August 3, 2010 at alt. 1836 m in Shuimogou, Mt. Helan, Alxa Zuoqi, Inner Mongolia Autonomous Region, accession no. MT734541, DNA voucher slide no. DNAYLL18118.

Distribution. China (Gansu, Hebei, Inner Mongolia, Liaoning, Ningxia, Qinghai, Shaanxi, Shanxi, Xinjiang, Xizang) (Fig. 7), Europe (Slamka 2019: 128, fig. 145), Canada, USA.

Host plants. Leguminosae: *Anthyllis vulneraria* L., *Astragalus dasyanthus* Pall., *Astracantha arnacanthoides*, *Lathyrus japonicus* Willd., *Lotus corniculatus* L., *Ononis spinosa* L., *O. arvensis* L., *Hibiscus esculentus* (Heinrich 1956; Leraut 2014; Slamka 2019).

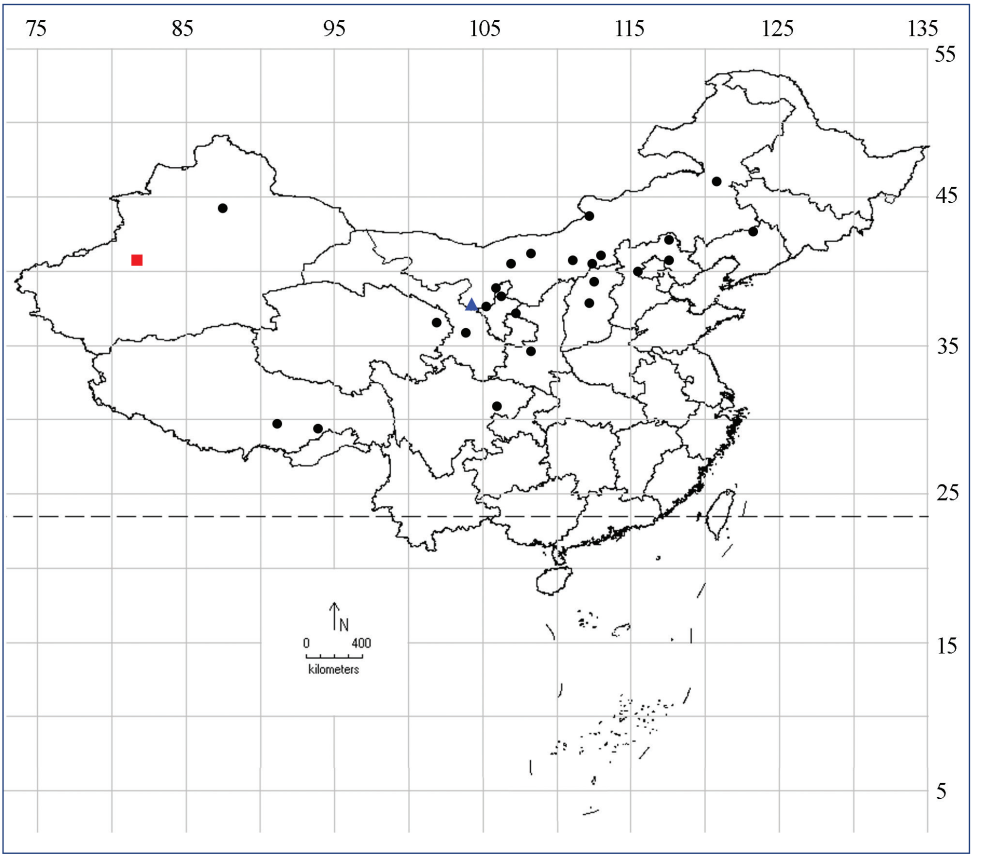


Figure 7. Geographical distribution of *Pima* in China: *P. tristriata* sp. nov. (triangle), *P. boisduvaliella* (circle); *P. trifidella* (square).

Discussion

Pima is a genus containing 25 species of which 15 are Palaearctic (Roesler 1990; Leraut 2014; Tsvetkov 2016; Vives Moreno and Gastón 2017; Slamka 2019), nine species are Nearctic (Heinrich 1956; Neunzig 2003), and two are Afrotropical (Joannis 1927) (Table 1). Species of *Pima* might be expected to occur at higher elevations, as most of them were recorded from mountainous areas. In China (Fig. 7), *P. boisduvaliella* is mainly distributed in the north, but also occurred in the west, such as Xinjiang and Tibet; *P. trifidella* is distributed in Xinjiang; and *P. tristriata* sp. nov. is only found in Zhongwei, Ningxia. Adults of the two species were collected from mountain areas with altitudes ranging from 900 m to 3050 m.

The genetic distance analysis was made based on the pairwise analysis of 38 sequences. According to the NJ bootstrap consensus tree (Fig. 8), ten well-supported

Table 1. Distribution of the *Pima* species in the worldwide .

Species	Distribution
P. albiplagiatella	southeastern Canada and northeastern USA
P. albocostalialis	southwestern Canada, Pacific Coast states and Rocky Mountain states of USA
P. aureliae	Tunisia
P. boisduvaliella	from Europe to Central Asia, Southern Canada and Northern USA
P. christophori	Armenia, Georgia, Iran, Turkey, Turkmenistan
P. difficilis	Mozambique
P. fergusoni	Oregon and California of USA
P. flavidorsella	Mozambique
P. fosterella	western Canada and USA
P. fulvirugella	south central and southwestern Canada and Northern California
P. granitella	Rocky Mountain and Pacific Coast states of USA
P. keredjella	Iran
P. leucoloma	Crimea, Croatia, Cyprus, Greece, Italy, Lebanon, Spain, Syria, W Turkey, Tunisia
P. marocana	Morocco
P. milka	Iran
P. occidentalis	Rocky Mountain and Pacific Coast states of USA
P. parkerella	Montana of Canada
P. pempeliella	Morocco
P. tabulella	Altai Republic, NW Mongolia, Turkmenistan
P. transfusor	South Urals
P. tricolorella	Spain
P. trifidella	China
P. tristriata sp. nov.	China
P. vilhelmseni	Libya, Morocco, Tunisia
P. yallai	Morocco, Tunisia

Table 2. Percentage of divergence in the cytochrome c oxidase subunit I (COI) gene sequences of the *Pima* species.

		1	2	3	4	5	6	7	8	9	10	11
1	*Epischnia illotella*											
2	*E. prodromella*	7.4										
3	*Pima albiplagiatella*	12.8–13	9.4–9.9	**0–1.2**								
4	*P. albiplagiatella* (sp. inquirenda)	12.1–12.5	9.2–9.9	5.4–6.2	**0–0.8**							
5	*P. fosterella*	11.1–12.5	9.4	1.7–2.2	5.2–6.4	**0**						
6	*P. fosterella* (sp. inquirenda)	11.4–12.3	9.0–9.2	6.2–7.5	3.5–4.7	5.4–6.0	**0.3–1.2**					
7	*P. albocostalialis*	12.9	9.4	5.0–5.9	5.2–5.7	5.4–5.6	6.0–6.4					
8	*Pima* sp.	11.3	9.4	5.2–5.9	4.7–5.5	5.4–5.7	5.9–6.0	2.6	**0**			
9	*P. boisduvaliella*	11.6–12.3	8.4–9.2	2.3–3.2	4.5–5.5	2.0–3.1	5.7–6.1	5.6–6.2	5.4–5.9	**0–0.6**		
10	*P. occidentalis*	11.7–12.1	8.5–8.7	5.4–6.4	3.9–4.9	5.5–5.8	4.6–5.2	4.7–5.0	5.9	5–5.9	**0.2–0.9**	
11	*P. parkerella*	14.4	12	8.1–9.1	7.6–7.8	8	7.3–8.2	6.5	7.3	8.1–9.2	6.2–6.4	
12	*P. tristriata* sp. nov.	15.6	13.6	13.3–13.8	15.5–15.9	13.3–13.6	15.9–16.4	15.1	15.1	12.5–13.4	15.3–15.5	18.6

Genetic distances (%) were corrected with the Kimura two-parameter (K2P) substitution model using MEGA X; extreme values of intraspecific and interspecific distances are given (the numbers in bold are the intraspecific distances).

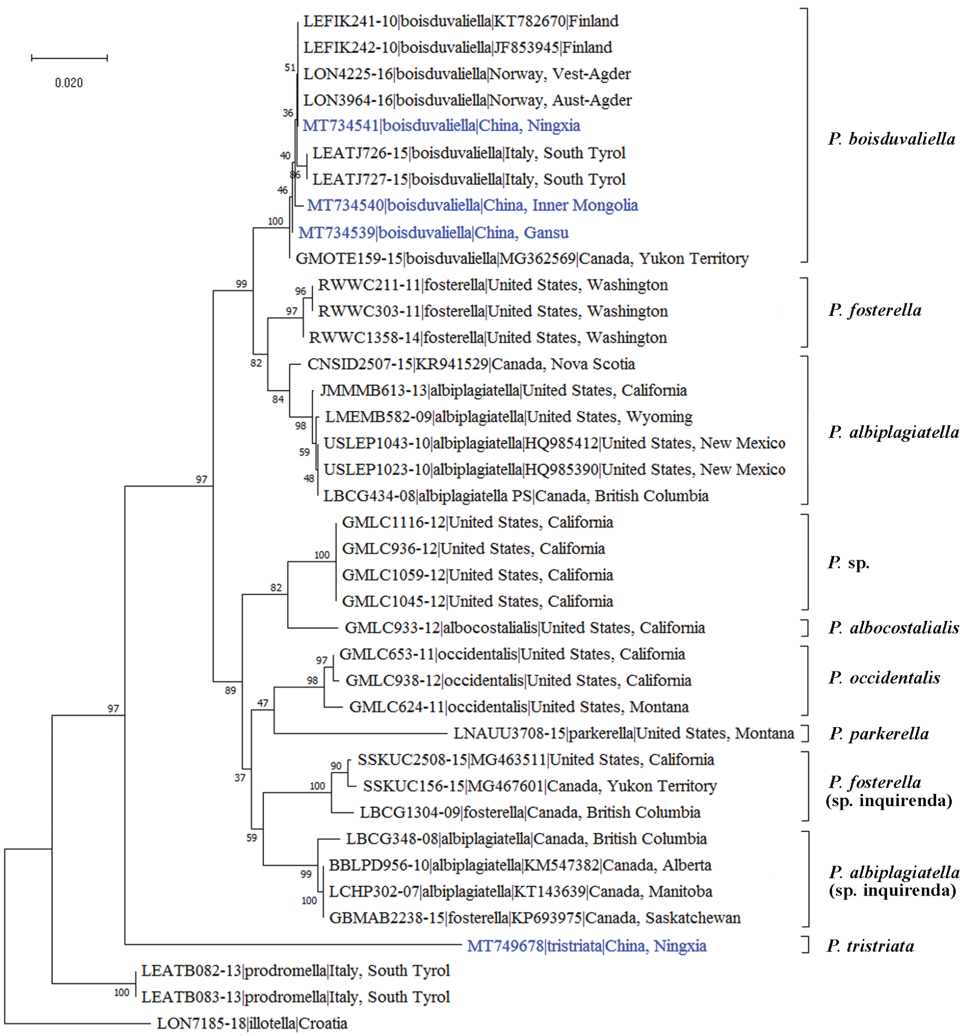


Figure 8. Neighbor-joining tree deduced from the cytochrome c oxidase subunit I (COI) gene sequences using MEGA X. Sequences were corrected with the Kimura two-parameter substitution model. Codon positions included were 1st + 2nd + 3rd + non-coding. Values represented at the nodes of branches are bootstrap values (1000 replicates).

clusters of *Pima* were revealed: *P. tristriata* sp. nov. is clearly distinguished from its congeners, and this is highly consistent with the morphological analysis; three specimens (LBCG348-08, BBLPD956-10, LCHP302-07) labeled *P. albiplagiatella*, two specimens (GBMAB2238-15, LBCG1304-09) labeled *P. fosterella*, and an additional two unidentified specimens (SSKUC2508-15, SSKUC156-15) might represent two unnamed species, as members show higher divergences with *P. albiplagiatella* and *P. fosterella*, here treated as *P. albiplagiatella* sp. inquirenda and *P. fosterella* sp. inquirenda. Sequence divergences among individuals (Table 2) indicated that minimal interspecific distances range from 1.7 to 2.2%, and the maximal intraspecific distances range from 0 to 1.2%. The present analysis is limited by the relatively small number of species that have been sequenced, and further study is necessary to determine the boundaries of intraspecific and interspecific distances, and whether the minor morphological difference is intraspecific variation or interspecific difference.

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References

Amsel HG (1961) Die Microlepidopteren der Brandt'schen Iran-Ausbeute. 5. Teil. Arkiv för Zoologi (2)13(17): 323–445. [pls 1–9]

Constant A (1865) Description de quelques lépidoptères nouveaux. Annales de la Société Entomologique de France (4)5: 189–198.

Curtis J (1850) Notes upon the smaller British Moths, with descriptions of some nondescript or imperfectly characterized species. Annals and Magazine of Natural History, including Zoology, Botany and Geology (2)5: 110–121. https://doi.org/10.1080/03745486009494898

Falck P, Karsholt O, Slamka F (2019) New data on Pyraloidea from the Canary Islands, Spain (Lepidoptera: Pyraloidea). SHILAP. Revista de Lepidopterologia 47(185): 33–48. https://www.researchgate.net/publication/332173100

Folmer O, Black M, Hoeh W, Lutz R, Vrijenhoek R (1994) DNA primers for amplification of mitochondrial cytochrome coxidase subunit I from diverse metazoan invertebrates. Molecular Marine Biology and Biotechnology 3: 294–299.

Guenée MA (1845) Essai sur une nouvelle classification des Microlépidoptères et catalogue des espèces européennes. Annales de la Société Entomologique de France (2)3: 105–192, 297–344.

Hannemann HJ (1964) Kleinschmetterlinge oder Microlepidoptera II. Die Wickler (s.l.) (Cochylidae und Carposinidae). Die Zünslerartigen (Pyraloidea). In: Dahl F (Ed.) Die Tierwelt Deutschlands 50. 401 pp. [pls 1–22]

Heinrich C (1956) American moths of the subfamily Phycitinae. Bulletin of the United States National Museum 207: 1–581. [figs 1–1138] https://www.biodiversitylibrary.org/page/32376942

Hijmans RJ, Guarino L, Jarvis A, O'Brien R, Mathur P, Bussink C, Cruz M, Barrantes I, Rojas E. 2005a. DIVA GIS 7.5. http://www.diva-gis.org/ [Accessed 2 December 2019]

Hulst GD (1888) New genera and species of *Epipaschiae* [sic] and Phycitidae. Entomologica Americana 4: 113–118.

Joannis J de (1927) Pyralidae d'Afrique australe principalement du district de Laurenço-Marquès. Bulletin de la Société lépidoptérologique de Genève, Genève 5: 181–256.

Leraut PJA (2014) Moths of Europe, Pyralids 2. N.A.P. Editions, Verrières-le-Buisson, France, 441 pp. [69 pls, 190 text figs]

Li HH (2002) The Gelechiidae of China (I) (Lepidoptera: Gelechioidea). Nankai University Press, Tianjin, 504 pp. [In Chinese]

Moreno AV, Gastón J (2017) Contribución al conocimiento de los Microlepidoptera de España, con la descripción de una especie nueva (Insecta: Lepidoptera). SHILAP. Revista de Lepidopterologia 45(178): 317–342. https://www.redalyc.org/pdf/455/45551614016.pdf

Neunzig HH (2003) Pyraloidea, Pyralidae (part). Phycitinae (part). In: Dominick RB, Franclemont JG, Hodges RW, Monroe EG (Eds) The Moths of America North of Mexico Including Greenland, fasc. 15.5. The Wedge Entomological Research Foundation, Washington, 338 pp.

Ragonot EL (1889) Phycitidae and Galleriidae of North America. Some new species and a general catalogue. Entomologica Americana 5(6): 113–117.

