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Revision of the genera *Xanthogaleruca* Laboissière, 1932 and Pyrrhalta Joannis, 1865 (Coleoptera, Chrysomelidae, Galerucinae) of Taiwan, with type designation of *Galerucella lineatipes* Takei

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Abstract

The taxonomic status of *Pyrrhalta* Joannis, 1865 and allied genera *Tricholochmaea* Laboissière, 1932 and *Xanthogaleruca* Laboissière, 1934 is discussed based on the study of Taiwanese species. Tentatively, *Xanthogaleruca* and *Pyrrhalta* are regarded as valid genera while *Tricholochmaea* is a synonym of *Pyrrhalta*. Fourteen species are recognized and redescribed, including *P. gressitti* Kimoto, 1969; *P. taiwana* Kimoto, 1969; *P. viridipennis* Kimoto, 1981; *P. igai* Kimoto, 1981; *P. meifena* Kimoto, 1976; *P. maculata* Gressitt & Kimoto, 1963; *P. tsoui* Bezděk & Lee, 2019; *P. semifulva* (Jacoby, 1885); *P. discalis* Gressitt & Kimoto, 1963; *P. ishiharai* Kimoto, 1994; *P. shirozui* Kimoto, 1969; *P. kobayashii* Kimoto, 1974; *P. ohbayashii* Kimoto, 1984; and *P. takizawai* Kimoto, 1996. Taiwanese populations identified as *Xanthogaleruca aenescens* (Fairmaire) were misidentified and those are described as a new species, *X. yuae* **sp. nov.** *Xanthogaleruca aenescens* is redescribed for comparison. Eight additional new species of *Pyrrhalta* are described: *P. alishanensis* **sp. nov.**, *P. houjayi* **sp. nov.**, *P. formosanensis* **sp. nov.**, *P. jungchani* **sp. nov.**, *P. lui* **sp. nov.**, *P. meihuai* **sp. nov.**, *P. tahsiangi* **sp. nov.**, and *P. wulaiensis* **sp. nov.** Type specimens of *Galerucella lineatipes* Takei, 1916 were rediscovered and are designated as lectotype and paralectotype. *Galerucella lineatipes* is removed from synonymy with *G. calmariensis* (Linnaeus, 1767) and regarded as a senior synonym of *P. humeralis* (Chen, 1942), **syn. nov.** Most *Pyrrhalta* species can be classified into four species groups based on their morphological and genitalic similarity. host plants and other biological information are provided for almost all species.

Keywords

host plant, leaf beetles, new species, new synonym, nomenclature, taxonomy, *Tricholochmaea*

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Introduction

The genus *Pyrrhalta* Joannis, 1865 is one of the most speciose genera of Galerucinae. Xue and Yang (2010) recorded 111 species and three subspecies from the Palearctic, Oriental, Australian, and Nearctic regions (cumulated species of *Pyrrhalta*, *Tricholochmaea* and *Xanthogaleruca*). Nie et al. (2017a) treated those three genera separately with 84 species of *Pyrrhalta*, 21 species and two subspecies of *Tricholochmaea*, and nine species of *Xanthogaleruca*. Six new species were described recently by Bezděk and Lee (2019). Two species were transferred from *Pyrrhalta* to *Xanthogaleruca* by Beenen and Talpur (2019).

In Taiwan, Chûjô (1962) recorded no species in his monograph. Kimoto (1969, 1974, 1976, 1981, 1984, 1994, 1996) dealt with almost all Taiwanese species as follows: three new records for *P. aenescens* (Fairmaire), *P. humeralis* (Chen), and *P. maculata* Gressitt & Kimoto, and three new species (*P. gressitti*, *P. shirozui*, and *P. taiwana*) added in 1969; *P. semifulva* Jacoby, *P. discalis* Gressitt & Kimoto, and a new species, *P. kobayashii* added in 1974; *P. aurata* (Maulik) and one new species, *P. meifena* added in 1976; two new species, *P. igai* and *P. viridipennis* added in 1981; one new species, *P. ohbayashii* was described in 1984; *P. aurata* was misidentified and described as a new species, *P. ishiharai* in 1994; and *P. takizawai*, the last new species in 1996 (Table 1). Recently, Bezděk and Lee (2019) described a new species, *P. tsoui*, while dealing with species having maculate elytra. In total, 16 species have been recorded or described from Taiwan previously.

Taxonomic status of the genera *Pyrrhalta* and its allied genera is controversial. *Tricholochmaea* Laboissière and *Xanthogaleruca* Laboissière are regarded as distinct genera by some European and American taxonomists (e.g., Silfverberg 1974; Riley et al. 2002, 2003; Beenen 2008, 2010); or synonyms with *Pyrrhalta* by Chinese and Japanese taxonomists (e.g., Kimoto and Takizawa 1997; Nie et al. 2012; Yang et al. 2015). Their taxonomic status is tentatively re-evaluated in the present paper by studying the Taiwanese species.

The Taiwan Chrysomelid Research Team (TCRT) was founded in 2005 and is composed of ten members. All of them are amateurs interested in producing a complete inventory of chrysomelid species in Taiwan. Members of the genus *Pyrrhalta* have been collected and studied, and host plants recorded. Life histories for almost all species were documented by laboratory rearing. The results of these efforts are the subject of the current paper.

Table 1. Taxonomic works on *Pyrrhalta* of Taiwan by Kimoto.

New species	Authority (reference)	New records or nomenclatural acts
P. gressitti, *P. shirozui*, *P. taiwana*	Kimoto, 1969	*P. aenescens* (Fairmaire), *P. humeralis* (Chen), *P. maculata* Gressitt & Kimoto
P. kobayashii	Kimoto, 1974	*P. semifulva* Jacoby, *P. discalis* Gressitt & Kimoto
P. meifena	Kimoto, 1976	*P. aurata* (Maulik)
P. igai, *P. viridipennis*	Kimoto, 1981	
P. ohbayashii	Kimoto, 1984	
P. ishiharai	Kimoto, 1994	*P. aurata* (Maulik): misidentification
P. takizawai	Kimoto, 1996	

Materials and methods

For rearing studies, larvae were placed in small glass containers (diameter 142 mm × height 50 mm) with cuttings from their host plants. When mature larvae began searching for pupation sites, they were transferred to smaller plastic containers (diameter 90 mm × height 57 mm) filled with moist soil (~ 80% of container volume).

For taxonomic study, the abdomens of adults were separated from the forebodies and boiled in 10% KOH solution, followed by washing in distilled water to prepare genitalia for illustrations. The genitalia were then dissected from the abdomens, mounted on slides in glycerin, and studied and drawn using a Leica M165 stereomicroscope. For detailed examinations, a Nikon ECLIPSE 50i microscope was used.

At least three pairs from each species were examined to delimit variability of diagnostic characters. For species collected from more than one locality, at least one pair from each locality was examined. Length was measured from the anterior margin of the eye to the elytral apex, and width at the greatest width of the elytra.

Specimens studied herein are deposited at the following institutes and collections:

BPBM	Bernice P. Bishop Museum, Hawaii, USA [James Boone];
CAS	California Academy of Sciences, California, USA [David H. Kavanaugh];
EUMJ	Ehime University, Matsuyama, Japan [Hiroyuki Yoshitomi];
IZAS	Institute of Zoology, Chinese Academy of Sciences, Beijing, China [Rui-E Nie];
JBCB	Jan Bezděk collection, Brno, Czech Republic;
HSC	Haruki Suenaga collection, Okayama, Japan;
KMNH	Kitakyushu Museum of Natural History and Human History, Kitakyushu, Japan [Yûsuke Minoshima];
KUEC	Faculty of Agriculture, Kyushu University, Fukuoka, Japan [Osamu Tadauchi];
MCZC	Museum of Comparative Zoology, Harvard University, Massachusetts, USA [Philip D. Perkins and Crystal Maier];
MNHN	Museum National d’Histoire naturelle, Paris, France [Antoine Mantilleri];
NHMUK	The Natural History Museum, London, UK [Michael F. Geiser, Maxwell V. L. Barclay];
NMNS	National Museum of Natural Science, Taichung, Taiwan [Jing-Fu Tsai];
NMPC	National Museum, Prague, Czech Republic [Lukáš Sekerka, Jiří Hájek];
OMNH	Osaka Museum of Natural History, Osaka, Japan [Shigehiko Shiyake];
SEHU	Laboratory for Systematic Entomology, Hokkaido University, Sapporo, Japan [Masahiro Ohara]

Exact label data are cited for all type specimens of described species; a double slash (//) divides the data on different labels and a single slash (/) divides the data in different rows. Other comments and remarks are in square brackets: [p] – preceding data are printed, [h] – preceding data are handwritten, [w] – white label, [y] – yellow label, [g] – green label, [b] – blue label, and [r] – red label.

Taxonomic account

Xanthogaleruca Laboissière, 1934

Galerucella (*Xanthogaleruca*) Laboissière, 1934: 67 (type species: *Chrysomela luteola* Müller, 1766, by original designation); Ogloblin 1936: 100; Chûjô 1962: 38.

Pyrrhalta (*Xanthogaleruca*): Wilcox, 1965: 36.

Xanthogaleruca: Silfverberg, 1974: 7; Riley et al. 2002: 655; Riley et al. 2003: 72; Beenen 2010: 455.

Included species. *Xanthogaleruca aenescens* (Fairmaire, 1878), *X. yuae* sp. nov., and the additional ca. ten Palaearctic species (Beenen 2010, 2019; Nie et al. 2012, 2017a; Beenen and Talpur 2019).

Diagnosis. Large sized species (7.9–9.5 mm). Antenna slender, antennomeres III–VII long (2.5–3.1 × longer than wide), VIII–X shorter. Body flattened (Fig. 1C, F). Elytra relatively narrower, 1.6–1.8 × longer than wide. Aedeagus (Figs 2C, D, 3C, D) asymmetrical; ostium covered by a more or less sclerotized membrane; endophallic sclerite composed of a single slender sclerite with base recurved, with one row of stout teeth along lateral margin. Ventrite VIII (Figs 2F, 3F) in females well sclerotized, with dense short setae along apical margin; spiculum extremely short. Gonocoxae (Figs 2E, 3E) well sclerotized and with dense short setae along apical margins. Apical margin of abdominal ventrite V with angular depression at middle in males (Figs 2H, 3H), followed by shallow notch; represented by a semicircular depression in females (Figs 2G, 3G). Mesotibia with apical spine in males (Figs 2I, 3K); but mesotarsi with tarsomere I not modified.

Biology. Larvae and adults feed on leaves of *Ulmus* species and *Zelkova serrata* (Thunb.) Makino (Ulmaceae).

Remarks. Tentatively we accept *Xanthogaleruca* as valid genus. Internal sclerite of aedeagus of *Xanthogaleruca* is characteristic, comb-like, and presumed to be an apomorphy (Silfverberg 1974; Beenen 2003, 2008; Matsumura et al. 2017; Beenen and Talpur 2019). Moreover, Nie et al. (2017b) showed phylogenetic distance between *Pyrrhalta* (*P. rufosanguinea* Say, 1827) and *Xanthogaleruca* (*X. maculicollis* (Motschulsky, 1853 and *X. aenescens*). See also Discussion below. In addition, larvae of *X. yuae* sp. nov. pupated on the leaves of the host plant. This differs from the habits of other Taiwanese species of *Pyrrhalta* that pupate in earthen cells.

Xanthogaleruca aenescens (Fairmaire, 1878)

Figs 1A–C, 2

Galeruca aenescens Fairmaire, 1878: 140 (China).

Galerucella aenescens: Fairmaire 1887: 334 (China: Beijing); Weise 1889: 569 (as synonym of *Apophylia thalassina* (Faldermann, 1835)); Weise 1896: 296 (note);

Weise 1924: 54 (catalogue); Laboissière 1926: 58 (distinct species); Bezděk 2003: 98 (excluded from *Apophylia*).

Galerucella (*Xanthogaleruca*) *aenescens*: Laboissière 1934: 67; Ogloblin 1936: 100 (redescription).

Pyrrhalta aenescens: Gressitt & Kimoto, 1963: 443 (China: Jilin, Rehe, Hebei, Shandong, Jiangsu); Medvedev and Voronova 1976: 230 (Mongolia); Medvedev and Zaytsev 1978: 135 (larva); Medvedev and Roginskaya 1988: 115 (host plants); Dubeshko and Medvedev 1989: 153; Li 1992: 185 (NE China); Yang 1992: 555 (China: Hunan); Yang et al. 1997: 864 (China: Hubei); Wang and Yang 2006: 109 (China: Gansu); Xue and Yang 2010: 120 (catalogue); Nie et al. 2012: 133 (biology); Yang et al. 2015 (China: Inner Mongolia, Gansu, Shanxi, Shaanxi, Henan).

Pyrrhalta (*Pyrrhalta*) *aenescens*: Wilcox 1971: 84

Pyrrhalta (*Xanthogaleruca*) *aenescens*: Medvedev 1982: 101 (key), 261; Medvedev 1992: 579 (key).

Xanthogaleruca aenescens: Lopatin et al. 2004: 129 (catalogue); Beenen 2010: 455 (catalogue); Park et al. 2015: 388 (Korea).

Types. Presumably deposited at the MNHN, but not available for study due to renovation of the roof (Antoine Mantilleri, pers. comm. 2 July 2020); it was studied by Bezděk (2003).

Other material. China. Beijing: 1♂, 1♀ (TARI), Wofosi (臥佛寺), 27.IV.1961, leg. S.-Y. Wang; Hebei: 8♂, 13♀ (TARI), 保定 (= Baoding), 5.IX.1943, leg. A. Tanaka; Tianjin: 1♂, 2♀ (JBCB), Wuquing Co., Dahuanqpu wetland natural conservation, 15.VII.2010, leg. P. Kment; Manchuria (outdated name, refers to Heilongjiang, Jilin, and Liaoning): 5♂ (TARI), 4♀ (TARI), Tokuniji, 23.VII.1937, leg. M. Hanano; 2♂, 2♀ (TARI), Mt. Riutan, Tolisu, 30.V.1937, leg. M. Hanano; 1♂, 3♀ (TARI), same but with "30.VII.1939"; 1♂ (TARI), Anto, 23.VII.1933, leg. K. Nomura.

Redescription. Length 8.2–9.5 mm, width 3.9–4.5 mm. Body color (Fig. 1A–C) yellowish brown; vertex with one rounded black spot at middle, antennae blackish brown but ventral discs of antennomeres IV-VI yellowish brown; pronotum with three large black spots, one spot at center, apically broadened, from basal 1/4 to apical 1/4, two spots laterally; scutellum black; elytra metallic green. Eyes relatively large, interocular space 2.29–2.56 × diameter of eye. Antennae filiform in males (Fig. 2A), length ratios of antennomeres I–XI 1.0: 0.5: 0.7: 0.8: 0.7: 0.7: 0.7: 0.6: 0.6: 0.5: 0.8, length to width ratios of antennomeres I–XI 3.0: 2.2: 2.7: 3.1: 2.7: 2.9: 2.9: 2.4: 2.5: 2.2: 3.0; similar in females (Fig. 2B), length ratios of antennomeres I–XI 1.0: 0.5: 0.6: 0.7: 0.7: 0.7: 0.7: 0.6: 0.6: 0.5: 0.8, length to width ratios of antennomeres I–XI 3.3: 2.0: 2.7: 2.9: 2.8: 2.7: 2.7: 2.1: 2.3: 2.0: 2.9. Pronotum and elytra dorso-ventrally depressed. Pronotum 2.0–2.2 × wider than long, disc with dense coarse punctures and short pubescence, with lateral depressions; lateral margins moderately rounded, apical margin slightly concave, basal margin straight. Elytra elongate, parallel-sided, 1.6–1.7 × longer than wide; disc with dense coarse punctures and short pubescence, with three indistinct longitudinal ridges, of which two near suture, one from humerus.

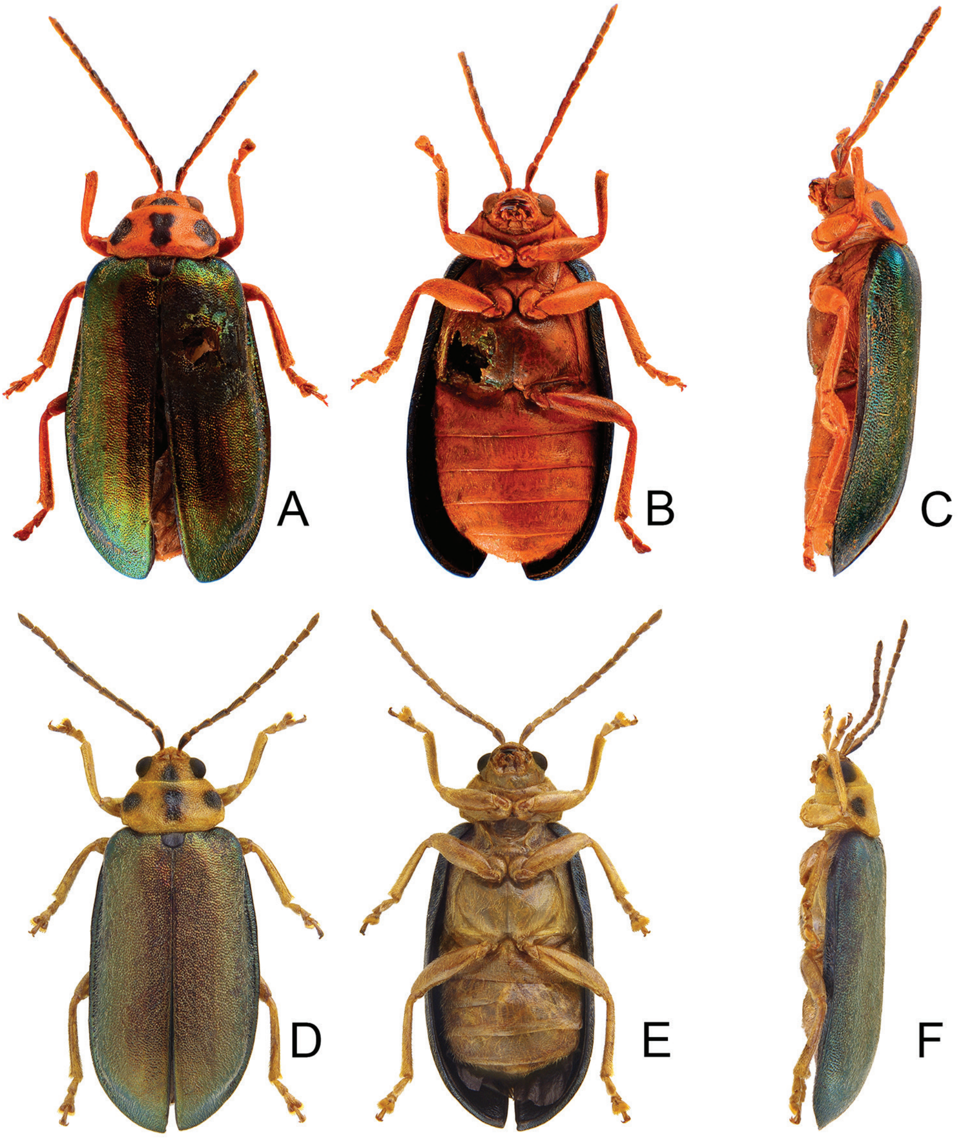

Figure 1. Habitus of *Xanthogaleruca aenescens* (Fairmaire) and *X. yuae* sp. nov. **A** *X. aenescens*, female, dorsal view **B** ditto, ventral view **C** ditto, lateral view **D** *X. yuae* sp. nov., female, dorsal view **E** ditto, ventral view **F** ditto, lateral view.

Apical spur of tibia of middle leg short (Fig. 2I); and tarsomere I of front and middle legs not modified in either sex (Fig. 2J, K). Aedeagus (Fig. 2C, D) slender in dorsal view, 5.1 × longer than wide, sides asymmetric, gradually broadened from apex to apical 1/5, parallel from apical 1/5 to near base, apex broadly rounded; strongly curved near base in lateral view, moderately broadened from apex to middle, apex narrowly rounded; ostium covered by a more or less sclerotized membrane; primary endophal-

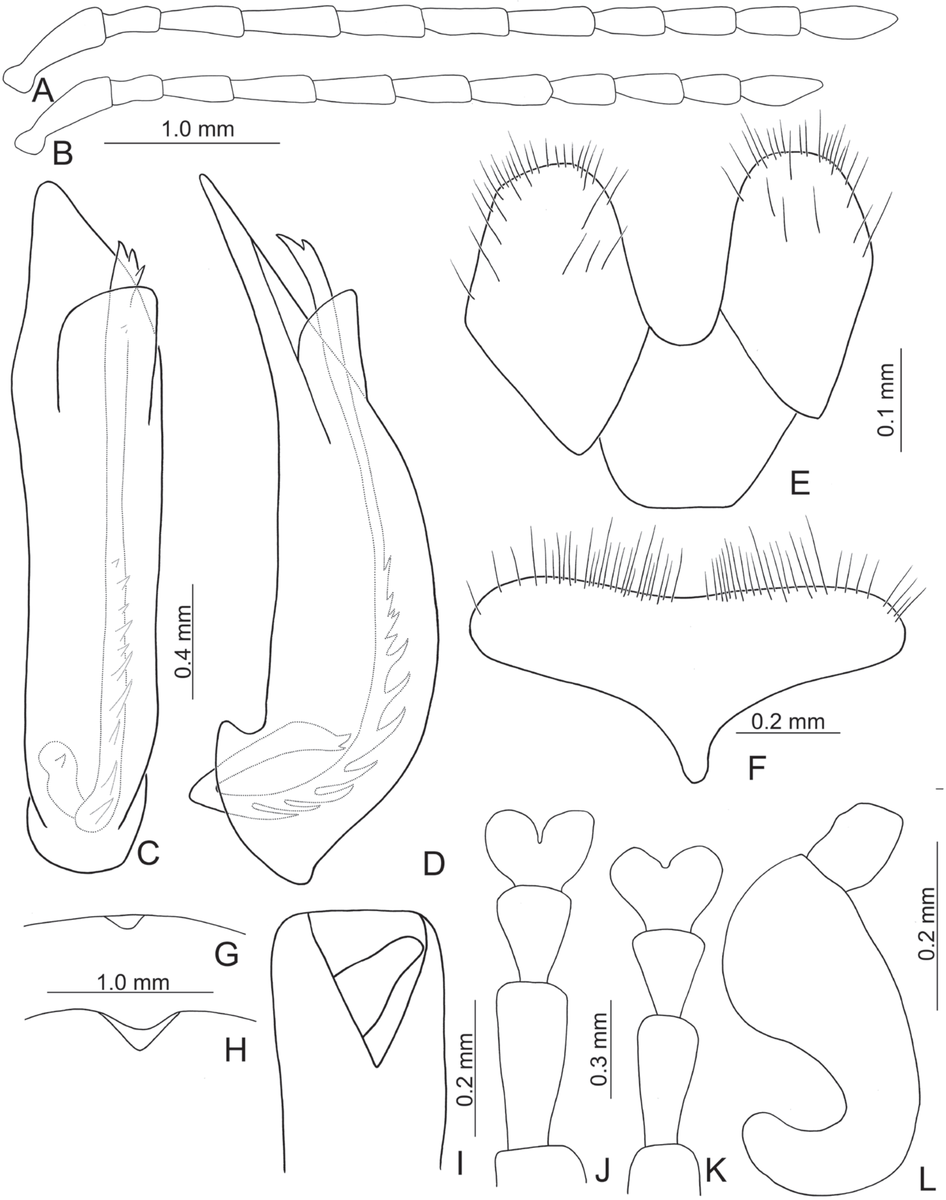

Figure 2. Diagnostic characters of *Xanthogaleruca aenescens* (Fairmaire) **A** antenna, male **B** antenna, female **C** aedeagus, dorsal view **D** ditto, lateral view **E** gonocoxae **F** abdominal ventrite VIII **G** abdominal ventrite V, female **H** abdominal ventrite V, male **I** apex of tibia of middle leg, male **J** tarsi of front leg, male **K** tarsi of front leg, female **L** spermatheca.

lic sclerite extremely long, 0.9 × as long as aedeagus, with three apical teeth, and additional longitudinal row of erect teeth from middle to base, become smaller towards apex, one short sclerite connected with base, apex with one short tooth. Gonocoxae

(Fig. 2E) transverse, both gonocoxae combined from basal basally connect, with dense short setae along apical margin or areas. Ventrite VIII (Fig. 2F) extremely transverse; disc with dense short setae along apical margin; spiculum extremely short. Receptacle of spermatheca (Fig. 2L) very swollen; pump short and strongly curved; sclerotized proximal spermathecal duct wide and short. Apical margin of abdominal ventrite V with angular depression at middle in males (Fig. 2H), followed by shallow notch; only with semicircle depression in females (Fig. 2G).

Host plants. Ulmaceae: *Ulmus pumila* Linnaeus, *U. laevis* Pallas, and *U. davidiana* Planch (Nie et al. 2012).

Remarks. adults of *X. aenescens* (Fairmaire) and *X. yuae* sp. nov. may be separated from those of other species in the genus by the entirely green elytra, presence of three black spots on the pronotum, elytra with fine and dense punctures. *Xanthogaleruca aenescens* differs from *X. yuae* sp. nov. by the wider aedeagus, 5.1 × longer than wide (Fig. 1C, D) (5.7 × longer than wide (Fig. 3C, D) in *X. yuae* sp. nov.), lacking teeth from near apex to middle of primary endophallic sclerite (with teeth from near apex to middle of primary endophallic sclerite in *X. yuae* sp. nov.), apex of tarsomere I of front legs uniform in both sexes (Fig. 2J, K) (broader in males of *X. yuae* sp. nov. (Fig. 3I, J)), and short apical spur on mesotibia (Fig. 2I) (long apical spur on mesotibia in *X. yuae* sp. nov. (Fig. 2K))

Distribution. Russia (Far East), Mongolia, North China (Gansu, Hebei, Henan, Hunan, Inner Mongolia, Jiangsu, Jilin, Shandong, Shanxi, Shaanxi; Beenen 2010; Yang et al. 2015); Korea (Park et al. 2015).

Xanthogaleruca yuae sp. nov.

http://zoobank.org/791BC545-8352-4100-8818-9BDFD162AB08
Figs 1D–F, 3, 4

Pyrrhalta aenescens: Kimoto, 1969: 28 (Taiwan); Kimoto 1986: 56 (additional records in Taiwan); Kimoto and Chu 1996: 55 (catalogue); Kimoto and Takizawa 1997: 300 (key), 373; Beenen 2010: 455 (catalogue); Yang et al. 2015: 115 (catalogue).

Types. ***Holotype*** ♂ (TARI), Taiwan. Taoyuan: Paling (巴陵), 27.V.2009 (reared from eggs), leg. M.-H. Tsou. ***Paratypes***. 3♂, 6♀ (TARI), same data as holotype; 1♀ (TARI), same but with "25.V.2009"; 3♀ (TARI), same but with "26.V.2009"; 7♂, 8♀ (TARI), same but with "28.V.2009"; 37♂, 29♀ (TARI), same but with "29.V.2009"; 1♀ (TARI), same locality, 19.IV.2009, leg. S.-F. Yu; 1♀ (TARI), same locality, 19.VI.2010, leg. H.-J. Chen; Chiayi: 3♀ (TARI), Shounouryo (= Channaoliao, 樟腦寮), near Mt. Ari (阿里山), 14.XII.1937, leg. Y. Yano; 1♂ (TARI), Dokuritsuzan (= Tulishan, 獨立山), near Mt. Ari (阿里山), 14.XII.1937, leg. Y. Yano; Nantou: 2♂ (TARI), Lienhuachi (蓮華池), 23–26.V.1980, leg. K. S. Lin & B. H. Chen; 1♂ (KMNH), Meiyuan (眉原), 21.V.198?, leg. C.-K. Yu (S. Osawa's Coll.), determined as *P. aenescens* by Kimoto, 1986; Taitung: 1♂ (TARI), Hsinwu (新武), 25.III.2013,

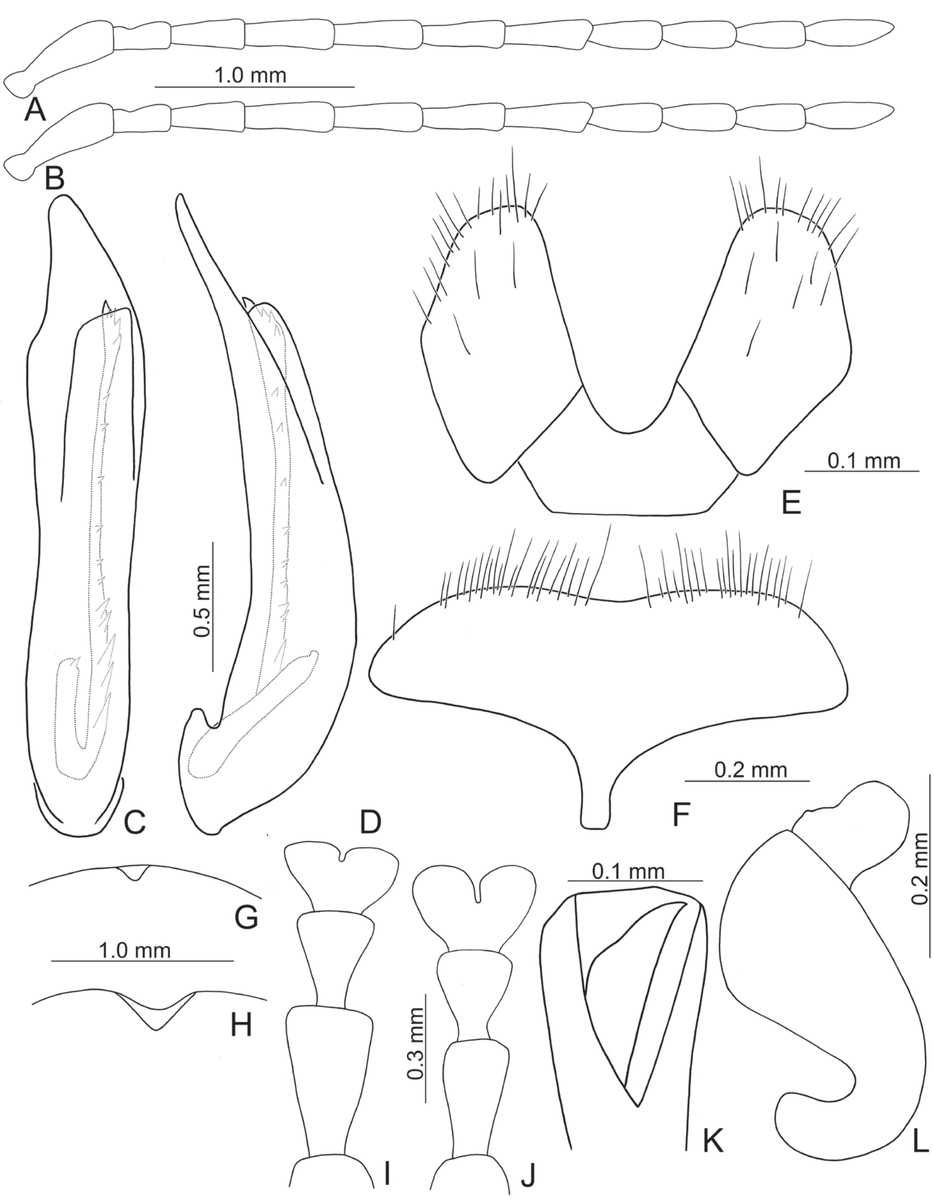

Figure 3. Diagnostic characters of *Xanthogaleruca yuae* sp. nov. **A** antenna, male **B** antenna, female **C** aedeagus, dorsal view **D** ditto, lateral view **E** gonocoxae **F** abdominal ventrite VIII **G** abdominal ventrite V, female **H** abdominal ventrite V, male **I** tarsi of front leg, male **J** tarsi of front leg, female **K** apex of tibia of middle leg, male **L** spermatheca.

leg. C.-L. Lee; 2♀ (TARI), Wulu (霧鹿), 29.III.2011, leg. C.-F. Lee; Taoyuan: 1♀ (TARI), Suleng (四稜), 9.IV.2016, leg. Y.-L. Lin; 1♀ (TARI), Tungyanshan (東眼山), 12.IV.2007, leg. S.-F. Yu.

Diagnosis. Body flattened. Pronotum with three large black spots, one in middle, two laterally. Elytra metallic green

Description. Length 7.9–8.8 mm, width 3.3–3.8 mm. Body color (Fig. 1D–F) yellowish brown; vertex with one rounded black spot at middle, antennae blackish brown but ventral discs of antennomeres IV–VI brown; pronotum with three large black spots, one spot at center, from apical 1/4 to basal 1/4, apically broadened, two spots laterally; scutellum black; elytra metallic green. Eyes relatively large, interocular space 2.33–2.45 × diameter of eye. Antennae filiform in males (Fig. 3A), length ratios of antennomeres I–XI 1.0: 0.5: 0.6: 0.8: 0.8: 0.7: 0.7: 0.6: 0.6: 0.6: 0.7, length to width ratios of antennomeres I–XI 3.1: 2.1: 2.5: 2.9: 3.1: 2.9: 3.0: 2.6: 2.8: 2.7: 3.4; similar in females (Fig. 3B), length ratios of antennomeres I–XI 1.0: 0.4: 0.6: 0.7: 0.7: 0.7: 0.7: 0.6: 0.6: 0.6: 0.8, length to width ratios of antennomeres I–XI 3.4: 1.9: 2.5: 3.0: 2.8: 2.8: 2.8: 2.6: 2.6: 2.5: 3.4. Pronotum and elytra dorso-ventrally depressed. Pronotum 1.9–2.0 × wider than long, disc smooth, with dense coarse punctures and short pubescence, with lateral depressions; lateral margins moderately rounded, apical margin slightly concave, basal margin straight. Elytra elongate, parallel-sided, 1.7–1.8 × longer than wide; disc smooth, with dense, fine punctures and short pubescence, with three indistinct longitudinal ridges, two near suture, one from humerus. Apical spur of tibia of middle leg elongate in males (Fig. 3K); tarsomeres I of front and middle legs apically broadened in males (Fig. 3I), less broadened in females (Fig. 3J). Aedeagus (Fig. 3C, D) slender in dorsal view, 5.8 × longer than wide, sides asymmetric, gradually broadened from apex to apical 1/4, slightly narrowed at middle, apex broadly rounded; moderately curved near base in lateral view, moderately broadened from apex to middle, apex narrowly rounded; ostium covered by a more or less sclerotized membrane; primary endophallic sclerite long, 0.7 × as long as aedeagus, with four apical teeth, and an additional longitudinal row of erect teeth from near apex to base, becoming smaller towards apex, one short sclerite connected with base, apex with one short tooth. Gonocoxae (Fig. 3E) transverse, both gonocoxae combined from basal connection, with a number of short setae along apical margin. Ventrite VIII (Fig. 3F) extremely transverse; disc with dense, short setae along apical margin; spiculum extremely short. Receptacle of spermatheca (Fig. 3L) very swollen; pump short and strongly curved; sclerotized proximal spermathecal duct wide and short. Apical margin of abdominal ventrite V with angular depression at middle in males, followed by shallow notch (Fig. 3H); represented by a semi-circular depression in females (Fig. 3G).