Ragonot EL (1893) Monographie des Phycitinae et des Galleriinae. In: Romanoff NM (Ed.) Mémoires sur les Lépidoptères 7: 1–658. [pls 1–23]

Ratnasingham S, Hebert PDN (2007) BOLD: The barcode of life data system. Molecular Ecology Notes 7: 355–364. https://doi.org/10.1111/j.1471-8286.2007.01678.x

Roesler RU (1990) Drei neue Taxa für die quadrifinen Acrobasiina sowie die neue Check-Liste für *Arsissa* Ragonot 1893 (Lepidoptera: Pyraloidea: Phycitinae). Entomologische Zeitschrift 100(3): 33–47.

Slamka F (2019) Phycitinae Pt 1. Identification – Distribution – Habitat – Biologie. Pyraloidea of Europe 4, František Slamka, Bratislava, 432 pp. [31 col + 175 b/w plates]

Tsvetkov EV (2016) Description of *Pima transfusor* sp. n. (Lepidoptera: Pyralidae, Phycitinae) from the South Urals. Several Results of Lepidoptera Study. Altprint, St. Petersburg I: 6–9.

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RESEARCH ARTICLE

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Genus *Meleonoma* Meyrick, 1914 (Lepidoptera, Autostichidae) from Hainan Island, China, with descriptions of sixteen new species

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Abstract
Sixteen new species of the genus *Meleonoma* Meyrick, 1914 from Hainan Island, China are described: *M. apicicurvata* Wang, **sp. nov.**, *M. apicirectangula* Wang, **sp. nov.**, *M. bicuspidata* Wang, **sp. nov.**, *M. bidentata* Wang, **sp. nov.**, *M. conica* Wang, **sp. nov.**, *M. hainanensis* Wang, **sp. nov.**, *M. latiunca* Wang, **sp. nov.**, *M. linearis* Wang, **sp. nov.**, *M. magnidentata* Wang, **sp. nov.**, *M. ornithorrhyncha* Wang, **sp. nov.**, *M. parilis* Wang, **sp. nov.**, *M. pectinalis* Wang, **sp. nov.**, *M. puncticulata* Wang, **sp. nov.**, *M. quadritaeniata* Wang, **sp. nov.**, *M. robustispina* Wang, **sp. nov.** and *M. rostellata* Wang, **sp. nov.** Images of adult dorsal habitus and genitalia of the new species are provided. A map showing the collecting localities and photos of the habitat where the specimens were collected are provided, along with two maps showing the distribution of each species.

Keywords
Distribution map, Gelechioidea, Microlepidoptera, morphology, taxonomy

Introduction

Meyrick (1914) described the genus *Meleonoma* and classified it in the family Oecophoridae. It was subsequently placed in Cosmopterigidae (Clarke 1965; Nye and Fletcher 1991; Li and Wang 2002, 2004), Lypusidae (Lvovsky 2015; Park and Park

2016), and back to Oecophoridae (Yin and Wang 2016a; Kitajima and Sakamaki 2019). In recent study, *Meleonoma* is hypothesized to be part of the subfamily Periacminae (Autostichidae) based on both molecular data and morphological study (Wang and Li 2020).

Meleonoma is characterized by having narrow to broad lanceolate forewings, the sacculus, in most species, separated from the valva entirely or distally, and a spinous patch on the tergites of both male and female. It is morphologically similar to the genus *Phaulolechia* Diakonoff, 1952, but can be distinguished by the termen of the forewing not concave below the apex, R_5 extended to the costa, and CuA_1 and CuA_2 separate. In species of *Phaulolechia*, the termen of the forewing is concave below the apex, R_5 extends to the termen, and CuA_1 and CuA_2 are fused at the base (Diakonoff 1952: 89).

Meleonoma is represented by 85 valid species (excluding five species with generic assignment uncertain) distributed in the Palearctic and Oriental regions (Wang et al. 2020; Wang and Tao 2020). Wang et al. (2020) proposed eight species groups for *Meleonoma* based on both molecular and morphological study, and assigned most described species to the proposed groups. The aim of the present paper is to report the species of *Meleonoma* collected on Hainan Island including the descriptions of sixteen new species.

Hainan Island is located in the South China Sea east of Viet Nam and has an area of 34,000 square kilometers. It lies between tropical and subtropical regions, so has an average temperature between 22 °C and 26 °C. Hainan Island is rich in natural resources and biological diversity. There are 5860 species of plants known to occur on Hainan Island with 502 endemic species (Yang 2013), which provides a diversity of habitat for insects (Fig. 1).

The sixteen new species can be assigned to five species groups. *Meleonoma apicicurvata* sp. nov., *M. linearis* sp. nov. and *M. rostellata* sp. nov. belong to the *facialis* group, which are characterized by a yellow forewing with a dark costal spot and a dark apical patch. *Meleonoma magnidentata* sp. nov. belongs to the *acutiuscula* group, which are characterized by a dark forewing usually with two small yellow costal spots. *Meleonoma bicuspidata* sp. nov., *M. latiunca* sp. nov., *M. pectinalis* sp. nov., *M. hainanensis* sp. nov., *M. ornithorrhyncha* sp. nov., *M. parilis* sp. nov. and *M. quadritaeniata* sp. nov. belong to the *segregnatha* group, which share a dark forewing with more yellow spots. *Meleonoma bidentata* sp. nov. can be assigned to the *annulignatha* group, which are characterized by having a dark forewing with two yellow costal spots and a dorsal spot, an uncus with a bifurcate apex, and a circular gnathos. *Meleonoma apicirectangula* sp. nov. can be assigned to the *fasciptera* group, which are characterized by the forewing having a median yellow fascia and a yellow costal spot. *Meleonoma conica* sp. nov., *M. puncticulata* sp. nov. and *M. robustispina* sp. nov. share a yellow forewing with some small dark costal and terminal dots. We tentatively place these three species in a new group, the *puncticulata* group, which needs to be confirmed by molecular data.

In addition to the new species, we also collected and identified five described species in Hainan Island during this study: *M. apicispinata* Wang, 2016 and *M. liui* (Wang, 2006) belong to the *segregnatha* group; *M. facialis* Li & Wang, 2002 and *M. polychaeta* Li, 2004 belong to the *facialis* group; and *M. microbyrsa* (Wang, 2003) belongs to the *malacobyrsa* group.

Two maps showing the localities of all 21 species collected on Hainan Island are provided (Fig. 2).

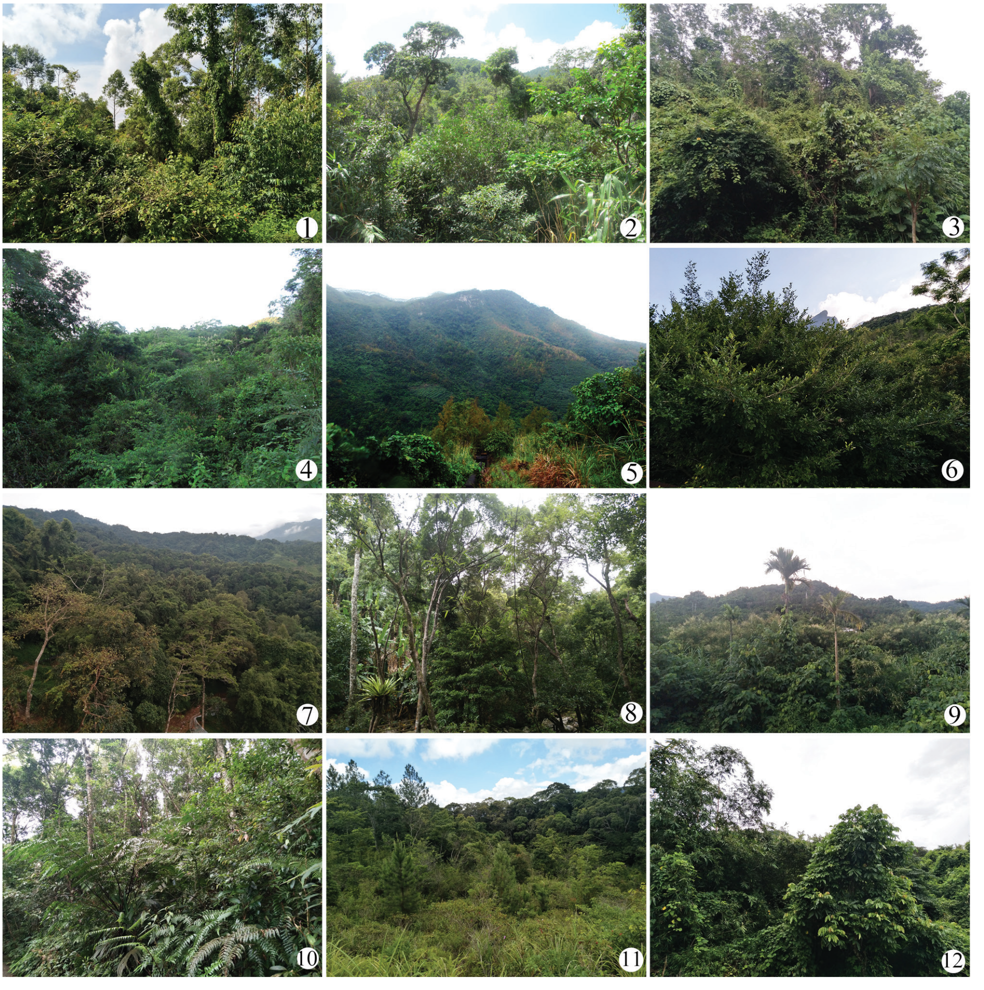


Figure 1. Ecological environment of collecting sites **1** Gaoshanling **2** Mt. Limu **3, 4** Bawangling **5, 6** Yinggeling **7, 8** Mt. Wuzhi **9** Mt. Diaoluo **10, 11** Jianfengling **12** Dali (Lingshui).

Material and methods

The identification of species was based on dried specimens collected on Hainan Island from 2007 to 2018 by using light traps, with a small number being netted during daytime. We made 22 expeditions to this island, covering almost all the mountains of Hainan Island (Table 1; Fig. 3).

Genitalia dissection and mounting follow the methods introduced by Li (2002), stained using Eosin Y, occasionally with Chlorazol Black E for membranous structure. Images of adults were taken with a Leica M205A stereomicroscope and genitalia were prepared using a Leica DM750 microscope, equipped with Leica Application Suite 4.2 software. Distribution maps were prepared using DIVA-GIS Ver. 7.5.0 and output as TIF files that were edited subsequently in Adobe Photoshop CC.

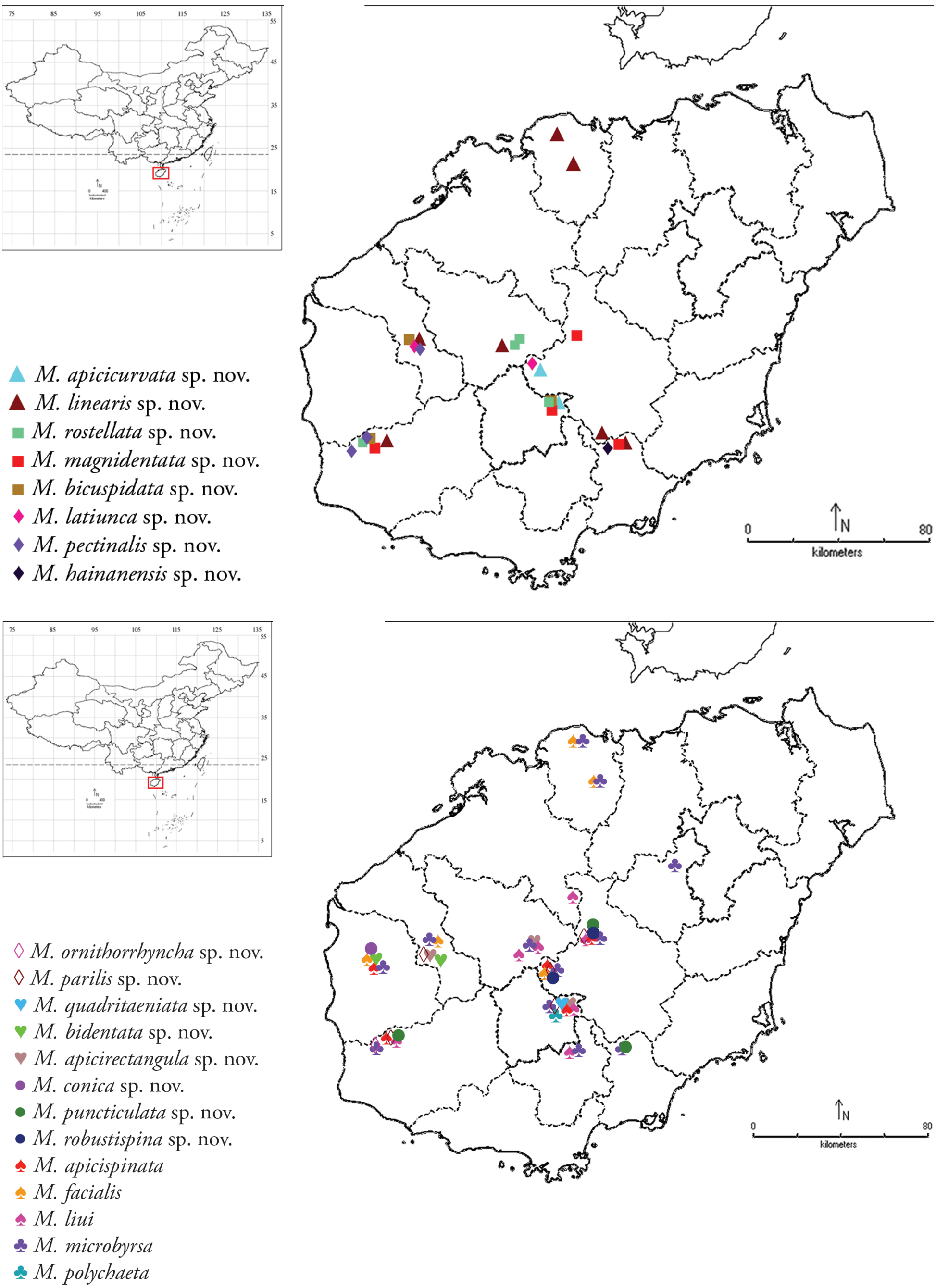


Figure 2. Distribution of the genus *Meleonoma* species in Hainan Island.

Terminology follows Wang et al. (2020). Species are arranged by species groups.

The type specimens are deposited in the Insect Collection of Nankai University, Tianjin, China (**NKU**).

Table 1. Collecting information.

Localities	Latitude and longitude	Date	Collectors
Duowenling	19.79N, 109.76E	VIII.2017	X Bai et al.
Gaoshanling	19.93N, 109.64E	VIII.2017, VI.2018	X Bai et al., P Liu et al.
Danzhou	19.32N, 109.69E	XII.2017	MJ Qi et al.
Mt. Wolong	19.46N, 110.12E	VI.2018	P Liu et al.
Mt. Limu	19.17N, 109.73E	IV.2008, V.2014, VII.2014, V.2015, VI.2015, I.2016, X.2016	BB Hu et al., TT Liu et al., PX Cong et al., KJ Teng et al., X Bai et al.
Bawangling	19.07N, 109.03E	IV.2008, IV.2009	BB Hu et al.
	19.10N, 109.11E	V.2013, VII.2013, VIII.2017, VI.2018	YH Sun et al., HL Yu et al., X Bai et al., P Liu et al.
	19.12N, 109.08E	VII.2014, VI.2015, III.2016	PX Cong et al., QY Wang et al.
	19.08N, 109.10E	VII.2015	QY Wang et al.
Dongfang	19.11N, 108.79E	XII.2009	ZH Du et al.
	19.04N, 108.84E	I.2018, VI.2018	MJ Qi et al., P Liu et al.
Yinggeling	19.03N, 109.55E	VI.2010, IX.2010. X.2013,	BB Hu et al., ZB Wang et al.
	19.08N, 109.50E	VI.2014, I.2016, III.2016, VII–VIII.2017	PX Cong et al., KJ Teng et al., QY Wang et al., X Bai et al.
	19.07N, 109.40E	XI.2016	X Bai et al.
Baisha	19.07N, 109.52E	IV.2014, VII.2014, VI.2015, VII.2015, III.2016	TT Liu et al., PX Cong et al., QY Wang et al.
Mt. Wuzhi	18.90N, 109.67E	V.2007, IV.2009, V.2010, VII.2014, VII.2015, II.2016, III.2016, VII.2016, X–XI.2016, VII.2017	ZW Zhang et al., BB Hu et al., Q Jin et al., PX Cong et al., QY Wang et al., X Bai et al.
	18.91N, 109.68E	IV.2014	TT Liu et al.
	18.91N, 109.70E	VIII.2017	X Bai et al.
Mt. Diaoluo	18.73N, 109.87E	V–VI.2007, IV.2014, V.2015	ZW Zhang et al., TT Liu et al., PX Cong et al.
	18.72N, 109.86E	VII.2014	PX Cong et al.
	18.67N, 109.92E	VII.2017	X Bai et al.
Jianfengling	18.75N, 108.87E	VI.2007, IV.2008, VII.2014, V.2015, VII.2015, III.2016, VIII.2016, VIII.2017, VI.2018	ZW Zhang et al., BB Hu et al., PX Cong et al., QY Wang et al., X Bai et al., P Liu et al.
	18.74N, 108.84E	VI.2010, VIII.2017	BB Hu et al., X Bai et al.
	18.70N, 108.79E	IV–V.2013, IV.2014	YH Sun et al., TT Liu et al.
Qixianling	18.70N, 109.67E	IV.2013, XII.2017	YH Sun et al., MJ Qi et al.