Remarks. Adults of *X. yuae* sp. nov. and *X. aenescens* may be separated from those of other species in the genus by their entirely green elytra, presence of three black spots on the pronotum, and elytra with fine and dense punctures. *Xanthogaleruca yuae* sp. nov. differs from *X. aenescens* in having a narrower aedeagus, 5.7 × longer than wide (Fig. 3C, D) (broader aedeagus (Fig. 2C, D), 5.1 × longer than wide in *X. aenescens*), teeth from near apex to middle of primary endophallic sclerite (lacking teeth from near apex to middle of primary endophallic sclerite in *X. aenescens*), apex of tarsomere I of front legs broader in males than females (Fig. 3I, J) (apex of tarsomere I of front legs uniform in both sexes of *X. aenescens* (Fig. 2J, K)), and long apical spur on mesotibia

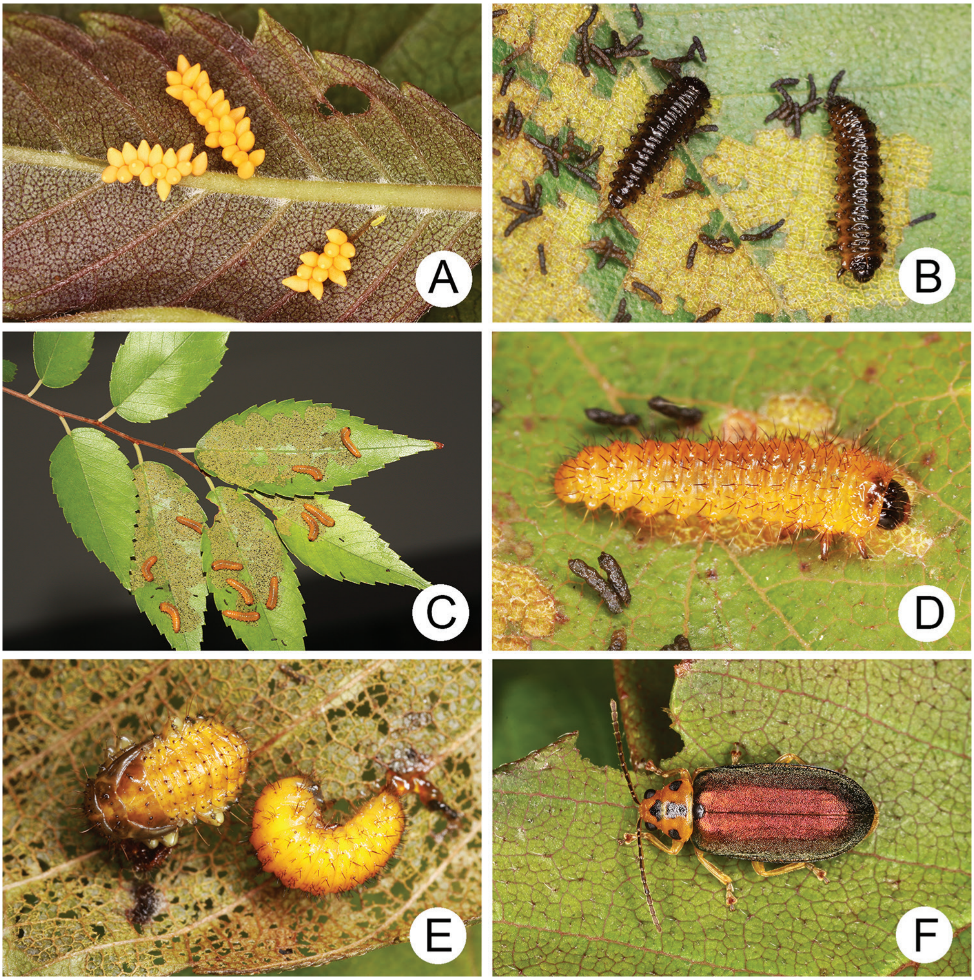

Figure 4. Field photographs of *Xanthogaleruca yuae* sp. nov. on host plant **A** egg masses **B** early instar larva **C** mature larvae **D** single mature larva **E** pupa and prepupa **F** adult.

(Fig. 3K) (short apical spur on mesotibia in *X. aenescens* (Fig. 3I)). This new species was misidentified as *Xanthogaleruca aenescens* by Kimoto (1969, 1986).

Host plants. Larvae and adults feed on leaves of *Zelkova serrata* (Thunb.) Makino (Ulmaceae) (present study).

Biology. *Xanthogaleruca yuae* sp. nov. populations are presumed to be univoltine. The following life cycle information is based on our (TCRT) observations made by Mr Mei-Hua Tsou (Lee and Cheng 2010). Females began to deposit an average of 10–20 eggs in two rows of a single egg mass on the undersides of leaves (Fig. 4A) during 22 April 2009. Larvae hatched in 7–8 days. Larvae fed on one side of leaves and left only one layer of tissue at the surface (Fig. 4B, C). The larval duration was 15–21 days. mature larvae (Fig. 4D) expelled an adhesive from the anus, then pupated on the undersides of leaves. Duration of the pupal stage was 8–13 days (Fig. 4E). adults were active during spring (Fig. 4F).

Distribution. Widespread in lowlands of Taiwan.

Etymology. Dedicated to Mrs Su-Fang Yu who was the first member of TCRT to collect specimens of this new species and rear them successfully from eggs to adults.

Pyrrhalta Joannis, 1865

Pyrrhalta Joannis, 1865: 82 (type species: *Galeruca vibruni* Paykull, 1799).
Galerucella (*Pyrrhalta*): Weise, 1886: 621; Reitter 1913: 138; Ogloblin 1936: 97.
Galeruca (*Pyrrhalta*): Seidlitz, 1891: 705.
Decoomanius Laboissière, 1927: 55 (type species: *Decoomanius limbatus* Laboissière, 1927; by monotypy). Synonymized by Kimoto 1989b: 18.
Chapalia Laboissière, 1929: 269 (type species: *Chapalia jeanvoinei* Laboissière, 1929; by monotypy). Synonymized by Kimoto 1989b: 18.
Lochmaea (*Tricholochmaea*) Laboissière, 1932: 963 (type species: *Gallerucella semifulva* Jacoby, 1885; by original designation). Synonymized by Gressitt and Kimoto 1963: 438.
Tricholochmaea: Chûjô & Kimoto, 1961: 169; Riley et al. 2002: 655; Riley et al. 2003: 71.
Pyrrhalta (*Tricholochmaea*): Wilcox, 1965: 37; Wilcox 1971: 80.
Pyrrhalta (*Pyrrhalta*): Wilcox, 1971: 84.

Remarks. Weise (1886), Reitter (1913), and Ogloblin (1936) overlooked the fact that *Pyrrhalta* Joannis, 1865 has priority over *Gallerucella* Crotch, 1873. Therefore, the former cannot be a subgenus of the latter (Gressitt and Kimoto 1963). There are no reliable characters for distinguishing *Pyrrhalta* Joannis and *Tricholochmaea* Laboissière. We conclude that establishing species groups as a basis for classification, rather than retaining the generic status of *Tricholochmaea* is a better approach. *Tricholochmaea* is regarded as synonym with *Pyrrhalta* in this study.

Pyrrhalta gressitti species group

Included species. *Pyrrhalta gressitti* Kimoto, 1969; *P. houjayi* sp. nov.; *P. tahsiangi* sp. nov.; *P. taiwana* Kimoto, 1969; and *P. viridipennis* Kimoto, 1981.

Diagnosis. Small to median sized species (3.5–7.8 mm). Antenna extremely slender, antennomeres III–VI long (3.1–4.5 × longer than wide), VII–X shorter. Body convex. Elytra relatively narrow, 1.6–1.8 × longer than wide. Aedeagus asymmetric, ostium covered by a membrane; endophallic sclerites composed of two slender sclerites (Figs 6C, D; 8C, D; 14D) except single sclerite in *P. tahsiangi* sp. nov. (Fig. 10C, D) and *P. houjayi* sp. nov. (Fig. 12C, D); primary sclerite with several fine teeth near apex (Figs 8C, D; 10C, 14C) except *P. gressitti* Kimoto (Fig. 6C, D) and *P. houjayi* sp. nov. (Fig. 12C, D). Ventrite VIII in female well sclerotized and recurved laterally, apically tapering and with cluster of setae near apex (Figs 6E, 8E, 12E, 14I) except *P. tahsiangi* sp. nov. (Fig. 10E); spiculum long. Gonocoxae apically sclerotized and longitudinally oriented, apex with four long setae (Figs 6G, 8I, 10K, 12F, 14J). Apical margin of abdominal ventrite V moderately concave medially, with deep depression at middle in males (Figs 6I, 8H, 10J, 12I, 14L); concave in females of *P. gressitti* (Fig. 6J), *P. houjayi* sp. nov. (Fig. 8G), and *P. taiwana* (Fig. 12H), or slightly depressed and with one short median internal ridge in females of *P. tahsiangi* sp. nov. (Fig. 10I) and *P. viridipennis* (Fig. 14K). Mesotibia with apical spine in males of *P. gressitti* (Fig. 6F), *P. tahsiangi* sp. nov. (Fig. 10F), and *P. viridipennis* (Fig. 14M) (lacking apical spine in others); mesotarsi with tarsomere I modified only in males of *P. tahsiangi* sp. nov. (Fig. 10H).

Biology. Larvae and adults feed on leaves of *Rhododendron* species or *Vaccinium randaiense* Hayata (Ericaceae).

Pyrrhalta gressitti Kimoto, 1969

Figs 5A–C, 6, 7A, B

Pyrrhalta gressitti Kimoto, 1969: 25; Kimoto and Chu 1996: 55 (catalogue); Kimoto and Takizawa 1997: 301 (key), 373; Beenen 2010: 452 (catalogue); Xue and Yang 2010: 123 (catalogue); Yang et al. 2015: 116 (catalogue).
Pyrrhalta (*Pyrrhalta*) *gressitti*: Wilcox, 1971: 86.

Types. ***Holotype*** ♀ (KUEC), labeled: "(TAIWAN) / Alishan / Chiai Hsien / 27. VII. 1966 [p, w] // Pyrrhalta / gressitti / Kimoto, n. sp. [h, w] // HOLOTYPE [p, r]". ***Paratypes***. 1 ♀ (KMNH) and 1♀ (BPBM): "(TAIWAN) / Alishan / Chiai Hsien / 27. VII. 1966 [p, w] // Pyrrhalta / gressitti / Kimoto, n. sp. [h, w] // PARATOPOTYPE [p, b]"; 1 ex. (KMNH): "(TAIWAN) / Alishan / Chiai Hsien [p] / 30 [h]. VII. 1966 [p, w] // Pyrrhalta / gressitti / Kimoto, n. sp. [h, w] // PARATYPE [p, b]"; 1♂, 1♀ (BPBM): "FORMOSA: / Arisan [阿里山] / VIII-18-1947 / J. L. Gressitt [p, w] // L. Gressitt / Collection [p, w] // Pyrrhalta / gressitti / Kimoto, n. sp. [h, w] // PARATYPE [p, b]".

Other material. TAIWAN. Chiayi: 12♂, 3♀ (TARI), Alishan (阿里山), 5–9. VIII.1981, leg. L. Y. Chou & S. C. Lin; 2♀ (TARI), same locality, 17–20.VIII.1982, leg. K. C. Chou & C. C. Pan; 2♀ (NMNS), same locality, 8.IX.1989, leg. I. S. Hsu; 1♀ (NMNS), same locality, 26.IV.1990, leg. C. C. Chiang; 8♂, 5♀ (TARI), Tatachia (塔塔加), 9.VI.2009, leg. C.-F. Lee; 3♂ (TARI), same locality, 20.VII.2009, leg. H. Lee and S.-F. Yu; Kaohsiung: 1♂ (TARI), Kuanshan Wind Gap (關山啞口), 30.VII.2015, leg. C.-F. Lee; Nantou: 1♂ (NMNS), Patungkuan (八通關), 20–22.VI.1990, leg. J. T. Yang; Pingtung: 2♂, 2♀ (TARI), Peitawushan (北大武山), 24.X.2013, leg. J.-C. Chen; 1♀ (TARI), same but with "12.IX.2015"; Taitung: 15♂, 4♀ (TARI), Hsiangyang (向陽), 2.VII.2009, leg. M.-H. Tsou; 1♀ (TARI), Liyuan (栗園), 19.VI.2013, leg. C.-F. Lee; 1♂, 2♀ (TARI), same locality, 19.VI.2014, leg. J.-C. Chen; 2♀ (TARI), Motien (摩天), 23.V.2011, leg. C.-F. Lee; 2♂ (TARI), same but with "19.VI.2011".

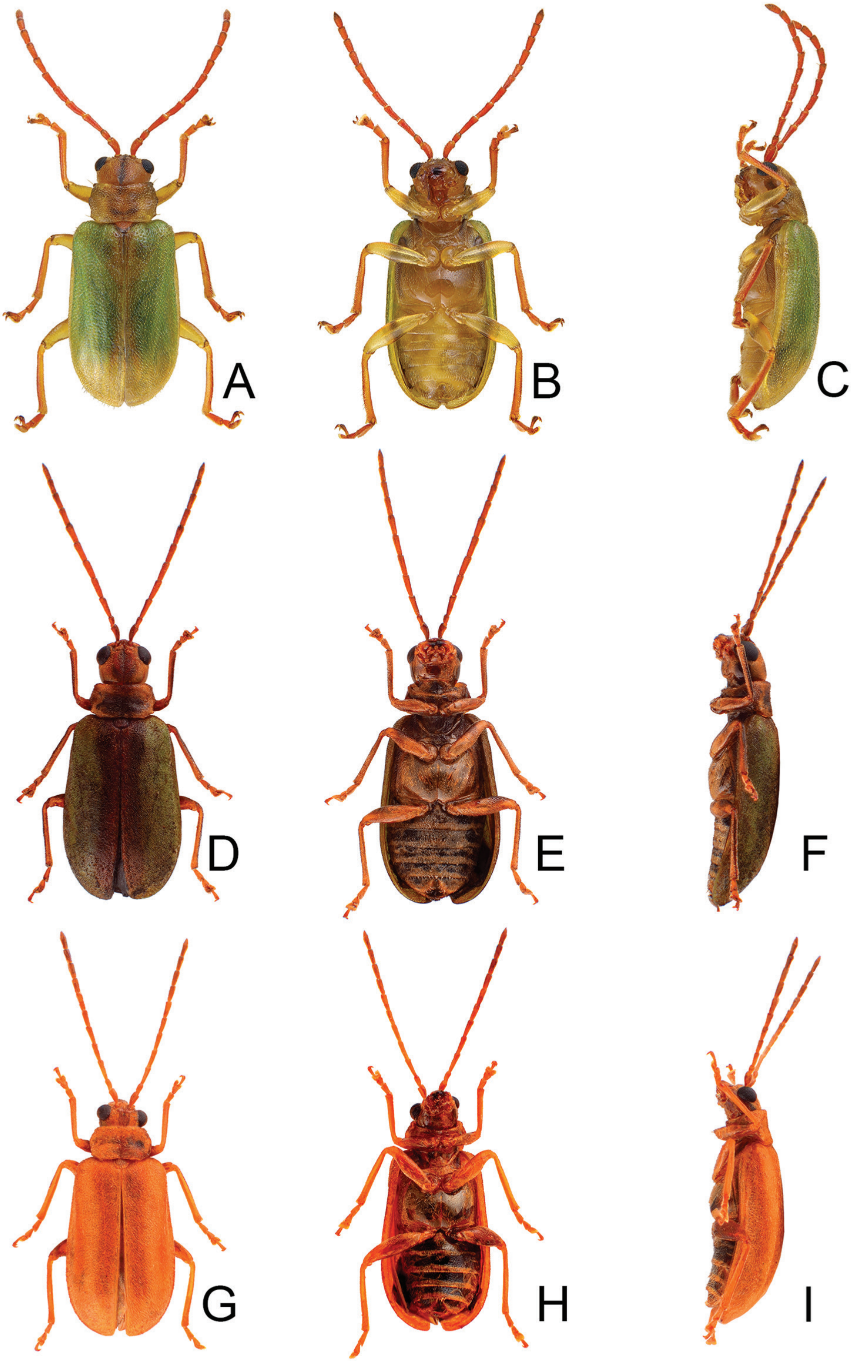

Figure 5. Habitus of *Pyrrhalta gressitti* Kimoto, *P. houjayi* sp. nov., and *P. tahsiangi* sp. nov. **A** *P. gressitti*, male, dorsal view **B** ditto, ventral view **C** ditto, lateral view **D** *P. houjayi* sp. nov., male, dorsal view **E** ditto, ventral view **F** ditto, lateral view **G** *P. tahsiangi* sp. nov., male, dorsal view **H** ditto, ventral view **I** ditto, lateral view.

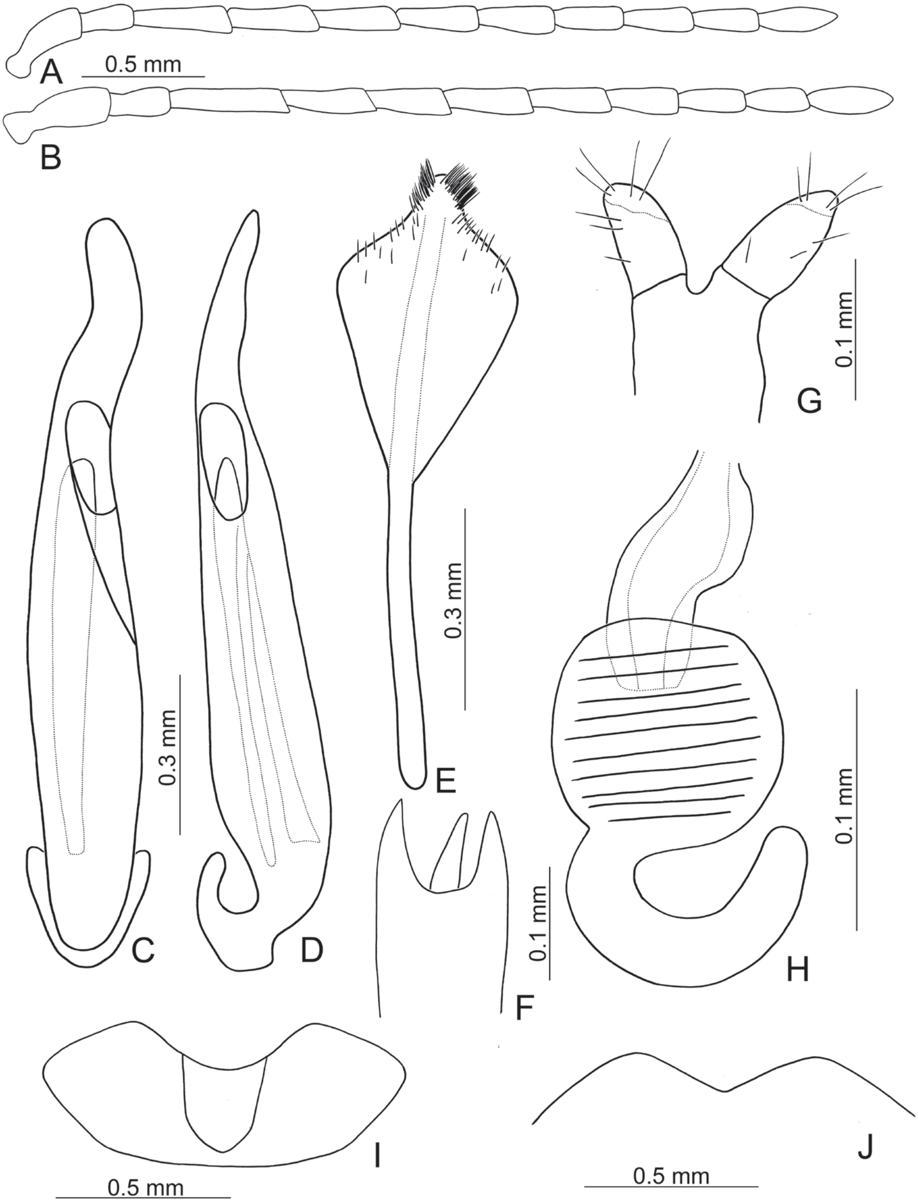

Figure 6. Diagnostic characters of *Pyrrhalta gressitti* Kimoto **A** antenna, male **B** antenna, female **C** aedeagus, dorsal view **D** ditto, lateral view **E** abdominal ventrite VIII **F** apex of tibia of middle leg, male **G**gonocoxae **H** spermatheca **I** abdominal ventrite V, male **J** abdominal ventrite V, female.

Redescription. Length 3.9–5.4 mm, width 1.7–2.4 mm. Body color (Fig. 5A–C) yellowish brown; head with median longitudinal black stripe; antennae reddish brown; elytra green but apical 1/3 and lateral margins yellowish brown; outer sides of tibiae more or less darkened. Eyes small, interocular space 2.76–3.48 × diameter of eye. Antennae filiform in males (Fig. 6A), length ratios of antennomeres I–XI 1.0: 0.6: 1.0: 0.9: 0.9: 0.9: 0.8: 0.8: 0.7: 0.7: 0.8, length to width ratios of antennomeres I–XI 3.1: 2.1: 3.5: 3.4: 3.4: 3.3: 2.8: 3.1: 2.8: 2.9: 3.1; similar in females (Fig. 6B), length ratios of antennomeres I–XI 1.0: 0.6: 1.0: 0.8: 0.7: 0.8: 0.7: 0.6: 0.6: 0.6: 0.8, length to width ratios of antennomeres I–XI 3.0: 2.1: 4.4: 3.1: 3.0: 3.1: 3.1: 2.7: 2.7: 2.5: 3.0. Pronotum and elytra convex. Pronotum 1.8–2.0 × wider than long, disc with reticulate microsculpture; with dense, coarse punctures, and short pubescence, with median longitudinal and lateral depressions; lateral margins moderately rounded, widest at apical 1/3, apical margin slightly concave, basal margin straight; anterior and posterior setiferous punctures slightly erect. Elytra elongate and broad, parallel-sided, 1.7 × longer than wide; disc smooth, with dense, coarse punctures, and short pubescence, with one pair of indistinct longitudinal ridges between suture and humeral calli, two indistinct longitudinal ridges arising from humeral calli, inner ridges separated into two at apical 1/3. Apical spur of tibia of middle leg slender (Fig. 6F), and tarsomere I not modified in males. Aedeagus (Fig. 6C, D) slender in dorsal view, 6.3 × longer than wide, asymmetric, curved at apical 1/4, recurved at apical 1/7, broadly rounded, ostium small and located at right side, not covered by membrane; straight but strongly curved near base in lateral view, recurved at apical 1/7, apex narrowly rounded; primary endophallic sclerite elongate, 0.6 × as long as aedeagus, deeply divided in lateral view. Only apices of gonocoxae (Fig. 6G) sclerotized, with several long setae at apical and lateral areas. Ventrite VIII (Fig. 6E) well sclerotized, strongly broadened near apex, outer sides strongly curved, several short setae along apical margin and bearing a cluster of long setae near middle, spiculum long. Receptacle of spermatheca (Fig. 6H) very swollen; pump long and strongly curved; sclerotized proximal spermathecal duct wide and short. Apical margin of abdominal ventrite V moderately concave medially, with deep depression at middle in males (Fig. 6I); only concave in females (Fig. 6J).

Remarks. adults of *P. gressitti* Kimoto and *P. viridipennis* Kimoto are characterized by their partly green elytra, which possess longitudinal ridges. However, *P. gressitti* can be separated from *P. viridipennis* by its smaller body sizes, 3.9–5.4 mm long (5.3–7.8 mm long in *P. viridipennis*), smooth and shining elytra, with coarse punctures (rough elytra with fine punctures in *P. viridipennis*); recurved apex of aedeagus and broadly rounded apex of primary endophallic sclerite lacking teeth (Fig. 6C, D) (curved apex of aedeagus and narrowly rounded apex of primary endophallic sclerite with teeth in *P. viridipennis* (Fig. 14C, D)); slender apical spur of tibia of middle leg in males (Fig. 6F) (small and stout apical spur of tibia of middle leg in males of *P. viridipennis* (Fig. 14M)); and moderately concave apical margin of abdominal ventrite V in females (Fig. 6J) (slightly concave apical margin of abdominal ventrite V with short internal ridge in females of *P. viridipennis* (Fig. 14L)).

Host plants. Larvae and adults feed on leaves of *Rhododendron rubropilosum* Hayata var. *rubropilosum* Hayata (Ericaceae) (Fig. 7A, B).

Distribution. The species is widespread at mid-altitudes (1,500–2,500 m) in southern Taiwan.

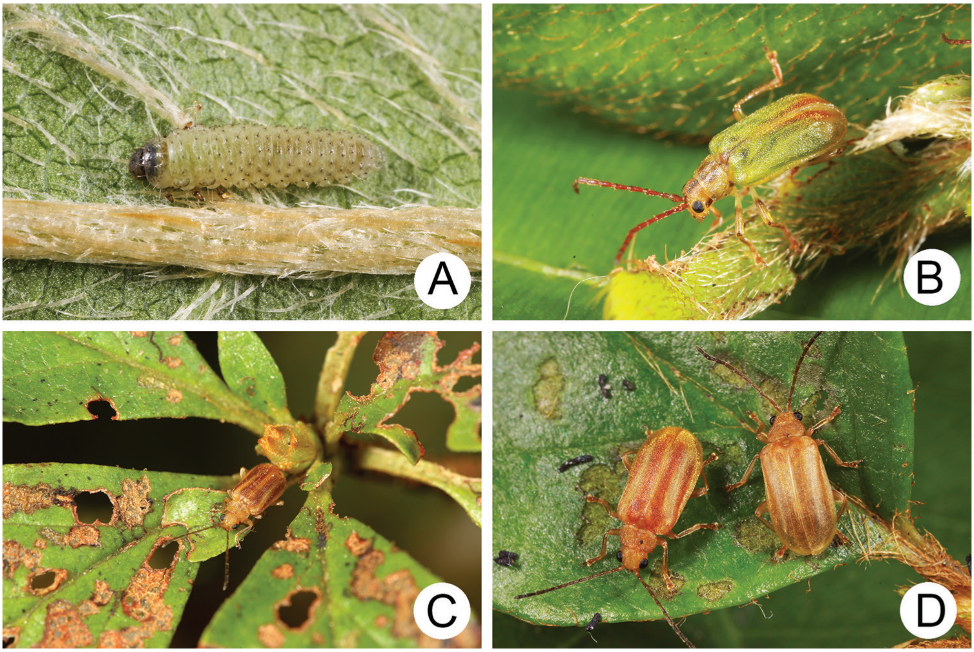

Figure 7. Field photographs of *Pyrrhalta gressitti* Kimoto and *P. tahsiangi* sp. nov. on host plant **A** mature larva of *P. gressitti* **B** *P. gressitti*, adult **C** adult of *P. tahsiangi* on *Rhododendron chilanshanense* **D** adult of *P. tahsiangi* on *R. mariesii*.

Pyrrhalta houjayi sp. nov.

http://zoobank.org/5DC94B2C-2EEE-40A1-9EF1-0D9457CCE01D
Figs 5D–F, 8, 9

Types. ***Holotype*** 1♂ (TARI), Taiwan. Pingtung: Lilungshan (里龍山), 30.VI.2016, leg. J.-C. Chen. ***Paratypes***. 2♂♂, 3♀♀ (TARI), same data as holotype; Hsinchu: 1♂ (TARI), Talu trail (大鹿林道), 1.VIII.2015, leg. Y.-L. Lin; Kaohsiung: 1♂, 1♀ (TARI), Chungchihkuan (中之關), 1.VII.2009, leg. S.-F. Yu; 1♂, 2♀♀ (TARI), same locality, 3.VII.2009, leg. M.-H. Tsou; 1♂ (TARI), Shihshan logging trail (石山林道), 19.VIII.2008, leg. C.-T. Yao; 1♀ (NMNS), Tengchih (天池), 6–7.VII.2000, leg. M. L. Chan; Nantou: 1♀ (TARI), Fenghuangshan (鳳凰山), 10.VIII.2011, leg. M.-H. Tsou; 3♂, 5♀ (TARI), Hsitou (溪頭), 28.V.2009, leg. C.-F. Lee; 2♀ (TARI), Juiyanhsi (瑞岩溪), 16.VIII.2015, leg. S.-F. Yu; 1♂ (TARI), Kuantaoshan (關刀山), 5.VII.2013, leg. Y.-L. Lin; 1♂ (TARI), Meifeng (梅峰), 5–9.X.1980, leg. C. C. Chen & C. C. Chien; 4♂, 1♀ (TARI), same locality, 24–26.VI.1981, leg. K. S. & and W. S. Tang; 3♂, 3♀ (TARI), same locality, 15.VII.1982, leg. S. C. Lin & C. N. Lin; 1♂ (TARI), same locality, 4–7.X.1982, leg. K. C. Chou; 2♂, 1♀ (TARI), same but with "1.VI.2009"; 1♂ (TARI), Peitungyanshan (北東眼山), 3.VII.2014, leg. C.-F. Lee; 3♂, 2♀ (NHMUK), Ruei River Major Wildlife Habitat (瑞岩溪野生動物重要棲息環境), 8.VIII.2008,

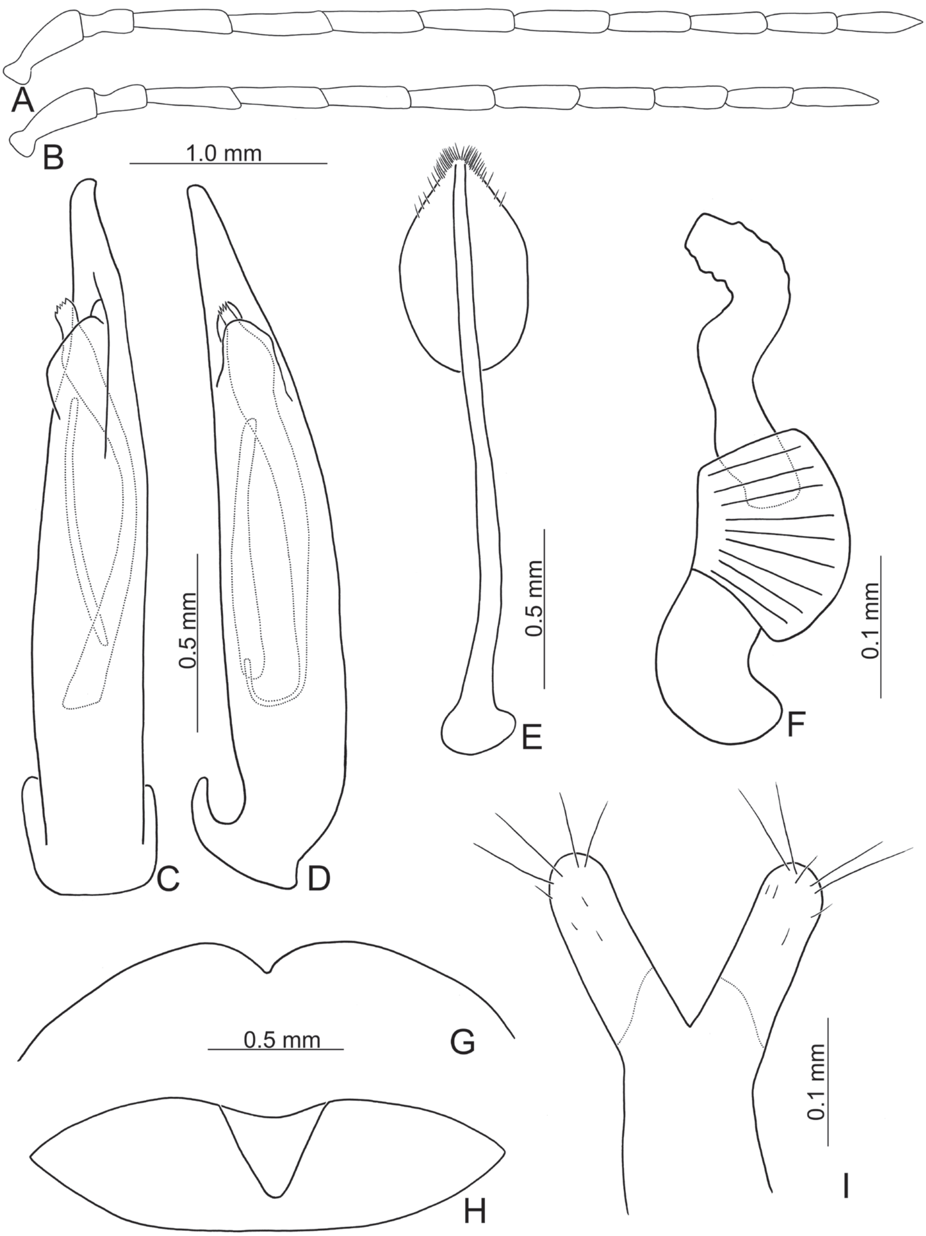

Figure 8. Diagnostic characters of *Pyrrhalta houjayi* sp. nov. **A** antenna, male **B** antenna, female **C** aedeagus, dorsal view **D** ditto, lateral view **E** abdominal ventrite VIII **F** spermatheca **G** abdominal ventrite V, female **H** abdominal ventrite V, male **I** gonocoxae.

leg. H. Mendel & M. V. L. Barclay; 2♂ (TARI), Tsuifeng (翠峰), 25–27.VI.1981, leg. K. S. Lin & W. S. Tang; 1♀ (TARI), same locality, 1–3.VIII.1981, leg. T. Lin & W. S. Tang; Pingtung: 2♂, 4♀ (TARI), Jinshuiying (浸水營), 16.VI.2011, leg. J.-C. Chen; 1♀

(TARI), Peitawushan (北大武山), 22.IX.2012, leg. J.-C. Chen; 1♀ (TARI), Tahanshan (大漢山), 21.VII.2013, leg. Y.-T. Chung; 1♂ (TARI), same but with "30.VII.2013"; 2♀ (TARI), same but with "29.VI.2018"; 1♀ (TARI), same but with "9.IX.2018"; 1♀ (TARI), same but with "1.IV.2020"; Taichung: 1♀ (TARI), Tahsuehshan (大雪山), 6.IV.2014, leg. C.-S. Lin; Taipei: 1♀ (TARI), Tatungshan (大桶山), 10.VIII.2008, leg. M.-H. Tsao; Taitung: 1♀ (TARI), Liyuan (栗園), 19.VI.2014, leg. J.-C. Chen; 1♂, 1♀ (TARI), Motien (摩天), 5.X.2010, leg. C.-F. Lee; 1♀ (TARI), Wululintao (霧鹿林道), 24.VI.2010, leg. M.-H. Tsou; Taoyuan: 1♂, 3♀ (TARI), Lalashan (拉拉山), 22.VII.2008, leg. H.-J. Chen; 1♂, 4♀ (TARI), same locality, 2.VIII.2008, leg. M.-H. Tsao (= Tsou); 2♂, 1♀ (TARI), same but with "leg. S.-F. Yu"; 1♂, 2♀ (TARI), same locality, 7.VIII.2008, leg. H.-J. Chen; 1♂ (TARI), same locality, 30.VIII.2008, leg. M.-H. Tsao; 1♀ (TARI), same locality, 28.IV.2009, leg. H.-J. Chen; 2♂, 1♀ (TARI), same but with "29.IV.2009"; 1♂, 2♀ (TARI), same locality, 5.V.2009, leg. C.-F. Lee; 1♂ (TARI), same but with "8.V.2009"; 1♂ (TARI), same locality, 21.V.2009, leg. M.-H. Tsou; 1♂, 1♀ (TARI), same locality, 25.VI.2009, leg. S.-F. Yu; 1♂, 3♀ (TARI), same locality, 4.V.2009, leg. C.-F. Lee; 1♂ (TARI), Ssuleng (四稜), 1.VI.2012, leg. S.-F. Yu; 3♂, 4♀ (TARI), Tamanshan (塔曼山), 3.VIII.2008, leg. M.-H. Tsao.

Diagnosis. Elytra smooth, lacking longitudinal ridges; green with wide reddish brown band along suture.