Taxonomy

Meleonoma Meyrick, 1914

Meleonoma Meyrick, 1914: 255. Type species: *Cryptolechia stomota* Meyrick, 1910: 224.
Acryptolechia Lvovsky, 2010: 255. Type species: *Cryptolechia malacobyrsa* Meyrick, 1921: 394.

The *facialis* species group

Meleonoma apicicurvata Wang, sp. nov.

http://zoobank.org/56174C79-42FE-4651-9300-B5797BC72A32
Figs 4, 20

Type material. China, Hainan: ***Holotype*** ♂, Yinggezui (19.05N, 109.56E), Yinggeling, 599 m, 30.VII.2017, leg. X Bai et al., slide No. ZXJ19011. ***Paratype*:** 1♂, Mt. Wuzhi, 732 m, 4.VIII.2017, leg. X Bai et al.

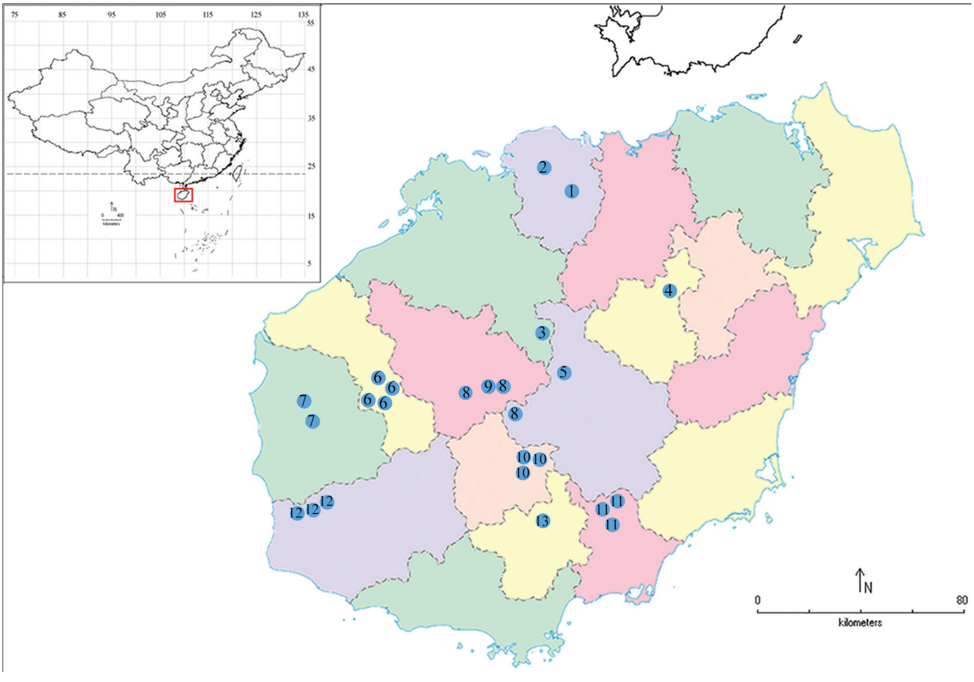


Figure 3. Collecting sites of *Meleonoma* species in Hainan Island **1** Duowenling **2** Gaoshanling **3** Danzhou **4** Mt. Wolong **5** Mt. Limu **6** Bawangling **7** Dongfang **8** Yinggeling **9** Baisha **10** Mt. Wuzhi **11** Mt. Diaoluo **12** Jianfengling **13** Qixianling.

Diagnosis. The new species can be distinguished from its congeners by having the apex of the valva curved dorsally at almost a right angle, a sub-ovate process extending from beyond the sacculus of the valva, and a large vinculum extended to a broadly rounded anterior margin.

Description. Adult (Fig. 4). Wingspan 8.0−10.0 mm. Head yellow, vertex mixed with black. Labial palpus yellow; second segment with distal 2/3 mixed with black scales, forming a black ring at apex; third segment mixed with black scales from middle to before apex on dorsal surface. Antenna yellow; flagellum alternated with black on dorsal surface except several basal flagellomeres yellow. Thorax yellow; tegula black basally, yellow distally. Forewing yellow, with black scales; costal margin with basal 1/4 black, diffused to above fold posteriorly; costal spot black, sub-triangular, from between basal 2/5 and 2/3 extending crossing anterior margin of cell posteriorly; apical patch black, running from distal part of costal margin along termen; tornal spot black, ill-defined; distal and plical spots black, ovate; black dot at anterior angle of cell distinct; fringe yellow, tinged with blackish brown. Hindwing and fringe grey. Legs yellow, with exception on ventral surface: foreleg mixed with black scales on femur and tibia, first tarsomere of tarsus with a black dot, apical three tarsomeres black; midleg with femur black apically, tibia black except yellow apically, tarsus black except yellow at apices of basal two tarsomeres; hindleg with scattered black scales.

Male genitalia (Fig. 20). Uncus slightly wide at base, narrowed from base to pointed apex. Tegumen widened medially; lateral arm slightly narrowed anteriorly. Valva wide at base, slightly narrowed from base to before basal 2/3, curved upward at ca. distal 1/3 almost at a right angle, obtusely rounded at apex; ventral margin heavily sclerotized, forming a wide band reaching ca. distal 1/3, with a large sub-ovate process beyond sacculus; costa wide, with sparse setae; transtilla short, narrowed to pointed apex. Sacculus sub-triangular, relatively small, heavily sclerotized on margins, with sparse long setae on dorsal surface. Vinculum extended anteriorly, broadly rounded on anterior margin. Juxta slender, arched in U-shape (attached to apex of phallus). Phallus slender, strongly curved medially, more than twice length of valva, heavily sclerotized distally, with a fusiform sclerite.

Female unknown.

Distribution. Hainan (Mt. Wuzhi, Yinggeling).

Etymology. The specific epithet is derived from the Latin *apic-* (adj., apical) and *curvatus* (adj., curved), referring to the valva curved dorsally at almost a right angle in the male genitalia.

Meleonoma linearis Wang, sp. nov.

http://zoobank.org/EE18FC98-AB59-42A0-B813-3E2ECD0C94D9
Figs 5, 21

Type material. China, Hainan: ***Holotype*** ♂, Tianchi (18.73N, 108.87E), Jianfengling, 787 m, 13.VII.2015, leg. QY Wang et al., slide No. YAH15402. ***Paratypes*** (15♂): 1♂, 12.VII.2015, other same data as holotype; 5♂, Tianchi, Jianfengling, 787 m, 5–8.III.2016, leg. QY Wang et al.; 1♂, Duowenling, 207 m, 20.VIII.2017, leg. X Bai et al.; 3♂, Gaoshanling, 171 m, 18–19.VIII.2017, leg. X Bai et al.; 1♂, Bawangling, 146 m, 16.VIII.2017, leg. X Bai et al.; 1♂, Nankai, Yinggeling, 270 m, 8.XI.2016, leg. X Bai et al.; 1♂, Dali, Lingshui, 229 m, 24.VIII.2017, leg. X Bai et al.; 2♂, Mt. Diaoluo, 84 m, 22.VII.2017, leg. X Bai et al.

Diagnosis. The new species can be distinguished from its congeners by the ventral margin of the valva with a spine apically, the rectangular sacculus with a longer digitate dorsoapical process and a small triangular ventroapical process, and the phallus with two stout spine-shaped cornuti. It is similar to *M. triangula* Wang, 2016 superficially, but can be distinguished by the valva subparallel from base to apex, the lineate transtilla, and the phallus with two cornuti. In *M. triangula*, the valva is widened distally and produced dorsoapically, the transtilla is triangular, and the phallus lacks a cornutus (Yin and Wang 2016b: 135, fig. 6).

Description. Adult (Fig. 5). Wingspan 9.5–10.0 mm. Head yellow, in some individuals, head blackish brown, yellow along dorsal margin of eyes and occiput. Labial palpus yellow; second segment with dense blackish brown scales on outer surface, forming a ring at apex; third segment ca. 1/2 length of second segment, with dense blackish brown scales. Antenna yellow; scape blackish brown basally; flagellum alternated with blackish brown on dorsal surface. Thorax blackish brown, pale yellow laterally; tegula blackish brown basally, pale yellow distally. Forewing pale yellow, with scattered blackish brown scales; with a rounded black spot at base below costal margin, with an ovate blackish brown spot near base of cell; costal margin blackish brown along basal 1/3; costal spot blackish brown, large, inverted triangular, from between basal 1/3 and basal 2/3 extending crossing anterior margin of cell posteriorly; apical patch blackish brown; tornal spot greyish black, small; discal and plical spots blackish brown; blackish brown dot at anterior and posterior angles of cell, touching costal and tornal spots respectively; dorsum with a diffused blackish brown spot at base; fringe greyish black. Hindwing and fringe grey. Legs yellow, with exception on ventral surface: fore tarsus blackish brown, yellow at apices of basal two tarsomeres, tarsi of mid- and hindlegs blackish brown except yellow at apex of each tarsomere; all tibiae blackish brown except yellow apically.

Male genitalia (Fig. 21). Uncus slightly wide at base, narrowed from base to rounded apex. Tegumen U-shaped, widened medially; lateral arm uniformly wide. Valva subparallel from base to apex, with dense long and stout setae distally; apex obtusely rounded, with a spine arising from above ventroapical corner; ventral margin sclerotized, forming a narrow band ending with a long spine apically, with a small subtriangular process at base; costa convex and sparsely setose basally, shallowly concave medially; transtilla lineate, straight inwards, shortly joined by membrane. Sacculus rectangular, shorter than width; dorsal margin narrowly sclerotized, concave before apex; apex shallowly concave, produced to a clavate dorsoapical process and a small triangular ventroapical process, with a fold from ventroapical process extending obliquely upward to ca. middle of sacculus. Saccus clavate, ca. twice as long as uncus, wide at base, narrowed from base to rounded apex. Juxta V-shaped. Phallus approximately 1.5 × length of valva, widened medially, partly membranous distally, with a straightly clubbed process apically; cornuti being two large stout spines, placed distally.

Female unknown.

Distribution. Hainan (Bawangling, Duowenling, Gaoshanling, Jianfengling, Lingshui, Mt. Diaoluo, Yinggeling).

Etymology. The specific epithet is derived from the Latin *linearis* (adj., lineate), referring to the lineate transtilla in the male genitalia.

Meleonoma rostellata Wang, sp. nov.

http://zoobank.org/A75EF0C9-334E-43E2-9EBE-448BC1D9DE57
Figs 6, 22, 36

Type material. China, Hainan: ***Holotype*** ♂, Hongkan (19.08N, 109.50E), Yinggeling, 540 m, 20.I.2016, leg. KJ Teng et al., slide No. ZXJ18130. ***Paratypes*** (17♂15♀): 3♀, Hongkan, Yinggeling, 540 m, 15.III.2016, leg. QY Wang et al., slide No. ZXJ19410; 1♂, Hongxin, Yuanmen, Baisha, 445 m, 3.VIII.2015, leg. QY Wang et al.; 3♂2♀, Mt. Wuzhi, 742 m, 6–8.VII.2014, leg. PX Cong et al.; 6♂7♀, 5–8.VII.2015, 1♂1♀, 27.II.2016, Lizudadian, Shuiman, Mt. Wuzhi, 766 m, leg. QY Wang et al.;

4♂2♀, 738 m, Mt. Wuzhi, 3.III.2016, leg. QY Wang et al.; 2♂, Tianchi, Jianfengling, 11.VI.2010, leg. BB Hu & J Zhang.

Diagnosis. The new species is similar to *M. dorsolobulata* Wang, 2016 in the male genitalia, but can be differentiated from the latter by the valva with a small rostral process at base on the ventral margin, the sacculus serrate and obliquely truncate apically, and the saccus shorter than the uncus; in *M. dorsolobulata*, the valva has a lobate process at base on the ventral margin, the sacculus is obliquely rounded dorsoapically, and the saccus is as long as the uncus (Yin and Wang 2016b: 136, fig. 7). The new species can be distinguished in the female genitalia by the lamella antevaginalis concave in V-shape medially on the anterior margin that forms two rounded reticulate anterolateral lobes, and the corpus bursae with two signa different in size.

Description. Adult (Fig. 6). Wingspan 7.0–8.0 mm. Head with frons yellow; vertex blackish grey, with yellow scales laterally; occiput yellow. Labial palpus yellow; second segment with scattered blackish grey scales on outer surface, with a blackish grey ring apically; third segment blackish grey medially, ca. 2/3 length of second segment. Antenna yellow, scape mixed with blackish brown scales dorsally; flagellum ringed with brown on dorsal surface. Thorax blackish brown medially, yellow laterally; tegula blackish brown basally, yellow distally. Forewing yellow, with scattered black scales; costal margin with a black stripe along basal 1/3, widened basally, with a small dim black dot before apex; costal spot black, large, semicircular, extending crossing anterior margin of cell posteriorly, slightly placed beyond middle; apical patch black, large; tornal spot black, diffused to apical patch along termen, before tornal spot situated a black dot; discal and plical spots black; black dot at anterior and posterior angles of cell respectively, almost inseparable from costal and tornal spots; dorsum with a black spot at base; fringe greyish black. Hindwing and fringe blackish grey. Legs yellow, with exception on ventral surface: foreleg mixed with blackish grey scales on coxa, tarsi of fore- and midlegs blackish grey except yellow at apices of basal two tarsomeres, tarsus of hindleg yellow at apex of each tarsomere; all femora mixed with blackish grey scales.

Male genitalia (Fig. 22). Uncus wide at base, narrowed to hooked apex. Tegumen broad U-shaped, widened medially; lateral arm almost uniform, sclerotized along outer and inner margins, rounded anteriorly. Valva narrow at base, subparallel from basal 1/4 to before rounded apex, densely setose; ventral margin sclerotized along basal 1/4, forming a narrow band, with a small rostral process at base; costa band-shaped, reaching basal 2/5 of valva, with sparse setae basally; transtilla ovately dilated. Sacculus wide at base, weakly narrowed to apex, densely setose in distal 1/4; apex obliquely truncate, finely serrate; dorsal margin concave at middle; ventral margin sclerotized, forming a narrow band, weakly serrate from basal 1/6 to middle, with sparse long setae in distal half. Vinculum extended anteriorly, forming a small papillary saccus. Saccus shorter than uncus. Juxta slender. Phallus slightly longer than valva, basal 3/5 tubular, distal 2/5 partly membranous, with several curved, irregularly shaped belts.

Female genitalia (Fig. 36). Papillae anales sub-quadrate, setose. Apophyses posteriores approximately 2.5 × as long as apophyses anteriores. Eighth sternal plate spiculate; posterior margin bearing long setae, deeply and narrowly incised medially, forming two large semicircular lateral lobes; anterior margin convex medially. Lamella antevaginalis straight on posterior margin, concave in V-shape medially on anterior margin, forming two rounded reticulate anterolateral lobes. Ductus bursae membranous, widened anteriorly; ductus seminalis arising from ductus bursae near entrance of corpus bursae. Corpus bursae rounded, nearly as long as ductus bursae, with two signa different in size: one sub-rounded, placed at entrance of corpus bursae, with dense teeth, the other elongate-ovate, with dense teeth and a large spine.