Description. Length 4.4–7.5 mm, width 2.5–3.1 mm. Body color (Fig. 5D–F) yellowish brown; head reddish, antenna dark brown; pronotum medially reddish brown; elytra green but with wide reddish brown stripe along suture; scutellum reddish brown; lateral margins of tibiae blackish brown. Eyes small, interocular space 2.20–2.60 × diameter of eye. Antennae filiform in males (Fig. 8A), length ratios of antennomeres I–XI 1.0: 0.6: 1.1: 1.2: 1.2: 1.1: 1.1: 1.0: 0.9: 0.8: 1.0, length to width ratios of antennomeres I–XI 2.7: 2.2: 3.7: 4.1: 4.3: 4.1: 4.2: 3.9: 3.6: 3.3: 4.1; similar in females (Fig. 8B), length ratios of antennomeres I–XI 1.0: 0.5: 1.0: 1.0: 1.0: 0.9: 0.9: 0.8: 0.8: 0.7: 0.9, length to width ratios of antennomeres I–XI 2.9: 2.2: 3.9: 4.2: 4.1: 3.5: 3.7: 3.9: 3.5: 3.3: 4.4. Pronotum and elytra convex. Pronotum 2.0–2.1 × wider than long, disc with reticulate microsculpture; with dense, coarse punctures, and extremely short pubescence, with median longitudinal and lateral depressions; lateral margins rounded, widest at apical 1/3, apical and basal margin slightly concave; anterior and posterior setiferous punctures erect. Elytra elongate and broad, parallel-sided, 1.8 × longer than wide; disc with reticulate microsculpture, with dense, fine punctures, and short pubescence. Apical spur of tibia of middle leg absent and tarsomere I not modified in males. Aedeagus (Fig. 8C, D) slender in dorsal view, 7.4 × longer than wide, asymmetric, curved subapically, apically narrowed from middle, apex narrowly rounded; ostium large, covered by a membrane; straight but strongly curved near base in lateral view, slightly curved at middle, apex narrowly rounded; two endophallic sclerites elongate, primary sclerite 0.7 × as long as aedeagus, apex with several fine teeth, basally recurved; secondary sclerite small, 0.5 × as long as the longer sclerite. Only apices of gonocoxae (Fig. 8I) sclerotized, elongate, with several short setae near apex, and four long setae at near apex. Ventrite VIII (Fig. 8E) well sclerotized, strongly broadened near apex, outer sides strongly curved, several short

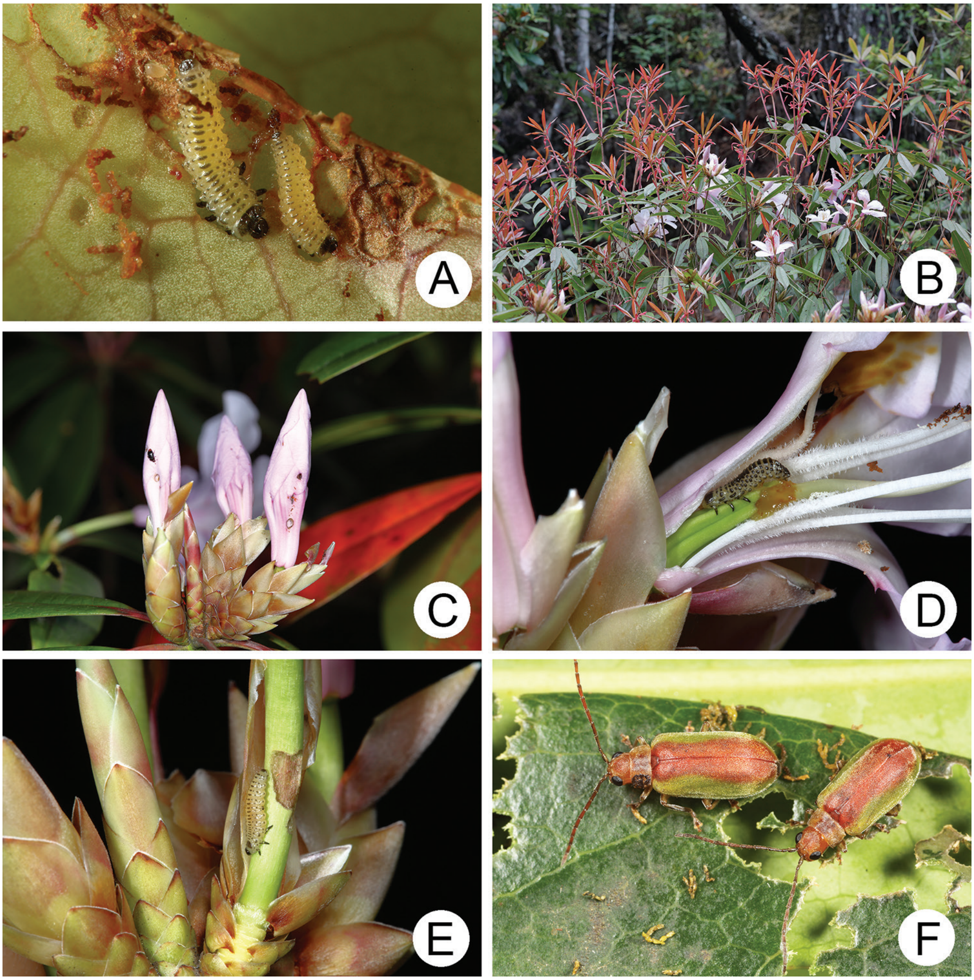

Figure 9. Field photographs of *Pyrrhalta houjayi* sp. nov. on host plant **A** young larvae feeding on tender shoots **B** host plant blooming and sprouting at the same time in Tahsuehshan (大雪山) **C** flower buds with holes caused by larvae **D** Larva found inside the flower buds **E** one larva feeding on pedicels **F** adults.

setae along apical margin and bearing cluster of long setae medially, spiculum long. Receptacle of spermatheca (Fig. 8F) slightly swollen; pump short and strongly curved; sclerotized proximal spermathecal duct wide and long. Apical margin of abdominal ventrite V slightly concave medially, with deep depression but with indistinct margin at middle in males (Fig. 8H); bearing median notch in females (Fig. 8G).

Variation. Specimens from southern Taiwan possess a broader aedeagus and the broader endophallic sclerite near apex that is almost straight in lateral view.

Remarks. Adults of *P. houjayi* sp. nov. and *P. taiwana* Kimoto are characterized by their partly green elytra lacking longitudinal ridges. *Pyrrhalta houjayi* sp. nov. can be distinguished from *P. taiwana* by presence of the wide brown band along the suture of the elytra, and more slender elytra (Figs 5D, 9F), 1.8 × longer than wide (lacking brown band on elytra, and wider elytra (Figs 11A, 13D), 1.6 × longer than wide in *P. taiwana*); slender aedeagus, 7.4 × longer than wide, with apex curved to right (Fig. 8C) (broad aedeagus, 6.8 × longer than wide, with tapering apex (Fig. 12C) in *P. taiwana*); two endophallic slerites, primary endophallic sclerite with teeth at apex (Fig. 8C, D) (one endophallic sclerite slender, lacking teeth at apex (Fig. 12C, D) in *P. taiwana*).

Host plants. Larvae and adults feed on leaves of *Rhododendron leptosanthum* Hayata (Ericaceae)

Biology. The first author, Mrs Hsueh Lee, and Mr Hou-Jay Chen found young larvae feeding on tender shoots (Fig. 9A) April 1, 2009 in Lalashan, northern Taiwan. mature larvae started to burrow into soil and built underground chambers for pupation April 11. The newly eclosed adults emerged from soil April 28. The first author and Mr. Ta-Hsiang Lee found the host plants blooming and sprouting at the same time (Fig. 9B) April 21, 2010 in Tahsuehshan, central Taiwan. Many larvae were found inside flower buds with holes (Fig. 9C, D). Some larvae preferred to feed on pedicels (Fig. 9E). Newly emerged adults appeared during late spring, into summer (Fig. 9F).

Distribution. This new species is widespread at mid-altitudes (1,500–2,500 m) in Taiwan.

Etymology. Dedicated to Mrs Su-Fang Yu who was the first member of TCRT to collect specimens of this new species and rear them successfully from eggs to adults.

Pyrrhalta tahsiangi **sp. nov.**

http://zoobank.org/6856834F-F395-492B-95C7-30D7F948A495
Figs 5G–I, 7C, D, 10

Types. ***Holotype*** ♂ (TARI), Taiwan. Ilan: Tsuifenghu (翠峰湖), 4.VII.2010, leg. M.-H. Tsou. ***Paratypes***. 3♂, 8♀ (TARI), same data as holotype; Ilan: 6♀ (TARI), Yuanyanghu (鴛鴦湖), 23.VIII.2011, leg. M.-H. Tsou; 1♂, 5♀ (TARI), same but with "leg. H. Lee"; 7♀ (TARI), Taipingshan (太平山), 25.V.2009 (reared from larvae), leg. C.-F. Lee.

Diagnosis. Elytra smooth, lacking longitudinal ridges; yellowish brown, with brown longitudinal stripes.

Description. Length 4.8–5.6 mm, width 2.1–2.4 mm. Body color (Fig. 5G–I) yellowish brown; antennae brown, four apical antennomeres darkened; elytra with two pairs of wide, poorly defined, longitudinal brown stripes, one pair near suture, the other arising from humeral calli. Eyes small, interocular space 2.55–2.58 × diameter of eye. Antennae filiform in males (Fig. 10A), length ratios of antennomeres I–XI 1.0: 0.6: 1.2: 1.0: 0.9: 0.9: 1.0: 0.9: 0.9: 0.8: 1.0, length to width ratios of antennomeres I–XI 2.6: 2.2: 4.3: 3.8: 3.8: 3.3: 3.4: 3.3: 3.0: 3.0: 4.0; similar in females (Fig. 10B), length ratios of antennomeres I–XI 1.0: 0.7: 1.1: 1.0: 1.0: 1.0: 1.0: 0.9: 0.9: 0.8: 1.1, length to width ratios of antennomeres I–XI 2.6: 2.6: 4.0: 3.6: 3.5: 3.4: 3.7: 3.2: 3.4: 3.3: 4.3. Pronotum and elytra convex. Pronotum 1.8–1.9 × wider than long, disc smooth; with extremely dense,

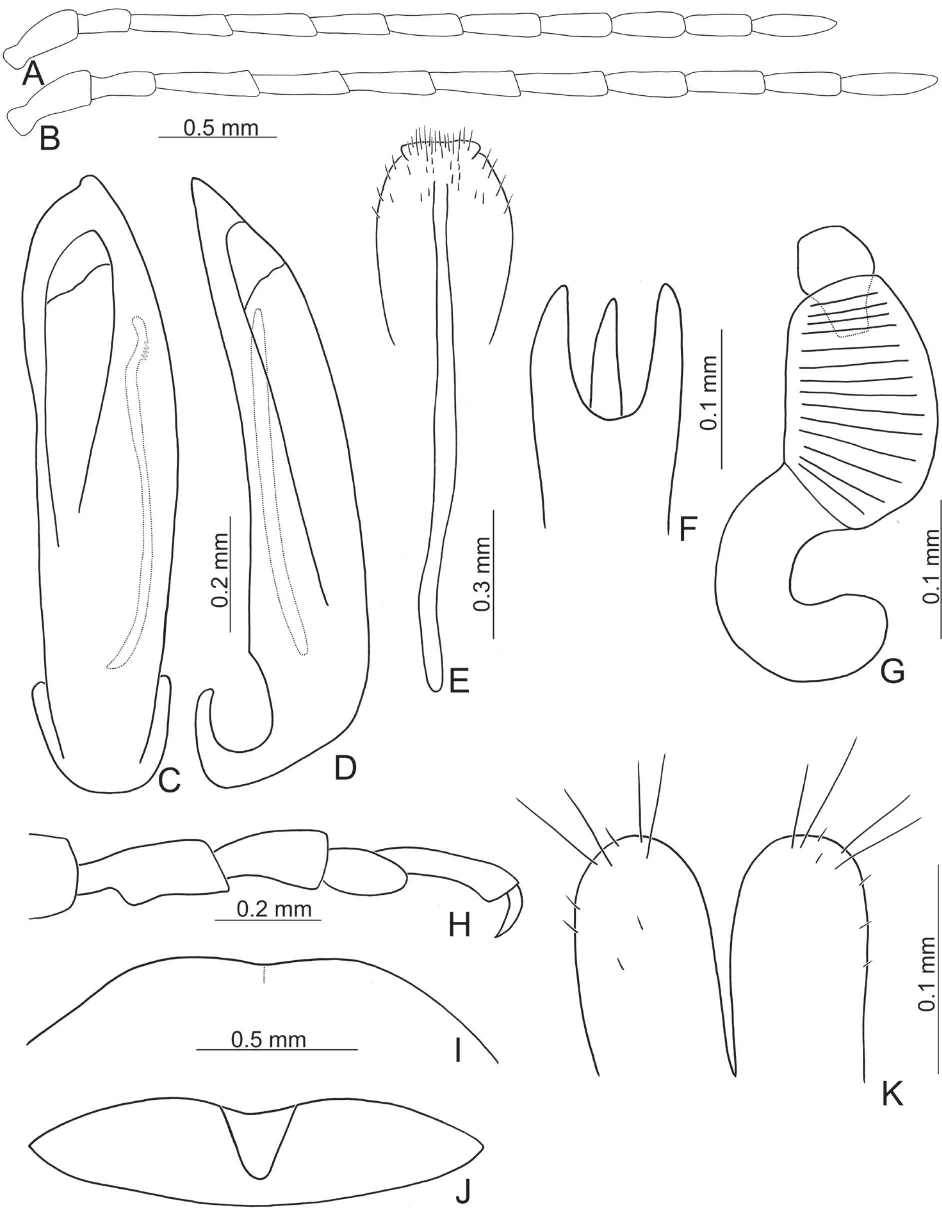

Figure 10. Diagnostic characters of *Pyrrhalta tahsiangi* sp. nov. **A** antenna, male **B** antenna, female **C** aedeagus, dorsal view **D** ditto, lateral view **E** abdominal ventrite VIII **F** apex of tibia of middle leg, male **G** spermatheca **H** tarsi of middle leg, male **I** abdominal ventrite V, female **J** abdominal ventrite V, male **K** gonocoxae.

coarse punctures, and short pubescence, with median longitudinal and lateral depressions; lateral margins slightly rounded, widest at apical 1/3, apical and basal margin slightly concave; anterior and posterior setiferous punctures slightly erect. Elytra elongate and broad, parallel-sided, 1.7 × longer than wide; disc rugose, with dense, coarse punctures, and short pubescence. Apical spur of tibia of middle leg slender (Fig. 10F), and tarsomere I ax-shaped in lateral view, with narrowed basal half and expanded apical half (Fig. 10H) in males. Aedeagus (Fig. 10C, D) broad in dorsal view, 5.0 × longer than wide, parallel-sided, asymmetric, curved at middle, apex narrowly rounded; ostium large, mostly covered by membrane; straight but strongly curved near base in lateral view, apex narrowly rounded; primary endophallic sclerite elongate, 0.5 × as long as aedeagus, with several fine teeth near apex. Only apices of gonocoxae (Fig. 10K) sclerotized, short, with several short setae near apex, and four long setae near apex. Ventrite VIII (Fig. 10E) well sclerotized, apex truncate, plate-shaped and projecting, several extremely short setae along lateral margin and apical area, apical margin with cluster of long setae near middle, spiculum extremely long. Receptacle of spermatheca (Fig. 10G) swollen; pump short and strongly curved; sclerotized proximal spermathecal duct wide and extremely short. Apical margin of abdominal ventrite V slightly concave medially and with deep depression in males (Fig. 10J); while slightly concave and with short internal ridge at middle in females (Fig. 10I).

Remarks. Adults of this new species are easily separated from other members of the species group by their yellowish brown elytra bearing longitudinal brown stripes and modified tarsi of the middle leg. In addition, some putative autapomorphies are found in genitalic characters, including the characteristic shape of the aedeagus and single endophallic sclerite bearing teeth near the apex (Fig. 10C). The truncate apex of abdominal ventrite VIII in females is also diagnostic (Fig. 10E) (tapering apex of abdominal ventrite VIII in females of others).

Host plants. adults feed on leaves of *Rhododendron chilanshanense* Kurashige (Fig. 7C); larvae and adults feed on leaves of *R. mariesii* Hemsl. and E. H. Wilson (Ericaceae) (Fig. 7D).

Biology. The first author and Mr Ta-Hsiang Lee collected young larvae on tender leaves of *Rhododendron mariesii* May 1, 2009 in Taipingshan, northeastern Taiwan, and reared them in the laboratory. Newly eclosed adults emerged from soil May 25. Mr. Mei-Hua Tsou collected a number of adults July 5, 2010 at the same locality (= Tsuifenghu) (Fig. 7C). The first author, Mrs. Hsueh Li, and Mr. Mei-Hua Tsou found adults feeding on leaves of *R. chilanshanense* (Fig. 7D) August 23, 2011 in Yuanyanghu, northeastern Taiwan.

Distribution. This new species is restricted to mid-altitudes (1,000–2,000 m) in northeastern Taiwan.

Etymology. Dedicated to Mr. Ta-Hsiang Lee. He and the first author were the first to find larvae of this new species and rear them successfully to adults.

Pyrrhalta taiwana Kimoto, 1969

Figs 11A–C, 12, 13A–D

Pyrrhalta taiwana Kimoto, 1969: 27 (Taiwan); Kimoto and Chu 1996: 57 (catalogue); Kimoto and Takizawa 1997: 300 (key), 374; Beenen 2010: 453 (catalogue); Xue and Yang 2010: 130 (catalogue); Yang et al. 2015: 121 (catalogue).

Pyrrhalta (*Pyrrhalta*) *taiwana*: Wilcox, 1971: 90 (catalogue).

Types. ***Holotype*** ♂ (KUEC): "[Formosa] / Hassenzan [= Pahsienshan, 八仙山] (Taichû-shû) / Kahodai [= Chiaobaotai, 佳保台]-Reimei [= Liming, 黎明] / 12. Vii. 1932 / Teiso Esaki [p, w] // Pyrrhalta/ taiwana / Kimoto, n. sp. [h, w] // HOLOTYPE [p, r]".

Other material. Taiwan. Chiayi: 11♂, 7♀ (TARI), Tzuchung (自忠), 5.VI.2011 (reared from larvae), leg. C.-F. Lee; Kaohsiung: 2♂, 2♀ (TARI), Chungchihkuan (中之關), 3.VII.2009, leg. S.-F. Yu; 1♂, 2♀ (TARI), same locality, 1.VII.2019, leg. M.-H. Tsou; 3♂ (TARI), Tengchih (藤枝), 31.VII.2008, leg. C.-T. Yao; Taichung: 1♂ (TARI), Tahsuehshan (大雪山), 23.VII.2011, leg. J.-C. Chen; Taitung: 6♂, 7♀ (TARI), Lichia trail (利嘉林道), 15.VII.2014, leg. B.-X. Guo.

Redescription. Length 5.6–7.0 mm, width 2.6–3.0 mm. Body color (Fig. 11A–C) yellowish brown; elytra green but with wide yellow stripe along lateral margin; lateral margins of tibiae darkened. Eyes small, interocular space 2.33–2.58 × diameter of eye. Antennae filiform in males (Fig. 12A), length ratios of antennomeres I–XI 1.0: 0.6: 1.1: 1.0: 1.0: 1.0: 0.9: 0.8: 0.8: 0.7: 1.0, length to width ratios of antennomeres I–XI 2.5: 2.3: 3.7: 3.6: 3.6: 3.6: 3.4: 3.2: 3.1: 3.1: 4.9; similar in females (Fig. 12B), length ratios of antennomeres I–XI 1.0: 0.6: 1.1: 1.0: 0.9: 0.8: 0.9: 0.8: 0.8: 0.7: 0.8, length to width ratios of antennomeres I–XI 2.5: 2.3: 4.0: 3.7: 3.5: 3.6: 3.5: 3.3: 3.1: 3.0: 3.7. Pronotum and elytra convex. Pronotum 2.1–2.2 × wider than long, disc with reticulate microsculpture; with dense, coarse punctures, and short pubescence, with median longitudinal and lateral depressions; lateral margins rounded, widest at middle, apical and basal margin slightly concave; anterior and posterior setiferous punctures strongly erect. Elytra elongate and broad, parallel-sided, 1.6 × longer than wide; disc smooth, with dense, fine punctures, and short pubescence. Apical spur of tibia of middle leg absent and tarsomere I not modified in males. Aedeagus (Fig. 12C, D) slender in dorsal view, 6.6 × longer than wide, parallel-sided, asymmetric, apically narrowed from apical 1/5, apex acute; ostium large, not covered by a membrane; straight but strongly curved near base in lateral view, slightly curved at middle, apex narrowly rounded; primary endophallic sclerite elongate, 0.4 × as long as aedeagus. Only apices of gonocoxae (Fig. 12F) sclerotized, elongate, with several short setae near apex, and four long setae in apical area. Ventrite VIII (Fig. 12E) well sclerotized, strongly broadened near apex, outer sides strongly curved, several short setae along apical margin and bearing cluster of long setae medially, spiculum long. Receptacle of spermatheca (Fig. 12G) very swollen; pump short and strongly curved; sclerotized proximal spermathecal duct wide and short. Apical margin of abdominal ventrite V slightly concave medially, with deep depression with an indistinct margin medially in males (Fig. 12I); deep notch in females (Fig. 12H).

Remarks. Adults of *P. taiwana* Kimoto and *P. houjayi* sp. nov. are characterized by their partly green elytra without longitudinal ridges. *Pyrrhalta taiwana* can be distinguished from *P. houjayi* sp. nov. by the entirely green elytra, except lateral margins, and wider elytra (Figs 11A, 13D), 1.6 × longer than wide (presence of the wide brown band along suture of elytra, and more slender elytra (Figs 5D, 9F), 1.8 × longer than wide in *P. houjayi* sp. nov.); broad aedeagus, 6.8 × longer than wide, with tapering apex (Fig. 12C) (slender aedeagus, 7.4 × longer than wide, with apex curved to right (Fig. 8C) in *P. houjayi* sp. nov.); one endophallic sclerite, slender, lacking teeth at apex

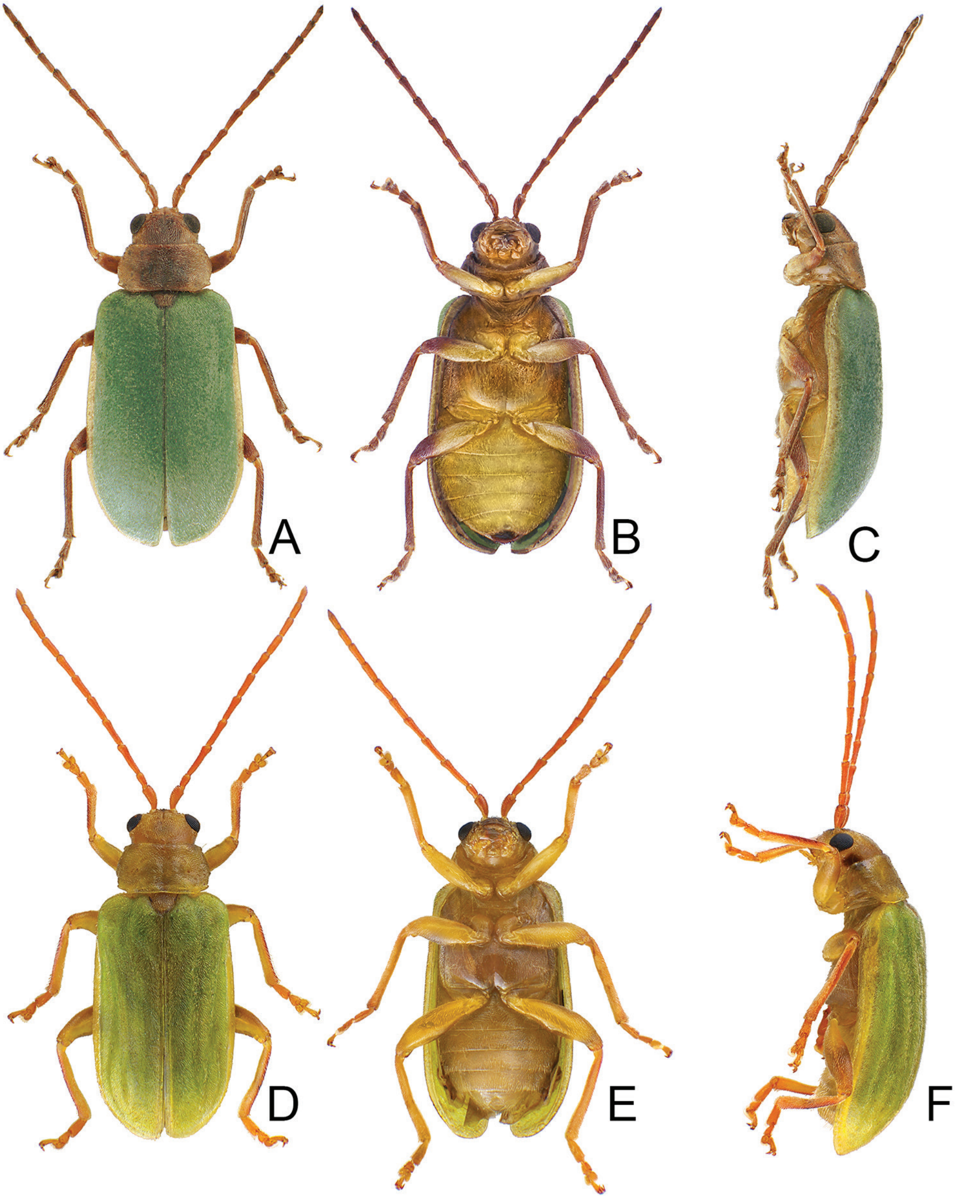

Figure 11. Habitus of *Pyrrhalta taiwana* Kimoto and *P. viridipennis* Kimoto **A** *P. taiwana*, male, dorsal view **B** ditto, ventral view **C** ditto, lateral view **D** *P. viridipennis*, male, dorsal view **E** ditto, ventral view **F** ditto, lateral view.

(Fig. 12C, D) (two endophallic slerites, primary endophallic sclerite with teeth at apex (Fig. 8C, D) in *P. houjayi* sp. nov.).

Host plants. Larvae and adults feed on leaves of *Vaccinium randaiense* Hayata (Fig. 13A); adults feed on leaves of *Rhododendron leptosanthum* Hayata (Ericaceae).

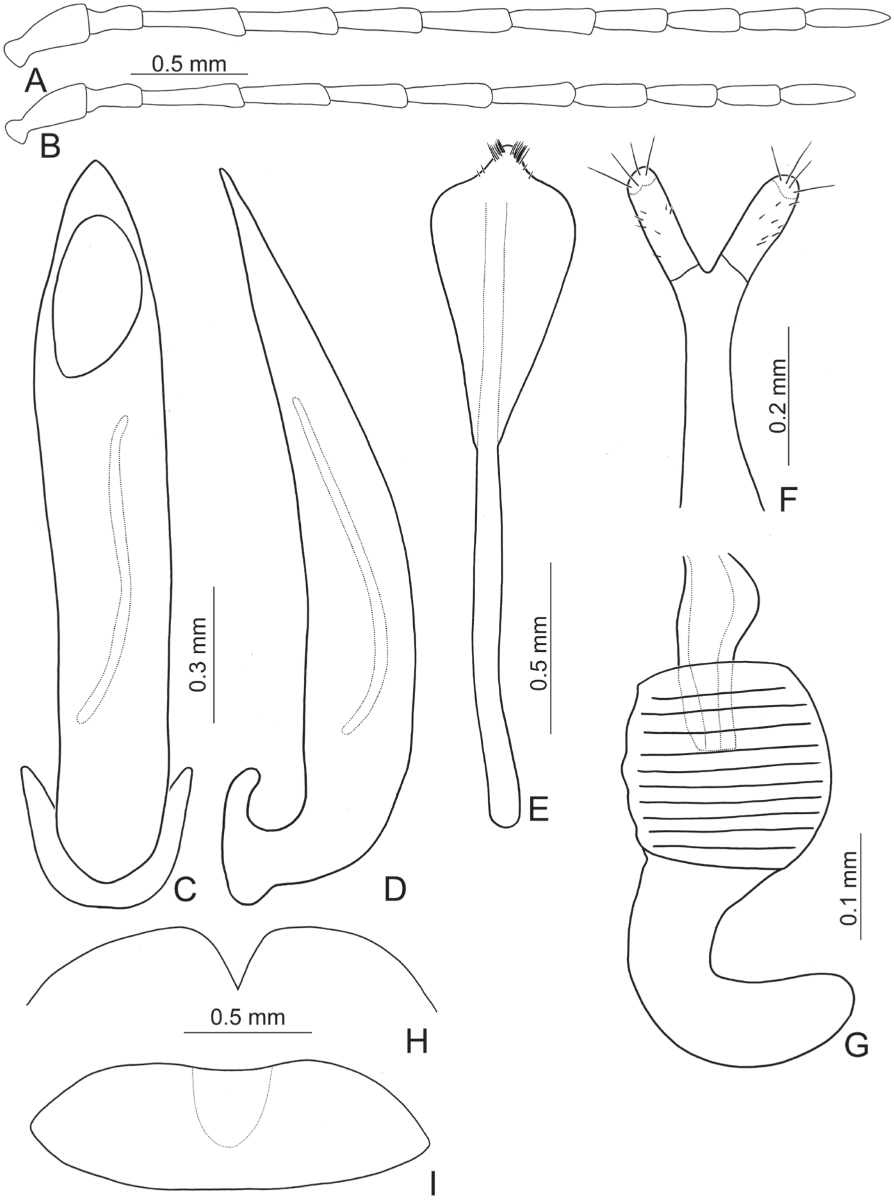

Figure 12. Diagnostic characters of *Pyrrhalta houjayi* sp. nov. **A** antenna, male **B** antenna, female **C** aedeagus, dorsal view **D** ditto, lateral view **E** abdominal ventrite VIII **F** spermatheca **G** gonocoxae **H** abdominal ventrite V, female **I** abdominal ventrite V, male.

Biology. Mrs Su-Fang Yu found adults feeding on leaves of *Rhododendron leptosanthum* July 3, 2009 in Chungchihkung, southern Taiwan. The first author and Mr. Mei-Hua Tsou found a number of larvae feeding tender leaves of *Vaccinium randaiense*

May 9, 2011 in Tzuchung, southern Taiwan. These were reared in the laboratory. They began burrowing into soil May 12 and built underground chambers for pupation. The newly eclosed adults emerged from soil May 25.

Distribution. This species is widespread at mid-altitudes (1,500–2,500 m) in southern Taiwan.

Pyrrhalta viridipennis **Kimoto, 1981**

Figs 11D–F, 13C, D, 14

Pyrrhalta viridipennis Kimoto, 1981: 2; Kimoto and Chu 1996: 57; Kimoto and Takizawa 1997: 301 (key), 374; Beenen 2010: 453 (catalogue); Xue and Yang 2010: 132 (catalogue); Yang et al. 2015: 122 (catalogue).

Types. ***Holotype*** ♂ (OMNH, by original designation): "NANSHANCHI [南山溪] / TAIWAN / 21. VII. 1974 / Y. KIYOYAMA [p, y] // Pyrrhalta / viridipennis / Kimoto, n. sp. [h, w] // HOLOTYPE [p, r] // PHOTO [p, r]". ***Paratype***. 1 ♂ (KMNH): "(Taiwan) [p] / Sungan [松安] / Miaoli [h] Hsien [p, w] // 10.IV.1967 [h] / B. S. Chang [p, w] // Pyrrhalta / viridipennis / Kimoto, n. sp. [h, w] // Det. S. Kimoto, 19 [p, w] // PARATYPE [p, b]".

Other material. Taiwan. Chiayi: 1♂, 1♀ (TARI), Alishan (阿里山), 5–9. VIII.1981, leg. L. Y. Chou & S. C. Lin; Kaohsiung: 1♂ (TARI), Kuanshanyakou (關山啞口), 30.VII.2015, leg. C.-F. Lee; 1♂, 1♀ (TARI), Tengchih (藤枝), 7.IX.2012, leg. W.-C. Liao; 2♂, 5♀ (TARI), same but with "10.VIII.2013"; 1♀ (TARI), same but with "27.IX.2013"; 2♂, 4♀ (TARI), same but with "5.X.2013"; 4♂, 1♀ (TARI), same locality, 4.VIII.2012, leg. J.-C. Chen; 2♂, 2♀ (TARI), same locality, 30.VIII.2014, leg. B.-X. Guo; 2♀ (TARI), Tsuyunshan (出雲山), 25.IV.1990, leg. C. C. Chiang; Nantou: 1♀ (NMNS), Huishun (惠蓀), 3.VII.1991, leg. C. S. Lin; 1♂ (NMNS), Shanlinchi (杉林溪), 11.V.1990, leg. C. C. Chiang; 2♀ (TARI), Tsuifeng (翠峰), 1–3.VIII.1981, leg. T. Lin & W. S. Tang; 1♂, 1♀ (TARI), same locality, 1–3.IX.1982, leg. L. Y. Chou & K. C. Chou; 1♂, 2♀ (TARI), same locality, 12–14.IX.1984, leg. K. S. Lin & S. C. Lin; Pingtung: 1♂, 1♀ (TARI), Ali (阿禮), 30.V.2014, leg. J.-C. Chen; Taichung: 1♂, 1♀ (NHMUK), Basianshan National Forest Recreation Area (八仙山國家森林遊樂區), 27.V.2007, leg. G. Martin & D. L. J. Quicke; 2♀ (TARI), Tahsuehshan (大雪山), 21.IV.2010, leg. C.-F. Lee; Taipei: 1♂, 1♀ (TARI), Shihfen (十分), 23.V.2016, leg. J.-C. Chen; 1♂ (TARI), Yingtzuling (鶯子嶺), 21.VI.2016, leg. Y.-L. Lin; Taitung: 3♂ (TARI), Hsiangyang (向陽), 2.VII.2009, leg. S.-F. Yu; 8♂, 5♀ (TARI), same but with "leg. M.-H. Tsou"; 1♀ (TARI), same locality, 22.XII.2013, leg. W.-C. Liao; 1♂ (TARI), Hsiangyangshan (向陽山), 20.VI.2014, leg. J.-C. Chen.

Redescription. Length 5.3–7.8 mm, width 2.3–3.5 mm. Body color (Fig. 11D–F) yellowish brown; antenna reddish brown; elytra green but with wide yellow stripe along lateral margin, apical area more or less yellowish brown. Eyes small, interocular space 2.67–2.75 × diameter of eye. Antennae filiform in males (Fig. 14A), length ratios of

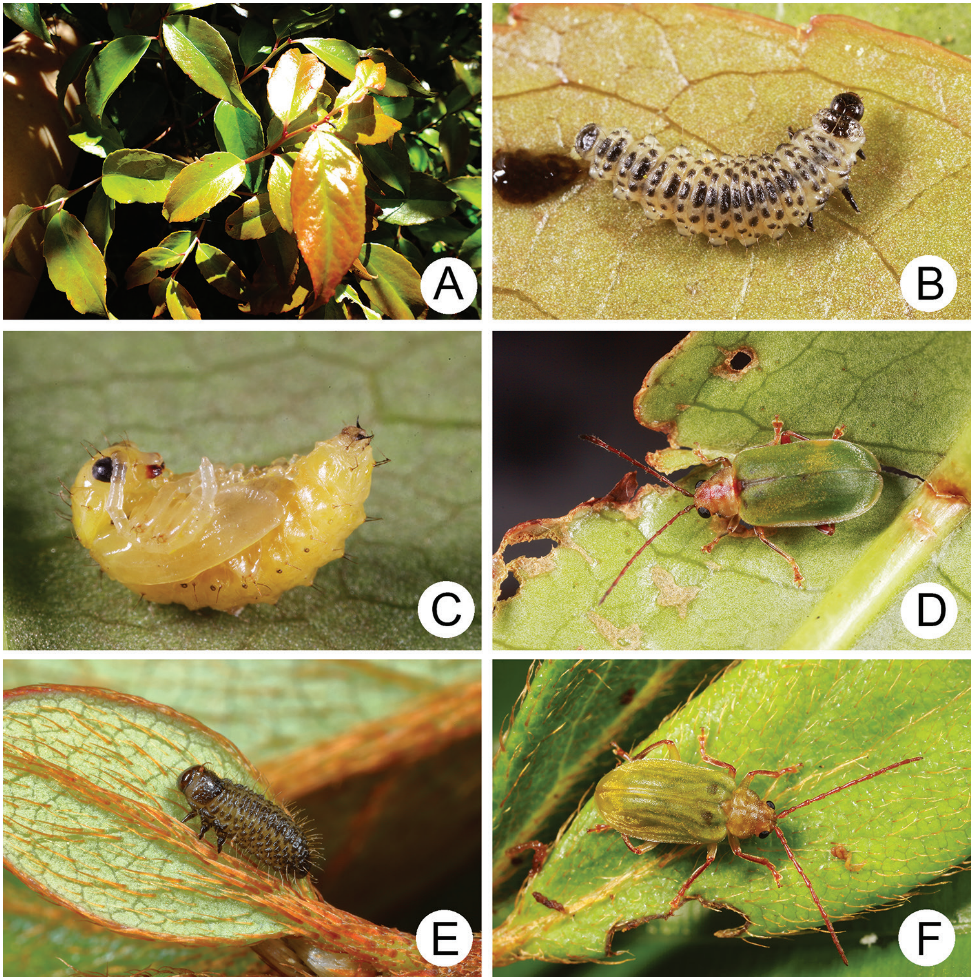

Figure 13. Field photographs of *Pyrrhalta taiwana* Kimoto and *P. viridipennis* Kimoto on host plant **A** host plant for *P. tahsiangi*, *Vaccinium randaiense* **B** mature larva of *P. taiwana* **C** pupa of *P. taiwana* **D** adult of *P. taiwana* **E** Third-instar larva of *P. viridipennis* **F** adult of *P. viridipennis*.

antennomeres I–XI 1.0: 0.7: 1.2: 1.1: 1.0: 1.0: 0.9: 0.9: 0.8: 0.7: 0.9, length to width ratios of antennomeres I–XI 2.6: 2.9: 4.5: 3.9: 3.7: 3.7: 3.4: 3.5: 3.1: 3.3: 4.4; similar in females (Fig. 14B), length ratios of antennomeres I–XI 1.0: 0.5: 0.9: 0.9: 0.9: 0.8: 0.8: 0.7: 0.7: 0.6: 0.8, length to width ratios of antennomeres I–XI 2.8: 2.1: 3.6: 4.0: 4.0: 3.6: 3.7: 3.2: 3.1: 2.9: 3.7. Pronotum and elytra convex. Pronotum 1.9–2.0 × wider than long, disc with reticulate microsculpture; with dense, coarse punctures, and short pubescence, with median longitudinal and lateral depressions; lateral margins rounded, widest at middle, apical and basal margin slightly concave; anterior and posterior setiferous punctures slightly erect. Elytra elongate and broad, parallel-sided, 1.6–1.7 × longer than wide; disc rough, with dense, fine punctures, and short pubescence. Apical spur of tibia of middle leg small and curved (Fig. 14M), and tarsomere

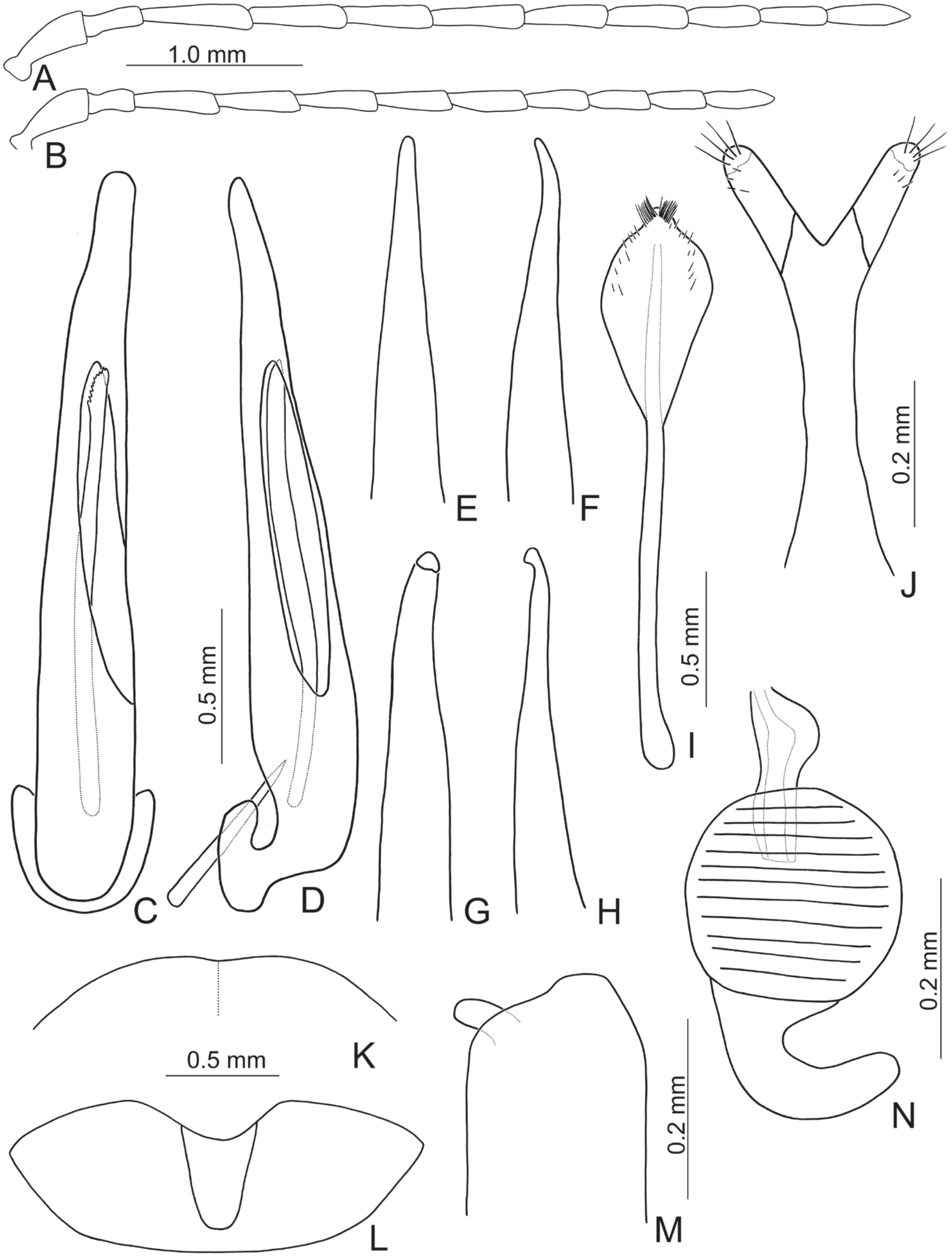

Figure 14. Diagnostic characters of *Pyrrhalta viridipennis* Kimoto **A** antenna, male **B** antenna, female **C** aedeagus, from Alishan (阿里山), dorsal view **D** ditto, lateral view **E** apex of aedeagus, from Shihfen (十分), dorsal view **F** ditto, lateral view **G** apex of aedeagus, from Hsiangyang, dorsal view **H** ditto, lateral view **I** abdominal ventrite VIII **J** gonocoxae **K** abdominal ventrite V, female **L** abdominal ventrite V, male **M** apex of tibia of middle leg **N** spermatheca.