Distribution. Hainan (Baisha, Jianfengling, Mt. Wuzhi, Yinggeling).

Etymology. The specific epithet is derived from the Latin *rostellatus* (adj., rostrated), referring to the rostral process at the base on the ventral margin of the valva in the male genitalia.

The *acutiuscula* species group

Meleonoma magnidentata **Wang, sp. nov.**
http://zoobank.org/489650A4-EC5B-49EE-A629-8F16824C32A0
Figs 7, 23, 37

Type material. China, Hainan: ***Holotype*** ♂, Tianchi (18.73N, 108.87E), Jianfengling, 787 m, 10.III.2016, leg. QY Wang et al., slide No. LJ17530. ***Paratypes*** (4♂3♀): 1♂, Forest Park, Mt. Limu, 607 m, 15.V.2015, leg. PX Cong et al.; 1♂1♀, Mt. Wuzhi, 738 m, X.29–XI.4.2016, leg. X Bai et al., slide No. ZXJ18261♀; 1♂, Mt. Wuzhi, 732 m, 2.VIII.2017, leg. X Bai et al.; 1♂1♀, Mt. Diaoluo, 940 m, 31.V–2.VI.2007, leg. ZW Zhang & WC Li; 1♀, Mt. Diaoluo, 922 m, 24.V.2015, leg. PX Cong et al.

Diagnosis. The new species can be distinguished from its congeners by the valva with several large, strong denticles different in number and size on the ventral margin, and by the lamella antevaginalis being broad rectangular ventrally, narrowly banded dorsally, and joined laterally.

Description. Adult (Fig. 7). Wingspan 18.0–18.5 mm. Head blackish brown, mixed with yellow. Labial palpus yellow; second segment with blackish brown scales on outer surface, with a blackish brown ring at apex; third segment slightly shorter than second segment, mixed with sparse blackish brown scales. Antenna with scape blackish brown basally, yellow distally; flagellum blackish brown. Thorax and tegula blackish brown. Forewing blackish brown; costal margin with two yellow spots: antemedian spot rectangular, from before basal 1/3 oblique outwards, crossing anterior margin of cell posteriorly, distal spot sub-triangular, at ca. distal 1/4; cell with a small yellow spot near outer margin; plical spot yellow, very small; fringe yellow, except greyish black along distal part of costal margin and around tornus. Hindwing and fringe yellowish grey. Legs yellow, with exception on ventral surface: foreleg blackish brown, femur scattered with yellow scales apically, tarsus yellow at apices of basal two tarsomeres; mid- and hindlegs blackish brown, tarsi yellow at apex of each tarsomere; all tibiae yellow apically.

Male genitalia (Fig. 23). Uncus clavate, uniformly wide from near base to before pointed apex. Gnathos sclerotized laterally, exceeding anterior margin of tegumen, membranous anteriorly. Tegumen V-shaped, uniformly wide, with sclerotized edges.

Valva narrow at base, widened from base to basal 1/3, thereafter narrowed to rounded apex, setose; ventral margin projected medially, with several large, strong denticles along basal 2/3, different in number and size on left and right valvae; costa lineate, reaching before apex of valva, with sparse setae basally; transtilla short and wide, narrowed to apex, with long setae at base. Sacculus wide at base, narrowed from base to before apex; apex triangularly produced, setose; ventral margin sclerotized and folded. Saccus ca. 1/2 length of uncus, wide at base, narrowed to rounded apex. Juxta U-shaped; lateral lobe clubbed, slightly enlarged distally. Phallus stout, approximately as long as valva, slightly widened medially, with a spine before apex and numerous teeth sparsely grouped below it.

Female genitalia (Fig. 37). Papillae anales sub-rectangular, setose. Apophyses posteriores ca. 2.5 × length of apophyses anteriores. Eighth sternal plate with posterior margin rounded, slightly concave at middle, lined with sparse long setae. Lamella antevaginalis ventrally broad rectangular, concave medially on anterior margin, narrowly banded dorsally, joined laterally. Ductus bursae with posterior 3/4 membranous, uniformly wide, anterior 1/4 sclerotized; ductus seminalis arising from anterior 1/3. Corpus bursae as long as ductus bursae, widened anteriorly; signum absent.

Distribution. Hainan (Jianfengling, Mt. Limu, Mt. Diaoluo, Mt. Wuzhi).

Etymology. The specific epithet is derived from the Latin *magni-* (adj., large) and *dentatus* (adj., dentate), referring to the large denticles on the ventral margin of the valva.

The *segregnatha* species group

***Meleonoma bicuspidata* Wang, sp. nov.**
http://zoobank.org/69D700C8-9B21-42D9-B359-C962E0143025
Figs 8, 24

Type material. China, Hainan: ***Holotype*** ♂, Mt. Wuzhi (18.90N 109.67E), 742 m, 8.VII.2014, leg. PX Cong et al., slide No. YAH15447. ***Paratypes*** (3♂): 1♂, Bawangling, 161 m, 7.VI.2015, leg. PX Cong et al.; 1♂, Jianfengling, 770 m, leg. 31.V.2015, PX Cong et al.; 1♂, Tianchi, Jianfengling, 787 m, 16.VII.2015, leg. QY Wang et al.

Diagnosis. The new species can be distinguished from its congeners by the uniformly wide tegumen straight on posterior margin, the sclerotized and widely banded ventral margin of the valva with two apical spines close at base, and the sacculus with a papillary process below middle of apex.

Description. Adult (Fig. 8). Wingspan 10.0–11.0 mm. Head greyish black, yellow laterally, occiput yellow tipped with greyish black. Labial palpus yellow; second segment mixed with dense black scales on outer surface, forming a black ring at apex; third segment shorter than second segment, with blackish grey scales in basal 2/3. Antenna with scape greyish black basally, yellow distally; flagellum greyish black, annulated with yellow on ventral surface. Thorax and tegula greyish black. Forewing greyish black; costal margin with median yellow spot before middle, small, distal yellow spot at distal 1/4, large, inverted triangular, extending crossing anterior angle of cell posteriorly, with a greyish black dot anteromedially; discal spot black, rounded, with crescent yellow spot encircled its anterior and outer margins; plical spot black, placed at distal 1/3, edged with yellow scales; cell with two black spots near outer margin, placed one above the other, with a large yellow spot between them; dorsal spot yellow, small, placed at end of fold; fringe greyish black mixed with yellow. Hindwing and fringe pale grey. Legs yellow, with exception on ventral surface: fore coxa greyish black, tarsi of fore- and midlegs greyish black, yellow at apices of basal two tarsomeres, hind tarsus greyish black, yellow at apex of each tarsomere; all tibiae greyish black, yellow apically.

Male genitalia (Fig. 24). Uncus wide at base, narrowed from base to ca. middle, uniformly narrow from middle to narrowly rounded apex. Gnathos sclerotized laterally, not exceeding posterior margin of tegumen, invisible anteriorly. Tegumen uniformly wide except lateral arm slightly narrowed anteriorly, straight on posterior margin, distinctly angled posterolaterally. Valva narrow basally, widened distally; apex obliquely obtuse, produced dorsoapically, with dense setae; ventral margin heavily sclerotized, forming a wide band, triangularly projected at base, concave medially, with two short apical spines close at base: dorsal spine large and narrowly rounded at apex, ventral spine short, pointed at apex; costa wide basally, slightly narrowed distally, reaching apex of valva; transtilla shortly enlarged, not extended. Sacculus wide at base, narrowed to apex; apex oblique, with a sclerotized edge along posterior half, with a setose papillary process below middle; ventral margin overlapped triangularly. Saccus more than twice length of uncus, narrowed from broad base to middle, subparallel from middle to before rounded apex. Juxta arched in V-shape, inflated apically. Phallus slightly longer than valva; basal half tubular, sclerotized, distal half partly membranous; narrow ribbon-like belt crossing beyond distal 1/4, then one branch curved and extending downward to before apex; the other branch extending outward, slender basally, widened from basal 1/3 to distal 1/3, fused with apex of phallus, being a large free spine distally.

Female unknown.

Distribution. Hainan (Bawangling, Jianfengling, Mt. Wuzhi).

Etymology. The specific epithet is derived from the Latin *bicuspidatus* (adj., having two spines), referring to the two apical spines on the ventral margin of the valva.

Meleonoma latiunca Wang, sp. nov.

http://zoobank.org/91847E42-3F86-4FAD-B28C-7E83EE14118E
Figs 9, 25

Type material. China, Hainan: ***Holotype*** ♂, Yinggezui (19.05N, 109.56E), Yinggeling, 599 m, 30.VII.2017, leg. X Bai et al., slide No. ZXJ18430. ***Paratypes*** (2♂): 1♂, 31.VII.2017, other same data as holotype; 1♂, Bawangling, 146 m, 16.VIII.2017, leg. X Bai et al.

Diagnosis. The new species can be distinguished from its congeners by the uncus with several long stout setae distally and the valva with a row of short setae arranged like a comb apically. It is similar to *M. pectinalis* sp. nov., and the differences between them are stated in the diagnosis of the latter species.

Description. Adult (Fig. 9). Wingspan 8.0–10.0 mm. Head greyish brown. Labial palpus yellow; first and second segments with dense blackish grey scales; second segment with two indistinct blackish brown rings in distal half; third segment shorter than second segment, with scattered blackish grey scales. Antenna yellow; scape with dense greyish black scales dorsally; flagellum annulated with blackish grey on dorsal surface. Thorax and tegula blackish grey. Forewing broad lanceolate, apex narrowly rounded; ground color blackish grey, with scattered black scales, with a rounded yellow spot at base below costal margin; costal margin with median yellow spot rectangular, from basal 2/5 extending obliquely outward to before posterior margin of cell, distal yellow spot elongate elliptical, from distal 1/4 extending to anterior angle of cell; cell with black spot at ca. basal 2/3 and at posterior angle respectively, edged with yellow scales; plical spot black, edged with yellow scales; dorsal yellow spot at end of fold, smaller; fringe blackish grey. Hindwing and fringe pale greyish brown. Legs greyish yellow; on ventral surface, foreleg mixed with greyish brown on coxa, tarsi of fore- and midlegs greyish brown, yellow at apices of basal two tarsomeres, hind tarsus greyish brown, yellow at apex of each tarsomere; all femora mixed with greyish brown scales, tibiae greyish brown except yellow apically.

Male genitalia (Fig. 25). Uncus wide at base, narrowed from base to basal 2/3, outer margin convex; distal 1/3 uniformly wide except narrowly rounded apex, with several stout setae. Gnathos sclerotized laterally, membranous anteriorly. Tegumen narrowed medially; lateral arm uniformly narrow, rounded anteriorly. Valva sub-triangular, narrow at base, widened to rounded apex; apex with a row of short setae arranged like a comb, running from pre-apex of costa along apex to ventroapex, obliquely rounded; ventral margin heavily sclerotized, with a crescent sclerite at base; costa straight, with sparse setae. Sacculus wide at base, slightly narrowed to obtuse apex; apex heavily sclerotized, forming a sclerotized band. Saccus slender, slightly longer than uncus, wide at base, narrowed from base to narrowly rounded apex. Juxta broadly U-shaped; lateral lobe short. Phallus longer than valva, tubular; cornutus absent.

Female unknown.

Distribution. Hainan (Bawangling, Yinggeling).

Etymology. The specific epithet is derived from the Latin *latus* (adj., broad) and the Latin term *uncus* (n., uncus), referring to the basally wide uncus.

Meleonoma pectinalis **Wang, sp. nov.**

http://zoobank.org/70354FC1-D460-4EDD-AF75-FB746AFB50E3

Figs 10, 26, 38

Type material. China, Hainan: ***Holotype*** ♂, Tianchi (18.73N, 108.87E), Jianfengling, 787 m, 15.VII.2015, leg. QY Wang et al., slide No. YAH15502. ***Paratypes*** (33♂4♀): 1♂, same data as holotype; 1♂, Tianchi, Jianfengling, 787 m, 8.III.2016, leg. QY Wang et al.; 3♂, Tianchi, Jianfengling, 787 m, 5.VIII.2016, leg. X Bai et al.; 1♂1♀, Jianfeng, 40 m, 25.IV.2014, leg. TT Liu et al., slide No. YAH15095♀; 1♂, Jianfeng, 40 m, 28.IV.2013, leg. YH Sun et al.; 20♂, Jianfengling, 770 m, 13–17.VII.2014, leg. PX Cong et al.; 1♂, Jianfengling, 745 m, 7.VIII.2017, leg. X Bai et al.; 1♂, Mingfenggu, Jianfengling, 954 m, 10.VIII.2017, leg. X Bai et al.; 1♂1♀, Jianfengling, 810 m, 12–14.VI.2018, leg. P Liu et al.; 1♂, Bawangling, 161 m, 20.VII.2014, leg. PX Cong et al.; 1♂, Bawangling, 161 m, 12.III.2016, leg. QY Wang et al.; 1♂2♀, Bawangling, 225 m, 12–14.VIII.2017, leg. X Bai et al.

Diagnosis. The new species can be distinguished from its congeners by the uncus with a tuft of long setae at apex, and by the elliptical corpus bursae full of dense denticles that form a conspicuous inverted U-shaped area. It is similar to *M. latiunca* sp. nov. in the male genitalia, but can be distinguished by the uncus dilated distally, the tegumen widened medially, and the saccus slightly shorter than the uncus; in *M. latiunca*, the uncus is not dilated distally, the tegumen is narrowed medially, and the saccus is longer than the uncus.

Description. Adult (Fig. 10). Wingspan 8.0–9.0 mm. Head black, vertex with yellow scales laterally. Labial palpus yellow; second segment with dense blackish brown in basal 2/3, with a blackish brown ring before apex; third segment nearly 2/3 length of second segment, with blackish brown scales medially. Antenna with scape yellow, mixed with blackish brown scales; flagellum blackish brown, ringed with yellow ventrally. Thorax greyish black, mixed with sparse yellow scales; tegula greyish black. Forewing greyish black, with a diffused yellow spot at base below costal margin; costal margin with two orange spots: first spot from basal 1/3 extending to middle of cell posteriorly, sub-rectangular, second spot triangular, from distal 1/4 extending obliquely to beyond anterior angle of cell posteriorly, with a blackish brown dot at middle anteriorly; cell with a black spot at basal 1/3, with two black spots near outer margin placed one above the other, with a large orange spot between them, small black dots on inside of yellow spot; plical spot black, rounded, bordered by orange-yellow spots on outside, placed at distal 1/3 of fold; dorsal spot orange, smaller, placed before end of fold; fringe greyish black, mixed with yellow basally. Hindwing and fringe greyish brown. Legs yellow, with exception on ventral surface: fore coxa blackish brown, tarsi of fore- and midlegs blackish brown, yellow at apices of basal two tarsomeres, hind tarsus blackish brown, yellow at apex of each tarsomere; all femora with dense blackish brown scales, tibiae blackish brown, yellow apically.

Male genitalia (Fig. 26). Uncus wide at base, narrowed from base to basal 1/5, uniformly wide from basal 1/5 to basal 3/5, thereafter dilated elliptically, with a vertical semicircular sclerite near base; apex rounded, with a tuft of long setae. Gnathos weakly sclerotized laterally, just exceeding posterior margin of tegumen, invisible anteriorly. Tegumen widened medially; lateral arm narrow and short, shorter than median width, narrowed anteriorly. Valva triangular, narrow at base, widened to apex, with a small pad bearing several long setae at basal 1/3 on inner surface, with strong long setae distally; apex obliquely rounded, with a row of short setae arranged like a comb; costa narrow, lineate in distal half, with sparse long setae; ventral margin heavily sclerotized, forming a narrow band. Sacculus wide at base, slightly narrowed from base to apex; apex rounded, heavily sclerotized, covered with sparse setae. Saccus wide at base, narrowed to rounded apex; slightly shorter than uncus. Juxta slender, weakly arched. Phallus longer than valva, wide medially, with a large U-shaped sclerite distally.

Female genitalia (Fig. 38). Papillae anales relatively short, rounded caudally, setose. Apophyses anteriores approximately 1/2 length of apophyses posteriores. Eighth sternal plate spiculate; posterior margin gently concave at middle, with long setae. Lamella antevaginalis trapezoidal. Ductus bursae membranous, narrower in posterior half, wide in anterior half, anteriorly with a round sclerotized area full of granules; ductus seminalis arising from middle of ductus bursae. Corpus bursae elliptical, slightly longer than ductus bursae, with dense denticles entirely, denticles larger from posterior 1/6 to middle, forming a conspicuous inverted U-shaped area.

Distribution. Hainan (Bawangling, Jianfengling).

Etymology. The specific epithet is derived from the Latin *pectinalis* (adj., comb-like), referring to the valva with a row of setae along apex arranged like a comb.

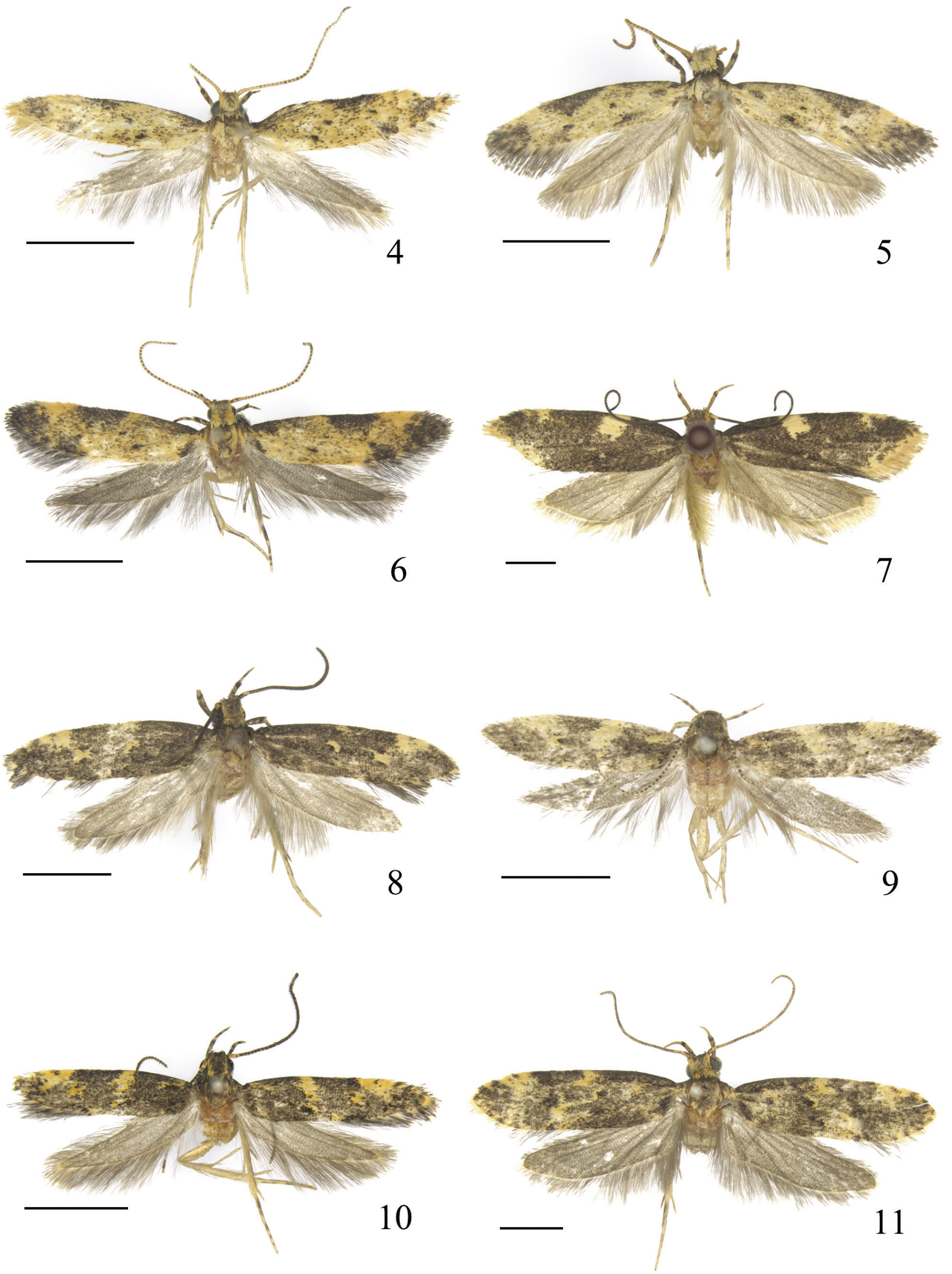
Meleonoma hainanensis **Wang, sp. nov.**

http://zoobank.org/91C8FDF5-D5E2-4698-B928-573D72EC106C
Figs 11, 27

Type material. China, Hainan: ***Holotype*** ♂, Mt. Diaoluo (18.73N, 109.87E), Lingshui, 980 m, 24.IV.2014, leg. TT Liu et al., slide No. YAH15508. ***Paratype*:** 1♂, same data as holotype.

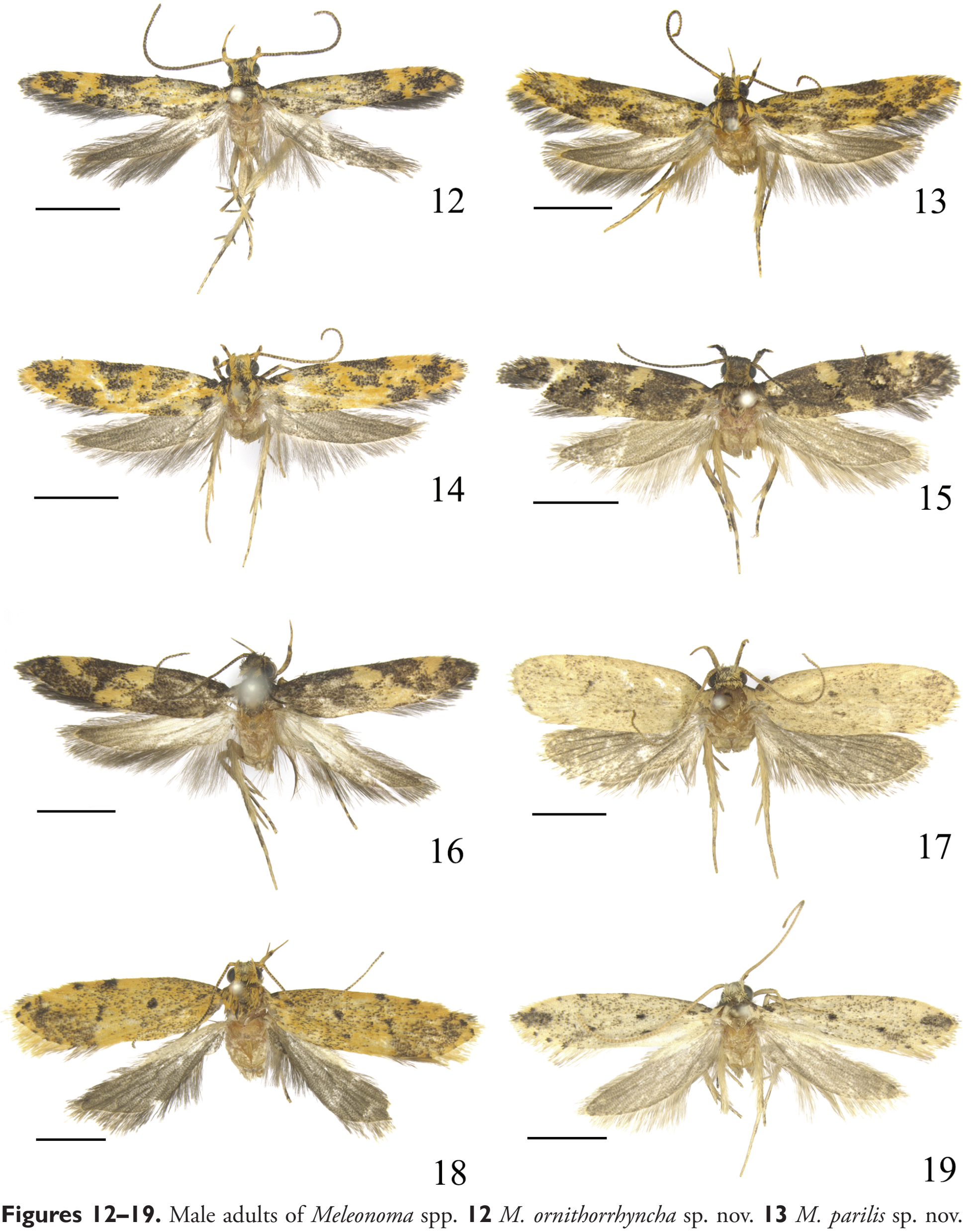
Diagnosis. The new species can be distinguished from its congeners by the uncus with a sclerotized conic plate from middle of base reaching distal 1/3, and the valva distinctly angled at basal 1/3 on the ventral margin.

Description. Adult (Fig. 11). Wingspan 14.5–15.0 mm. Head with frons yellow on upper half, black on lower half; vertex blackish brown, yellow along dorsal margin of eyes and occiput. Labial palpus yellow; second segment mixed with dense black scales on outer surface, forming a black ring apically; third segment mixed with sparse black scales. Antenna with scape black, yellow along posterior margin; flagellum black annulated with yellow dorsally, yellow ventrally. Thorax blackish brown, edged with yellow scales; tegula blackish brown, tinged with yellow scales distally. Forewing blackish brown, with yellow and black scales; costal yellow spot situated before middle, crossing anterior margin of cell posteriorly, distal yellow spot at 1/4, sub-triangular, narrowed posteriorly, extending beyond anterior angle of cell, with a blackish brown dot at middle anteriorly; dorsal yellow spot diffused, ill-defined; cell with a black spot beyond basal 2/3 and at posterior angle respectively, both edged with yellow scales; plical spot black, at distal 2/5 of fold; terminal dots blackish brown interrupted by yellow scales, extending from distal part of costal margin through termen to before tornus; fringe blackish grey tinged with yellow. Hindwing and fringe deep grey. Legs yellow, with exception on ventral surface: foreleg with coxa greyish black, tarsus greyish black except yellow at apices of basal two tarsomeres, tibiae of fore- and midlegs greyish black, yellow apically, mid tarsus greyish black except yellow at apex of each tarsomere, hind tibia greyish black, tarsus mixed with sparse greyish black scales; all femora covered with dense greyish black scales.



Figures 4–11. Male adults of *Meleonoma* spp. **4** *M. apicicurvata* sp. nov. **5** *M. linearis* sp. nov. **6** *M. rostellata* sp. nov. **7** *M. magnidentata* sp. nov. **8** *M. bicuspidata* sp. nov. **9** *M. latiunca* sp. nov. **10** *M. pectinalis* sp. nov. **11** *M. hainanensis* sp. nov. All holotypes. Scale bars: 2.0 mm.

Male genitalia (Fig. 27). Uncus triangular, wide at base, narrowed to basal 2/3, then abruptly narrowed and sclerotized to hooked apex, edged with long setae; ventral surface with a sclerotized conic plate extending from middle of base to 2/3



Figures 12–19. Male adults of *Meleonoma* spp. **12** *M. ornithorrhyncha* sp. nov. **13** *M. parilis* sp. nov. **14** *M. quadritaeniata* sp. nov. **15** *M. bidentata* sp. nov. **16** *M. apicirectangula* sp. nov. **17** *M. conica* sp. nov. **18** *M. puncticulata* sp. nov. **19** *M. robustispina* sp. nov. All holotypes. Scale bars: 2.0 mm.

length of uncus. Tegumen inverted U-shaped, widened medially; lateral arm narrowed anteriorly. Valva narrow at base, distinctly widened to basal 1/3, thereafter slightly narrowed to obtuse apex, setose; ventral margin heavily sclerotized along basal 1/3, forming a sclerotized band, distinctly angled at basal 1/3; costa straight, wide at base, narrowed distally, reaching beyond middle length of valva, lined with sparse setae; transtilla narrow, extending obliquely downward, not meeting medially. Sacculus wide at base, narrowed to basal 2/3; distal 1/3 sub-quadrate, heavily sclerotized, setose, obtuse at apex; dorsal margin concave at middle, ventral margin concave before distal 1/3. Saccus sub-triangular, wide at base, narrowed to narrowly rounded apex. Juxta V-shaped. Phallus slightly longer than valva, wide medially, with curved, irregularly wide belts distally.

Female unknown.

Distribution. Hainan (Mt. Diaoluo).

Etymology. The specific epithet is from the type locality, Hainan, China.

Meleonoma ornithorrhyncha Wang, sp. nov.

http://zoobank.org/89D979E4-ACBC-4B3A-9B97-93AF18FD019D
Figs 12, 28, 39

Type material. China, Hainan: ***Holotype*** ♂, Tianchi (18.74N, 108.84E), Jianfengling, 1050 m, 30.IV.2013, leg. YH Sun et al., slide No. YAH15446. ***Paratypes*** (2♂1♀): 1♂1♀, 29–30.IV.2013, other same data as holotype, slide No. ZXJ19027♀; 1♂, 770 m, Jianfengling, 30.V.2015, leg. PX Cong et al.

Diagnosis. The new species can be distinguished from its congeners by the distally dilated valva with a beak-shaped process ventroapically, the U-shaped juxta with large spine-shaped lateral lobes sharp at apex, and the sacculus fused with the valva, and by the entirely sclerotized ductus bursae, and the two large signa of the corpus bursae each with a strong spine medially.

Description. Adult (Fig. 12). Wingspan 10.0–11.0 mm. Head with frons yellow; vertex blackish brown, with yellow scales laterally. Labial palpus yellow; first segment black on outer surface; second segment with dense blackish brown scales in basal 3/4 on outer surface, with a black ring apically; third segment with a black dot medially on dorsal surface, nearly 2/3 as long as second segment. Antenna yellow; flagellum ringed with blackish brown. Thorax blackish brown, yellow at base laterally; tegula blackish brown on basal half, yellow on distal half. Forewing elongate narrow, apex pointed; ground color blackish brown, with an irregular longitudinal yellow stripe from base to middle; costal margin with median yellow spot placed before middle, diffused to preceding stripe posteriorly, distal yellow spot large, irregular, mixed with blackish brown scales, placed beyond distal 1/3, extending to posterior angle of cell posteriorly, with a blackish brown dot at middle anteriorly; small yellow spots running from apex along termen, last spot extending to distal spot of costal margin; dorsum with small yellow spot near base and at end of fold respectively; plical spot black, at distal 1/3 of fold; fringe blackish brown, with a pale yellow basal line. Hindwing and fringe greyish black. Legs yellow, with exception on ventral surface: fore coxa black, femur black; femora of mid- and hindlegs with scattered black scales, tarsi black except yellow at apices of basal three tarsomeres; hind tarsus black, yellow at apex of each tarsomere; all tibiae black except yellow apically.

Male genitalia (Fig. 28). Uncus slender, clavate, pointed at apex. Gnathos relatively wide, sclerotized laterally, just exceeding posterior margin of tegumen, invisible anteriorly. Tegumen uniform except lateral arm slightly narrowed anteriorly. Valva uniform from base to beyond distal 1/3, birdhead-shaped distally, rounded dorsoapically, with a beak-shaped process ventroapically; costa banded, slightly concave at distal 1/4; transtilla slender, clavate, joined by membrane medially. Sacculus irregularly quadrangular, fused with valva, boundary narrowly banded; ventral margin heavily sclerotized, forming a sclerotized band, convex medially, with dense short setae in distal half, with several denticles distally; apex straight, heavily sclerotized, dentate ventroapically. Saccus wide at base, narrowed to middle; distal half uniformly narrow, apex rounded; same length as uncus. Juxta broad U-shaped; lateral arm slender, heavily sclerotized, spine-shaped, sharp at apex. Phallus longer than valva, membranous in part distally; with a sub-quadrate sclerite bearing a short apical spine; cornutus long, spine-shaped, placed in vesica.