I not modified in males. Aedeagus (Fig. 14C, D) slender in dorsal view, 7.9 × longer than wide, asymmetric, curved at apical 1/7, apically narrowed, apex broadly rounded; ostium large, not covered by membrane; straight but strongly curved near base in lateral view, slightly curved near apex, apex narrowly rounded; two endophallic sclerites elongate, primary sclerite longer and 0.6 × as long as aedeagus, apex with several fine teeth; secondary sclerite small, 0.4 × as long as the longer sclerite. Only apices of gonocoxae (Fig. 14J) sclerotized, elongate, with several short setae near apex, and four long setae near apex. Ventrite VIII (Fig. 14I) well sclerotized, strongly broadened near apex, outer sides strongly curved, several short setae along apical margin and bearing cluster of long setae medially, spiculum long. Receptacle of spermatheca (Fig. 14N) very swollen; pump short and strongly curved; sclerotized proximal spermathecal duct wide and short. Apical margin of abdominal ventrite V moderately concave medially, with deep, indistinctly margined depression at middle in males (Fig. 14L); slightly concave, with median, longitudinal internal ridge in females (Fig. 14K).

Variation. The apex of the aedeagus is variable among populations; more slender in north and central Taiwan (Fig. 14E, F); recurved in southeast Taiwan (Fig. 14G, H).

Host plant. Larvae and adults feed on leaves of *Rhododendron rubropilosum* Hayata var. *rubropilosum* Hayata (Ericaceae) (Fig. 13E, F).

Biology. The first author and Mr. Ta-Hsiang Lee collected one larva feeding on leaves April 20, 2010 in Tahsuehshan, central Taiwan (Fig. 13E). It was reared in the laboratory. The newly eclosed adult appeared May 20 (Fig. 13F).

Remarks. Adults of *P. viridipennis* Kimoto and *P. gressitti* Kimoto are both characterized by the green elytra with longitudinal ridges. However, *P. viridipennis* differs from *P. gressitti* by the larger body sizes, 5.3–7.8 mm long (3.9–5.4 mm long in *P. gressitti*), rough elytra with fine punctures (smooth and shining elytra with coarse punctures in *P. gressitti*); curved apex of aedeagus and narrowly rounded apex of primary endophallic slerite with teeth (Fig. 14C, D) (recurved apex of aedeagus and broadly rounded apex of primary endophallic sclerite lacking teeth in *P. gressitti* (Fig. 6C, D)); small and stout apical spur of tibia of middle leg in males (Fig. 14M) (slender apical spur of tibia of middle leg in males of *P. viridipennis* (Fig. 6F)); and slightly concave apical margin of abdominal ventrite V with short internal ridge in females (Fig. 14L) (moderately concave apical margin of abdominal ventrite V in females of *P. viridipennis* (Fig. 6J))

Distribution. The species is widespread at mid-altitudes (1,500–2,500 m) in central and southern Taiwan.

Pyrrhalta meifena species group

Included species. *Pyrrhalta alishanensis* sp. nov.; *P. igai* Kimoto, 1981; *P. meifena* Kimoto, 1976; and *P. meihuai* sp. nov.

Diagnosis. Medium to large sized species (5.6–8.7 mm). Antenna stout, antennomeres VII-X shortest (1.5–2.2 × longer than wide), III–VI similar or slender. Body convex. Elytra relatively broad, 1.4–1.6 × longer than wide. Aedeagus apically tapering and symmetric (Figs 16C, 20C, 22C) except *P. meihuai* sp. nov. (Fig. 20C), ostium obliquely longitudinal and lacking cover; endophallic sclerites composed of primary sclerite with several teeth at apex in *P. igai* (Fig. 19C) and *P. meifena* (Fig. 20C), with one secondary sclerite in *P. meihuai* sp. nov. (Fig. 22C, D) or two secondary sclerites in *P. alishanensis* sp. nov. (Fig. 16C, D) Ventrite VIII in females apically sclerotized, apical margin widely rounded and with dense short setae; spiculum long (Figs 16E, 19E, 20E, 22E). Gonocoxae apically sclerotized and longitudinal, with dense, long setae along lateral and apical margins (Figs 16I, 19I, 20I, 22F). Apical margin of abdominal ventrite V with one pair of rounded ridges at middle and slightly concave between ridges in males (Figs 16H, 19H, 20H, 22I); widely rounded in females (Figs 16G, 20G, 22H) except concave in those of *P. igai* (Fig. 19G). Mesotibia lacking apical spine in males and tarsomere I not modified.

Biology. Larvae and adults feed on leaves of *Acer* species (Sapindaceae).

***Pyrrhalta alishanensis* sp. nov.**

http://zoobank.org/F257BF90-025E-4CC9-8B1B-836B74EDE26C
Figs 15A–C, 16, 17A, B

Types. ***Holotype*** ♂ (TARI), Taiwan. Chiayi: Alishan (阿里山), 22.IV.2009, leg. M.-H. Tsou. ***Paratypes.*** 7♂, 11♀ (TARI), same data as holotype.

Diagnosis. Medium-sized species, 7.3–8.7 mm. Body black. Elytra with fine dense punctures.

Description. Length 7.7–8.7 mm, width 3.8–4.6 mm. Body black (Fig. 15A–C); mouth parts black; abdominal ventrites yellow in males, ventrites II and III darker in females. Eyes small, interocular space 2.12–2.44 × diameter of eye. Antennae filiform in males (Fig. 16A), antennomeres V–VII broadest, length ratios of antennomeres I–XI 1.0: 0.6: 0.6: 0.8: 0.8: 0.8: 0.8: 0.7: 0.7: 0.7: 0.9, length to width ratios of antennomeres I–XI 2.5: 2.1: 1.9: 2.6: 2.4: 2.3: 2.3: 2.3: 2.5: 2.5: 3.5; similar in females (Fig. 16B), length ratios of antennomeres I–XI 1.0: 0.7: 0.6: 0.8: 0.8: 0.7: 0.8: 0.7: 0.7: 0.7: 0.8, length to width ratios of antennomeres I–XI 2.9: 2.4: 2.0: 2.5: 2.5: 2.1: 2.2: 2.1: 2.3: 2.2: 2.8. Pronotum and elytra convex. Pronotum 2.5–2.7 × wider than long, disc smooth and sparse short pubescence; and with extremely dense, coarse punctures laterally, reduced medially; with median longitudinal and lateral depressions; lateral margins moderately rounded, widest at middle, apical and basal margins slightly concave; anterior and posterior setiferous punctures slightly erect. Elytra broad, parallel-sided, 1.5–1.6 × longer than wide; disc smooth, with dense, coarse punctures, and short pubescence. Apical spur of tibia of middle leg absent and tarsomere I not modified in males. Aedeagus (Fig. 16C, D) broad in dorsal view, 4.6 × longer than wide, broadest at basal 2/5, slightly asymmetric, apically narrowed, apex acute; ostium obliquely longitudinal, not covered by a membrane; strongly curved near base in lateral view, apex narrowly rounded; primary endophallic sclerites elongate, 0.4 × as long as aedeagus,

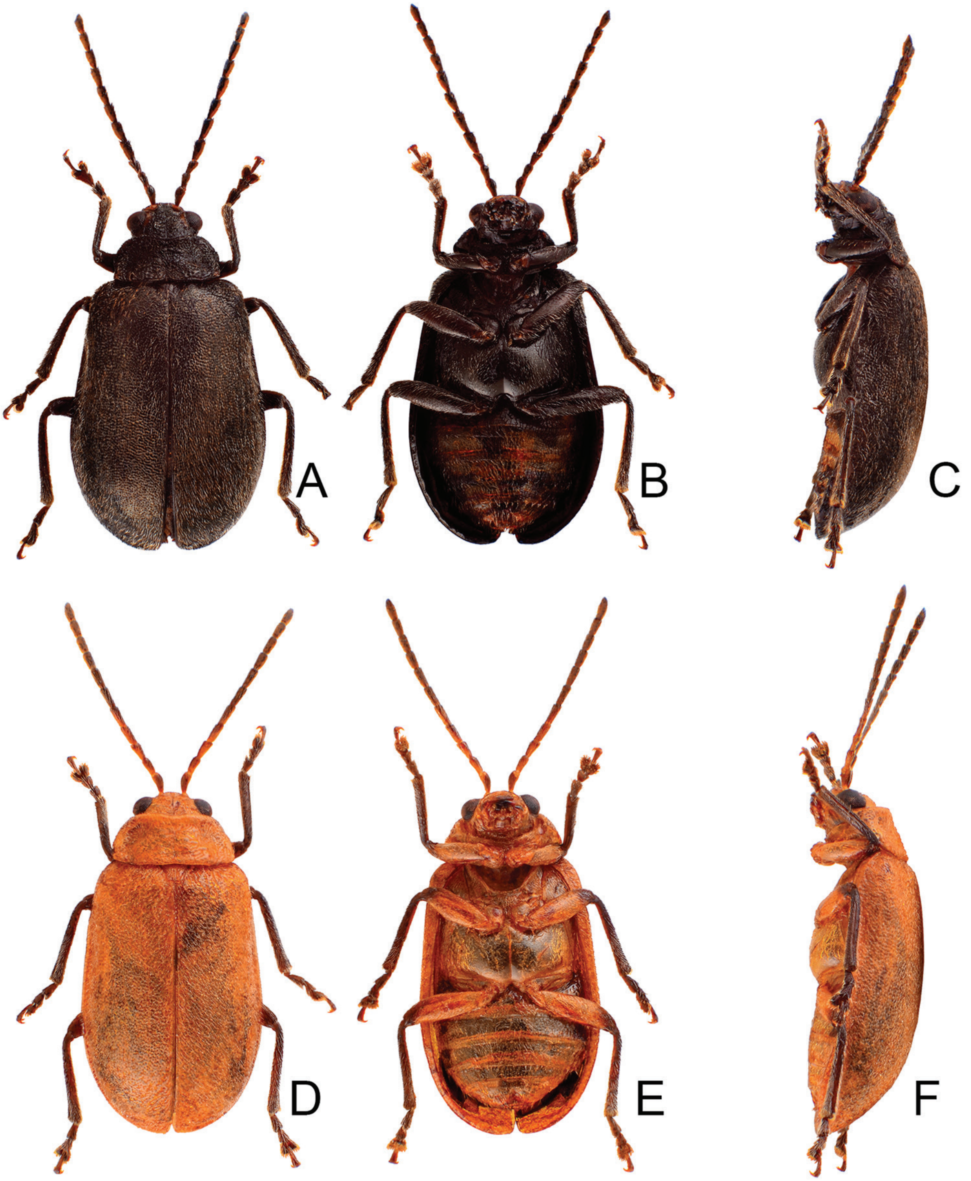

Figure 15. Habitus of *Pyrrhalta alishanensis* sp. nov. and *P. meifena* Kimoto **A** *P. alishanensis* sp. nov., male, dorsal view **B** ditto, ventral view **C** ditto, lateral view **D** *P. meifena*, male, dorsal view **E** ditto, ventral view **F** ditto, lateral view.

with several apical teeth, two secondary sclerites small and wide, 0.3 × as long as primary sclerite, with teeth along apical margins. Only apices of gonocoxae (Fig. 16I) sclerotized, longitudinal, with dense, long setae along lateral and apical margins. Ventrite VIII (Fig. 16E) well sclerotized, lateral margin slightly curved, with dense, long setae covering apex, spiculum long. Receptacle of spermatheca (Fig. 16F) slightly swollen;

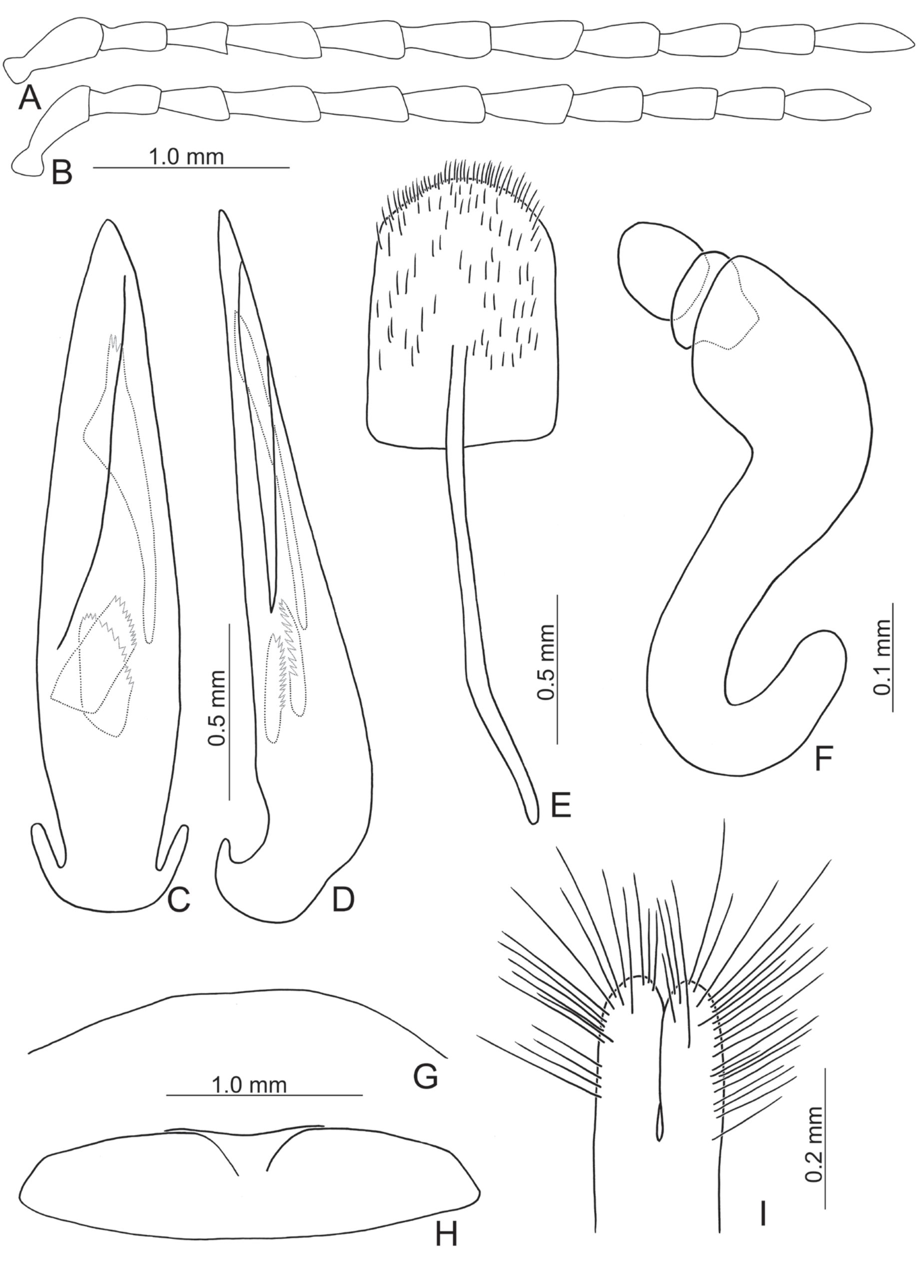

Figure 16. Diagnostic characters of *Pyrrhalta alishanensis* sp. nov. **A** antenna, male **B** antenna, female **C** aedeagus, dorsal view **D** ditto, lateral view **E** abdominal ventrite VIII **F** spermatheca **G** abdominal ventrite V, female **H** abdominal ventrite V, male **I** gonocoxae.

pump extremely long and strongly curved; sclerotized proximal spermathecal duct wide and short. Apical margin of abdominal ventrite V with one pair of rounded ridges at middle, slightly concave between ridges in males; truncate in females.

Remarks. Adults of *P. alishanensis* sp. nov. are easily separated from other members of the species group by their black bodies (Fig. 15A–C) (yellow body in *P. meifena* Kimoto (Fig. 15D–F), brown body in *P. igai* Kimoto (Fig. 18 A–C) and *P. meihuai* sp. nov. (Fig. 18 D–F)). The lanceolate aedeagus is similar to those of *P. meifena* and *P. meihuai* sp. nov., but differs in possessing two secondary endophallic sclerites with toothed apical margins (Fig. 16C, D) (no secondary endophallic sclerites in *P. meifena* (Fig. 20C, D), one secondary endophallis sclerite with smooth apical margin in *P. meihuai* sp. nov. (Fig. 22C, D)). The elongate pump of the spermatheca is also diagnostic.

Host plant. Larvae and adults feed on leaves of *Acer rubescens* Hayata (Sapindaceae) (Fig. 17A, B).

Biology. The first author and Mr Mei-Hua Tsou found more than 20 mature larvae (Fig. 17A) on leaves of *Acer rubescens* Hayata in May 10, 2011, and reared them in the laboratory. Five pupae and one newly eclosed adult were observed June 25 (Fig. 17B).

Distribution. Only known from the type locality.

Etymology. Dedicated to the type locality, Alishan.

Pyrrhalta igai Kimoto, 1981

Figs 17C, D, 18A–C, 19

Pyrrhalta igai Kimoto, 1981: 1; Kimoto 1989a: 248 (additional records); Kimoto and Chu 1996: 56 (catalogue); Kimoto and Takizawa 1997: 300 (key), 373; Beenen 2010: 452 (catalogue); Xue and Yang 2010: 124 (catalogue); Yang et al. 2015: 117 (catalogue).

Types. ***Holotype*** ♂ (OMNH): "MUSHA [霧社] / FORMOSA / 25.V.1970 / A. RIN [p, y] // HOLOTYPE [p, r] // Pyrrhalta / igai / Kimoto, n. sp. [h, w] // PHOTO [p, r]". ***Paratype.*** 1♂ (KMNH): "Mt. Shitoushan [獅頭山] / Miaoli Hsien / Taiwan / 3.VI.1976 / H. Makihara leg. [p, w] // Pyrrhalta / igai / Kimoto, n. sp. [h, w] // PARATYPE [p, b]".

Other material. Taiwan. Hsinchu: 1♂ (TARI), Talu trail (大鹿林道), 12.V.2018, leg. Y.-L. Lin; Kaohsiung: 3♂ (TARI), Neiyingshan (内英山), 5.V.2016, leg. B.-X. Guo; 1♀ (KMNH), Shyk Shan (石山), near Liu Kui (六龜), 28.VI.1986, leg. K. Baba, det. S. Kimoto, 1989; 3♂ (TARI), Tengchih (藤枝), 4.VII.2011, leg. M.-H. Tsou; 1♂ (TARI), 2.V.2015, leg. J.-C. Chen; Pingtung: 3♂, 7♀ (TARI), Machia (瑪家), 25.V.2016, leg. Y.-T. Chung; 1♂, 5♀ (TARI), Peitawushan (北大武山), 28.V.2014, leg. Y.-T. Chung; 1♂, 1♀ (TARI), Tahanshan (大漢山), 13.VI.2015, leg. W.-C. Liao; Taitung: 1♂, 2♀ (TARI), Litao (利稻), 23.IV.2011, leg. M.-H. Tsou; 4♂, 5♀ (TARI), Wulu (霧鹿), 18.IV.2011, leg. C.-F. Lee; 5♂, 3♀ (TARI), same locality, 21–27.IV.2011, leg. M.-H. Tsou; 1♂, 8♀ (TARI), same locality, 22.V.2011, leg. C.-F. Lee; Taoyuan: 2♀ (TARI), Paling (巴陵), 3–5.V.1983, leg. K. C. Chou & C. C. Pan; 1♀ (TARI), same locality, 26.V.2014, leg. M.-H. Tsou.

Redescription. Length 8.1–8.5 mm, width 4.0–4.5 mm. Body brown (Fig. 18A–C); antennae and legs black. Eyes small, interocular space 3.20–3.33 × diameter of

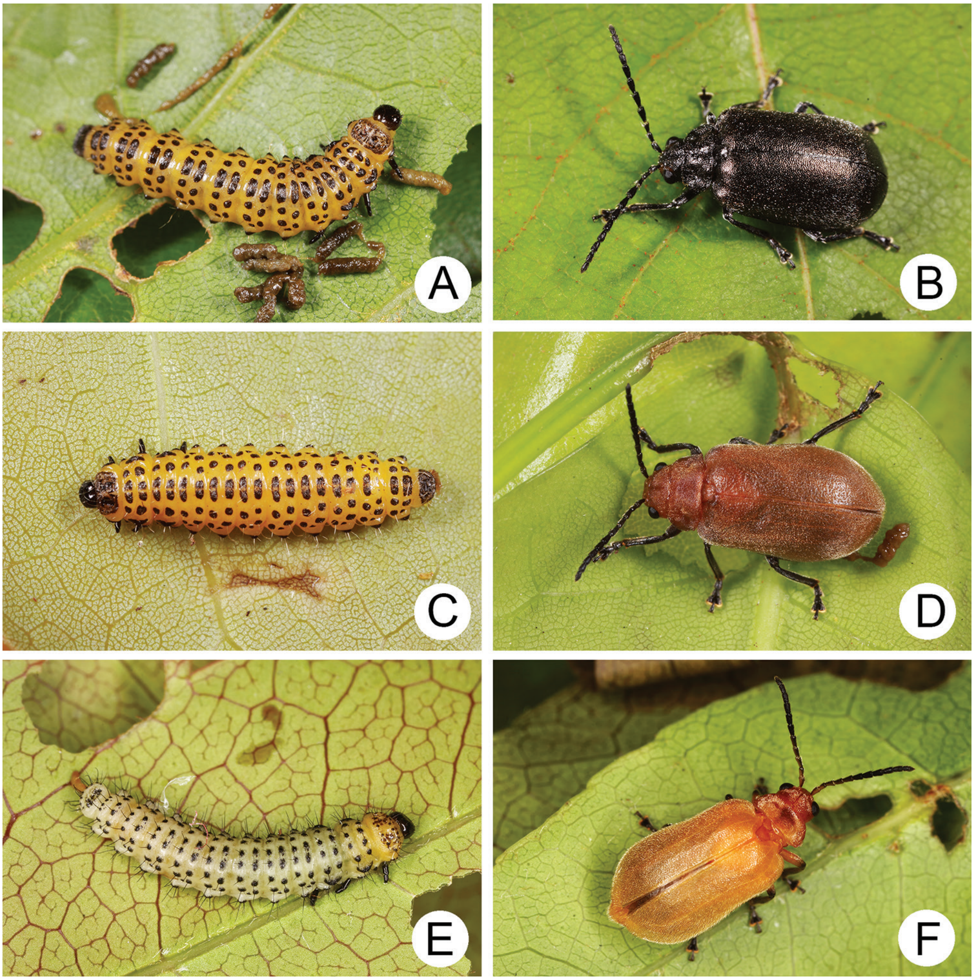

Figure 17. Field photographs of *Pyrrhalta alishanensis* sp. nov., *P. igai* Kimoto, and *P. meihuai* sp. nov. on host plant **A** mature larva of *P. alishanensis* sp. nov. **B** adult of *P. alishanensis* sp. nov. **C** mature larva of *P. igai* **D** adult of *P. igai* **E** mature larva of *P. meihuai* sp. nov. **F** adult of *P. meihuai* sp. nov.

eye. Antennae filiform in males (Fig. 19A), gradually broadened from antennomere V to X, length ratios of antennomeres I–XI 1.0: 0.6: 0.7: 0.7: 0.8: 0.7: 0.7: 0.6: 0.6: 0.6: 0.8, length to width ratios of antennomeres I–XI 3.0: 2.1: 2.3: 2.3: 2.6: 2.3: 2.1: 2.2: 2.0: 1.8: 2.5; similar in females (Fig. 19B), length ratios of antennomeres I–XI 1.0: 0.6: 0.7: 0.7: 0.8: 0.7: 0.6: 0.6: 0.6: 0.5: 0.7, length to width ratios of antennomeres I–XI 2.6: 2.1: 2.0: 2.0: 2.2: 1.8: 1.8: 1.7: 1.7: 1.5: 2.3. Pronotum and elytra convex. Pronotum 2.4–2.5 × wider than long, disc with reticulate microsculpture; with extremely dense, coarse punctures, and long pubescence; with transverse ridge along apical margin deflexed at antero-lateral angles, ridge smooth, lacking pubescence but with sparse punctures; with median longitudinal and lateral depressions; lateral margins moderately rounded, widest in apical 1/3, apical and basal margins

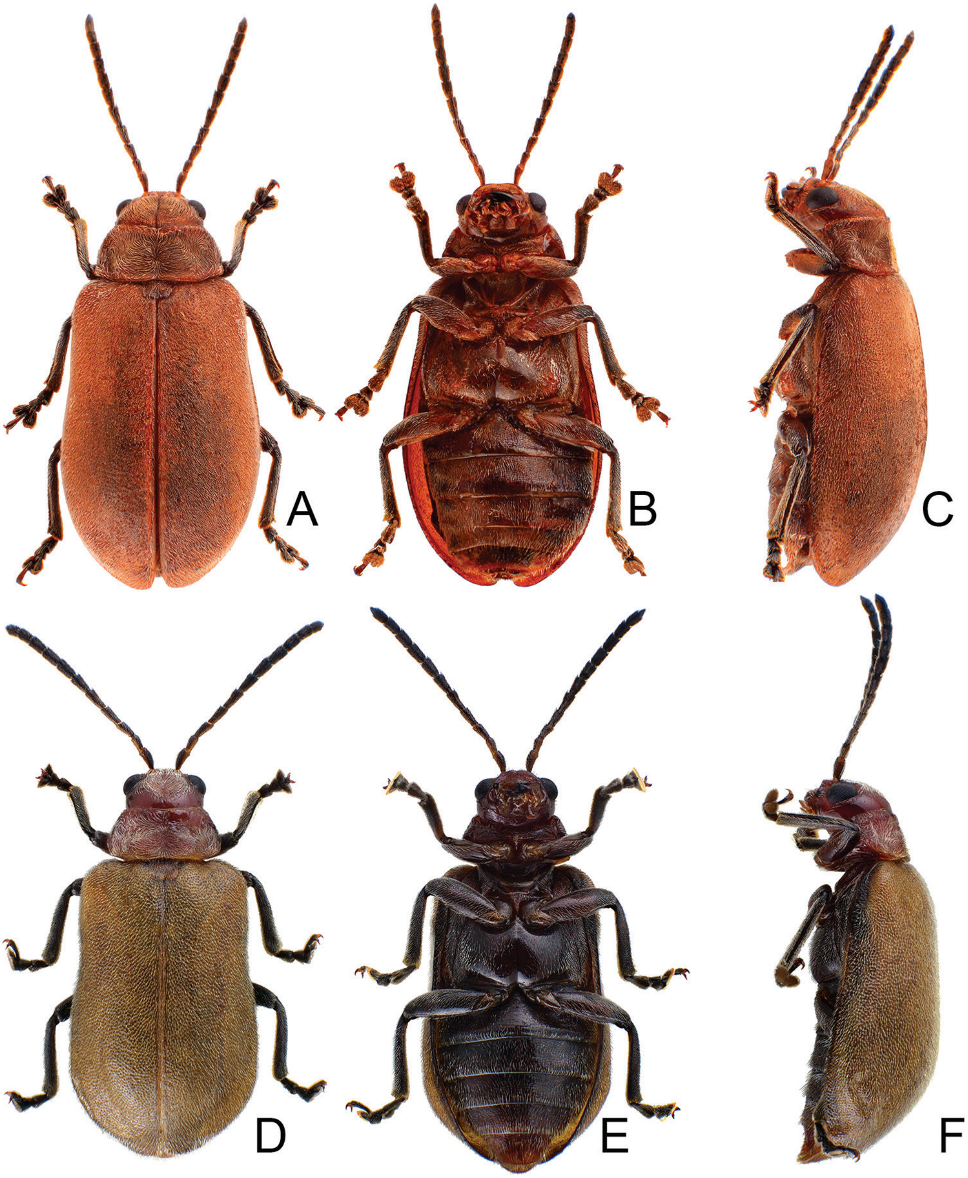

Figure 18. Habitus of *Pyrrhalta igai* Kimoto and *P. meihuai* sp. nov. **A** *P. igai*, female, dorsal view **B** ditto, ventral view **C** ditto, lateral view **D** *P. meihuai* sp. nov., female, dorsal view **E** ditto, ventral view **F** ditto, lateral view.

slightly concave; anterior and posterior setiferous punctures slightly erect. Elytra broad, parallel-sided, 1.4–1.5 × longer than wide; disc with reticulate microsculpture, with dense, coarse punctures, and short pubescence. Apical spur of tibia of middle leg absent and tarsomere I not modified in males. Aedeagus (Fig. 19C, D) slender in dorsal view, 6.8 × longer than wide, broadest at base, asymmetric, apically narrowed,

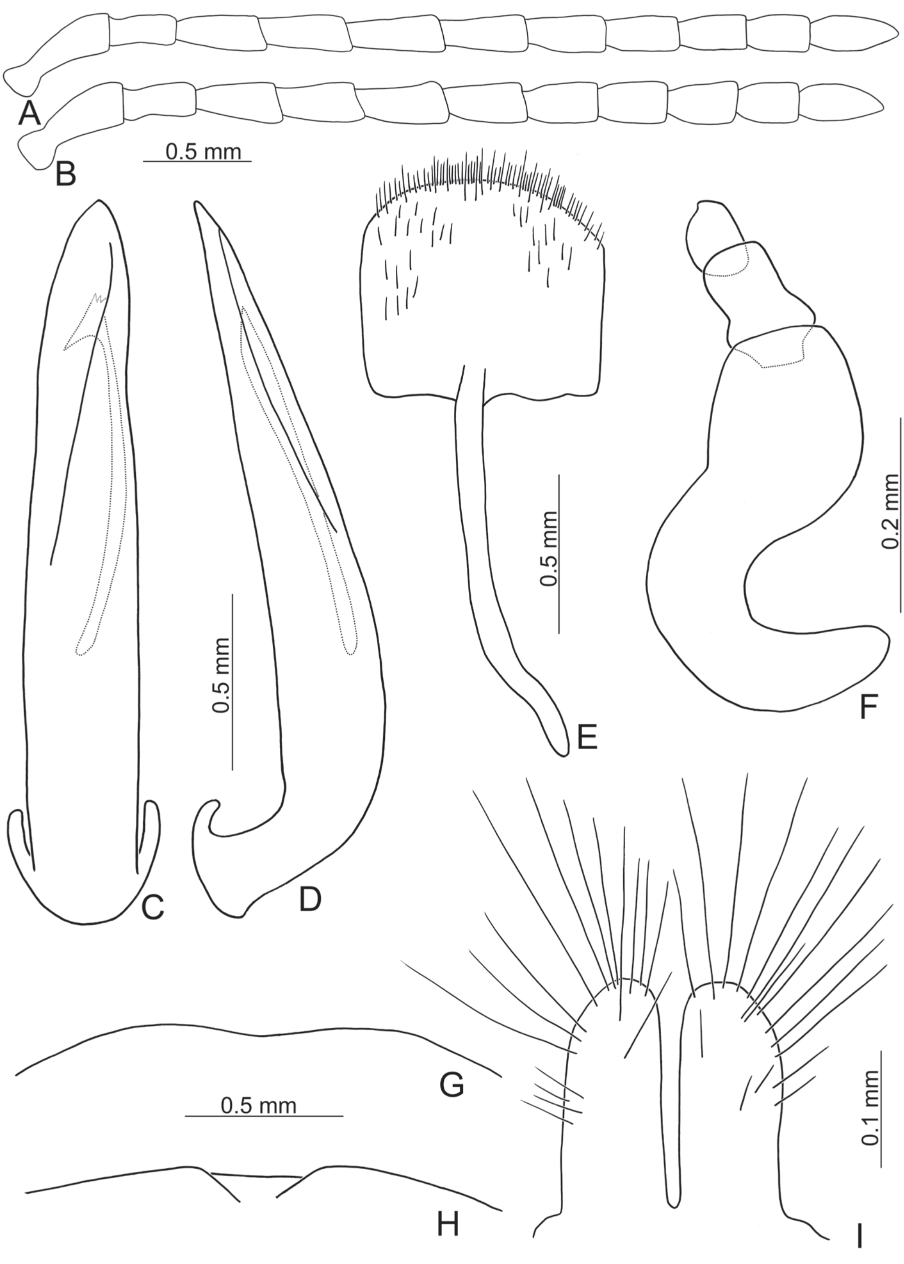

Figure 19. Diagnostic characters of *Pyrrhalta igai* Kimoto **A** antenna, male **B** antenna, female **C** aedeagus, dorsal view **D** ditto, lateral view **E** abdominal ventrite VIII **F** spermatheca **G** abdominal ventrite V, female **H** abdominal ventrite V, male **I** gonocoxae.

curved at apical 1/5, apex acute; ostium obliquely longitudinal, not covered by a membrane; strongly curved near base in lateral view, apex narrowly rounded; primary endophallic sclerites elongate, 0.5 × as long as aedeagus, with three teeth at apex.

Only apices of gonocoxae (Fig. 19I) sclerotized, longitudinal, with dense, long, setae along lateral and apical margins. Ventrite VIII (Fig. 19E) well sclerotized, with dense, long setae laterally, apical area, and along apical margin, spiculum long. Receptacle of spermatheca (Fig. 19F) very swollen; pump long and strongly curved; sclerotized proximal spermathecal duct wide and short. Apical margin of abdominal ventrite V with one pair of rounded ridges at middle, slightly concave between ridges in males (Fig. 19G) and females (Fig. 19H).