Female genitalia (Fig. 39). Papillae anales sub-quadrate, setose. Apophyses anteriores ca. 2/3 length of apophyses posteriores. Eighth sternal plate spiculate; posterior margin notched at middle, sparsely setose. Lamella antevaginalis concave medially on posterior margin, produced laterally. Antrum sub-trapezoidal, extended posterolaterally. Ductus bursae entirely sclerotized, shrunk laterally below antrum, slightly narrowed medially. Corpus bursae rounded, with rumples; with two large singa, each with a strong spine medially.

Distribution. Hainan (Jianfengling).

Etymology. The specific epithet is derived from the Latin *ornithorrhynchus* (adj., beak-like), referring to the distally birdhead-shaped valva with a beak-shaped process ventroapically.

Meleonoma parilis Wang, sp. nov.

http://zoobank.org/41EE2EA6-DC40-4C7F-9390-0C3DC9A10A8A

Figs 13, 29, 40

Type material. China, Hainan: ***Holotype*** ♂, Forest Park (19.17N, 109.73E), Mt. Limu, 607 m, 24.VII.2014, leg. PX Cong et al., slide No. YAH15444. ***Paratypes*** (49♂8♀): 2♂1♀, 23–24.VII.2014, other same data as holotype, slide No. YAH15503♀; 1♀, Bawangling, 650 m, 7.IV.2008, leg. BB Hu & HY Bai; 11♂4♀, Yinggezui, Yinggeling, 599 m, 27.VII–1.VIII.2017, leg. X Bai et al.; 27♂1♀, Mt. Wuzhi, 738 m, 2–3.III.2016, leg. QY Wang et al.; 1♂, Jianfengling, 940 m, 4.VI.2007, leg. ZW Zhang & WC Li; 1♂1♀, Tianchi, Jianfengling, 790 m, 1.IV.2008, leg. BB Hu & HY Bai; 1♂, Jianfengling, 1050 m, 27.IV.2014, leg. TT Liu et al.; 1♂, 15.VII.2015, 2♂, 5–6.III.2016, Tianchi, Jianfengling, 787 m, QY Wang et al.; 3♂, Mingfenggu, Jianfengling, 954 m, 8–9.VIII.2017, leg. X Bai et al.

Diagnosis. The new species can be distinguished from its congeners in the male genitalia by the straightly uniform uncus with a truncate apex. It is similar to *M. quadritaeniata* sp. nov. in the male genitalia, but can be separated from the latter by the sacculus lacking a ventroapical process, the elongate saccus longer than the uncus, and the phallus with a wide banded plate distally; in *M. quadritaeniata*, the sacculus has a spine-shaped ventroapical process, the small saccus is shorter than the uncus, and the phallus has four narrowly banded sclerites distally. It is similar to *M. flavifasciana* Kitajima & Sakamaki, 2019 in the female genitalia, but can be distinguished by the lamella antevaginalis convex medially on the anterior margin, and the corpus bursae without a signum; whereas the lamella antevaginalis is concave medially on the anterior margin, and the corpus bursae has a signum in *M. flavifasciana* (Kitajima and Sakamaki 2019: 41, fig. 24).

Description. Adult (Fig. 13). Wingspan 11.0–12.0 mm. Head with frons blackish grey mixed with yellow scales; vertex blackish grey, yellow laterally. Labial palpus yellow; first and second segments mixed with dense blackish grey scales, with a black ring apically; third segment 2/3 length of second segment, blackish grey in basal 2/3. Antenna yellow; scape with scattered blackish grey scales; flagellum ringed with blackish grey. Thorax blackish grey, yellow laterally; tegula blackish grey basally, yellow distally. Forewing elongate-lanceolate, apex narrowly rounded; ground color orange-yellow; costal margin with four black spots: first one at base, rounded, extending to above fold posteriorly; second one horizontally narrow rectangular, from between basal 1/6 and 1/3 extending to above anterior margin of cell posteriorly; third one largest, parallelogram-shaped, from between 2/5 and distal 1/3 crossing anterior margin of cell posteriorly; fourth one small, at ca. distal 1/4, consisting of a few black scales; apex with a large black spot, diffused to costal margin and termen; tornal spot black, large, extending to posterior corner of cell; cell with a diffused black spot near base and a rectangular spot at ca. distal 1/3; plical spot black, large, at basal 2/3 of fold, diffused to discal spot anteriorly; dorsum greyish black along basal 2/3, forming a large stripe; fringe blackish grey, yellow basally. Hindwing and fringe deep grey, yellow basally. Legs orange-yellow, with exception on ventral surface: fore coxa blackish brown; tarsi of fore- and midlegs blackish brown, yellow at apices of basal two tarsomeres; hind tarsus blackish brown, yellow at apex of each tarsomere; all femora tinged with blackish brown scales, tibiae blackish brown, yellow apically.

Male genitalia (Fig. 29). Uncus straight, uniform in width from near base to truncate apex. Gnathos sclerotized laterally, crossing anterior margin of tegumen, membranous anteriorly. Tegumen widened medially, concave anteriorly; lateral arm narrowed anteriorly, shorter than median width. Valva with basal half uniformly wide, widened from middle to apex, with a small setose pad at base; apex obtusely rounded, produced dorsoapically, with long setae; ventral margin heavily sclerotized, forming a wide band with a spine-shaped apical process ca. 2/5 length of uncus, directing downward, almost forming a right angle with ventral margin; costa widely banded, reaching pre-apex of valva; transtilla weakly sclerotized, indistinctly joined by membrane medially. Sacculus sub-rectangular, shorter than width, broadly overlapped ventrally; apex heavily sclerotized, with dense setae. Saccus wide at base, narrowed from base to rounded apex, slightly longer than uncus. Juxta slender, arched in C-shape. Phallus longer than valva, basal half uniformly wide, weakly sclerotized; distal half mostly membranous, with fine wrinkles; long and wide banded plate from before apex far exceeding apex, widened and truncate apically; cornuti being two large spines joined at base.

Female genitalia (Fig. 40). Papillae anales sub-quadrate, setose. Apophyses posteriores approximately 3.0 × length of apophyses anteriores. Eighth sternal plate spiculate, emarginate at middle on posterior margin, with sparse setae, straight on anterior margin. Lamella antevaginalis U shaped; lateral arm widened laterally, forming two large fan-shaped plates, arched and serrate on inner margin, obliquely straight on outer margin, convex on anterior margin. Antrum quadrate. Ductus bursae membranous; ductus seminalis arising from ductus bursae, dilated basally. Corpus bursae almost as long as ductus bursae, rounded, densely spiculate; signum absent.

Distribution. Hainan (Bawangling, Jianfengling, Mt. Limu, Mt. Wuzhi, Yinggeling).

Etymology. The specific epithet is derived from the Latin *parilis* (adj., evenly wide), referring to the evenly wide uncus.

Meleonoma quadritaeniata Wang, sp. nov.

http://zoobank.org/846A642E-69B2-4D88-BF6F-927BBEAD770C
Figs 14, 30

Type material. China, Hainan: ***Holotype*** ♂, Mt. Wuzhi (18.91N, 109.68E), 710 m, 21.IV.2014, leg. TT Liu et al., slide No. YAH15450. ***Paratypes*:** 2♂, Mt. Wuzhi, 740 m, 12–14.IV.2009, leg. Q Jin & BB Hu.

Diagnosis. The new species can be distinguished from its congeners by the phallus with four narrowly band-shaped sclerites in distal 1/3. It is similar to *M. parilis* sp. nov., and the differences between them can be found in the diagnosis of the preceding species.

Description. Adult (Fig. 14). Wingspan 10.0–11.0 mm. Head orange, frons with blackish brown scales, vertex with scales tipped blackish brown. Labial palpus orange; first and second segments with black scales on outer surface; second segment with a black ring apically; third segment tinged with brown scales, nearly 2/3 length of second segment. Antenna yellow; scape black on basal half dorsally; flagellum ringed with blackish brown on dorsal surface. Thorax black medially, yellow laterally; tegula black basally, yellow distally. Forewing orange-yellow; costal margin with four black spots: first spot at base, sub-rectangular, extending to fold posteriorly; second spot from beyond basal 1/4 diffused and narrowed to middle of cell posteriorly; third spot from basal 1/3 widened to before distal 1/3; fourth spot small, placed at distal 1/5, consisting of several black scales; apex with a large diffused black spot, anteriorly diffused to costal margin; cell with a diffused black spot at middle and a rectangular black spot at distal 1/3, the latter below third costal spot; plical spot at middle of fold, diffused to second costal spot; tornal spot large, equally sized with apical spot; dorsum with black spot at base and before middle respectively; fringe greyish blackish except yellow basally. Hindwing and fringe blackish grey. Legs yellow, with exception on ventral surface: fore- and midlegs scattered with dense black scales, tibiae of fore- and midlegs yellow apically, tarsi of fore- and midlegs yellow at apices of basal two tarsomeres, hindleg whitish yellow mixed with black scales.

Male genitalia (Fig. 30). Uncus extremely long and slender, slightly wide at base, pointed at apex. Gnathos sclerotized laterally, just exceeding posterior margin of tegumen, invisible anteriorly. Tegumen uniformly wide medially; lateral arm narrowed anteriorly. Valva wide at base, narrowed to middle, widened from middle to apex; apex obliquely obtuse, produced dorsoapically, with dense fine setae; ventral margin heavily sclerotized, forming a wide band, concave near base, produced to a strong spine directing exceeding apex of valva apically; costa wide basally, narrowed to middle, projected triangularly near base; transtilla short and stout. Sacculus sub-quadrate, dorsal margin heavily sclerotized, sinuate; ventral margin heavily sclerotized, forming a wide band with a strong spine-shaped apical process; apex heavily sclerotized, truncate, with a large tooth dorsoapically. Vinculum extended anteriorly, forming a small saccus. Juxta slightly arched. Phallus nearly as long as valva; basal 3/5 sclerotized, tubular; distal 2/5 membranous, with four narrowly banded sclerites pointed apically.

Female unknown.

Distribution. Hainan (Mt. Wuzhi).

Etymology. The specific epithet is derived from the Latin *quadri-* (of four) and *taeniatus* (adj., banded), referring to the four banded plates of the phallus.

The *annulignatha* species group

Meleonoma bidentata Wang, sp. nov.

http://zoobank.org/16D5C9E5-5B92-4CD1-935B-64F831849121
Figs 15, 31, 41

Type material. China, Hainan: ***Holotype*** ♂, Bawangling (19.10N, 109.11E), 245 m, 8.V.2013, leg. YH Sun et al., slide No. ZXJ18110. ***Paratypes*** (8♂2♀): 3♂1♀, 7−9.V.2013, other same data as holotype, slide No. YAH15442♀; 1♂, Bawangling, 28.VII.2013, leg. HL Yu & KL Liu; 2♂, 146 m, 1♀, 225 m, 13–14.VIII.2017, Bawangling, leg. X Bai et al.; 2♂, Lemei, Dongfang, 81 m, 3.I.2018, leg. MJ Qi & S Yu.

Diagnosis. The new species can be distinguished by the uncus with two denticles apically and the medially widened tegumen with slender lateral arm slightly extending inward anteriorly; and by the entirely spiculate corpus bursae with an elongate dentate signum at bottom.

Description. Adult (Fig. 15). Wingspan 10.0−11.0 mm. Head yellow; vertex blackish brown, lateral scales yellow basally. Labial palpus yellow; first and second segments with dense blackish grey scales on outer surface; second segment inflated at apex by rough scales; third segment shorter than 1/2 length of second segment, greyish black on basal half. Antenna with scape yellowish brown on dorsal surface, yellow on ventral surface; flagellum yellow alternated with greyish black. Thorax and tegula greyish black. Forewing dark brown, with diffused yellow spot near base below costal margin and at base of dorsum respectively; costal margin with median yellow spot rounded, from before middle reaching middle of cell posteriorly, edged with sparse black scales, distal yellow spot larger, inverted triangular, from distal 1/4 extending ventrad crossing middle of wing, with a small black dot at middle anteriorly; cell with a black spot beyond middle, anteriorly touching median spot of costal margin, with a large diffused black spot at outer margin, interrupted by a yellow spot; plical spot black, placed at distal 2/5 of fold, bordered by a yellow spot at outside; yellow dorsal spot rounded, at end of fold; fringe greyish black, tinged with yellow basally. Hindwing and fringe grey. Legs yellow, with exception on ventral surface: fore coxa with scattered blackish brown scales, tarsi of fore- and midlegs blackish brown, yellow at apices of basal two and apical one tarsomeres, hind tarsus with basal three tarsomeres blackish brown except yellow at apex of each tarsomere; all femora with dense blackish brown scales, tibiae blackish brown except yellow apically.

Male genitalia (Fig. 31). Uncus narrowed sub-basally, widened at basal 2/5, thereafter slightly narrowed to apex; apex bifurcated, forming two denticles apically. Gnathos sclerotized laterally, membranous anteriorly. Tegumen widened medially; lateral arm slender, slightly extending inward anteriorly. Valva wide at base, weakly narrowed medially, gradually widened to apex; apex broadly rounded, with large dense setae; ventral margin heavily sclerotized, forming a sclerotized band with an apical spine exceeding apex of valva; costa narrowly banded, reaching apex of valva, with long setae; transtilla bilobed: dorsal lobe narrowly extended to pointed apex, indistinctly connected by membrane, ventral lobe shorter than dorsal lobe, rounded at apex. Sacculus sub-quadrate; apex heavily sclerotized, forming a setose narrow band; dorsal margin narrowly sclerotized. Saccus wide at base, narrowed to before obtuse apex; longer than uncus. Juxta broadly arched. Phallus stout, almost twice length of valva, narrow at base, widened medially; distal half membranous, full of fine rumples, with a wide sclerotized band from middle curved spirally to near apex.

Female genitalia (Fig. 41). Papillae anales rectangular, setose. Apophyses posteriores approximately 3.0 × as long as apophyses anteriores. Eighth sternal plate spiculate; posterior margin with long setae, notched at middle. Lamella antevaginalis straight posteriorly and laterally, slightly concave medially on anterior margin, with two reticulate areas anterolaterally. Antrum band-shaped, arched backwards medially. Ductus bursae membranous, posterior 3/4 narrower, wrinkled; anterior 1/4 wide, with dense granules; ductus seminalis arising from anterior 1/3 of ductus bursae. Corpus bursae half as long as ductus bursae, entirely spiculate, irregular in shape; signum elongate rectangular, with numerous teeth and one large apical spine, placed at bottom of corpus bursae.

Distribution. Hainan (Bawangling, Dongfang).

Etymology. The specific epithet is derived from the Latin *bidentatus* (adj., bidentate), referring to the two apical denticles of the uncus.