Remarks. Adults of *P. igai* Kimoto are similar to those of *Pyrrhalta meihuai* sp. nov. in body sizes and color patterns (Fig. 17D, F), but differ by the rough pronotum and elytra covered with reticulate microsculpture (shining and smooth pronotum and elytra in *P. meihuai* sp. nov.). In males of *P. igai*, the single endophallic sclerites (Fig. 19C) are shared with those of *P. meifena* (Fig. 20C), and the aedeagus is characterized by its asymmetrical shape (lanceolate shape in others of the species group (Figs 16C, 20C, 22C).

Host plant. Larvae and adults feed on leaves of *Acer albopurpurascens* Hayata (Sapindaceae).

Biology. The first author and Mr Mei-Hua Tsou found larvae feeding on leaves (Fig. 17C) March 29, 2009 in Wulu, Southeast Taiwan. They were transferred to the laboratory for rearing. mature larvae began to burrow into soil March 30, and built underground chambers for pupation. Duration of the pupal stage was 19–23 days. adults (Fig. 17D) appeared in spring and summer.

Remarks. The collecting data of the label on the holotype is inconsistent with Kimoto (1981) probably because of typos.

Distribution. The species is widespread at mid-altitudes (1,500–2,500 m) in Taiwan.

Pyrrhalta meifena Kimoto, 1976

Figs 15D–F, 20, 21

Pyrrhalta meifena Kimoto, 1976: 4; Kimoto 1987: 188 (additional records); Kimoto and Chu 1996: 56 (catalogue); Kimoto and Takizawa 1997: 3010 (key), 373; Beenen 2010: 453 (catalogue); Xue and Yang 2010: 126 (catalogue); Lee and Cheng 2010: 119 (redescription); Takahashi 2012: 323 (deposition of type material); Yang et al. 2015: 119 (catalogue).

Types. ***Holotype*** ♂ (OMNH, by original designation): "[TAIWAN] / Meifeng [梅峰] / Nantou Hsien [h, w] // 26.VI.1971/ Y. Miyatake [h, w] // Pyrrhalta / meifena / Kimoto, n. sp. [h, w] // HOLOTYPE [p, r] // (Regd. O.M.N.H.) [p, w]". ***Paratypes.*** 1 ♀ (KMNH): "(Taiwan) / Wushe [霧社] / Nantou Hsien [h, w] // 30.V.1965 / B. S. Chang [h, w] // Pyrrhalta / meifena / Kimoto, n. sp. [h, w] // Det. S. Kimoto, 19 [p, w] // PARATOPOTYPE [p, b]"; 1 ♂ (KMNH): "[TAIWAN] / Meifeng [梅峰] / Nantou Hsien [h, w] // 26.VI.1971 / Y. Miyatake [h, w] // Pyrrhalta / meifena / Kimoto, n. sp. [h, w] // PARATOPOTYPE [p, b]".

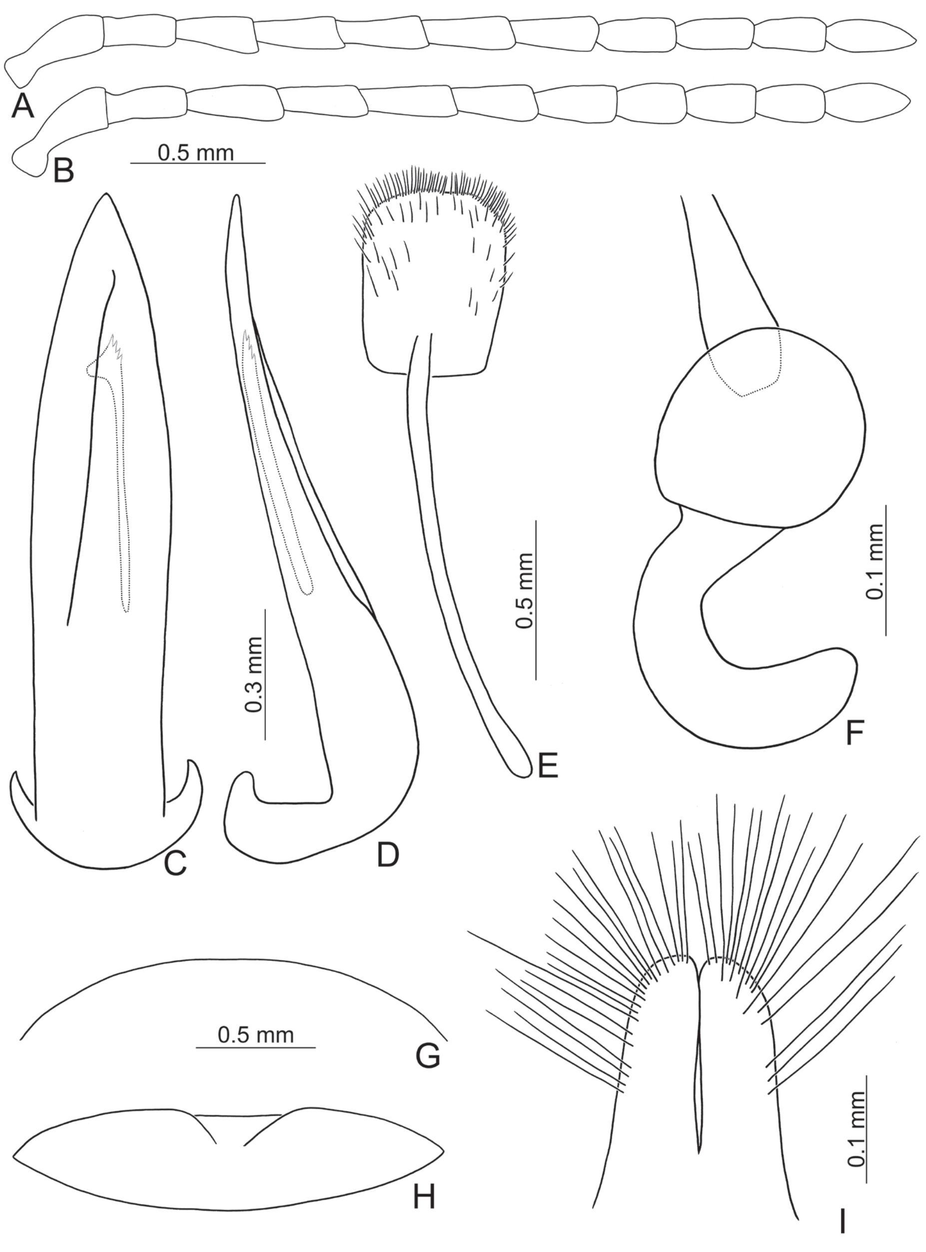

Figure 20. Diagnostic characters of *Pyrrhalta meifena* Kimoto **A** antenna, male **B** antenna, female **C** aedeagus, dorsal view **D** ditto, lateral view **E** abdominal ventrite VIII **F** spermatheca **G** abdominal ventrite V, female **H** abdominal ventrite V, male **I** gonocoxae.

Other material. Taiwan. Chiayi: 1♂, 2♀ (TARI), Alishan (阿里山), 22.IX.2009, leg. M.-H. Tsou; 2♂♂ (TARI), same locality, 29.V.2016, leg. Y.-T. Chung; 1♂ (TARI), Shizilu (十字路), 23.VII.2015, leg. U. Ong; Hsinchu: 9♂, 2♀, Litungshan (李棟山),

24–25.III.2009, leg. M.-H. Tsou; 4♂, 3♀ (TARI), same locality, 28.III.2009, leg. S.-F. Yu; 1♀ (TARI), same locality, 16.VI.2010, leg. Y.-L. Lin; Hualien: 1♂, 2♀ (TARI), Kuanyuan (關原), 2.VII.2008, leg. S.-F. Yu and M.-H. Tsou; 1♀ (TARI), Pilu (碧綠), 15.VII.2019, leg. B.-X. Guo; 1♀ (TARI), Tayuling (大禹嶺), 2.VII.2018, leg. J.-C. Chen; Kaohsiung: 1♀ (TARI), Chungchihkung (中之關), 1.VII.2009, leg. S.-F. Yu; 1♀ (TARI), same locality, 2.VII.2009, leg. M.-H. Tsou; 1♀ (TARI), same locality, 17.IV.2012, leg. L.-P. Hsu; 1♂, 1♀ (TARI), Tienchih (天池), 2.VII.2009, leg. M.-H. Tsou; Nantou: 1♂, 2♀ (TARI), Meifeng (梅峰), 24–26.VI.1981, leg. K. S. Lin & W. S. Tang; 1♀ (TARI), same locality, 1–3.VIII.1981, leg. T. Lin & W. S. Tang; 6♂ (TARI), Tatachia (塔塔加), 13.VII.2014, leg. W.-C. Liao; 1♂ (TARI), Tsuifeng (翠峰), 25–27.VI.1981, leg. K. S. Lin & W. S. Tang; 1♀ (TARI), same locality, S. C. Lin & C. N. Lin; Taichung: 5♂, 7♀ (TARI), Anmashan (鞍馬山), 7.VI.2010, leg. C.-F. Lee; Taitung: 1♂ (TARI), Hsiangyang (向陽), 9.V.2013, leg. J.-C. Chen; 1♂ (TARI), same locality, 18.VII.2014, leg. W.-C. Huan; 2♀ (TARI), Liyuan (栗園), 19.VI.2013, leg. C.-F. Lee.

Redescription. Length 5.6–6.5 mm, width 2.7–3.2 mm. Body yellow (Fig. 15D–F); antennae black but four or five basal antennomeres paled; tibiae and tarsi black or blackish brown. Eyes small, interocular space 2.35–3.58x diameter of eye. Antennae filiform in males (Fig. 20A), gradually broadened from antennomere V to X, length ratios of antennomeres I–XI 1.0: 0.7: 0.7: 0.8: 0.8: 0.8: 0.8: 0.7: 0.7: 0.7: 0.8, length to width ratios of antennomeres I–XI 2.8: 2.2: 2.3: 2.5: 2.6: 2.7: 2.6: 2.4: 2.3: 2.1: 2.7; similar in females (Fig. 20B), length ratios of antennomeres I–XI 1.0: 0.7: 0.8: 0.7: 0.9: 0.7: 0.7: 0.6: 0.6: 0.6: 0.8, length to width ratios of antennomeres I–XI 2.7: 2.5: 2.8: 2.7: 2.8: 2.3: 2.1: 1.8: 1.8: 1.9: 2.3. Pronotum and elytra convex. Pronotum 2.2–2.3 × wider than long, disc smooth; with extremely dense, coarse punctures, and sparse long pubescence, with median longitudinal and lateral depressions; lateral margins moderately rounded, widest at middle, apical and basal margins slightly concave; anterior and posterior setiferous punctures slightly erect. Elytra broad, parallel-sided, 1.5–1.6 × longer than wide; disc smooth, with extremely dense, coarse punctures, and short pubescence. Apical spur of tibia of middle leg absent and tarsomere I not modified in males. Aedeagus (Fig. 20C, D) broad in dorsal view, 5.7 × longer than wide, symmetric, subparallel from base to middle, then apically narrowed, apex acute; ostium obliquely longitudinal, covered by a membrane; strongly curved near base in lateral view, slight recurved at apical 1/6, apex acute; primary endophallic sclerites elongate, 0.5 × as long as aedeagus, with several teeth at apex. Only apices of gonocoxae (Fig. 20I) sclerotized, longitudinal, with dense, long setae along lateral and apical margins. Ventrite VIII (Fig. 20E) well sclerotized, with dense, long setae laterally, apical area, and along apical margin, spiculum long. Receptacle of spermatheca (Fig. 20F) very swollen; pump long and strongly curved; sclerotized proximal spermathecal duct narrow and short. Apical margin of abdominal ventrite V with one pair of rounded ridges at middle and slightly concave between ridges in males (Fig. 20H); broadly rounded in females (Fig. 20G).

Remarks. adults of *P. meifena* Kimoto are characterized by their small body sizes, 5.6–6.5 mm long (7.3–8.7 mm long in others), and yellow bodies (Fig. 15D–F) (black bodies in *P. alishanensis* sp. nov. (Fig. 15A–C); brown bodies in *P. igai* and *P. meihuai*

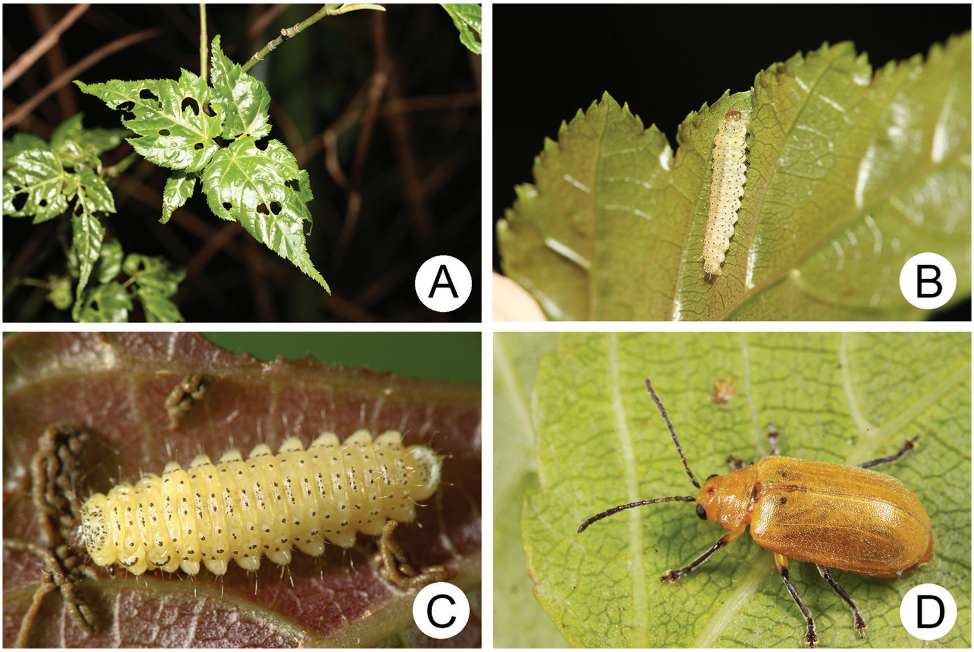

Figure 21. Field photographs of *Pyrrhalta meifena* Kimoto on host plant **A** host plant, *Acer insulare* var. *caudatifolium* **B** Second-instar larva **C** third-instar larva **D** adult.

sp. nov. (Fig. 18)) within the species group. In males of *P. meifena*, the lanceolate aedeagus (Fig. 20C) is similar to those of *P. alishanensis* sp. nov. (Fig. 16C) and *P. meihuai* sp. nov. (Fig. 22C) but differs in lacking secondary endophallic sclerite in addition to the primary endophallic sclerite (one secondary sclerite in *P. meihuai* sp. nov.; two secondary sclerites in *P. alishanensis* sp. nov.).

Host plants. Larvae and adults feed on leaves of *Acer insulare* Hayata var. *caudatifolium* (Hayata) and *A. rubescens* Hayata (Sapindaceae).

Biology. Mrs Su-Fang Yu found young larvae (Fig. 21B) feeding on tender leaves of *Acer insulare* var. *caudatifolium* (Fig. 21A) February 26, 2009, in Litungshan, northern Taiwan; and reared them in the laboratory. mature larvae (Fig. 20C) began to burrow into soil March 2, and built underground chambers for pupation. Duration of the pupal stage was 22–24 days. adults (Fig. 21D) appeared from spring to summer.

Distribution. The species is widespread at mid-altitudes (1,500–2,500 m) in Taiwan.

Pyrrhalta meihuai sp. nov.

http://zoobank.org/0D75E209-97C3-4F69-A865-B056DAE8BF64

Figs 17E, F, 18D–F, 22

Types. ***Holotype*** ♂ (TARI), Taiwan. Ilan: Mingchi (明池), 2.V.2009, leg. M.-H. Tsou. ***Paratypes.*** 3♂, 3♀ (TARI), same data as holotype; 1♂, 3♀ (TARI), same but with “1.V.2009”; Pingtung: 1♂ (TARI), Tahanshan (大漢山), 18.VI.2012, leg. Y.-T. Chung; 1♂ (TARI), same but with “11.VII.2012”; 2♂, 1♀ (TARI), same but with “24.IV.2013”; 3♂, 5♀ (TARI), same but with “15.V.2013”; 2♂ (TARI), same but with “25.V.2013”; 2♀ (TARI), same but with “30.V.2013”; 3♀ (TARI), same but with “17.VI.2013”; 3♂ (TARI), same but with “2.VII.2013”; 1♂ (TARI), same but with “10.VII.2013”; 1♀ (TARI), same but with “30.VII.2013”; 1♀ (TARI), same but with “12.VI.2014”; 1♀ (TARI), same but with “4.VI.2020”; 1♀ (TARI), same locality, 19.VII.2012, leg. C.-F. Lee; 1♂ (TARI), Tahantrail (大漢林道), 20.VIII.2012, leg. J.-C. Chen; 1♀ (TARI), same but with “27.V.2013”; Taipei: 1♀ (TARI), Hsiungkungshan (熊空山), 15.VI.2014, leg. Y.-L. Lin; Taitung: 1♀ (TARI), Lichia (利嘉), 15.VII.2014, leg. Y.-T. Chung; 1♂ (TARI), same but with “16.VII.2014”; Taoyuan: 1♂ (TARI), Hsiaowulai (小烏來), 29.IX.2009, leg. M-H. Tsou; 1♀ (TARI), same locality, 1.VI.2010, leg. S.-F. Yu; 1♀ (TARI), Lalashan (拉拉山), 4.V.2009, leg. H.-J. Chen; 1♂ (TARI), Tungyanshan (東眼山), 12.VII.2015, leg. H. Lee.

Diagnosis. Medium-sized species, 7.3–8.7mm. Body brown. Elytra with fine dense punctures. Discs of pronotum and elytra smooth, lacking reticulate microsculpture.

Redescription. Length 7.3–8.6 mm, width 3.4–4.0 mm. Head and prothorax reddish brown (Fig. 18D–F), but antennae black; scutellum and elytra yellowish brown; meso- and metathoracic ventrites, and legs black. Eyes small, interocular space 2.24–2.76 × diameter of eye. Antennae filiform in males (Fig. 22A), gradually broadened from antennomere V to X, length ratios of antennomeres I–XI 1.0: 0.6: 0.7: 0.7: 0.8: 0.7: 0.8: 0.8: 0.7: 0.7: 0.9, length to width ratios of antennomeres I–XI 2.8: 2.1: 2.2: 2.2: 2.6: 2.2: 2.4: 2.3: 2.0: 1.9: 2.7; similar in females (Fig. 22B), length ratios of antennomeres I–XI 1.0: 0.6: 0.8: 0.6: 0.7: 0.7: 0.8: 0.7: 0.8: 0.7: 0.9, length to width ratios of antennomeres I–XI 2.7: 2.2: 2.2: 2.0: 2.1: 2.2: 2.1: 1.9: 2.2: 2.0: 2.8. Pronotum and elytra convex. Pronotum 2.2–2.3 × wider than long, disc smooth; with extremely dense, coarse punctures, and long pubescence, with median longitudinal and lateral depressions; lateral margins slightly rounded, widest at middle, apical margin slightly concave, basal margin straight; anterior and posterior setiferous punctures not erect. Elytra broad, parallel-sided, 1.6 × longer than wide; disc smooth, with dense, coarse punctures, and short pubescence. Apical spur of tibia of middle leg absent and tarsomere I not modified in males. Aedeagus (Fig. 22C, D) broad in dorsal view, 5.4 × as long as aedeagus, with several teeth along lateral margin near apex, secondary sclerite small and wide, 0.2 × as long as primary sclerite. Only apices of gonocoxae (Fig. 22F) sclerotized, longitudinal, with dense, long setae along lateral and apical margins. Ventrite VIII (Fig. 22E) well sclerotized, sides strongly curved, with dense, long setae laterally, apical area, and along apical margin, spiculum extremely long. Receptacle of spermatheca (Fig. 22G) very swollen; pump long and strongly curved; sclerotized proximal spermathecal duct wide and short. Apical margin of abdominal ventrite V broadly rounded with deep depression at middle in males (Fig. 22I); while lacking depression in females (Fig. 22H).

Remarks. Adults of *P. meihuai* sp. nov. are similar to those of *P. igai* Kimoto in body sizes and color patterns (Fig. 17D, F), but differ by the shining, smooth

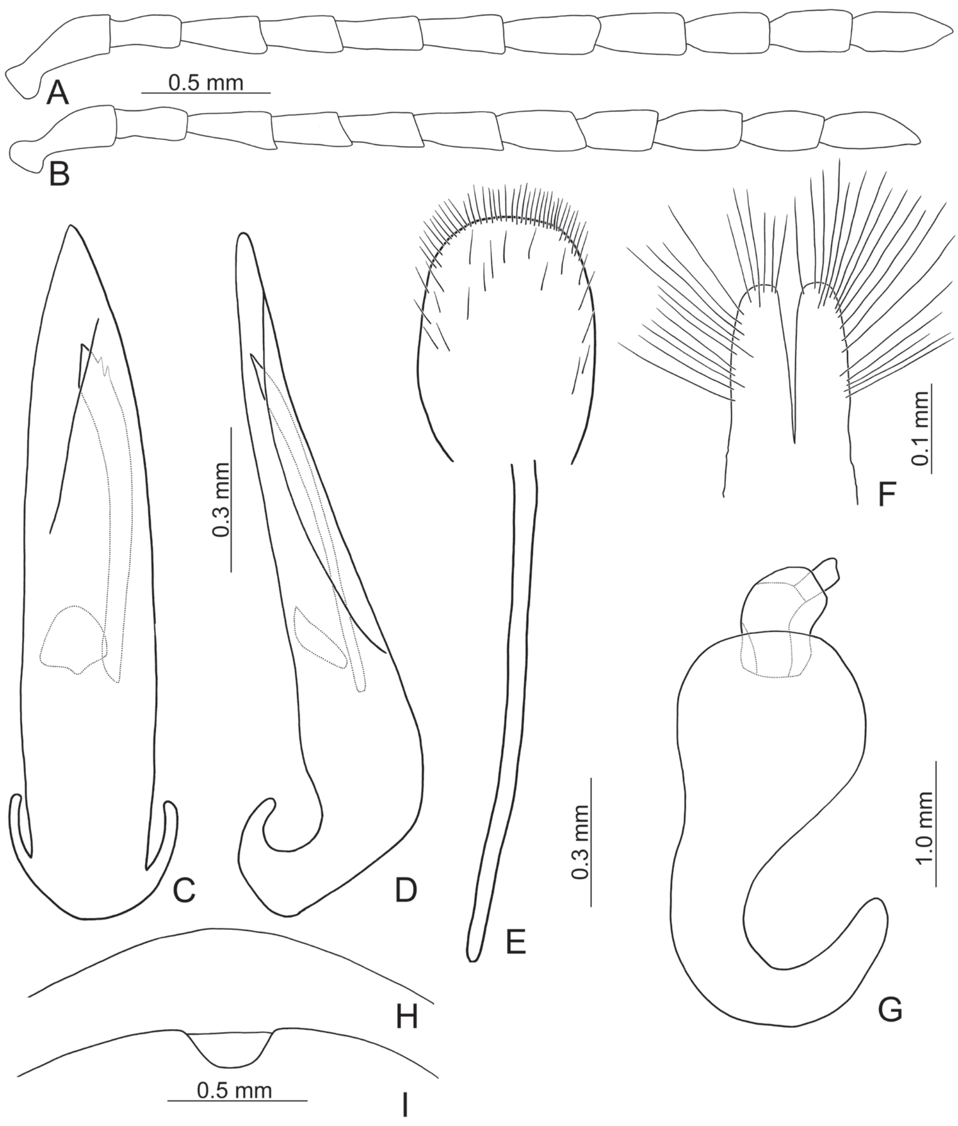

Figure 22. Diagnostic characters of *Pyrrhalta meihuai* sp. nov. **A** antenna, male **B** antenna, female **C** aedeagus, dorsal view **D** ditto, lateral view **E** abdominal ventrite VIII **F** gonocoxae **G** spermatheca **H** abdominal ventrite V, female **I** abdominal ventrite V, male.

pronotum and elytra (rough pronotum and elytra covered by reticulate microsculpture in *P. igai*). In males of *P. meihuai* sp. nov., the lanceolate aedeagus (Fig. 22C) is similar to that of *P. alishanensis* sp. nov. (Fig. 16C) and *P. meifena* (Fig. 20C) but differs in possessing one secondary endophallic sclerite in addition to the primary endophallic sclerite (no secondary sclerite in *P. meifena*; two secondary sclerites in *P. alishanensis* sp. nov.).

Host plant. Larvae and adults feed on leaves of *Acer serrulatum* Hayata (Sapindaceae).

Biology. Mr Mei-Hua Tsou collected mature larvae (Fig. 14E) April 5, 2009 in Mingchi, Northeast Taiwan. They began burrowing into soil at the same day, and built underground chambers for pupation. Duration of the pupal stage was 24–27 days. adults (Fig. 17F) appeared from spring to summer.

Distribution. The species is widespread at mid-altitudes (1,500–2,500 m) in Taiwan.

Etymology. Dedicated to Mr. Mei-Hua Tsou. He, the first author, and Mr. Hou-Jay Chen were the first to collect larvae of this new species and rear them successfully to adults.

Pyrrhalta semifulva species group

Included species. *Pyrrhalta maculata* Gressitt & Kimoto, 1963; *P. tsoui* Bezděk & Lee, 2019; *P. formosanensis* sp. nov.; *P. semifulva* (Jacoby, 1885); *P. discalis* Gressitt & Kimoto, 1963; *P. ishiharai* Kimoto, 1976; and *P. wulaiensis* sp. nov.

Diagnosis. Small sized species (3.3–5.6 mm). Antenna stout, antennomeres VIII–X stout (1.4–2.0x longer than wide), III-VI slender. Body convex. Elytra relatively wider, 1.4–1.6 × longer than wide. Aedeagus asymmetric; ostium covered by a membrane or lacking cover; endophallic sclerites composed of two slender sclerites, with several teeth on apex of primary sclerite and with one additional tooth near apex of secondary sclerite except *P. formosanensis* sp. nov. with only primary sclerite (Fig. 28D–F), *P. maculata* lacking teeth on sclerites (Fig. 24C, D), *P. semifulva* (Fig. 29C, D) and *P. discalis* (Fig. 32C, D) lacking additional tooth on secondary sclerite. The ventrite VIII in females apically sclerotized, with dense short and long setae mixed along apical margin; spiculum long (Figs 24F, 25F, 28H, 29G, 32E, 35F, 36E). Gonocoxae apically sclerotized and with variable number of setae; both gonocoxae small and connected, with two long setae on each gonocoxa in *P. maculata* (Fig. 24H) and *P. tsoui* (Fig. 25J), both gonocoxae longitudinally oriented and connected, with a number of setae near apices in *P. discalis* (Fig. 32I), gonocoxae longitudinal and with dense, long setae in *P. ishiharai* (Fig. 35K), both gonocoxae separated, transverse, and disc with a number of scattered short setae in *P. wulaiensis* sp. nov. (Fig. 36I). Both gonocoxae separated, small and with dense short setae in *P. formosanensis* sp. nov. (Fig. 28J) and *P. semifulva* (Fig. 29K). Apical margin of abdominal ventrite V truncate or slightly concave, with deeply rounded depression at middle in males(Figs 24J, 25I, 28K, 29J, 32H, 35J, 36H); slightly concave or widely rounded in females (Figs 24I, 25H, 28L, 29I, 32G, 35I, 36G). Mesotibia with apical spine in males of *P. maculata* (Fig. 24E), *P. tsoui* (Fig. 25E), *P. formosanensis* sp. nov. (Fig. 28G), and *P. ishiharai* (Fig. 35E); or lacking apical spine in those of the remaining species; mesotarsi with tarsomere I modified in males of *P. maculata* (Fig. 24K), *P. formosanensis* sp. nov. (Fig. 38M), and *P. ishiharai* (Fig. 35H).

Remarks. Included species can be subdivided into species complexes based on similar color patterns. For example, Bezděk and Lee (2019) treated the *P. maculata* species complex, including *P. maculata*, *P. tsoui*, and five more species. They are characterized by their maculate elytra (Fig. 23), strongly curved aedeagi (Figs 24C, D, 25C, D), and only two setae on each gonocoxa (Figs 24H, 25J). *Pyrrhalta semifulva* and *P. formosanensis* sp. nov. belong to another species complex characterized by their reddish brown elytra (Fig. 27) and small gonoxae possessing dense setae (Figs 28J, 29K). *Pyrrhalta ishiharai* is grouped with *P. wulaiensis* sp. nov. based on the longitudinal ridges of the elytra (Fig. 34A, D) and angular apices of aedeagi (Figs 35C, 36C).

Biology. Anthophagous species. Larvae and adults feed on flowers of *Meliosma rhoifolia* (Sabiaceae) or species of Rosaceae.

Pyrrhalta maculata Gressitt & Kimoto, 1963

Figs 23A–C, 24

Pyrrhalta maculata Gressitt & Kimoto, 1963: 456; Kimoto 1969: 28 (additional records in Taiwan); Kimoto 1987: 188 (additional records in Taiwan); Kimoto 1989a: 248 (additional records in Taiwan); Kimoto 1991: 9 (additional records in Taiwan); Kimoto and Chu 1996: 56 (catalogue); Kimoto and Takizawa 1997: 300 (key), 373; Yang 2002: 627 (China: Fujian); Beenen 2010: 453 (catalogue); Xue and Yang 2010: 126 (catalogue); Medvedev 2013: 268 (key); Yang et al. 2015: 118 (catalogue); Bezděk and Lee 2019: 519 (redescription).

Pyrrhalta (*Pyrrhalta*) *maculata*: Wilcox, 1971: 88 (catalogue).

Type (types examined by Bezděk and Lee (2019) exclude)**.** ***Paratype.*** 1♂ (CAS): “TAIWAN (C.), Mu- / sha (Wuse) 1100 m, / V-19-32. Gressitt [p, w] // PARATYPE / Pyrrhalta / maculata [h] / Gressitt and Kimoto [p, y]”.

Other material (specimens examined by Bezděk and Lee (2019) exclude)**.** Taiwan. Nantou: 1♀ (TARI), Huakang (華岡), 24.IV.2019, leg. J.-C. Chen; 1♂, 3♀♀ (NMNS), Meifeng (梅峰), 9.IV. –7.V.2002, leg. C. S. Lin & W. T. Yang; 1♀ (NMNS), same but with “7.V. –11.VI.2002”; 1♀ (NMNS), same but with “11.VI. –9.VII.2002”; 1♂ (NMNS), same but with “10.IX.-15.X.2002”; 1♀ (NMNS), same but with “14. VII. –7.VIII.2007”; 1♂, 1♀ (TARI), Peitungyanshan (北東眼山), 16.IX.2013, leg. F.-S. Huang; 1♂ (TARI), Sungkang (松崗), 2.IV.1997, leg. W.-Y. Chou; 1♀ (TARI), same locality, 10.IV.2016, leg. Y.-T. Chung.

Redescription. Length 4.7–5.2 mm, width 2.3–2.5 mm. Body color (Fig. 23A–C) reddish brown; vertex with one black spot at center; pronotum with three large black spots, one poorly defined, elongate spot at center, from basal 1/3 to apical 1/3, one pair laterally; scutellum black; five pairs of large black spots on elytra, one pair near base at middle, two pairs on the line at middle, one pair at apical 2/5 laterally, one pair at apical 1/5 near suture; metathoracic ventrites darker. Eyes small, interocular space 1.94–2.86 × diameter of eye. Antennae filiform in males (Fig. 24A), antennomere III apically broadened at apex, length ratios of antennomeres I–XI 1.0: 0.5: 1.0: 0.6: 0.5: 0.5: 0.5: 0.5: 0.4: 0.5: 0.7, length to width ratios of antennomeres I–XI 3.3: 2.2: 2.0: 2.1: 1.7: 1.9: 1.8: 1.8: 1.5: 1.6: 2.5; filiform in females (Fig. 24B), antennomere III not

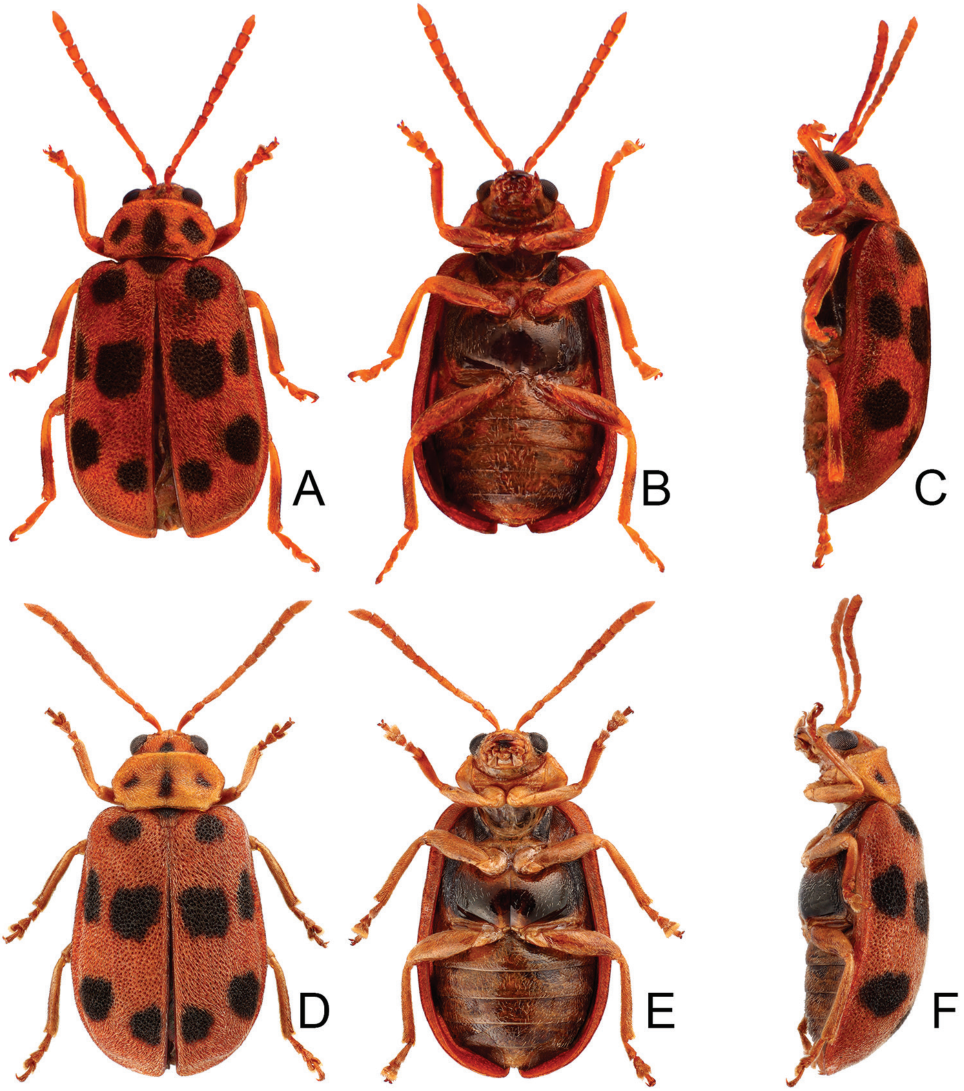

Figure 23. Habitus of *Pyrrhalta maculata* Gressitt & Kimoto and *P. tsoui* Bezděk & Lee **A** *P. maculata*, female, dorsal view **B** ditto, ventral view **C** ditto, lateral view **D** *P. tsoui* female, dorsal view **E** ditto, ventral view **F** ditto, lateral view.

modified, length ratios of antennomeres I–XI 1.0: 0.6: 1.1: 0.6: 0.5: 0.5: 0.5: 0.5: 0.5: 0.5: 0.8, length to width ratios of antennomeres I–XI 3.2: 2.3: 4.5: 2.4: 1.9: 1.8: 1.7: 1.7: 1.7: 1.6: 2.6. Pronotum and elytra convex. Pronotum 1.9–2.1 × wider than long, disc with reticulate microsculpture; dense, extremely coarse punctures and extremely short pubescence; with median longitudinal and lateral depressions; lateral margins moderately rounded, apical margin slightly concave, basal margin straight; only posterior setiferous punctures erect. Elytra elongate and broad, parallel-sided, 1.5–1.6 ×

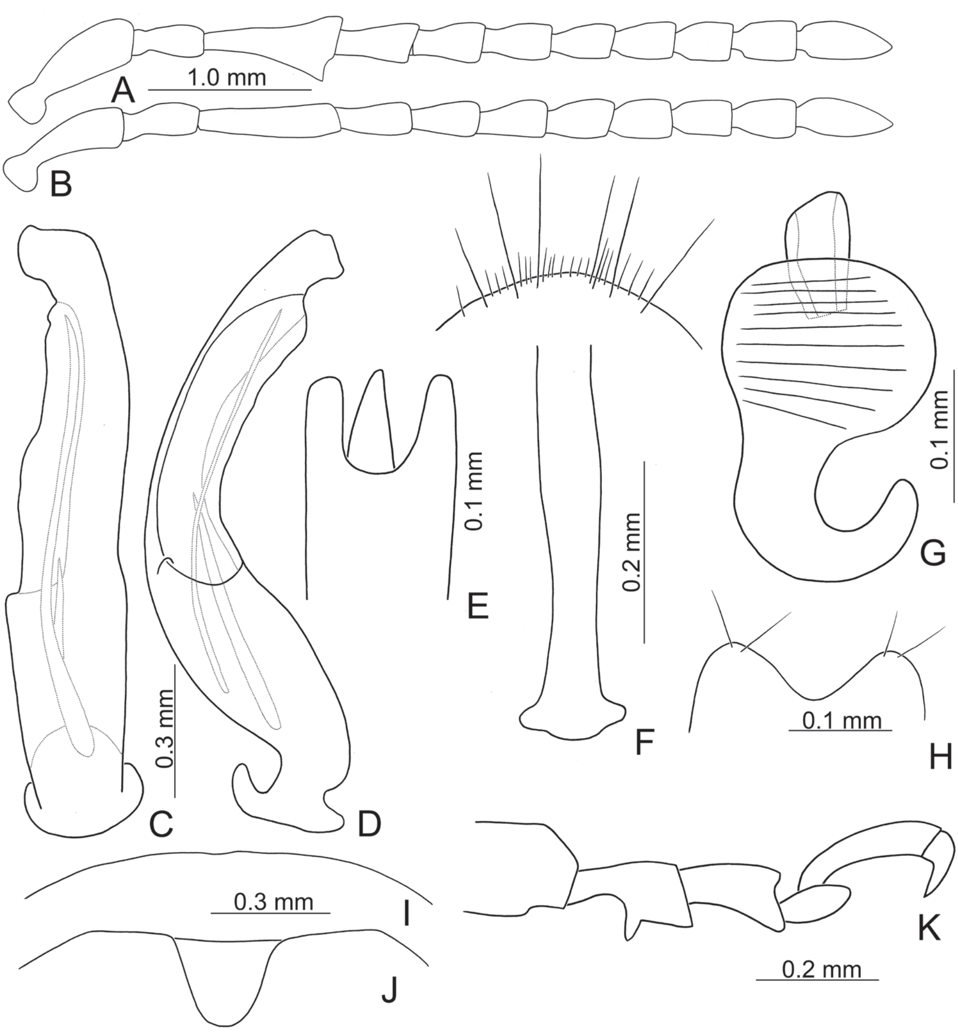

Figure 24. Diagnostic characters of *Pyrrhalta maculata* Gressitt & Kimoto **A** antenna, male **B** antenna, female **C** aedeagus, dorsal view **D** ditto, lateral view **E** apex of tibia of middle leg, male **F** abdominal ventrite VIII **G** spermatheca **H** gonocoxae **I** abdominal ventrite V, female **J** abdominal ventrite V, male **K** tarsi of middle leg, male.

longer than wide; disc with reticulate microsculpture, and with dense, extremely coarse punctures and short pubescence. Apical spur of middle tibia small (Fig. 24E), tarsomere I basally narrowed in lateral view, with small tooth at middle ventrally in males (Fig. 24K). Aedeagus (Fig. 24C, D) slender in dorsal view, 5.5 × longer than wide, sides asymmetric, curved near apex, apex truncate; strongly curved at middle in lateral view; ostium not covered by membrane, ventrally located, located along lateral margin; two endophallic sclerites elongate, apex of primary endophallic sclerite acute, 0.6 × as long as aedeagus, secondary sclerite much shorter, 0.6 × as long as primary endophallic sclerite, apex acute. Only apices of gonocoxae (Fig. 24H) sclerotized, transverse, with two long setae at apex of each gonocoxa. Ventrite VIII (Fig. 24F) transverse; disc with several long setae and dense short setae along apical margin; spiculum long. Receptacle of spermatheca (Fig. 24F) very swollen; pump short and strongly curved; sclerotized proximal spermathecal duct wide and short. Apical margin of abdominal ventrite V truncate, with deeply rounded depression at middle in males (Fig. 24J); slightly concave in females (Fig. 24I).