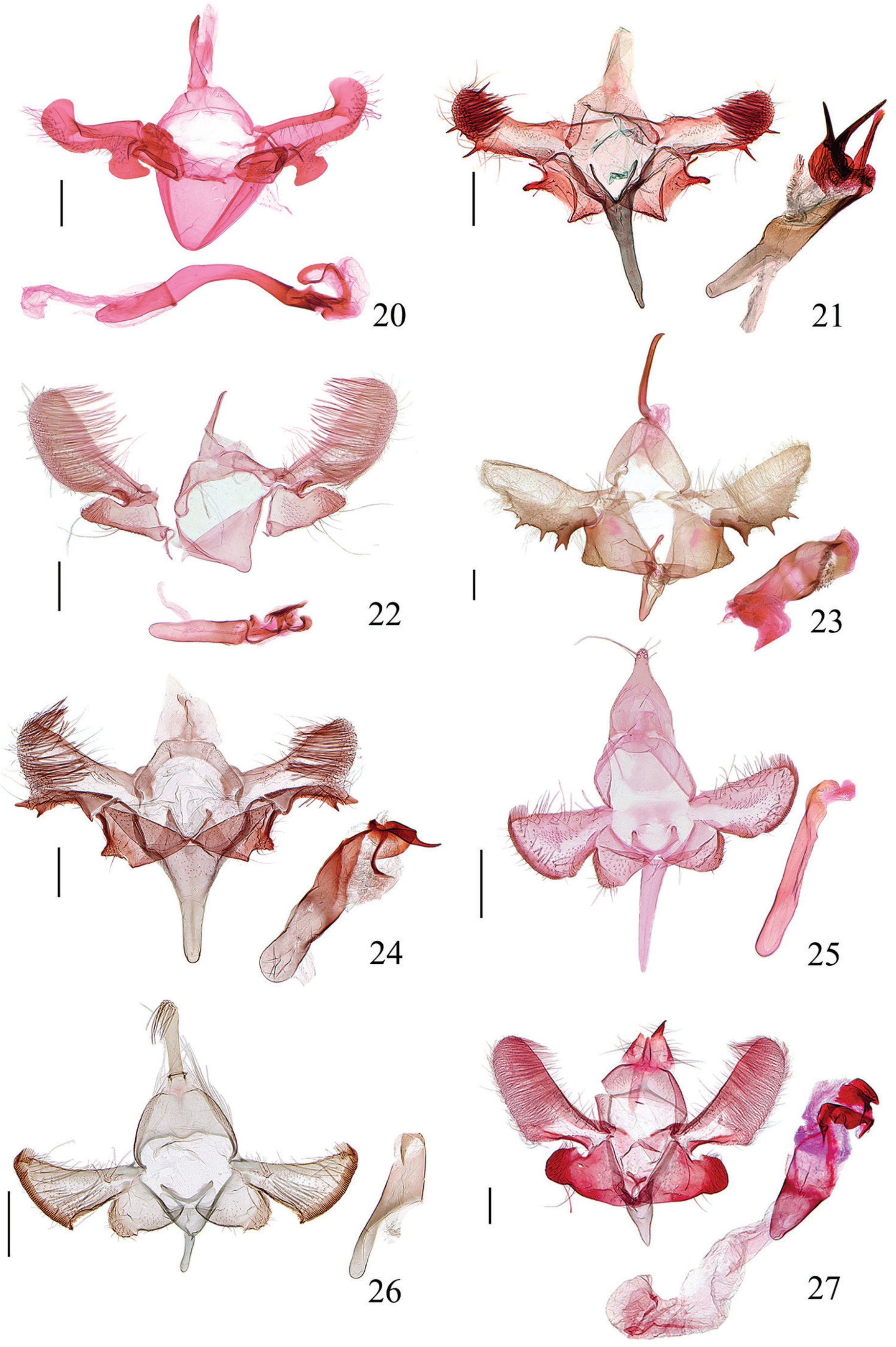
The *fasciptera* species group

Meleonoma apicirectangula **Wang, sp. nov.**

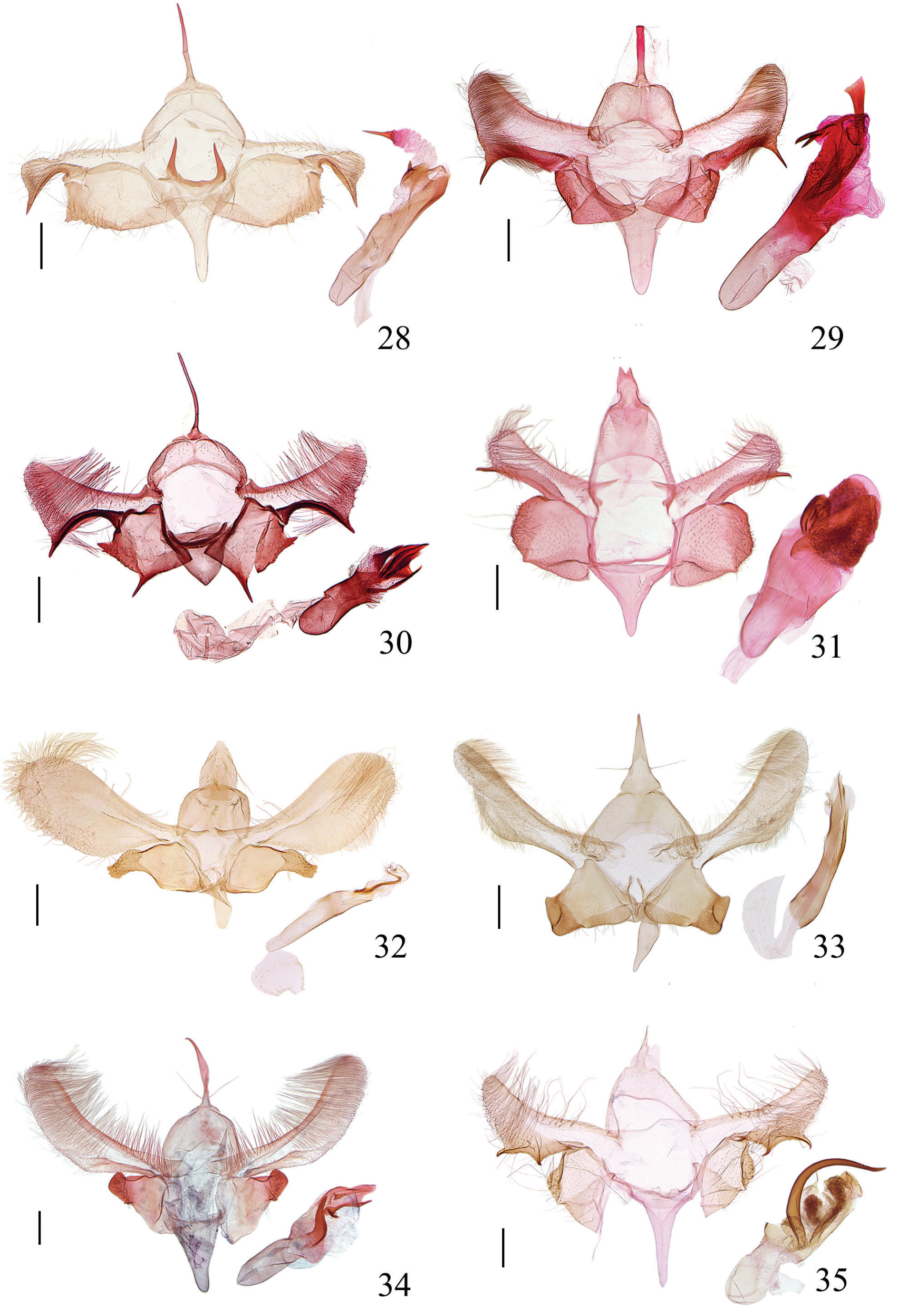
http://zoobank.org/293594B3-C2B2-4922-8899-29F7EF4811E3
Figs 16, 32

Type material. China, Hainan: ***Holotype*** ♂, Bawangling (19.07N, 109.03E), 650 m, 7.IV.2008, leg. BB Hu & HY Bai, slide No. LJ17529. ***Paratypes*** (3♂): 1♂, Bawangling, 1000 m, 9.IV.2008, leg. BB Hu & HY Bai; 1♂, Hongxin, Yuanmen, Baisha, 430 m, 16.IV.2014, leg. TT Liu et al.; 1♂, Mt. Wuzhi, 738 m, 2.XI.2016, leg. X Bai et al.

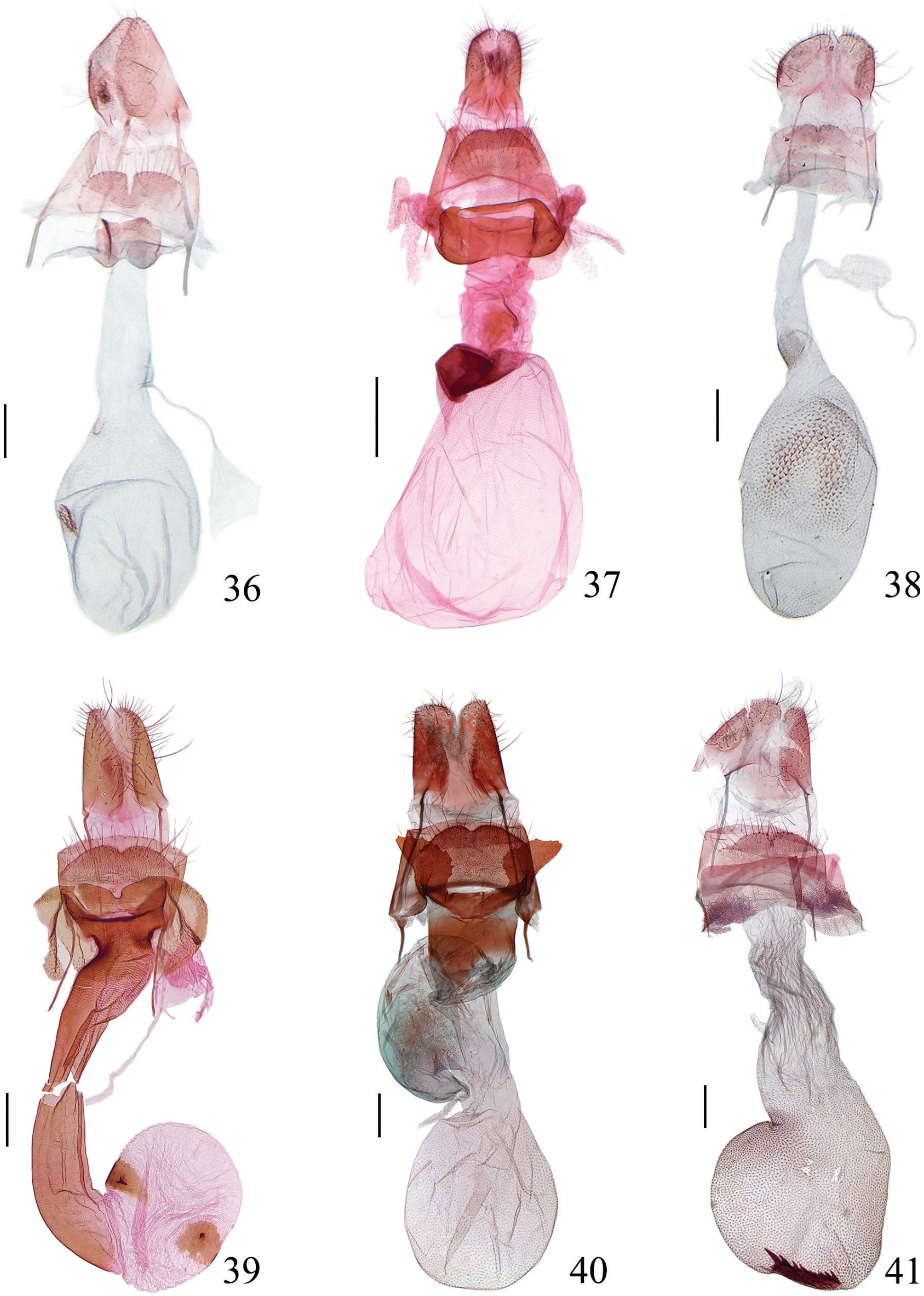
Diagnosis. The new species is similar to *M. neargometra* (Wang, 2003) in the male genitalia. It can be separated from the latter by the transtilla pointed at apex and the sacculus produced to a sub-rectangular process dorsoapically. In *M. neargometra*, the



Figures 20–27. Male genitalia of *Meleonoma* spp. **20** *M. apicicurvata* sp. nov., slide No. ZXJ19011 **21** *M. linearis* sp. nov., slide No. YAH15402 **22** *M. rostellata* sp. nov., slide No. ZXJ18130 **23** *M. magnidentata* sp. nov., slide No. LJ17530 **24** *M. bicuspidata* sp. nov., slide No. YAH15447 **25** *M. latiunca* sp. nov., slide No. ZXJ18430 **26** *M. pectinalis* sp. nov., slide No. YAH15502 **27** *M. hainanensis* sp. nov., slide No. YAH15508. All holotypes. Scale bars: 0.2 mm.



Figures 28–35. Male genitalia of *Meleonoma* spp. **28** *M. ornithorrhyncha* sp. nov., slide No. YAH15446 **29** *M. parilis* sp. nov., slide No. YAH15444 **30** *M. quadritaeniata* sp. nov., slide No. YAH15450 **31** *M. bidentata* sp. nov., slide No. ZXJ18110 **32** *M. apicirectangula* sp. nov., LJ17529 **33** *M. conica* sp. nov., slide No. LJ17553 **34** *M. puncticulata* sp. nov., slide No. YAH15063 **35** *M. robustispina* sp. nov., slide No. ZXJ19014. All holotypes. Scale bars: 0.2 mm.



Figures 36–41. Female genitalia of *Meleonoma* spp. **36** *M. rostellata* sp. nov., slide No. ZXJ18410 **37** *M. magnidentata* sp. nov., slide No. ZXJ18261 **38** *M. pectinalis* sp. nov., slide No. YAH15095 **39** *M. ornithorrhyncha* sp. nov., slide No. ZXJ19027 **40** *M. parilis* sp. nov., slide No. YAH15503 **41** *M. bidentata* sp. nov., slide No. YAH15442. All paratypes. Scale bars: 0.2 mm (**36, 38–41**); 0.5 mm (**37**).

transtilla is rounded at apex and the sacculus is produced to a sub-triangular process dorsoapically (Wang 2003: 202, fig. 9).

Description. Adult (Fig. 16). Wingspan 13.0–14.0 mm. Head with frons yellowish white mixed with blackish brown, vertex blackish brown. Labial palpus yellow; distal half of second segment mixed with dense black scales on outer surface, forming a black ring at apex; third segment mixed with dense black scales from distal half to before apex ventrally. Antenna blackish brown; scape mixed with yellow; flagellum annulated with yellow ventrally. Thorax and tegula blackish brown. Forewing blackish brown, tinged with pale yellow to yellow scales; median fascia yellow, with blackish brown scales medially, extending from basal 2/5 of costal margin obliquely outward to around tornus, widened posteriorly; costal spot yellow, inverted triangular, edged with sparse blackish brown scales, extending to outer margin of cell posteriorly; fringe blackish brown. Hindwing and fringe greyish brown. Legs yellow, with exception on ventral surface: fore coxa blackish brown; femora of fore- and midlegs with dense blackish brown scales, hind femur with sparse blackish brown scales; tarsi of fore- and midlegs blackish brown, yellow at apices of basal two and apical one tarsomeres, hind tarsus with basal three tarsomeres blackish brown except yellow apically; all tibiae blackish brown except yellow apically.

Male genitalia (Fig. 32). Uncus broad at base, narrowed to rounded apex, with long setae mediolaterally. Tegumen narrowed medially; lateral arm narrowed anteriorly. Valva narrow at base, widened from base to basal 1/3, uniformly wide from basal 1/3 to pre-apex, rounded at apex; costa band-shaped, uniformly wide, reaching distal 1/3 of valva, with sparse long setae; transtilla heavily sclerotized, uniformly wide except pointed apically, joined by membrane medially; sclerotized fold from base of ventral margin extending to middle of valva, parallel with costa. Sacculus sub-quadrate, dorsoapically produced to a heavily sclerotized sub-rectangular process, densely setose, straight at apex, sinuate dorsally; sclerotized on dorsal and ventral margins. Saccus wide at base, slightly narrowed to rounded apex. Juxta arched. Phallus shorter than valva, widened medially; distal half membranous, with a curved slender belt as long as 2/5 length of phallus.

Female unknown.

Distribution. Hainan (Baisha, Bawangling, Mt. Wuzhi).

Etymology. The specific epithet is derived from the Latin *apic*- (adj., apical) and *rectangulus* (adj., rectangular), referring to the shape of the apical process of the sacculus.

The *puncticulata* species group

Meleonoma conica Wang, sp. nov.

http://zoobank.org/6FFC20C6-9F39-4006-8992-A70C559EBE9C
Figs 17, 33

Type material. China, Hainan: ***Holotype*** ♂, Datian (19.11N, 108.79E), Dongfang, 56 m, 7.VI.2018, leg. P Liu et al., slide No. LJ17553.