Remarks. Adults of *P. maculata* Gressitt and Kimoto and *P. tsoui* Bezděk and Lee may be separated from others within the species group by the five pairs of large black spots on the elytra (Fig. 23), the strongly curved aedeagus in lateral view (Figs 24C, 25C), and gonocoxa with only two setae (Figs 24H, 25J). adults of *P. maculata* differ from those of *P. tsoui* by the apically broadened antennomere III in males (Fig. 24A) (unmodified antennomere III, but IV with a large tubercle in those of *P. tsoui* (Fig. 25A)), and extremely slender antennomere III in females, > 4.0 × longer than wide (Fig. 24B); (slender antennomere III, < 4.0 × longer than wide in those of *P. tsoui* (Fig. 25B)). In males of *P. maculata*, the apex of the primary endophallic sclerite is acute, and lacks additional teeth on the secondary sclerite (Fig. 24C, D). The apex of the primary endophallic sclerite have several teeth and one additional tooth on the secondary sclerite in those of *P. tsoui* (Fig. 25C, D).

Food plants. Possibly adults fed flowers of Lauraceae based on the following events. A specimen was collected by Mr Yi-Ting Chung 10 April 2016 in Sungkang by sweeping flowers of Lauraceae. Two specimens were collected by Mr Fu-Sheng Huang 16 September 2013 in Peitungyanshan by fogging *Neolitsea aciculata* (Bl.) Koidz. var. *variabillima* J.C. Liao (Lauraceae).

Distribution. China, Taiwan.

***Pyrrhalta tsoui* Bezděk & Lee, 2019**

Figs 23D–F, 25, 26A

Pyrrhalta tsoui Bezděk & Lee, 2019: 531.

Other material (specimens examined by Bezděk and Lee (2019) excluded). Taiwan. Nantou: 2♀ (KMNH), Lushan Wenchuan（廬山溫泉）, 6.VI.1976, leg. H. Makihara (one identified as *P. maculata* by Kimoto, 1983); 1♂ (TARI), Tsuifeng (翠峰), 12–14.IX.1984, leg. K. S. Lin & S. C. Lin.

Redescription. Length 4.6–5.3 mm, width 2.3–2.8 mm. Body color (Fig. 23D–F) reddish brown; vertex with one black spot at center; pronotum with three large black spots, one poorly defined elongate spot at center, from basal 1/3 to middle, one pair laterally; scutellum black; five pairs of large black spots on elytra, one pair near base at middle, two pairs in line with middle, one pair at apical 2/5 laterally, one pair at apical 1/5 near suture; metathoracic ventrites darker. Eyes small, interocular space 2.37–2.42 × diameter of eye. Antennae filiform in males (Fig. 25A), antennomere I

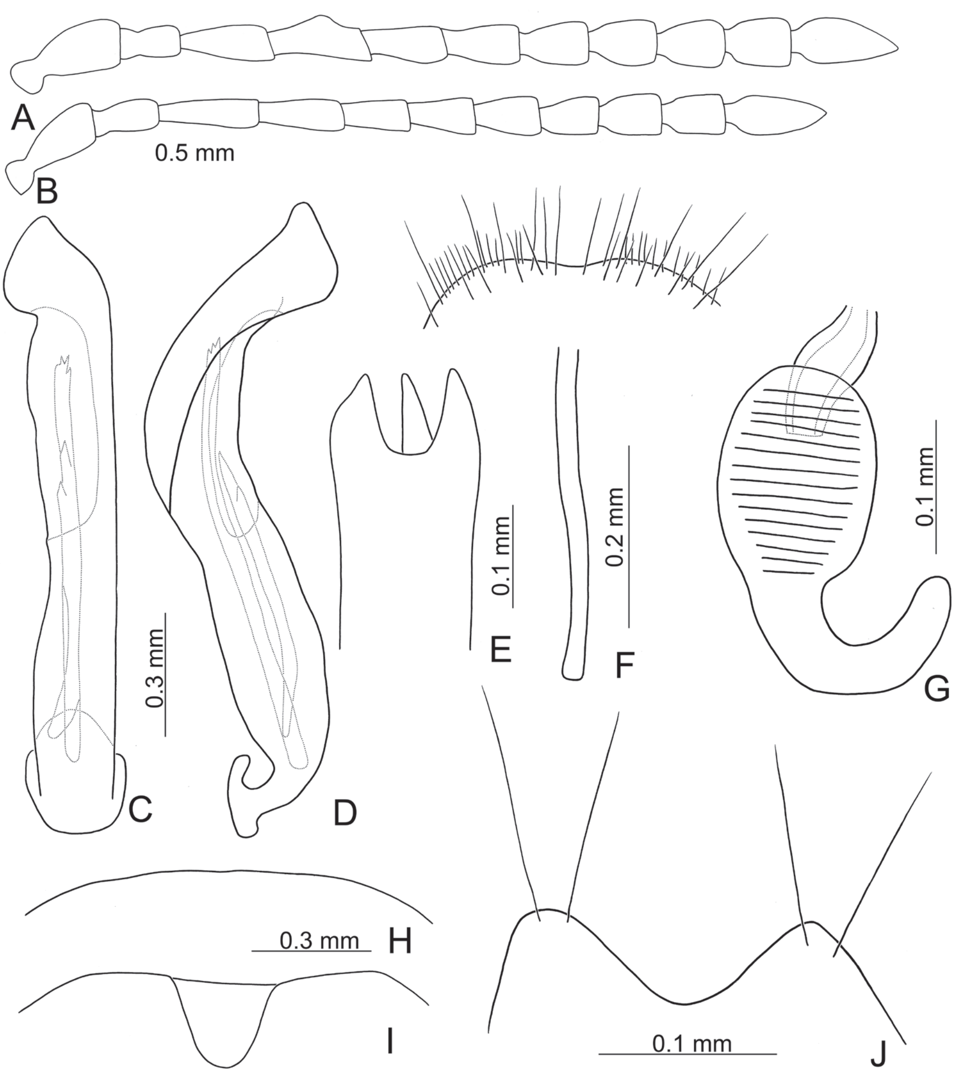

Figure 25. Diagnostic characters of *Pyrrhalta tsoui* Bezděk & Lee **A** antenna, male **B** antenna, female **C** aedeagus, dorsal view **D** ditto, lateral view **E** apex of tibia of middle leg, male **F** abdominal ventrite VIII **G** spermatheca **H** abdominal ventrite V, female **I** abdominal ventrite V, male **J** gonocoxae.

swollen, IV with a large tubercle on outer sides at middle, length ratios of antennomeres I–XI 1.0: 0.5: 0.8: 0.9: 0.7: 0.7: 0.6: 0.6: 0.6: 0.6: 1.0, length to width ratios of antennomeres I–XI 2.1: 1.9: 2.7: 2.6: 2.1: 1.9: 1.6: 1.5: 1.5: 1.4: 2.4; filiform in females (Fig. 25B), antennomere I and IV not modified, length ratios of antennomeres I–XI 1.0: 0.6: 0.9: 0.8: 0.7: 0.6: 0.6: 0.6: 0.6: 0.6: 1.0, length to width ratios of antennomeres I–XI 2.4: 2.1: 3.4: 2.7: 2.2: 1.9: 1.7: 1.5: 1.6: 1.6: 2.5. Pronotum and elytra convex. Pronotum 1.9–2.0 × wider than long, disc with reticulate microsculpture; dense, extremely coarse punctures and extremely short pubescence; with

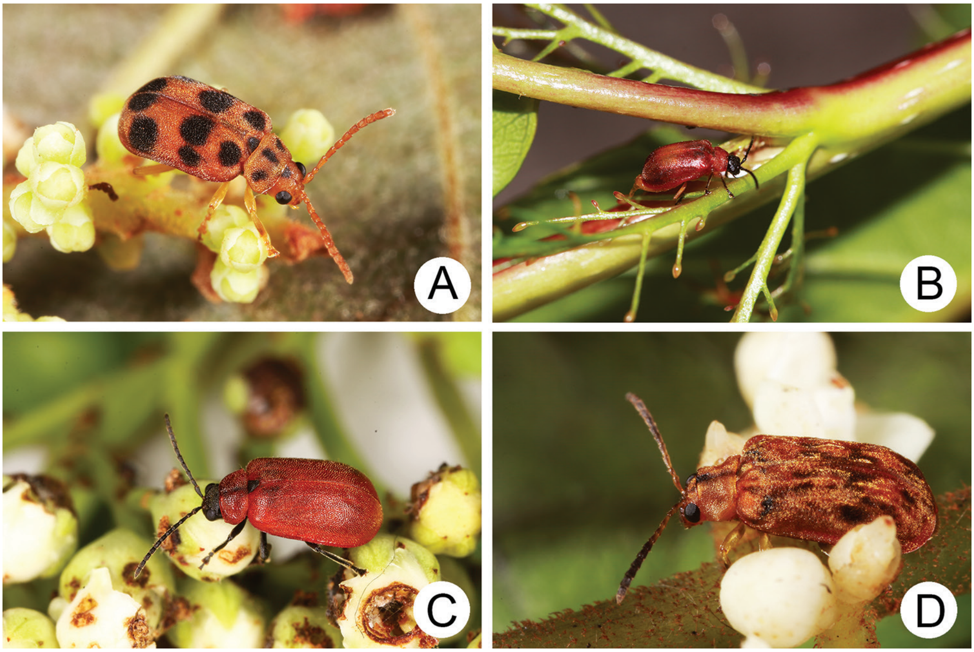

Figure 26. Field photographs of adults of *Pyrrhalta* species on host plants **A** *P. tsoui* Bezděk & Lee **B** *P. formosanensis* sp. nov. **C** *P. semifulva* (Jacoby) **D** *P. ishiharai* Kimoto.

median longitudinal and lateral depressions; lateral margins moderately rounded, apical and basal margins straight; anterior and posterior setiferous punctures erect. Elytra elongate and broad, parallel-sided, 1.4–1.6 × longer than wide; disc with reticulate microsculpture, and with dense extremely coarse punctures and short pubescence. Apical spur of tibia of middle leg small (Fig. 25E), tarsomere I not modified in males. Aedeagus (Fig. 25C, D) extremely slender in dorsal view, 8.4 × longer than wide, sides asymmetric, curved near apex, apex truncate; strongly curved at apical 1/3 and near base in lateral view, apex truncate; ostium not covered by membrane, ventrally located, along lateral margin; two endophallic sclerites elongate, apex of primary endophallic sclerite with several teeth, 0.6 × as long as aedeagus, secondary sclerite much shorter, 0.7 × as long as primary endophallic sclerite, apex acute, with one tooth near apex. Only apices of gonocoxae (Fig. 25J) sclerotized and transverse, with two long setae at apex of each gonocoxa. Ventrite VIII (Fig. 25F) transverse; disc with several long setae and dense short setae along apical margin; spiculum long. Receptacle of spermatheca (Fig. 25G) slightly swollen; pump short and strongly curved; sclerotized proximal spermathecal duct wide and short. Apical margin of abdominal ventrite V truncate, with deeply rounded depression at middle in males (Fig. 25I); slightly concave in females (Fig. 25H).

Remarks. Adults of *P. tsoui* Bezděk & Lee and *P. maculata* Gressitt & Kimoto may be separated from others within the species group by the five pairs of large black spots on the elytra (Fig. 23), the strongly curved aedeagus in lateral view (Figs 24C, 25C), and gonocoxa with only two setae (Figs 24H, 25J). adults of *P. tsoui* differ from those of *P. maculata* by the normal antennomere III and antennomere IV with a large tubercle in males (Fig. 25A) (antennomere III apically broadened in *P. maculata* (Fig. 24A)), and slender antennomere III, < 4.0 × longer than wide in females (Fig. 25B) (extremely slender antennomere III, > 4.0 × longer than wide; in those of *P. maculata* (Fig. 24B)). In males of *P. tsoui*, the apex of the primary endophallic sclerite has several teeth and one additional tooth on the secondary sclerite (Fig. 25C, D). In *P. maculata* the primary endophallic sclerite is acute apically, and the secondary sclerite lacks additional teeth (Fig. 24C, D).

Food plant. Adults feed on flowers of *Meliosma rhoifolia* Maxim. (Sabiaceae).

Distribution. This species is widespread in lowlands of Taiwan.

Pyrrhalta formosanensis sp. nov.

http://zoobank.org/8AB36966-903B-4853-8A90-7D6122D2DFFB

Figs 26B, 27A–C, 28

Types. ***Holotype*** ♂ (TARI), Taiwan. Kaohsiung, Tienchih (天池), 2.VII.2009, leg. M.-H. Tsou. ***Paratypes.*** 1♂, 12♀, same data as holotype; Hualien: 1♂ (TARI), Kuanyuan (關原), 2.VII.2008, leg. M.-H. Tsou; 1♂ (TARI), Pilu (碧綠), 6.VII.2018, leg. H.-F. Lu; Ilan: 1♀ (TARI), Chienching trail (見晴步道), 23.IV.2019, leg. M.-D. Chen; 1♀ (TARI), Tsuifenghu (翠峰湖), 15.VIII.2007, leg. S.-S. Li; Kaohsiung: 1♂ (TARI), Chungchihkuan (中之關), 10.VI.2015, leg. C.-F. Lee; Nantou: 1♂ (TARI), Meifeng (梅峰), 24–26.VI.1981, leg. K. S. Lin & W. S. Tang; 1♂ (TARI), Piluhsi (碧綠溪), 8.VII.2015, leg. C.-F. Lee; 1♂ (TARI), Tsuifeng (翠峰), 30.VII.2014, leg. C.-F. Lee.

Diagnosis. Legs reddish brown; tibia of middle leg with apical spine; tarsomere I modified. Sides of ventrite V strongly shortened in males.

Description. Length 4.6–5.5 mm, width 2.4–2.9 mm. Body color (Fig. 27A–C) reddish brown; head black but antennae dark brown. Eyes small, interocular space 2.62–2.69 × diameter of eye. Antennae filiform in males (Fig. 28A), length ratios of antennomeres I–XI 1.0: 0.6: 0.8: 0.8: 0.6: 0.7: 0.6: 0.6: 0.6: 0.6: 0.8, length to width ratios of antennomeres I–XI 2.8: 1.9: 2.5: 2.4: 2.0: 2.2: 2.0: 1.9: 1.9: 2.0: 2.4; similar in females (Fig. 28B), length ratios of antennomeres I–XI 1.0: 0.5: 0.7: 0.6: 0.6: 0.6: 0.6: 0.6: 0.6: 0.5: 0.7, length to width ratios of antennomeres I–XI 3.2: 2.0: 2.4: 2.2: 1.9: 2.0: 1.9: 1.7: 1.7: 1.6: 2.2. Pronotum and elytra convex. Pronotum 2.1–2.2 × wider than long, disc with dense, extremely coarse punctures and extremely short pubescence, with transverse ridge near apical margin deflexed near antero-lateral corners, with median longitudinal and lateral depressions; lateral margins moderately rounded, apical margin slightly concave, basal margin straight; anterior and posterior setiferous punctures slightly erect. Elytra elongate and broad, parallel-sided, 1.4–1.5 × longer than wide; disc with dense, extremely coarse punctures and extremely short pubescence. Apical spur of tibia of middle leg slender (Fig. 28G), tarsomere I axe-shaped in lateral view, with narrow basal part and expanded apical 2/3, posterior angles of ex-

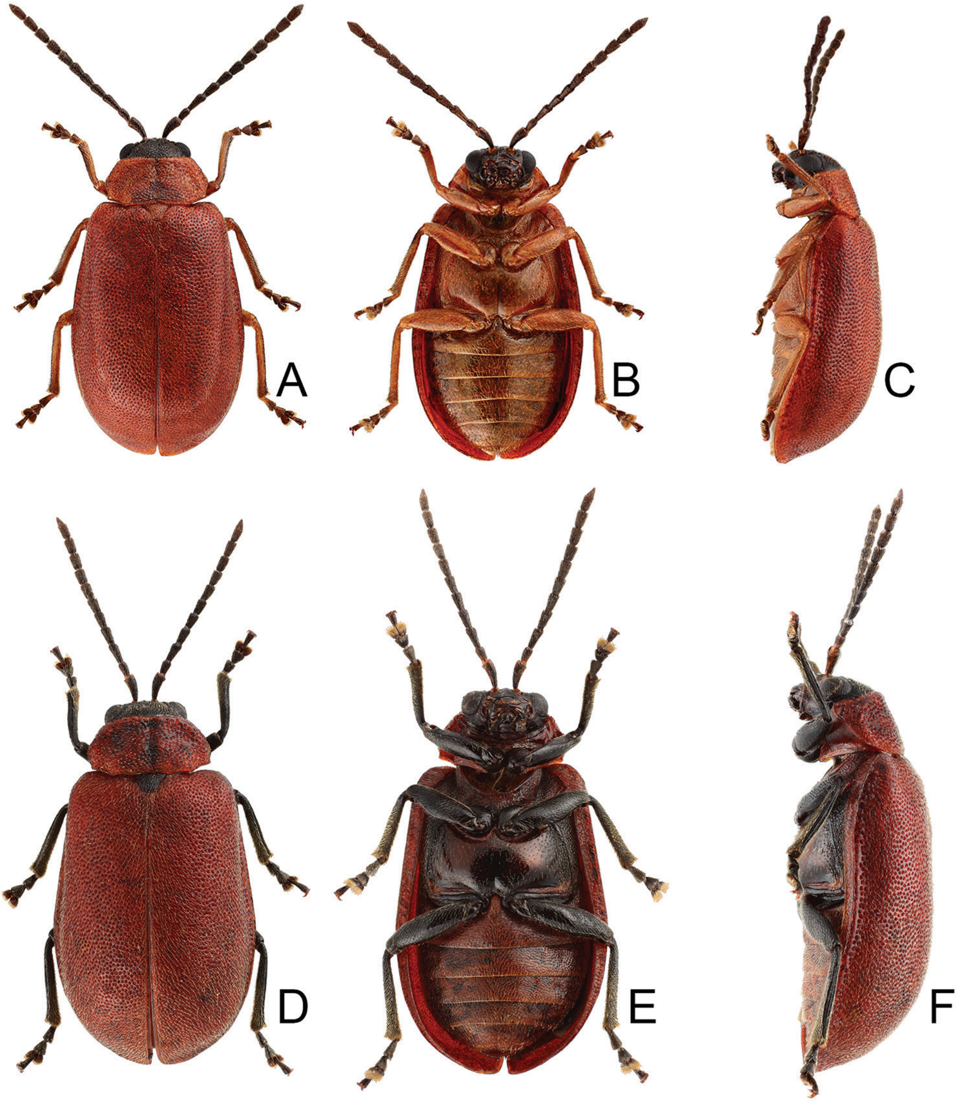

Figure 27. Habitus of *Pyrrhalta formosanensis* sp. nov. and *P. semifulva* (Jacoby) **A** *P. formosanensis* sp. nov., female, dorsal view **B** ditto, ventral view **C** ditto, lateral view **D** *P. semifulva*, from Taiwan, female, dorsal view **E** ditto, ventral view **F** ditto, lateral view.

panded part narrowly rounded (Fig. 28M) in males. Aedeagus (Fig. 28C–E) extremely asymmetric in dorsal view, inner margin of right side expending at apical 1/3, covering right side of ostium, lateral margin of right side expanding downwards, with a notch at middle; inner margin of left side expanding inwards at basal 2/5 and apical 2/5; primary endophallic sclerite elongate, several fine teeth on apex. Sclerotized gonocoxae (Fig. 28J) transverse, both gonocoxae separated, with several long setae near apices. Ventrite VIII (Fig. 28H) transverse; disc with dense, long setae along apical margin;

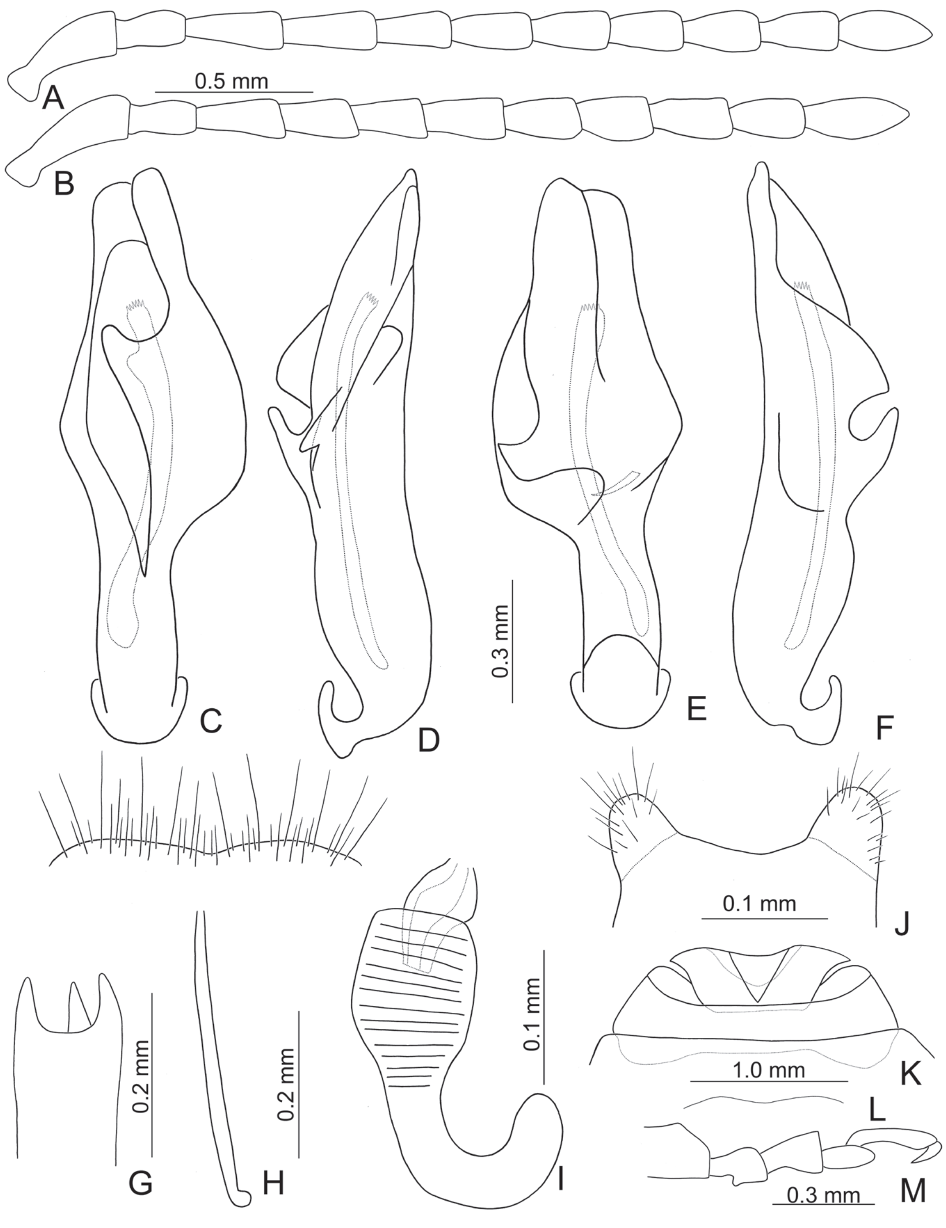

Figure 28. Diagnostic characters of *Pyrrhalta formosanensis* sp. nov. **A** antenna, male **B** antenna, female **C** aedeagus, dorsal view **D** ditto, left-side view **E** ditto, ventral view **F** ditto, right-side view **G** apex of tibia of middle leg, male **H** abdominal ventrite VIII **I** spermatheca **J** gonocoxae **K** abdominal ventrite V, male **L** abdominal ventrite V, female **M** tarsi of middle leg, male.

spiculum short. Receptacle of spermatheca (Fig. 28I) slightly swollen; pump short and strongly curved; sclerotized proximal spermathecal duct wide and short. Apical margin of abdominal ventrite V slightly concave medially, with deep triangular depression at middle in males, sides of abdominal ventrite V shortened, sides of basal margin of abdominal ventrite IV expanding downwards in males (Fig. 28K); only slightly concave in females (Fig. 28L).

Remarks. Adults of *P. formosanensis* sp. nov. are similar to those in Taiwanese populations of *P. semifulva* with their reddish bodies, but differ in the reddish brown scutellum, legs, and thoracic ventrites (Fig. 27B) (black scutellum, legs, and thoracic ventrites (Fig. 27E) in *P. semifulva*), modified sides of abdominal ventrite V (Fig. 28K), and mesotarsomere I of middle leg (Fig. 28M) in males, and very characteristic aedeagus (Fig. 28C–E).

Food plant. Adults feed on flowers of *Prunus campanulata* Maxim. (Rosaceae) (Fig. 26B).

Distribution. The species is widespread at mid-altitudes (1,500–2,500 m) in Taiwan.

Etymology. This species is named after Taiwan, a beautiful island.

Pyrrhalta semifulva (Jacoby, 1885)

Figs 26C, 27D–F, 29, 30

Gallerucella semifulva Jacoby, 1885: 745 (Japan: Kiga).

Lochmaea (*Tricholochmaea*) *semifulva*: Laboissière 1932: 964; Ogloblin 1936: 91 (redescription); Chûjô 1940: 112 (Japan: Kyushu, Shikoku); Chûjô 1954: 57 (Japan: Shikoku); Wilcox 1971: 82 (catalogue).

Tricholochmaea semifulva: Chûjô & Kimoto 1961: 169 (catalogue); Kimoto 1964b: 373 (deposition of type specimens); Lopatin et al. 2004: 130 (catalogue); Beenen 2010: 455 (catalogue).

Pyrrhalta semifulva: Kimoto 1964a: 299; Kimoto and Hiura 1971: 15 (Japan); Kimoto and Gressitt 1966: 476 (key), 520 (Ryukyus); Kimoto 1974: 24 (Taiwan); Nakane 1984: 626 (Japan); Kimoto 1985: 4 (catalogue); Kimoto 1986: 56 (additional records in Taiwan); Kimoto 1987: 188 (additional records in Taiwan); Medvedev and Roginskaya 1988: 116 (host plants); Kimoto 1989a: 268 (additional records in Taiwan); Kimoto 1991: 9 (additional records in Taiwan); Li 1992: 184 (China: Liaoning); Kimoto and Takizawa 1994: 234 (key), 307 (Japan); Kimoto and Chu 1996: 57 (catalogue); Kimoto and Takizawa 1997: 300 (key), 374; Wang and Yang 1998: 68 (China: Fujian); Yang 2002: 628 (China: Fujian); Xue and Yang 2010: 129 (catalogue); Yang et al. 2015: 120 (catalogue); Matsumura et al. 2017: 85 (female reproductive system).

Pyrrhalta (*Tricholochmaea*) *semifulva*: Wilcox 1965: 38; Medvedev 1992: 580 (key); Medvedev and Dubeshko 1992: 133 (key); Medvedev 2006: 141 (Russia: Far East).

Gallerucella modesta Jacoby, 1885: 745 (Japan: Nikko). Synonymized by Chûjô 1954: 57.

Lochmaea (*Tricholochmaea*) *modesta*: Chûjô 1940: 112 (Japan: Shikoku).

Gallerucella signaticeps Weise, 1887: 191 (Vladivostok). Synonymized by Ogloblin 1936: 91.

Lochmaea japonica Weise, 1922: 67 (Japan: Honshu). Synonymized by Laboissière 1932: 964.

Types. *Gallerucella semifulva*. ***Lectotype*** ♀ (NHMUK, here designated): "Kiga [h, w, underside of card glued with specimen] // Type / H.T. [p, w, circle label with red border] // Japan. / G. Lewis. / 1910-320. [p, w] // *Galeruca* / *semifulva* Jac [h, b] // SYN- / TYPE [p, w, circle label with blue border]". Paralectotypes. 1♂ (NHMUK): "Kiga [h, w, underside of card glued with specimen] // Japan / Lewis [h, w] // Jacoby Coll. / 1909-28a. [p, w] // semifulva Jac [h, b]"; 1♂ (NHMUK): "Kiga [h, w, underside of card glued with specimen] // Japan. / G. Lewis. / 1910-320. [p, w]"; 1♀ (NHMUK): "Japan. / G. Lewis. / 1910-320. [p, w]"; 1 (TARI, sex undetermined): "KIGA [h] / JAPAN [p] / 18.III.1880 [h] / Col. G. LEWIS [p, w] // CO / Type [p, circle label with yellow letters border] // *Gallerucella* / *semifulva* / Jacoby [h] / DET. M. CHUJO [p, w] // *Gallerucella* / *semifulva* Jac. [h] / Det. T. Shiraki [p, w] // 1934 [p, w]"; 1 (MCZC, sex undetermined): "Japan / Lewis [h, w] // 1st Jacoby / Coll. [p, w] // Type. / Sp. figured. [p, w] // Type [p] / 17878 [h, r]". Since types much be collected from "Kiga" based on Jacoby (1885). Those specimens with different localities but with type labels should not be regarded as type series, including 1 (NHMUK, sex undetermined): "marshes / nagasaki (h, w) // Japan. / G. Lewis. / 1910-320. [p, w] // SYN- / TYPE [p, w, circle label with blue border]"; 1♂ (NHMUK): "Subashiri [h, w, underside of card glued with specimen] // Japan. / G. Lewis. / 1910-320. [p, w] // SYN- / TYPE [p, w, circle label with blue border]"; 1 (TARI, sex undetermined): "Ipongi [h] / JAPAN [p] / III.1881 [h] / Col. G. LEWIS [p] // CO / Type [p, circle label with yellow letters border] // *Galerucella* / *semifulva* / Jacoby [h] / DET. M. CHUJO [p, w]".

Gallerucella modesta. Lectotype (sex undetermined, NHMUK, here designated): "Nikko [h, w, underside of card glued with specimen] // Type / H.T. [p, w, circle label with red border] // Japan. / G. Lewis. / 1910-320. [p, w] // Nikko. [p, w] // *Galerucella* / *modesta* Jac. [h, b]". Paralectotypes. 1 (NHMUK, sex undetermined): "Nikko. [p, w] // Japan. / G. Lewis. / 1910-320. [p, w] // *Galerucella* / *modesta* / Jac [h, w] // *Lochmaea* / (*Tricholochmaea*) *semifulva* Jacob. [h] / D. Ogloblin det. [p, w]"; 1 (MCZC, sex undetermined): "Japan / Lewis [h, w] / 1st Jacoby / Coll. [p, w] // modesta Jac. [h, b] // Type [p] / 17877 [h, r]".