Diagnosis. The new species is similar to *M. leishana* (Wang, 2006), *M. stica* (Wang, 2006) and *M. puncticulata* sp. nov. in the forewing patterns. It can be distinguished from *M. leishana* and *M. stica* by the uncus longer than the saccus and the phallus without sclerotized belts distally; in *M. leishana* (Wang, 2006) (Wang 2006a: 131, fig. 216) and *M. stica* (Wang, 2006) (Wang 2006b: 25, fig. 15), the uncus is shorter than the saccus and the phallus has sclerotized belts distally. It can be separated from *M. puncticulata* by the uncus tapered from base to apex, the relatively narrower and shorter saccus ca. 3/5 the length of the uncus, and the phallus without cornutus; in *M. puncticulata*, the uncus is widened from base to middle, thereafter narrowed to apex, the saccus is almost as long as the uncus, and the phallus has a strong cornutus.

Description. Adult (Fig. 17). Wingspan 14.5 mm. Head yellow. Labial palpus yellow; second segment with blackish brown scales dorsally, forming a dark dot before apex; third segment with sparse blackish brown scales dorsally. Antenna yellow, flagellum annulated with brown (worn). Thorax yellow (worn); tegula yellow, blackish brown at base. Forewing yellow, with blackish brown scales; costal margin with blackish brown dot at base, beyond middle and at distal 1/3 respectively; cell with a blackish brown spot beyond middle and at outer margin respectively; plical spots blackish brown, small, rounded; terminal dots running from distal part of costal margin along termen to tornus, evenly spaced; fringe yellow. Hindwing and fringe grey. Legs yellow, with exception on ventral surface: fore- and midlegs blackish brown, tibia of midleg yellow apically, tarsus of midleg yellow at apex of each tarsomere, hindleg covered with blackish brown scales.

Male genitalia (Fig. 33). Uncus conic, wide at base, distinctly tapered from base to apex, with a single long seta at basal 1/3 laterally. Tegumen slightly widened medially; lateral arm uniformly wide, obtuse anteriorly. Valva with basal 1/3 narrow, wide and subparallel medially, slightly narrowed from distal 1/5 to rounded apex, setose, with a densely setose pad at base; ventral margin weakly sclerotized, concave basally; costa with basal half uniformly wide, distal half narrowed to before apex; transtilla short, not meeting medially. Sacculus wide at base, narrowed from base to rounded apex; distal 1/3 heavily sclerotized, setose, overlapped with an ovate plate; ventral margin heavily sclerotized from base to distal 1/3, forming a wide band, with long setae. Saccus ca. 3/5 length of uncus, wide at base, narrowed from base to rounded apex. Juxta U-shaped; lateral lobe slender. Phallus approximately 4/5 length of valva, with lineate ridges distally; cornutus absent.

Female unknown.

Distribution. Hainan (Dongfang).

Etymology. The specific epithet is derived from the Latin *conicus* (adj., conic), referring to the shape of the uncus in the male genitalia.

Meleonoma puncticulata Wang, sp. nov.

http://zoobank.org/65AACDFC-71DA-41B5-ADD6-03CFCB116E84
Figs 18, 34

Type material. China, Hainan: ***Holotype*** ♂, Mt. Diaoluo (18.73N, 109.87E), 980 m, 23. IV.2014, leg. TT Liu et al., slide No. YAH15063. ***Paratypes*** (3♂): 1♂, Mt. Diaoluo, 940 m, 2.VI.2007, leg. ZW Zhang & WC Li; 1♂, Mt. Limu, 640 m, 1.V.2014, leg. TT Liu et al.; 1♂, Jianfengling, 940 m, 4.VI.2007, leg. ZW Zhang & WC Li.

Diagnosis. The new species is similar to *M. leishana* (Wang, 2006) and *M. stica* (Wang, 2006) superficially. It differs from the latter two species by the saccus almost as long as the uncus and the valva evenly wide distally; whereas the saccus is distinctly longer than the uncus and the valva is widened distally before apex in *M. leishana* (Wang 2006a: 131, fig. 216) and *M. stica* (Wang 2006b: 25, fig. 15). The new species is similar to *M. conica* sp. nov., and the differences between them are stated in the preceding species.

Description. Adult (Fig. 18). Wingspan 12.0–13.0 mm. Head yellow, vertex with brown scales, frons pale yellow. Labial palpus yellow; second segment with sparse blackish brown scales on outer surface, with a blackish brown ring before apex; third segment slightly shorter than second segment, blackish brown ventrally. Antenna with scape yellow, with blackish brown scales on anterior margin; flagellum blackish brown annulated with yellow dorsally, yellow ventrally. Thorax and tegula yellow mixed with sparse blackish brown scales. Forewing pale yellow to orange-yellow, with blackish brown scales; costal margin with blackish brown dot at base, at basal 3/5 and distal 1/4 respectively; discal and plical spots blackish brown, small and rounded; cell with a round blackish brown at middle, with a transversely elongate spot before posterior angle of cell; dense blackish brown scales from apex along termen to tornus, forming an apical patch; terminal dots blackish brown, running from apex through termen to tornus; fringe yellow except blackish grey on distal part of costal margin and around tornus. Hindwing and fringe greyish brown. Legs yellow, with exception on ventral surface: foreleg blackish brown except coxa yellow mixed with blackish brown, tarsus yellow at apices of basal two tarsomeres; midleg with blackish brown scales on femur, tibia blackish brown except yellow apically, tarsus blackish brown except yellow at apices of basal two tarsomeres; hindleg tinged with blackish brown scales on tibia and tarsus.

Male genitalia (Fig. 34). Uncus elongate, narrow at base, widened from base to middle, thereafter narrowed to pointed apex, with a single long seta laterally near base. Gnathos very short, only distinct basally. Tegumen widened medially; lateral arm short, slightly narrowed anteriorly. Valva elongate, widened from base to basal 1/3, subparallel from basal 1/3 to rounded apex, setose; ventral margin with basal 1/3 sclerotized, forming a narrow band; costa wide at base, narrowed to before apex, with stout setae in basal half; transtilla expanded, with dense long setae. Sacculus wide at base, base 3.0 × width of apex, narrowed from base to before distal 1/3; distal part heavily sclerotized, setose, quadrate, truncate apically; dorsal margin sinuate, sclerotized, concave before apex; ventral margin normal, not sclerotized. Saccus almost as long as uncus, wide at base, narrowed to rounded apex. Juxta slender, arched. Phallus approximately 2/3 length of valva; basal 2/5 tubular, sclerotized, distal 3/5 membranous except sclerotized in part, with a small sclerite and indistinct folds distally; curved, sclerotized belt from ca. distal 1/4 exceeding apex of phallus, dilated and with a small sclerite basally; cornutus large and stout, spine-shaped, curved at base, extending from beyond basal 2/5 to before distal 1/4.

Female unknown.

Distribution. Hainan (Jianfengling, Mt. Diaoluo, Mt. Limu).

Etymology. The specific epithet is derived from the Latin *puncticulatus* (adj., having dots), referring to the forewing with several blackish brown dots.

Meleonoma robustispina **Wang, sp. nov.**
http://zoobank.org/B09235D7-D563-413A-8998-852710040EC8
Figs 19, 35

Type material. China, Hainan: ***Holotype*:** ♂, Mt. Limu (19.17N, 109.73E), 632 m, 29.VI.2015, leg. QY Wang et al., slide No. ZXJ19014. ***Paratype*:** 1♂, Yinggezui, Yinggeling, 599 m, 1.VIII.2017, leg. X Bai et al.

Diagnosis. The new species can be distinguished from its congeners by the ventral band of the valva widened distally and having two spines apart from each other, the sacculus produced to a short semielliptical process apically, and the phallus with a large spine-shaped cornutus more than 1/2 length of the phallus.

Description. Adult (Fig. 19). Wingspan 11.0–13.0 mm. Head yellowish white. Labial palpus pale yellow; second segment with blackish brown scales on outer surface, with a black ring apically; third segment with blackish brown scales on dorsal surface. Antenna yellow; scape with blackish brown scales on posterior margin; flagellum annulated with greyish brown on dorsal surface. Thorax pale yellow except black at base; tegula black basally, pale yellow distally. Forewing pale yellow, with scattered blackish brown scales, with blackish brown spot at base and between Sc and fold respectively; costal margin with four blackish brown dots spaced from before middle to pre-apex, becoming smaller; apex with an elliptical blackish brown spot; termen with three blackish brown dots evenly spaced from below apical spot; cell with a small rounded blackish brown spot before posterior angle of cell; plical spot blackish brown, placed at middle of fold; fringe pale yellow, tinged with blackish brown on extension of apical spot, or blackish brown tinged with yellow except yellow on distal part of costal margin. Hindwing and fringe grey. Legs yellow, with exception on ventral surface: foreleg black, coxa yellow, tibia yellow apically, tarsus yellow at apices of basal two tarsomeres; mid tibia black, yellow apically, tarsus black except yellow at apices of basal two and apical one tarsomeres; hindleg mixed with sparse black scales on tibia and tarsus.

Male genitalia (Fig. 35). Uncus with basal half evenly wide, distal half narrowed to pointed apex. Tegumen U-shaped, widened medially, sclerotized along outer and inner margins; lateral arm uniformly narrow. Gnathos very weak laterally, just exceeding posterior margin of tegumen, invisible anteriorly. Valva narrow at base, widened medially, thereafter narrowed to rounded apex, with long setae; ventral margin heavily sclerotized, forming a band widened distally, with two spines apart from each other: short preapical spine directing downward and curved inward, longer apical spine extending outward and exceeding ventroapical corner; costa slightly concave medially, with sparse long setae in distal 2/3; transtilla slender, meeting medially. Sacculus irregularly shaped, with a sclerotized narrow edge dorsally, produced to a setose, semielliptical process apically; ventral margin overlapped triangularly. Saccus longer than twice length of uncus, wide at base, narrowed to rounded apex. Juxta widely arched. Phallus slightly longer than valva; basal 2/5 tubular, weakly sclerotized; distal 3/5 partly membranous, wrinkled, with a sclerotized band from middle to pre-apex, ending with a spine; cornutus large spine-shaped, more than 1/2 length of the phallus, strongly arched medially, narrowed to pointed apex, extending from middle to beyond apex of phallus apically.

Female unknown.

Distribution. Hainan (Mt. Limu, Yinggeling).

Etymology. The specific epithet is derived from the Latin *robustispinus* (adj., having strong spines), referring to the strong spine-shaped cornutus of the phallus in the male genitalia.

List of described species of *Meleonoma* in Hainan Island

The *segregnatha* species group

Meleonoma apicispinata Wang, 2016

Meleonoma apicispinata Wang, 2016, In: Yin and Wang 2016a: 26.

Distribution. Hainan (Dongfang, Jianfengling, Mt. Limu, Mt. Wuzhi, Yinggeling).

Meleonoma liui (Wang, 2006)

Cryptolechia liui Wang, 2006a: 132.
Meleonoma liui: Wang et al., 2020: 383.

Distribution. Hainan (Baisha, Danzhou, Jianfengling, Mt. Limu, Mt. Wuzhi, Yinggeling, Qixianling).

The *facialis* species group

Meleonoma facialis Li & Wang, 2002

Meleonoma facialis Li & Wang, 2002: 230.

Distribution. Hainan (Bawangling, Dongfang, Duowenling, Gaoshanling, Yinggeling).

Meleonoma polychaeta Li, 2004

Meleonoma polychaeta Li, 2004, In: Li & Wang, 2004: 35.

Distribution. Hainan (Mt. Wuzhi).

The *malacobyrsa* species group

Meleonoma microbyrsa (Wang, 2003)

Cryptolechia microbyrsa Wang, 2003: 198.
Meleonoma microbyrsa: Wang et al., 2020: 382.

Distribution. Hainan (Bawangling, Baisha, Dongfang, Duowenling, Gaoshanling, Jianfengling, Mt. Diaoluo, Mt. Limu, Mt. Wolong, Mt. Wuzhi, Qixianling, Yinggeling).

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References

Clarke JFG (1965) Catalogue of the Type Specimens of Microlepidoptera in the British Museum (Natural History) Described by Edward Meyrick (Vol. 5). Trustees of the British Museum Natural History, London, 581 pp.

Diakonoff A (1952) Entomological results from the Swedish expedition 1934 to Burma and British India. Lepidoptera collected by Rene Malaise. Microlepidopera I. Arkiv for Zoologi Stockholm 3: 59–94.

Kitajima Y, Sakamaki Y (2019) Three new species of the genus *Meleonoma* Meyrick (Lepidoptera: Oecophoridae) from Japan. Lepidoptera Science 70(2): 33–46.

Li HH (2002) The Gelechiidae of China (I) (Lepidoptera, Gelechioidea). Nankai University Press, Tianjin, 538 pp. [In Chinese]

Li HH, Wang SX (2002) A study on the genus *Meleonoma* Meyrick from China, with descriptions of two new species (Lepidoptera: Cosmopterigidae). Acta Entomologica Sinica 45(2): 230−233.

Li HH, Wang XP (2004) New species of *Meleonoma* Meyrick (Lepidoptera: Cosmopterigidae) from China. Entomotaxonomia 26(1): 35−40.

Lvovsky AL (2010) A new genus of broad-winged moths of the family Cryptolechiidae (*Acryptolechia*, Lepidoptera, Gelechioidea) from southeastern Asia. Entomological Review 90(2): 255–258. https://doi.org/10.1134/S0013873810020119

Lvovsky AL (2015) Composition of the subfamily Periacminae (Lepidoptera, Lypusidae) with descriptions of new and little known species of the genus *Meleonoma* Meyrick, 1914 from south, east, and south-east Asia. Entomological Review 95(6): 766–778. https://doi.org/10.1134/S0013873815060111

Meyrick E (1910) Notes and descriptions of Indian Micro-Lepidoptera. Records of the Indian Museum 5(4): 217–232. https://doi.org/10.5962/bhl.part.10499

Meyrick E (1914) Exotic Microlepidoptera. Wilts, Marlborough 1(8): 225–256.

Meyrick E (1921) Exotic Microlepidoptera. Wilts, Marlborough 2(13): 385–416.

Nye IWB, Fletcher DS (1991) The Generic Names of Moths of the World. Microlepidoptera (Vol. 6). Trustees of the British Museum (Natural History), London, 368 pp. https://doi.org/10.5962/bhl.title.119516

Park KT, Park YM (2016) Two new species of the genus *Meleonoma* Meyrick (Lepidoptera, Lypusidae) from Korea. Journal of Asia-Pacific Biodiversity 9: 485–488. https://doi.org/10.1016/j.japb.2016.07.006

Wang SX (2003) A study of *Cryptolechia* Zeller (Lepidoptera: Oecophoridae) in China (I), with descriptions of fifteen new species. Entomologia Sinica 10(3): 195–213. https://doi.org/10.1111/j.1744-7917.2003.tb00384.x

Wang SX (2006a) Oecophoridae of China (Insecta: Lepidoptera). Science Press, Beijing, 258 pp.

Wang SX (2006b) The Cryptolechia Zeller (Lepidoptera: Oecophoridae) of China (III): Checklist and descriptions of new species. Zootaxa 1195(1): 1–29. https://doi.org/10.11646/zootaxa.1330.1.4

Wang QY, Li HH (2020) Phylogeny of the superfamily Gelechioidea (Lepidoptera: Obtectomera), with an exploratory application on geometric morphometrics. Zoologica Scripta 00: 1–22. https://onlinelibrary.wiley.com/doi/10.1111/zsc.12407

Wang SX, Tao ZL (2020) The genus *Meleonoma* Meyrick (Lepidoptera: Autostichidae) from Thailand. Zootaxa 4801(2): 383–388. https://doi.org/10.11646/zootaxa.4801.2.12

Wang SX, Zhu XJ, Zhao BX, Yang XF (2020) Taxonomic review of the genus *Meleonoma* Meyrick (Lepidoptera: Autostichidae), with a checklist of all the described species. Zootaxa 4763(3): 371–393. https://doi.org/10.11646/zootaxa.4763.3.3

Yang XB (2013) Catalogue of Plants in Hainan. Science Press, Beijing, 579 pp.

Yin AH, Wang SX (2016a) Two new species in the genus *Meleonoma* Meyrick (Lepidoptera: Oecophoridae) from Taiwan. Entomotaxonomia 38(1): 24–28.

Yin AH, Wang SX (2016b) Taxonomic study of the genus *Meleonoma* Meyrick from Thailand (Lepidoptera, Gelechioidea). ZooKeys 571: 133–141. https://doi.org/10.3897/zookeys.571.6897