Other material. Japan. Hokkaido: 1♀ (HSC), Etetsu-shi, Nopporo, 18.VI.2011, leg. H. Suenaga; 1♀ (HSC), Tomakomai-shi, Lake Utonai-ko, 29.VIII.2011, leg. H. Suenaga; 1♂ (HSC), same but with "22.V.2012"; Honshu: 1♂, 1♀ (HSC), Akita Pref., Nikaho-shi, Chôkaisan, Hokodate, 10.VI.2016, leg. S. Sejima; 1♀ (TARI), Aomori Pref., 29.VI. 1934, leg. F. Watanabe; 1♀ (TARI), Aomori Pref., Hatinohe, 1.VI.1933, leg. A. Fukuda; 1♀ (KMNH), Fukui Pref., Mt. Monju, 3.V.1963, leg. H. Sasaji; 1♀ (NMNS), Gifu Pref., 2.IV.1946; 1♂ (NMNS), same locality, 6.V.1947, leg. K. Ohbayashi; 1♂ (NMNS), Gifu Pref., Suhara, 15.IV.1956, leg. K. & M. Ohbayashi; 1♀ (NMNS), same locality, 5.V.1955, leg. K. Ohbayashi; 1♂ (NMNS), same but with "13.V.1956"; 1♂, 1♀ (NMNS), same but with "15.V.1956"; 1♂ (NMNS), same locality, 3.V.1957, leg. N. Ohbayashi; 1♂ (NMNS), same but with "19.V.1957"; 1♂ (NMNS), same but with "1♂ (NMNS), Gifu Pref., Tanigumi, 11.VI.1941, leg. K. Ohbayashi; 1♀ (HSC), Gunma Pref., Minakami-machi, Fujiwara, 6.VI.2008, leg. S. Sejima; 1♀ (HSC), Hiroshima Pref., Akioota-cho, Mt. Mushiki-toge, 14.VI.2010, leg. H. Suenaga; 2♀ (HSC), Hiroshima Pref., Takano-cho, Takano, 13.VI.2009, leg. H. Suenaga; 8♂, 5♀ (NMNS), Hyogo Pref. Mt. Oginosen, 4.V.1964, leg. M.-H. Chûjô; 8♂, 4♀ (TARI), same locality, 2.V.1965, leg. Y. Ohira; 1♂ (HSC), Kanagawa Pref., Zushi-shi, Junmu-ji, 18.IV.2012, H. Suenaga; 1♀ (TARI), Nagano Pref., Koganezawa, 12.V.1935, leg. S. Miyamoto; 1♂, 1♀ (KMNH), Nagano Pref., Misuzuko, 27.VII.1973, leg. S. Kimoto; 1♂ (KMNH), Nagano Pref., Wada, 10.VII.1951, leg. M. Takahashi; 1♂ (TARI), Nagano Pref., Yarisawa, 25.VII.1931, leg. K. Obayashi; 1♂ (TARI), Niigata Pref., Sado, Suizu, 22.V.1937, leg. K. Baba; 1♂, 2♀ (HSC), Okayama Pref., Tomata-Gun, Kagamino-cho, 4.V.2006, leg. H. Suenaga; 1♀ (HSC), same but with "Shiraka-keikoku";1♀ (HSC), Okayama Pref., Niimi-shi, Toyanagakôma, 2.VII.2006, leg. S. Sejima; 1♂ (TARI), Tochigi Pref., Nikko, Sanno-Toge, 16.VI.1940, leg. Tn. Nakane; Kyushu: 2♂ (TARI), Fukuoka Pref., Mt. Hiko, 7.VII.1934, leg. K. Yamauchi; 1♀ (TARI), same locality, 14.VII.1941, leg. M. Chujo; 1♀ (TARI), Kagoshima Pref., Kirishima, 16.VII.1939, leg. Y. Takemura; 1♂, 1♀ (HSC), Kagoshima Pref., Minamioosumi-machi, Sata-misaki, 6.V.2013, leg. H. Suenaga; 1♀ (HSC), Oita Pref., Kamizue-cho, Hakuso, 5.V.2013, leg. H. Suenaga; 1♀ (HSC), Oita Pref., Yufu-shi, Kurodake, 11.VI.2006, leg. S. Sejima; Shikoku: 1♀ (HSC), Ehime Pref., Kumakogen-cho, Mt. Ishizuchi, Tsuchigoya, 28.VI.2009, leg. H. Suenaga; 1♂ (HSC), Ehime Pref., Kumakogen-cho, Mt. Saraga-mine, 23.V.2009, leg. H. Suenaga; 1♂ (HSC), Ehime Pref., Kumakogen-cho, Omogokei, 16.VII.2007, leg. H. Suenaga; 1♀ (HSC), Ehime Pref., Matsuyama-shi, Komenono, 27.V.2007, leg. T. Ichiyanagi; 1♀ (HSC), same locality, 26.V.2007, leg. H. Suenaga; 3♀♀ (HSC), Ehime Pref., Matsuyama-shi, Shukuno, near the dame of Ishitegawa, 2.V.2010, leg. K. Hashimoto; 1♀ (HSC), Ehime Pref., Uwajima-shi, Onigajôzan to Yatsurayama, 7.V.2007, leg. S. Sejima; 1♂, 1♀ (HSC), Kagawa Pref., Mannou-cho, Nakadouri, Mt. Daisenzan, 29.VII.2007, leg. H. Suenaga; 2♀♀ (TARI), Kooti-Ken (= Kochi Pref.), leg. I. Okubo; 1♀ (TARI), same but with "26.V.1935"; 1♂, 1♀ (TARI), same but with "24.VII.1936"; 1♀ (HSC), Tokushima Pref., Yoshinokawa-shi, Mt. Kotsu-zan, 18.V.1987, leg. S. Mano; Taiwan. Chiayi: 1♀ (KMNH), Alishan (阿里山), 6.VII.1965, leg. S. Kimoto, det. S. Kimoto, 1974; Hsinchu: 1♀ (TARI), Lupi (魯壁), 10.VII.2010, leg. M.-H. Tsou; Hualien: 1♀ (TARI), Hahuan Cross-Ridge (合歡越嶺古道), 4.VIII.2018, leg. H.-F. Lu; Ilan: 1♀ (TARI), Ssuyuan (思源), 28.IV.2009, leg. M.-H. Tsou; Kaohsiung: 1♀ (KMNH), Liukuei (六龜), V.1985, leg. W. L. Chen, Nagoya Univ. Col., det. S. Kimoto, 1987; Nantou: 1♂ (NMNS), Shanlinchi (杉林溪), 11.V.1990, leg. C. C. Chiang; 1♀ (TARI), Sungkang (松崗), 18.IV.2015, leg. B.-X. Guo; 1♀ (TARI), Tsuifeng (翠峰), 12–14.IX.1984, leg. K. S. Lin and S. C. Lin; Taoyuan: 1♀ (KMNH), Lalashan (拉拉山), 7.V.1982, leg. N. Ohbayashi.

Redescription. Length 4.3–5.4 mm, width 2.4–3.0 mm. Body color (Fig. 27D–F) reddish brown; head (including antennae), scutellum, thoracic ventrites, and legs black. Eyes small, interocular space 2.50–2.86 × diameter of eye. Antennae filiform in males (Fig. 29A), length ratios of antennomeres I–XI 1.0: 0.6: 0.6: 0.6: 0.6: 0.6: 0.5: 0.5: 0.5: 0.5: 0.8, length to width ratios of antennomeres I–XI 3.1: 2.6: 2.2: 2.1: 2.3: 2.1: 2.0: 2.0: 1.9: 1.9: 3.2; similar in females (Fig. 29B), length ratios of anten-

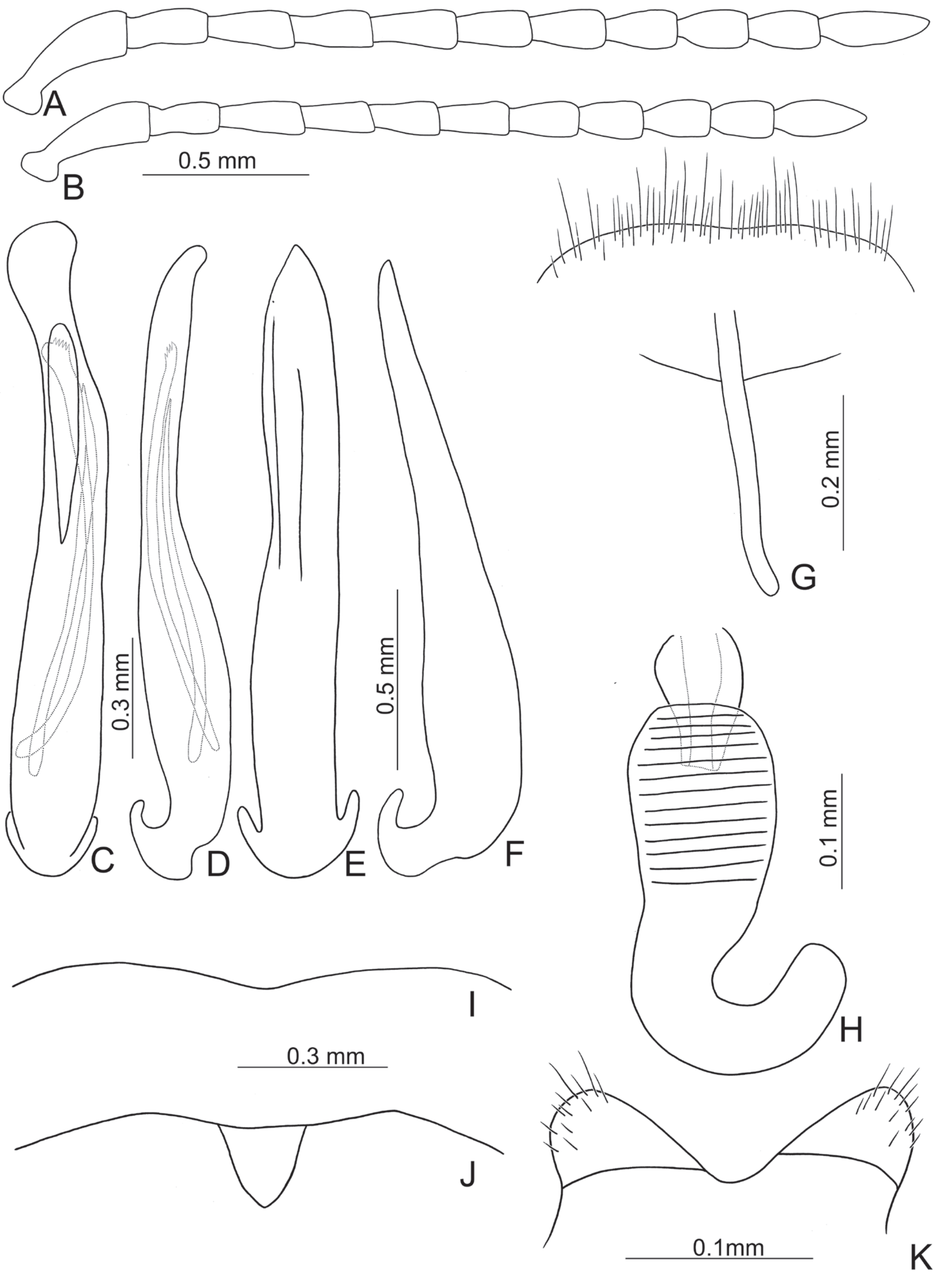

Figure 29. Diagnostic characters of *Pyrrhalta semifulva* (Jacoby) **A** antenna, male **B** antenna, female **C** aedeagus, typical form, dorsal view **D** ditto, lateral view **E** aedeagus, variation (endophallic sclerites omitted), dorsal view apex of tibia of middle leg, male **F** ditto, lateral view **G** abdominal ventrite VIII **H** ermatheca **I** abdominal ventrite V, female **J** abdominal ventrite V, male **K** gonocoxae.

nomeres I–XI 1.0: 0.5: 0.6: 0.5: 0.5: 0.6: 0.5: 0.5: 0.5: 0.5: 0.7, length to width ratios of antennomeres I–XI 3.1: 1.9: 2.2: 1.9: 1.8: 2.0: 1.8: 1.8: 1.9: 1.8: 2.5. Pronotum and elytra convex. Pronotum 2.2–2.3 × wider than long, disc with reticulate microsculpture; with dense, extremely coarse punctures and extremely short pubescence, with transverse ridge near apical margin that curves downwards near antero-lateral corners, no punctures or pubescence above ridge but coarse punctures present on antero-lateral corners; with median longitudinal and lateral depressions; lateral margins moderately rounded, apical margin slightly concave, basal margin straight; anterior and posterior setiferous punctures slightly erect. Elytra elongate and broad, parallel-sided, 1.4–1.5 × longer than wide; disc smooth, with extremely coarse, dense punctures and extremely short pubescence. Apical spur of tibia of middle leg absent, tarsomere I not modified in males. Aedeagus (Fig. 29C, D) extremely slender in dorsal view, 7.9 × longer than wide, sides asymmetric, parallel-sided, apex truncate, curved near apex; strongly curved near base in lateral view, apex narrowly rounded; ostium not covered membrane; two endophallic sclerites elongate, several fine teeth on apex of primary endophallic sclerite, 0.6 × as long as aedeagus, secondary sclerite a little shorter, 0.9 × as long as primary endophallic sclerite, apex acute. Sclerotized gonocoxae (Fig. 29K) stout and cylindrical, gonocoxae separated, disk with several longer setae mixed with dense, shorter setae. Ventrite VIII (Fig. 29G) transverse; disc with three layers of different lengths of setae on apical area, shortest setae along apical margin, longest setae a slightly before apex, intermediate setae further from apex; spiculum short. Receptacle of spermatheca (Fig. 29H) slightly swollen; pump short and strongly curved; sclerotized proximal spermathecal duct wide and short. Apical margin of abdominal ventrite V slightly concave medially, with deep depression at middle in males (Fig. 29J); only slightly concave in females (Fig. 29I).

Variation. Aedeagi of many individuals have apically tapering apices and look straight in lateral view (Fig. 29E, F). Japanese populations display great color variation. Some individuals (Hokkaido) have the entire reddish brown bodies but one black spot is present on the vertex, and five apical antennomeres are darkened. Some are similar to the previous ones, but the head is black except mouth parts (Fig. 30A, B). Some are similar the previous ones, but the pronotum has one black spot at center, without a clear margin; legs are reddish brown but outer sides of tibiae and entire tarsi are dark brown, antennae and the scutellum are blackish brown (Fig. 30C, D). Some specimens are similar to Taiwanese populations but with different degrees of darkness on the pronotum (Fig. 30E, F).

Remarks. *Pyrrhalta semifulva* (Jacoby) and *P. formosanensis* sp. nov. may be separated from others within the species group by the reddish brown bodies (Figs 27, 30) and short, cylindrical gonocoxae with dense setae (Figs 28J, 29K). Taiwanese populations of *P. semifulva* differ from *P. formosanensis* sp. nov. by the black scutellum, legs, and thoracic ventrites (Fig. 27E) (reddish brown scutellum, legs, and thoracic ventrites (Fig. 27B) in *P. formosanensis* sp. nov.), normal abdominal ventrite V (Fig. 29I), and unmodified mesotarsomere I of middle leg in males (modified abdominal ventrite V

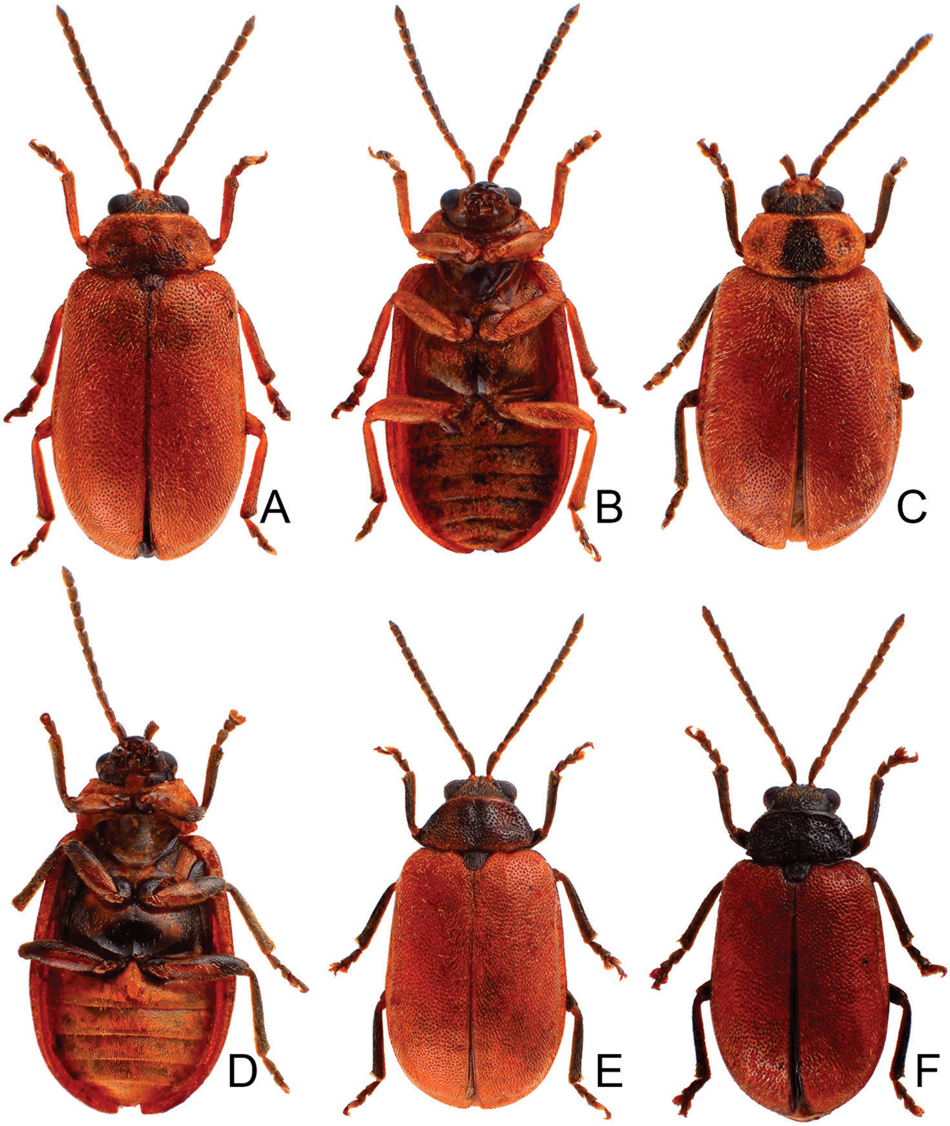

Figure 30. Habitus of *Pyrrhalta semifulva* (Jacoby) from Japan **A** female, color variation, dorsal view **B** ditto, ventral view **C** Female, color variation, dorsal view **D** ditto, ventral view **E** female, color variation, dorsal view **F** male, color variation, dorsal view.

(Fig. 28K) and mesotarsomere of middle leg (Fig. 28M in males of *P. formosanensis* sp. nov.). In males of *P. semifulva*, the elongate and apically curved aedeagus is similar to that of *P. discalis* Gressitt and Kimoto, but differs in the relatively longer secondary endophallic sclerite, 0.9x as long as primary endophallic sclerite (Fig. 29C, D) (vs. relatively shorter secondary endophallic sclerite, 0.6x as long as primary endophallic sclerite in *P. discalis* (Fig. 32C, D).

Food plants. Rosaceae: *Prunus jamasakura* Sieb., ex Koidz., *P. yedoensis* Matsum., and *Sorbus japonica* (Decne.) Hedl.; Hamamelidaceae: *Corylopsis gotoana* Makino, (Chûjô and Kimoto 1961). adults of Taiwanese populations feed on flowers of *Photinia niitakayamensis* Hayata (Rosaceae) (Fig. 26C).

Distribution. Japan, Russian, Taiwan. The species is widespread at mid-altitudes (1,500–2,500 m) in Taiwan.

Pyrrhalta discalis Gressitt & Kimoto, 1963

Figs 31–33

Pyrrhalta discalis Gressitt & Kimoto, 1963: 448 (China: Hubei); Kimoto 1974: 24 (Taiwan); Kimoto and Chu 1996: 55 (catalogue); Kimoto and Takizawa 1997: 300 (key), 373; Beenen 2010: 452 (catalogue); Xue and Yang 2010: 122 (catalogue); Yang et al. 2015: 116 (catalogue).

Pyrrhalta (*Pyrrhalta*) *discalis*: Wilcox 1971: 85 (catalogue).

Types. ***Holotype*** ♂ (CAS, by original designation): “Suisapa, 1000 M. / Lichuan Distri. / W. Hupeh, China / VII- [p] 25 [h] -48 [p, w] // Ridge above / 1200-1500 M [p, w] // J. L. Gressitt / Collector [p, w] // Pyrrhalta / discalis / G&K [h] / J. L. Gressitt det. // HOLOTYPE [p] / Pyrrhalta / discalis [h] / Gressitt & Kimoto [p, r]. ***Paratypes.*** 1♀ (CAS): “Suisapa, 1000 M. / Lichuan Distri. / W. Hupeh, China / VII- [p] 23 [h] -48 [p, w] // J. L. Gressitt / Collector [p, w] // ALLOTYPE [p] / Pyrrhalta / discalis / S. Kimoto & [h] / J. L. Gressitt [p, r] // Pyrrhalta / discalis / Gress & Kim. [h] / Gressitt & Kimoto det. 196[p]2 [h, w]”; 1♂ (CAS): “W. HUPEH / China, Suisapa, / Lichuan, 1000 m. / IX-[p] 17 [h] 1948 [p, w] // Gressitt & / Djou Collrs. [p, w] // PARATYPE [p] / Pyrrhalta / discalis [h] / Gressitt & Kimoto [p, y]”; 1♀ (CAS): “Suisapa, 1000 M. / Lichuan Distri. / W. Hupeh, China / VII- [p] 23 [h] -48 [p, w] // J. L. Gressitt / Collector [p, w] // PARATYPE [p] / Pyrrhalta / discalis [h] / Gressitt & Kimoto [p, y]”; 1♀ (CAS): “Suisapa, 1000 M. / Lichuan Distri. / W. Hupeh, China / VII- [p] 24 [h] -48 [p, w] // J. L. Gressitt / Collector [p, w] // PARATYPE [p] / Pyrrhalta / discalis [h] / Gressitt & Kimoto [p, y]”; 1♀ (BPBM): “Suisapa, 1000 M. / Lichuan Distri. / W. Hupeh, China / VII- [p] 22 [h] -48 [p, w] // Gressitt & / Djou Collrs. [p, w] // PARATYPE [p, b] // Pyrrhalta / discalis / Paratype G&K [h] / J.L. Gressitt det. [p, w].

Other material. TAIWAN. Hsinchu: 1♂ (TARI), Litungshan (李棟山), 15.III.2009, leg. S.-F. Yu; 1♀ (TARI), Lupi (魯壁), 25.II.2010, leg. S.-F. Yu; 1♀ (TARI), Wuchihshan (五指山), 27.III.2008, leg. H. Lee; 1♂ (TARI), same locality, 14.V.2008, leg. S.-F. Yu; Hualien: 1♀ (TARI), Pulowan (布洛灣), 26.III.2016, leg. H.-F. Lu; 1♂, 1♀ (TARI), same but with “31.III.2016”; 10♂, 4♀ (TARI), same but with “30.IV.2016”; 1♀ (TARI), same but with “9.V.2016”; Pingtung: 1♂ (TARI), Tahanshan (大漢山), 29.VI.2018, leg. Y.-T. Chung; Taichung: 1♀ (KMNH), Pahsienshan (八仙山), 29.V.1971, leg. K. Kanmiya, det. S. Kimoto, 1973; Taipei: 1♂ (TARI), Chihshanyan (芝山岩), 2.V.2016, leg. M.-H. Tsou; 1♂ (TARI), Wulai (烏來), 17.V.2008, leg. M.-H.

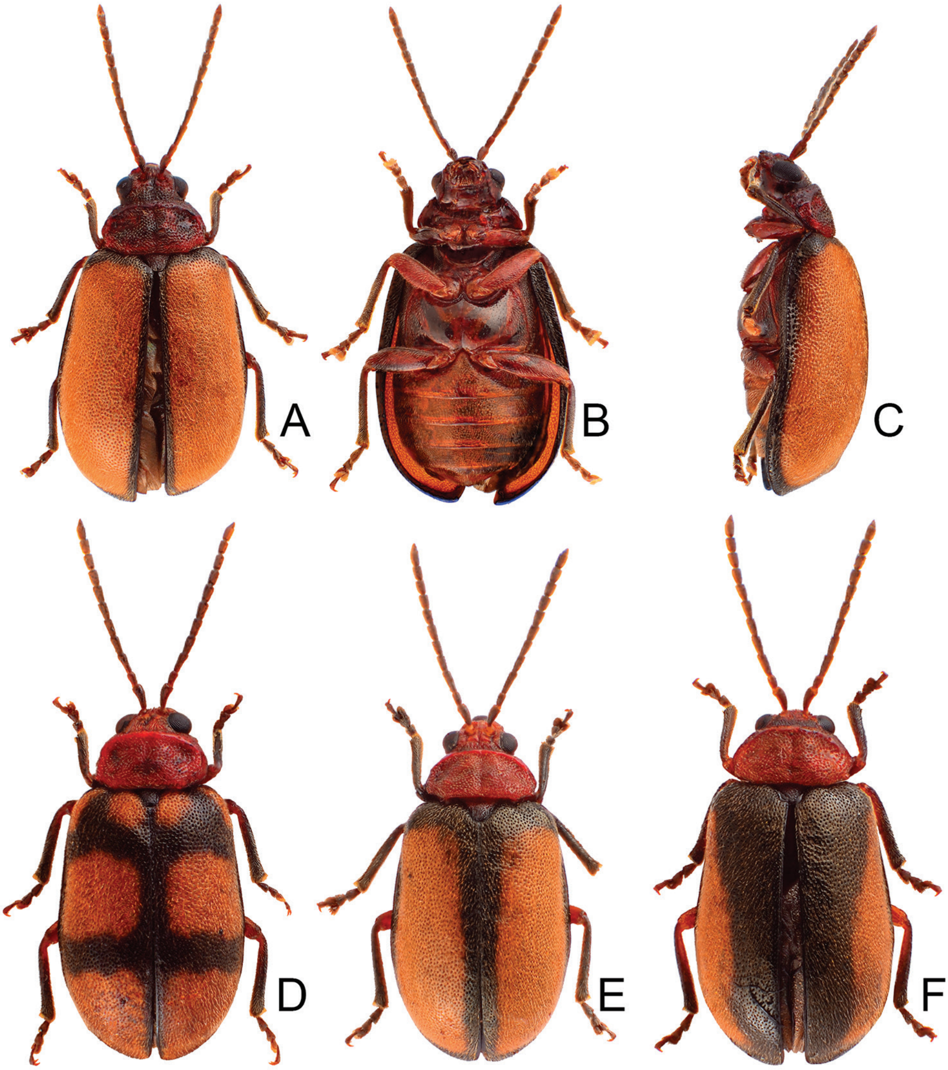

Figure 31. Habitus of *Pyrrhalta discalis* Gressitt & Kimoto **A** male, typical form, dorsal view **B** ditto, ventral view **C** ditto, lateral view **D** male, color variation, dorsal view **E** male, color variation, dorsal view **F** male, color variation, dorsal view.

Tsou; Taoyuan: 1♀ (TARI), Lalashan (拉拉山), 2.IV.2009, leg. H. Lee; 1♀ (TARI), Nantzukou (湳仔溝), 24.IV.2016, leg. M.-H. Tsou; 1♀ (TARI), Yongfu (永福), 17.IV.2011, leg. M.-H. Tsou; 1♂, 1♀ (TARI), same but with "30.IV.2011"; 2♂, 1♀ (TARI), same but with "11.V.2011"; 1♂ (TARI), same but with "20.IV.2015".

Redescription. Length 4.6–5.6 mm, width 2.3–2.8 mm. Body color (Fig. 31A–C) yellowish brown; head and prothorax reddish brown, but antennae blackish brown; with wide black stripes along lateral margins and suture of elytra; tibiae and tarsi black. Eyes small, interocular space 2.09–2.49 × diameter of eye. Antennae filiform in males

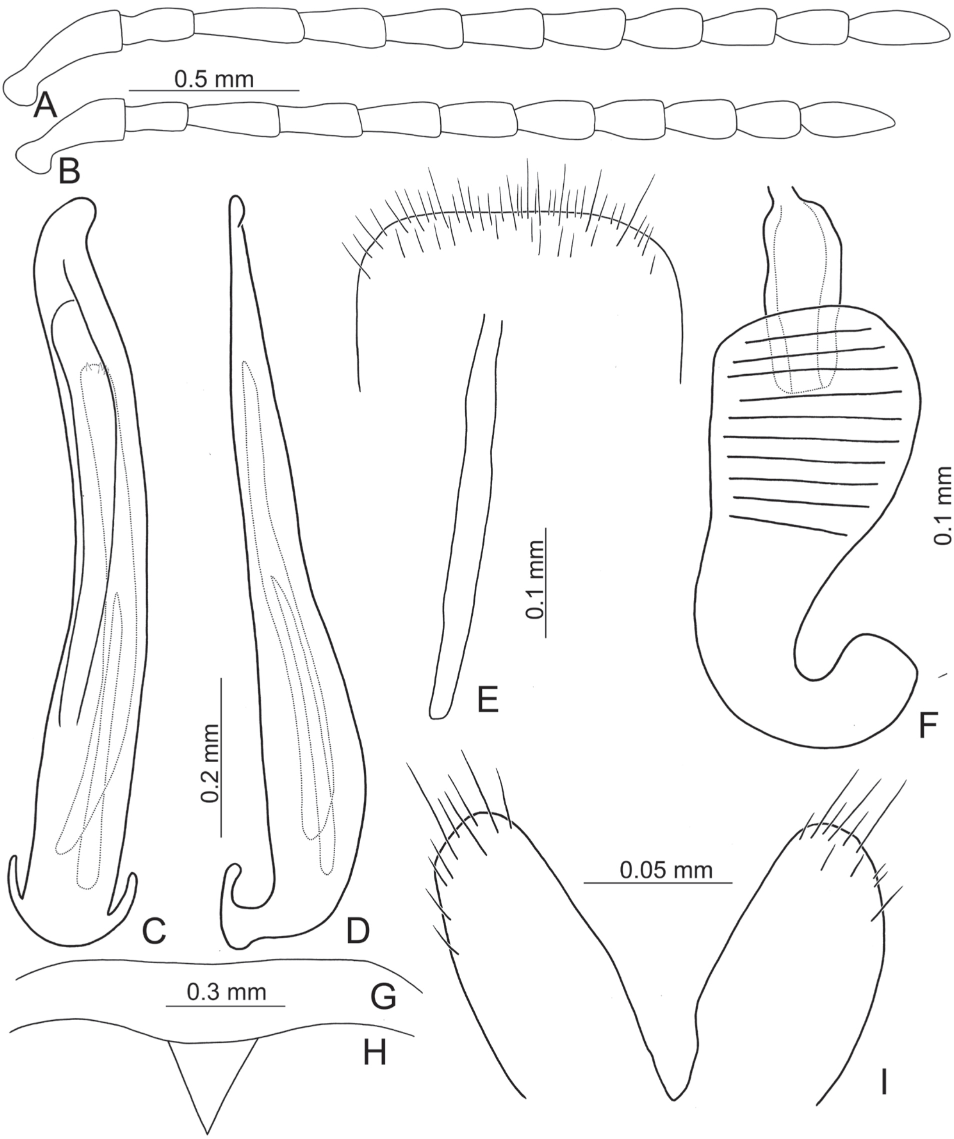

Figure 32. Diagnostic characters of *Pyrrhalta discalis* Gressitt & Kimoto **A** antenna, male **B** antenna, female **C** aedeagus, dorsal view **D** ditto, lateral view **E** abdominal ventrite VIII **F** spermatheca **G** abdominal ventrite V, female **H** abdominal ventrite V, male **I** gonocoxae.

(Fig. 32A), length ratios of antennomeres I–XI 1.0: 0.5: 0.8: 0.6: 0.6: 0.6: 0.6: 0.6: 0.5: 0.5: 0.7, length to width ratios of antennomeres I–XI 3.4: 2.3: 3.2: 2.2: 2.1: 2.0: 2.0: 2.0: 2.0: 2.0: 2.9; similar in females (Fig. 4B), length ratios of antennomeres I–XI 1.0: 0.5: 0.8: 0.7: 0.7: 0.7: 0.7: 0.6: 0.6: 0.5: 0.8, length to width ratios of antennomeres I–XI 2.7: 2.2: 2.7: 2.4: 2.3: 2.2: 2.0: 1.8: 1.9: 1.7: 2.6. Pronotum and elytra convex. Pronotum 2.0–2.1 × wider than long, disc with dense, extremely coarse punctures and

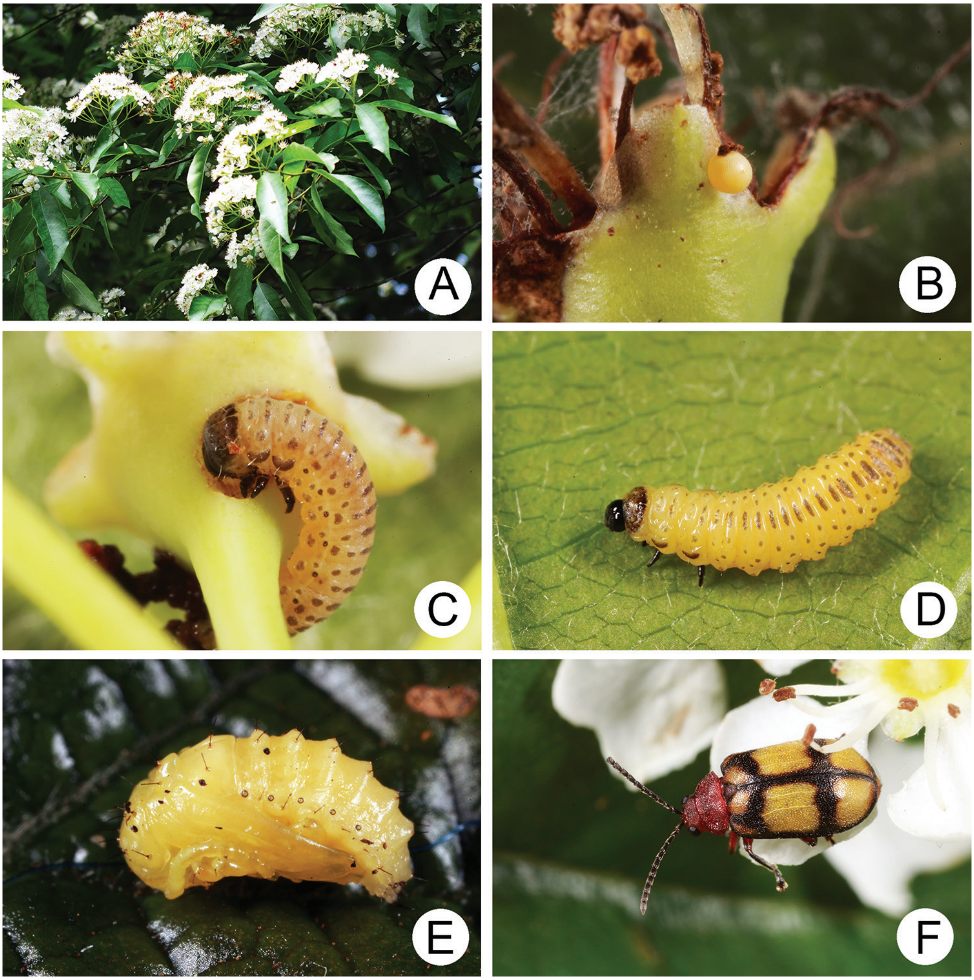

Figure 33. Field photographs of *Pyrrhalta discalis* Gressitt & Kimoto on host plant **A** host plant, *Pourthiaea lucida* **B** egg **C** Three-instar larva **D** mature larva **E** pupa **F** adult.

extremely short pubescence, with median longitudinal and lateral depressions; lateral margins moderately rounded, apical margin slightly concave, basal margin straight; anterior and posterior setiferous punctures slightly erect. Elytra elongate and broad, parallel-sided, 1.4 × longer than wide; disc with dense extremely coarse punctures and extremely short pubescence. Apical spur of tibia of middle leg absent and tarsomere I not modified in males. Aedeagus (Fig. 32C, D) extremely slender in dorsal view, 8.6 × longer than wide, sides asymmetric, curved at middle, recurved near apex, apex narrowly rounded; straight but strongly curved near base in lateral view, apex narrowly rounded; ostium not covered by membrane; two elongate endophallic sclerite, several fine teeth on apex of primary endophallic sclerite, 0.6 × as long as aedeagus, secondary sclerite much shorter, 0.6 × as long as primary endophallic sclerite, apex narrowly rounded. Sclerotized gonocoxae (Fig. 32I) transverse, both gonocoxae basally connected and membranous, with several short and long setae near apices. Ventrite VIII (Fig. 32E) transverse; disc with dense, short and few longer setae along apical margin; spiculum long. Receptacle of spermatheca (Fig. 32F) slightly swollen; pump short and strongly curved; sclerotized proximal spermathecal duct wide and short. Apical margin of abdominal ventrite V slightly concave medially, with deep, triangular depression at middle in males (Fig. 32H); only slightly concave in females (Fig. 32G).

Variation. Taiwanese populations display great variation of color patterns on the elytra. Some individuals have two additional transverse black stripes (Fig. 31D): anterior stripe at basal 1/5, with a longitudinal black stripe at middle, anteriorly connected with basal stripe; posterior stripe at middle. Some individuals have a black stripe along suture expanding laterally at base (Fig. 31E), sometimes covering entire base, and gradually narrowing towards apex (Fig. 31F).

Remarks. adults of *P. discalis* Gressitt and Kimoto are easily recognized by the yellowish brown bodies. In males of *P. discalis*, the elongate and apically curved aedeagus is similar to that of *P. semifulva* (Jacoby), but differs by the relatively shorter secondary endophallic sclerite, 0.6 × as long as primary endophallic sclerite (Fig. 32C, D) (relatively longer secondary endophallic sclerite, 0.9 × as long as primary endophallic sclerite in *P. discalis* (Fig. 29C, D).

Host plants. Larvae and adults feed on flowers of *Pourthiaea lucida* Decne. (Fig. 33A) and *Pyracantha koidzumii* (Hayata) Rehder (Rosaceae).

Biology. eggs (Fig. 33B), mature larvae (Fig. 33C), and adults (Fig. 33F) were found on flowers of *Pourthiaea lucida* April 14, 2011 in Yongfu, northern Taiwan by Mr Mei-Hua Tsou. mature larvae (Fig. 33D) burrowed into soil and built underground chambers for pupation at the same day. Duration of the pupal stage (Fig. 33E) was 14 days.

Distribution. China, Taiwan. It is widespread at lowlands (0–1,500 m) in Taiwan.

Pyrrhalta ishiharai **Kimoto, 1976**

Figs 26D, 34A–C, 35, 37F

Pyrrhalta aurata: Kimoto, 1976: 4 (Taiwan). Misidentification (after Kimoto 1994)!
Pyrrhalta ishiharai Kimoto, 1994: 191; Kimoto and Chu 1996: 56 (catalogue); Kimoto and Takizawa 1997: 300 (key), 373; Beenen 2010: 452 (catalogue); Xue and Yang 2010: 124 (catalogue); Yang et al. 2015: 117 (catalogue).

Types. ***Holotype*** ♀ (EUMJ, by original designation): "(TAIWAN) / Kueishan [龜山] / ~ Wulai [烏來] / Taipei Hsien / 5. VI, 1970 / Y. Hori leg. [p, w] // Pyrrhalta / ishiharai / Kimoto, n. sp [h] / Det. S. Kimoto, 19[p]93 [h, w] // msp [h, w] // PHOTO [p, r] // HOLOTYPE [p, r]". ***Paratype.*** 1♀ (KMNH): "NANSHANCHI [南山溪] / TAIWAN / 2. V. 1982 / F. KIMURA [p, y] // Pyrrhalta / ishiharai / Kimoto, n. sp [h] / Det. S. Kimoto, 19[p]93 [h, w] // PARATYPE [p, b]".

Other material. Taiwan. Hsinchu: 1♂, 1♀ (TARI), Chienshih (尖石), 10.VII.2010, leg. M.-H. Tsou; 1♂ (TARI), same locality, 5.VIII.2012, leg. Y.-L. Lin; Nantou: 1♂ (NMNS), Chunyang (春陽), 7.I. –13.II.2003, leg. C. S. Lin & W. T. Yang; Taipei: 2♀ (TARI), Fushan (福山), 26.VI.2011, leg. M.-H. Tsou; 2♂, 1♀ (TARI), same but with "8.VII.2011"; 3♂, 3♀ (TARI), same but with "21.VI.2015"; 2♂, 2♀ (TARI), Hsinhsien (信賢), 8.VII.2011, leg. M.-H. Tsou; 4♂, 3♀ (TARI), same but with "6.VII.2019"; 4♂, 2♀ (TARI), same but with 7.VII.2019"; 3♂ (TARI), same but with "27.VI.2020"; 1♂, 1♀ (TARI), same but with "5.VII.2020"; 4♂, 3♀ (TARI), Wulai (烏來), 8.VII.2011, leg. M.-H. Tsou; 1♂, 1♀ (TARI), same but with "17.VI.2018"; 1♂, 7♀ (TARI), same but with "27.VI.2020"; 5♂, 8♀ (TARI), same but with "5.VII.2020"; Taitung: 2♂ (TARI), Liyuan (栗園), 19.VI.2013, leg. Y.-T. Chung; 2♂ (TARI), same but with "leg. B.-X. Guo".

Redescription. Length 4.8–5.1 mm, width 2.3–2.5 mm. Body color (Fig. 34A–C) yellowish brown; vertex with one dark spot at center; antennae dark brown, but four or five basal antennomeres basally paler; pronotum with three black spots, one elongate spot at center, one pair laterally; scutellum basally darker; four pairs of transverse dark spots on elytra, one pair near base and behind scutellum, three pairs at basal 2/5, 3/5, 4/5 respectively, intercepted by two pairs of longitudinal yellowish brown ridges, all dark spots poorly defined; meso- and metathoracic ventrites darker; apical 2/3 of tibiae and entire tarsi black except inner side of protibia. Eyes small, interocular space 2.35–2.38 × diameter of eye. Antennae filiform in males (Fig. 35A), length ratios of antennomeres I–XI 1.0: 0.6: 0.9: 0.7: 0.7: 0.7: 0.6: 0.6: 0.6: 0.6: 0.9, length to width ratios of antennomeres I–XI 3.1: 2.1: 3.2: 2.5: 2.4: 2.1: 1.8: 1.8: 1.8: 1.6: 2.2; filiform in females (Fig. 35B), length ratios of antennomeres I–XI 1.0: 0.6: 0.7: 0.7: 0.6: 0.6: 0.6: 0.6: 0.5: 0.5: 0.8, length to width ratios of antennomeres I–XI 3.4: 2.5: 2.9: 2.8: 2.2: 1.7: 1.6: 1.6: 1.5: 1.4: 2.3. Pronotum and elytra convex. Pronotum 1.7–1.9 × wider than long, disc with reticulate microsculpture; coarse, extremely dense punctures, and extremely short pubescence; with median longitudinal and lateral depressions; lateral margins angular, widest at apical 1/3, apical and basal margins truncate; posterior setiferous punctures strongly erect. Elytra elongate, broad, parallel-sided, 1.5 × longer than wide; disc with reticulate microsculpture and coarse, extremely dense punctures and short pubescence; with two pairs of long longitudinal ridges near suture, apically abbreviated; several oblique ridges exterior to longitudinal ridges. Apical spur of middle tibia of middle small (Fig. 35E), tarsomere I with a small tooth at middle ventrally in males (Fig. 35H). Aedeagus (Fig. 35C, D) slender in dorsal view, 5.9 × longer than wide, sides asymmetric, widest at middle, apex angular; strongly curved near base in lateral view, weakly recurved apically, apex acute; ostium longitudinal, not covered by membrane; two endophallic sclerites elongate, apex of primary endophallic sclerite with several teeth, 0.6 × as long as aedeagus, secondary sclerite much shorter, 0.7 × as long as primary sclerite, apex acute, with one additional tooth near apex. Only apices of gonocoxae (Fig. 35K) sclerotized and longitudinal, with dense, long setae along lateral and apical margins. Ventrite VIII (Fig. 35F) narrow; disc with several long setae and dense short setae along apical margin; spiculum long. Receptacle of spermatheca

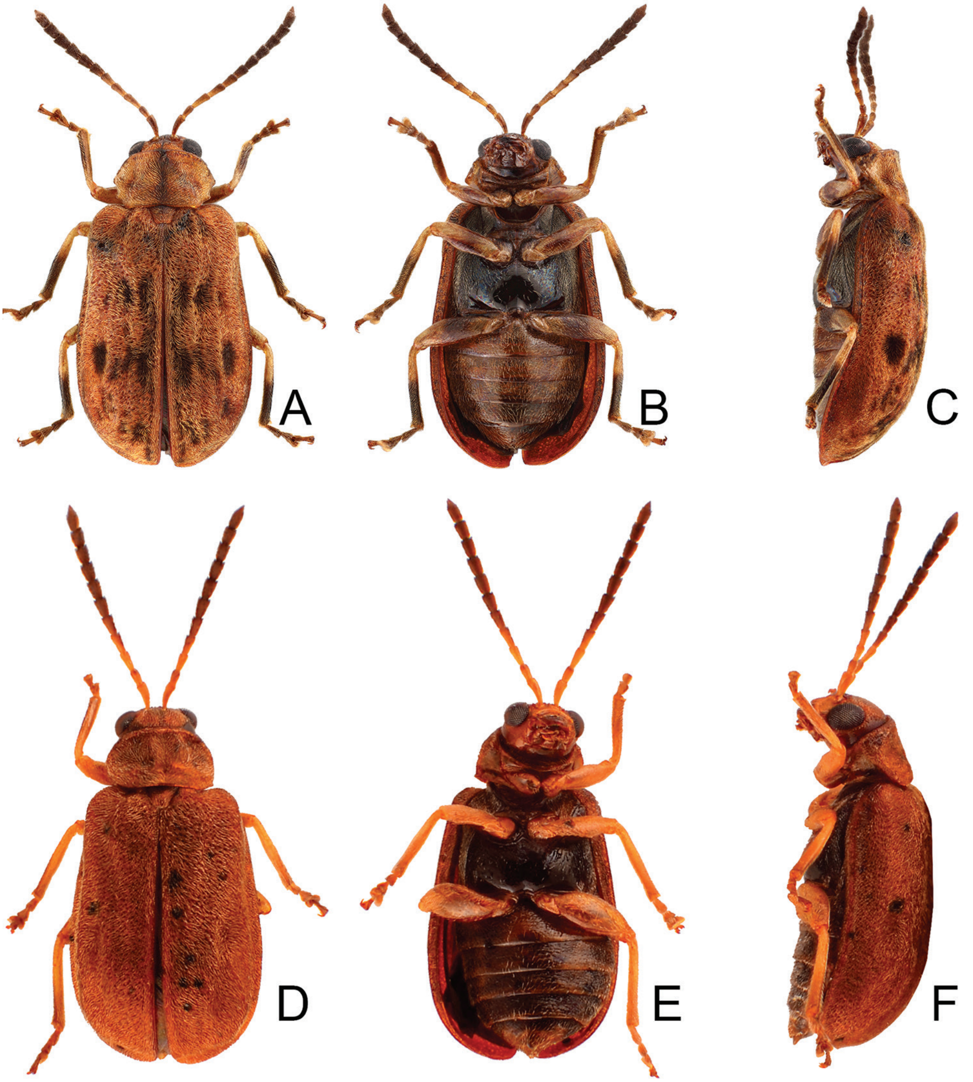

Figure 34. Habitus of *Pyrrhalta ishiharai* Kimoto and *P. wulaiensis* sp. nov. **A** *P. ishiharai*, female, typical form, dorsal view **B** ditto, ventral view **C** ditto, lateral view **D** *P. wulaiensis* sp. nov., female, dorsal view **E** ditto, ventral view **F** ditto, lateral view.

(Fig. 35G) very swollen; pump short and strongly curved; sclerotized proximal spermathecal duct wide and short. Apical margin of abdominal ventrite V slightly concave, with deeply rounded depression at middle in males (Fig. 35J); slightly concave in females (Fig. 35I).

Remarks. Adults of *P. ishiharai* Kimoto and *P. wulaiensis* sp. nov. are easily separated from other species within the species group by the longitudinal ridges on the elytra (Fig. 34) and the angular apices of the aedeagi (Figs 35C, 36C). *Pyrrhalta ishiharai* is

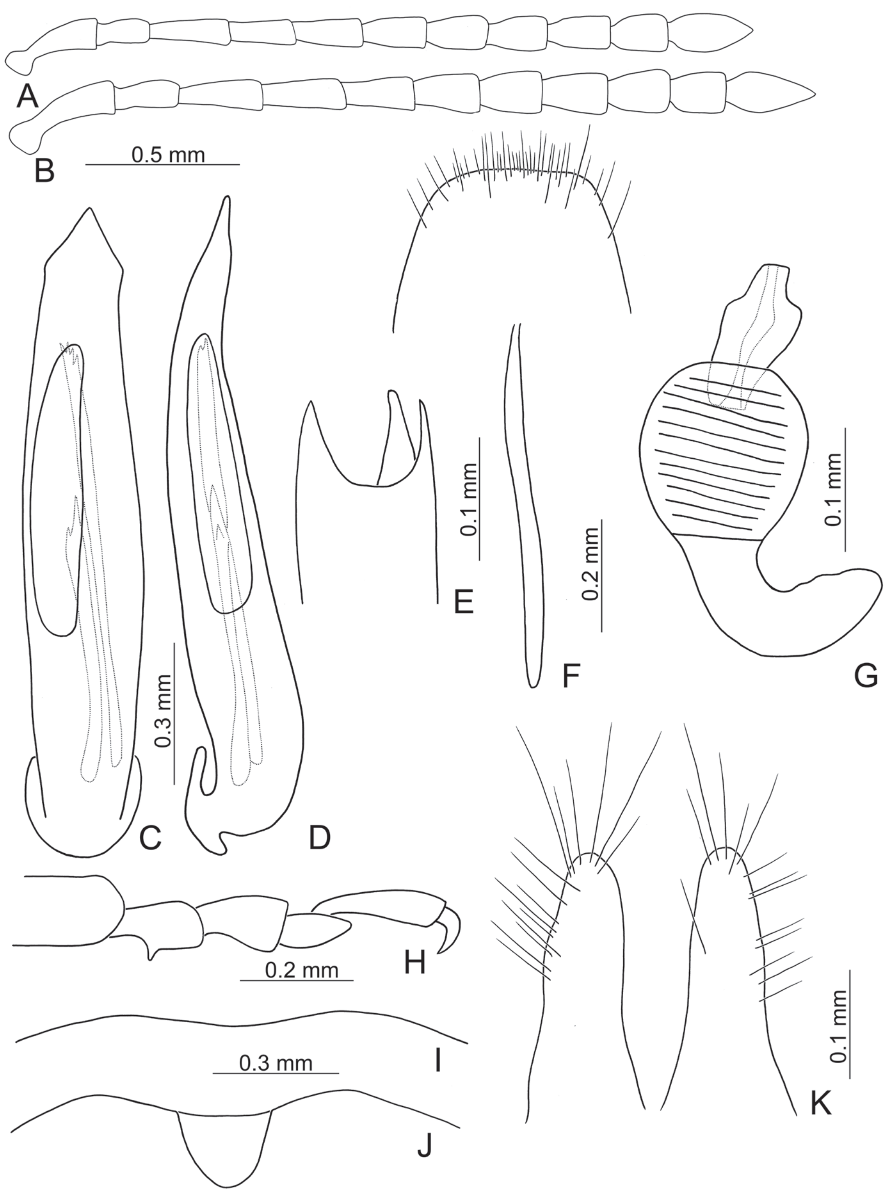

Figure 35. Diagnostic characters of *Pyrrhalta ishiharai* Kimoto **A** antenna, male **B** antenna, female **C** aedeagus, dorsal view **D** ditto, lateral view **E** apex of tibia of middle leg, male **F** abdominal ventrite VIII **G** spermatheca **H** tarsi of middle leg, male **I** abdominal ventrite V, female **J** abdominal ventrite V, male **K** gonocoxae.

distinguished from *P. wulaiensis* sp. nov. by the larger body size (Fig. 37F), 4.8–5.1 mm long (3.3–3.7 mm long in *P. wulaiensis* sp. nov.), dark spots present between the longitudinal ridges on the elytra (Fig. 34A) (dark spots absent between longitudinal ridges on elytra in *P. wulaiensis* sp. nov. Fig. 34D), apical spine present on tibia (Fig. 35E) and modified tarsomere I of middle leg (Fig. 35H) in males (lacking apical spine on tibia and normal tarsomere I of middle leg in males of *P. wulaiensis* sp. nov.), longitudinal ostium and aedeagus recurved in apical 1/3 (Fig. 35C, D) (transverse ostium and aedeagus curved at middle in *P. wulaiensis* sp. nov. (Fig. 36C, D)), longitudinally cylindrical gonocoxae with dense, long setae (Fig. 35K) (transversely rounded gonocoxae with scattered short setae in *P. wulaiensis* sp. nov. (Fig. 36I)).

Food plant. Adults feed on flowers of *Meliosma rhoifolia* Maxim. (Sabiaceae) (Fig. 26D).

Distribution. The species is widespread at lowlands (0–1,500 m) in Taiwan.

***Pyrrhalta wulaiensis* sp. nov.**

http://zoobank.org/ECCE0D20-4E5F-4CC3-B17B-24BBE0BAF34F
Figs 34D–F, 36, 37A–E

Types. ***Holotype*** ♂ (TARI), Taiwan. Nantou: Peitungyanshan (北東眼山), 3.VII.2014, leg. F.-S. Huang, 變葉新木薑子 (*Neolitsea aciculata* (Bl.) Koidz. var. *variabillima* J.C. Liao) 噴霧 (fogging). ***Paratypes.*** 1♂ (TARI), same locality as holotype, 3.VII.2014, leg. C.-F. Lee; Ilan: 1♂ (TARI), Fushan (福山), 5.VII.2013, leg. Y.-T. Wang; Miaoli: 1♂ (TARI), Hsuehchien (雪見), 5.III.2013, leg. W.-B. Yeh; Nantou: 1♀ (TARI), Meifeng (梅峰), 28–29.VIII.1981, leg. L. Y. Chou & S. C. Lin; 1♀ (TARI), same locality, 15.VII.1982, leg. S. C. Lin & C. N. Lin; 1♀ (NMNS), same locality, 13.VI. –18.VII.2001, leg. C. S. Lin & W. T. Yang, Malaise trap (KCN); 1♂ (NMNS), same but with "15.XI. –19.XII.2001"; 1♀ (NMNS), same but with "5.X. –16.XI.2004"; Taipei: 1♂ (TARI), Fushan (福山) – 烏來 (Wulai), 21.VI.2015, leg. M.-H. Tsou; 1♂ (TARI), Hsinhsien (信賢), 5.VII.2020, leg. M.-H. Tsou; 1♀ (TARI), same but with "27.VI.2020"; 1♀ (TARI), Wulai (烏來), 19.VII.2011, leg. M.-H. Tsou.

Diagnosis. Smaller species, 3.3–3.7 mm in length. Elytra relatively broad, 1.5 × longer than wide; unicolorous, without dark spots; with ridges.

Description. Length 3.3–3.7 mm, width 1.6–1.9 mm. Body color (Fig. 34D–F) brown or dark brown; antennae black but antennomeres I–III yellow, IV, and V brown. Eyes large, interocular space 1.75–1.83 × diameter of eye. Antennae filiform in males (Fig. 36A), length ratios of antennomeres I–XI 1.0: 0.5: 0.6: 0.7: 0.6: 0.6: 0.7: 0.6: 0.6: 0.6: 0.9, length to width ratios of antennomeres I–XI 3.2: 2.2: 2.9: 3.0: 2.9: 2.9: 2.5: 2.0: 2.1: 2.0: 2.9; similar in females (Fig. 36B), length ratios of antennomeres I–XI 1.0: 0.5: 0.7: 0.7: 0.6: 0.6: 0.7: 0.6: 0.6: 0.6: 0.8, length to width ratios of antennomeres I–XI 3.5: 2.3: 2.9: 2.8: 2.5: 2.2: 2.3: 1.9: 1.8: 1.8: 2.7. Pronotum and elytra convex. Pronotum 1.7–2.0 × wider than long, with transverse ridge along apical margin deflexed at antero-lateral angles; disc smooth on ridge, but with reticulate microsculpture below ridge, with extremely dense and coarse punctures, with one short seta at each puncture; with median longitudinal and lateral depressions; lateral margins moderately rounded, widest at apical 1/3, apical and basal margins slightly concave;

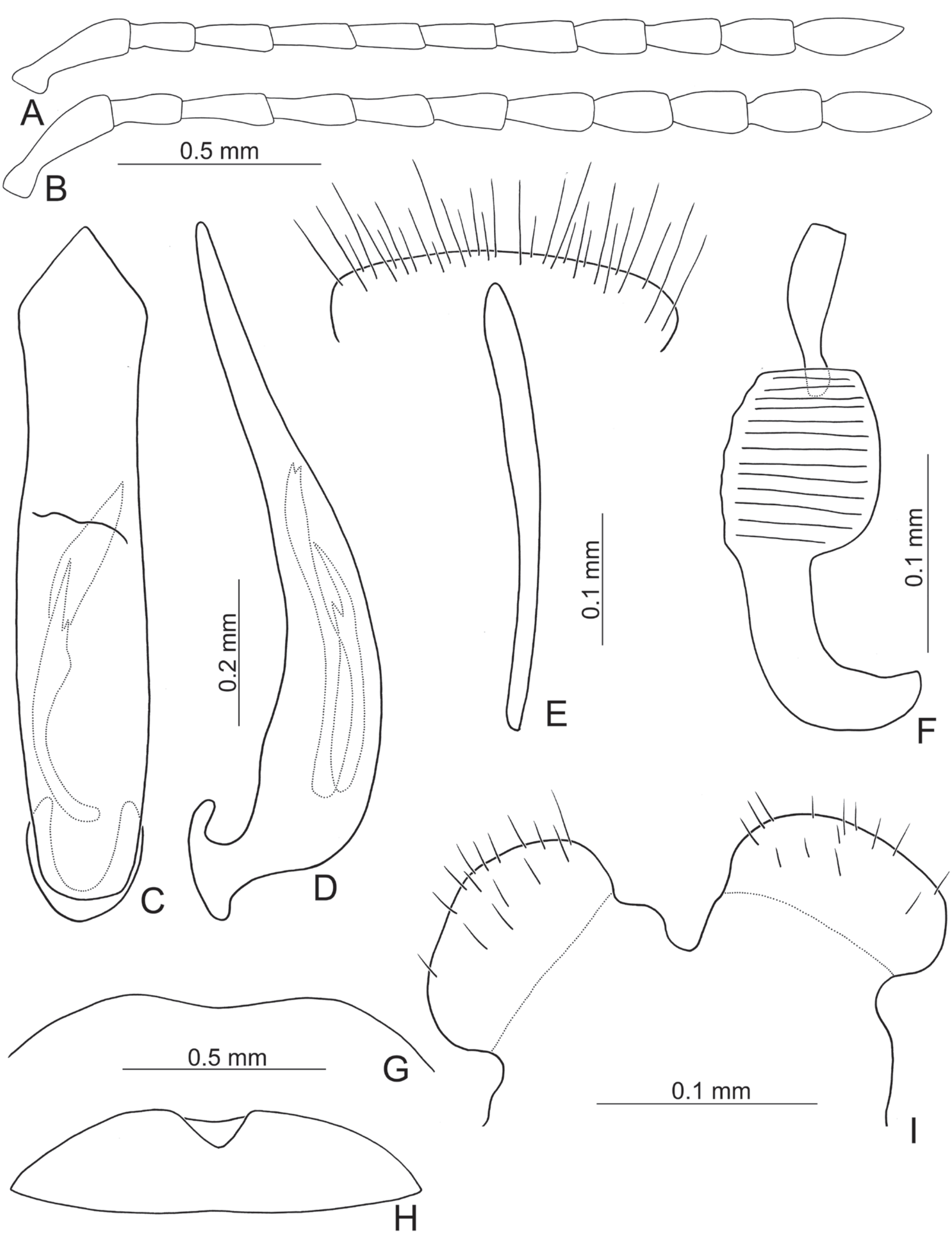

Figure 36. Diagnostic characters of *Pyrrhalta wulaiensis* sp. nov. **A** antenna, male **B** antenna, female **C** aedeagus, dorsal view **D** ditto, lateral view **E** abdominal ventrite VIII **F** spermatheca **G** abdominal ventrite V, female **H** abdominal ventrite V, male **I** gonocoxae.

posterior setiferous punctures slightly erect. Elytra elongate and broad, parallel-sided, 1.5 × longer than wide; disc with reticulate microsculpture, and with coarse and sparse punctures, with extremely dense short pubescence, all of pubescence located between

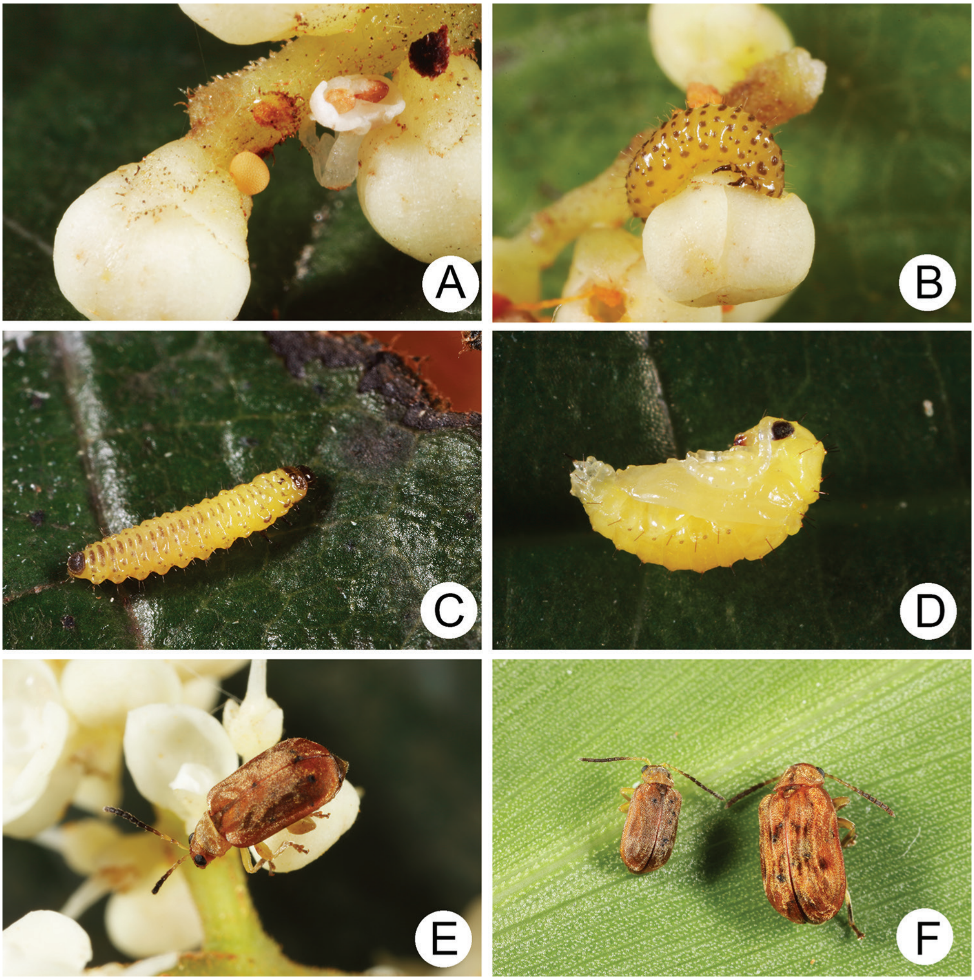

Figure 37. Field photographs of *Pyrrhalta wulaiensis* sp. nov. on host plant **A** egg **B** third-instar larva **C** mature larva **D** pupa **E** adult **F** adults: *P. wulaiensis* sp. nov. (left) and *P. ishiharai* (right).

punctures; with indistinct, obliquely longitudinal ridges arising from behind humeral calli, with depressions between ridges and suture at apical 1/3 and middle. Apical spur of tibia of middle leg absent and tarsomere I not modified in males. Aedeagus (Fig. 36C, D) slender in dorsal view, 5.9 × longer than wide, sides symmetric, parallel-sided but slightly narrowed at apical 1/4, apex angular; strongly curved near base in lateral view, apex acute; ostium transverse, covered by a membrane; two endophallic sclerite elongate, apex of primary endophallic sclerite with two teeth, 0.4 × as long as aedeagus, secondary sclerite 0.8 × as long as primary sclerite, apex acute, with one additional tooth at apical 1/4. Only apices of gonocoxae (Fig. 36I) sclerotized and transverse, with short, scattered setae. Ventrite VIII (Fig. 36E) with only apical area sclerotized; disc with several long setae and dense short setae along apical margin;

spiculum long. Receptacle of spermatheca (Fig. 36F) very swollen; pump short and strongly curved; sclerotized proximal spermathecal duct narrow and short. Apical margin of abdominal ventrite V slightly concave, with shallow triangular depression at middle in males (Fig. 36H); slightly concave in females (Fig. 36G).

Remarks. Adults of *P. wulaiensis* sp. nov. and *P. ishiharai* Kimoto are easily separated from other species within the species group by the longitudinal ridges on the elytra (Fig. 34) and the angular apices of aedeagi (Figs 35C, 36C). *Pyrrhalta wulaiensis* sp. nov. is distinguished from *P. ishiharai* by the smaller body size (Fig. 37F), 3.3–3.7 mm long (4.8–5.1 mm long in *P. ishiharai*), absence of dark spots between the longitudinal ridges on the elytra (Fig. 34D) (dark spots present between longitudinal ridges on elytra in *P. ishiharai* Fig. 34A), lacking apical spine on tibia and normal tarsomere I of middle leg in males (apical spine present on tibia (Fig. 35E) and modified tarsomere I of middle leg in males of *P. ishiharai* (Fig. 35H)), transverse ostium and medially curved aedeagus (Fig. 36C, D) (in longitudinal ostium and recurved at apical 1/3 of aedeagus *P. ishiharai* (Fig. 35C, D)), transversely rounded gonocoxae with scattered short setae (Fig. 36I) (longitudinally cylindrical gonocoxae with dense, long setae in *P. ishiharai* (Fig. 35K))

Host plant. Larvae and adults feed on flowers of *Meliosma rhoifolia* Maxim. (Sabiaceae).

Biology. One female was collected on flowers of the host plant (Fig. 37E) July 8, 2011 in Wulai, northern Taiwan by Mr Mei-Hua Tsou. The female deposited eggs (Fig. 37A) singly on flowers July 12. Larvae hatched in seven days. The larvae (Fig. 37B) fed on flowers and the larval duration was eleven days. mature larvae (Fig. 37C) burrowed into soil and built underground chambers for pupation. Duration of the pupal stage (Fig. 37D) was eight days.

Distribution. The species is widespread at lowlands (0–1,500 m) in northern Taiwan and mid-altitudes (1,500–2,500 m) in central Taiwan.

Etymology. The species is named for the locality where specimens were collected and used for laboratory rearing.

Pyrrhalta shirozui species group

Included species. *Pyrrhalta jungchani* sp. nov.; *P. lui* sp. nov.; and *P. shirozui* Kimoto, 1969.

Diagnosis. adults small to medium sized (3.3–6.8 mm). Antenna slender, antennomere III longest, V–X similar in size. Body convex. Elytra relatively wider for *P. shorozui* 1.5 × longer than wide (Fig. 38D–I), or relatively narrow for *P. jungchani* sp. nov. and *P. lui* sp. nov., 1.7–1.8 × longer and wide (Figs 38A–C, 41). Aedeagus asymmetric; ostium longitudinal, covered by a membrane or without cover; endophallic sclerites composed of two slender sclerites, with several teeth on apex of primary sclerite (Figs 39C, D, 42C, D, 43C, D). Ventrite VIII in females apically sclerotized, with dense, mixed short and long setae along apical margin; spiculum long (Figs 39E, 42E, 43F). Gonocoxae apically sclerotized, with dense, long setae on apices (Figs 39G, 42I, 43G). Apical margin of abdominal ventrite V slightly concave medially and with deep depression in males (Figs 39J, 42H, 43J); depression broadly rounded in females (Figs 39I, 42G, 43I). Mesotibia with apical spine in males of *P. jungchani* sp. nov. (Fig. 39F) and *P. shirozui* (Fig. 43E). Mesotarsi with tarsomere I modified in males of *P. jungchani* sp. nov. (Fig. 39H) and *P. shirozui* (Fig. 43K).

Biology. Larvae and adults feed on leaves of *Viburnum* species (Adoxaceae).

Pyrrhalta jungchani sp. nov.

http://zoobank.org/4C599464-5532-40EB-B379-B4C92C03ABE2

Figs 38A–C, 39, 40A

Types. ***Holotype*** ♂ (TARI), Taiwan. Pingtung, Tahantrail (大漢林道), 30.VII.2012, leg. J.-C. Chen. ***Paratypes.*** Chiayi: 1♀ (TARI), Zengwen Reservoir (曾文水庫), 2.IV.2016, leg. U. Ong; Nantou: 2♀ (NMNS), Juiyenhsi (瑞岩溪), Shuikuan Road (水管路), 19.II.2009, Beating,leg. M. L. Chan; 1♂ (NMNS), same locality, 19–21. II.2009, UV light trap, leg. H. H. Lian & C. D. Tang; 1♀ (TARI), Tsuifeng (翠峰), 23.V.1982, leg. L. Y. Chou; 1♀ (TARI), same locality, 20.IV.1983, leg. K. C. Chou & S. P. Huang; 1♀ (TARI), same as holotype but with "22.XI.2010"; 1♀ (TARI), same but with "13.IX.2012"; 1♀ (TARI), same but with "16.X.2013"; Pingtung: 1♀ (TARI), Lilungshan (里龍山), 5.XI.2009, leg. M.-H. Tsou; 1♀ (TARI), same locality, 28.XI.2009, leg. J.-C. Chen; 1♀ (TARI), same but with "8.I.2010"; 1♂, 1♀ (TARI), same but with "2.III.2012"; 3♀ (TARI), same but with "13.III.2012"; 1♀ (TARI), same but with "27.III.2012"; 1♀ (TARI), same but with "8.I.2013"; 2♂, 4♀ (TARI), Shuangliu (雙流), 14.III.2018, leg. Y.-T. Chung; 2♂, 2♀ (TARI), Tahanshan (大漢山), 18.IV.2018, leg. C.-F. Lee; 1♀ (TARI), same locality, 3.III.2020, leg. Y.-T. Chung; Taitung: 1♀ (TARI), Hsiangyang (向陽), 23.VI.2010, leg. M.-H. Tsou; 1♀ (TARI), same locality, 8.VII.2010, leg. J.-C. Chen; 1♂ (TARI), same but with "12.VII.2012"; 1♀ (TARI), same but with "9.V.2013"; 1♀ (TARI), same but with "17.V.2014"; 1♀ (TARI), Motien (摩天), 23.VI.2010, leg. M.-H. Tsou.

Diagnosis. Small species, 4.3–5.0 mm in length. Pronotum with three large black spots, one at middle, two laterally. Elytra relatively narrow, 1.7 × longer than wide, disc with dense coarse punctures, with black stripes at humeral calli, with one additional pair of longitudinal dark stripes between humeral calli and suture.

Description. Length 4.3–5.0 mm, width 1.9–2.3 mm. Body yellowish brown (Fig. 38A–C); vertex with median longitudinal dark stripe, expanding laterally at base; antennae dark brown, but five or six basal antennomeres paler; pronotum with one pair of large dark spots at lateral depressions, with three small dark spots medially, one pair at apical 1/3, the other at basal 1/3; elytra with three pairs of longitudinal dark stripes, first pair arising from humeral calli, abbreviated at apical 1/3, second pair halfway between first pair and suture, present from base to apical 1/3; third pair along suture, from apical 1/3 to base; those dark spots or stripes more or less reduced in different individuals; lateral margins of femora and tibiae dark brown. Eyes small,

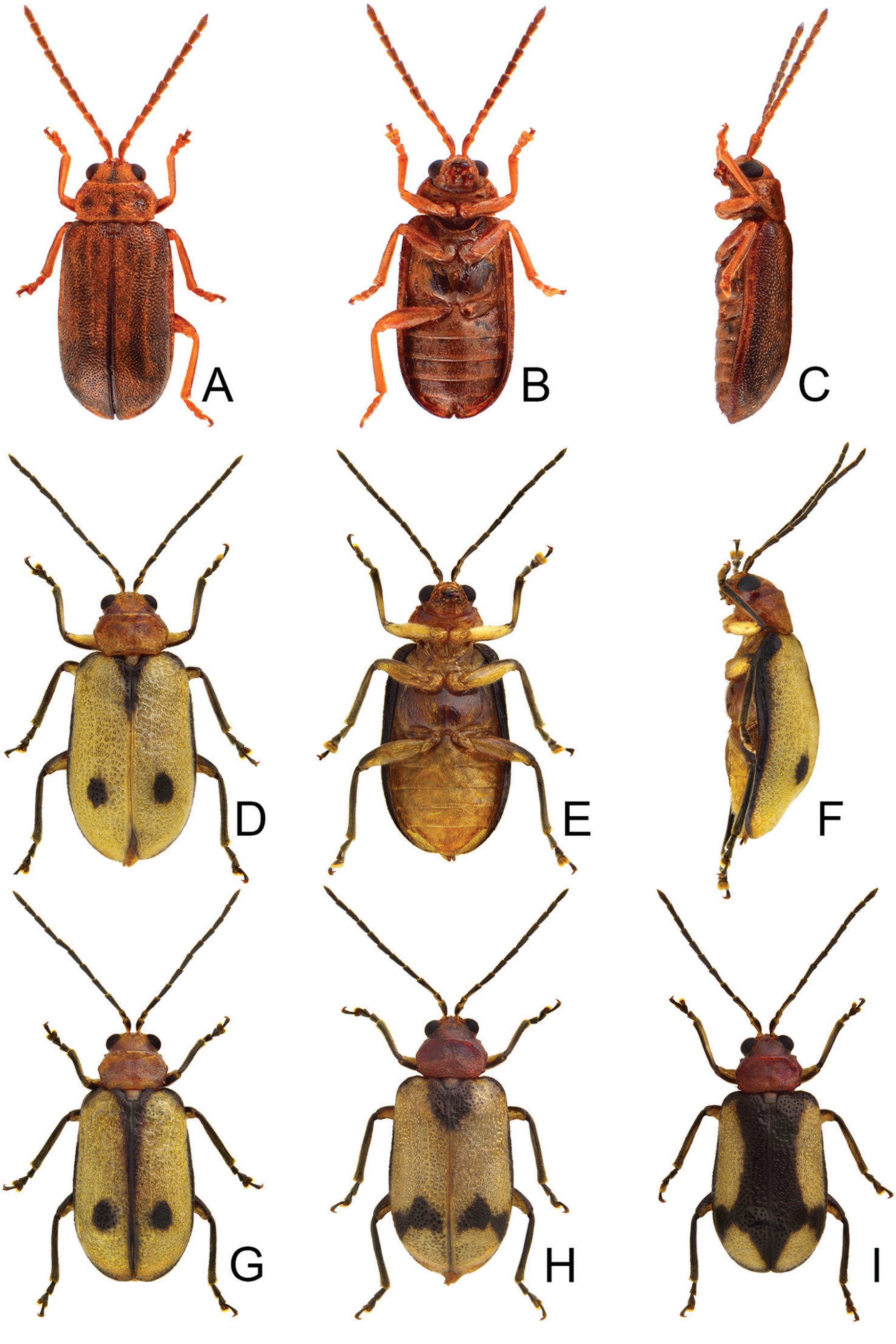

Figure 38. Habitus of *Pyrrhalta jungchani* sp. nov. *and P. shirozui* Kimoto **A** *P. jungchani* sp. nov., male, dorsal view **B** ditto, ventral view **C** ditto, lateral view **D** *P. shirozui*, female, dorsal view **E** ditto, ventral view **F** ditto, lateral view **G** Same species, color variation **H** Same species, color variation **I** Same species, color variation.

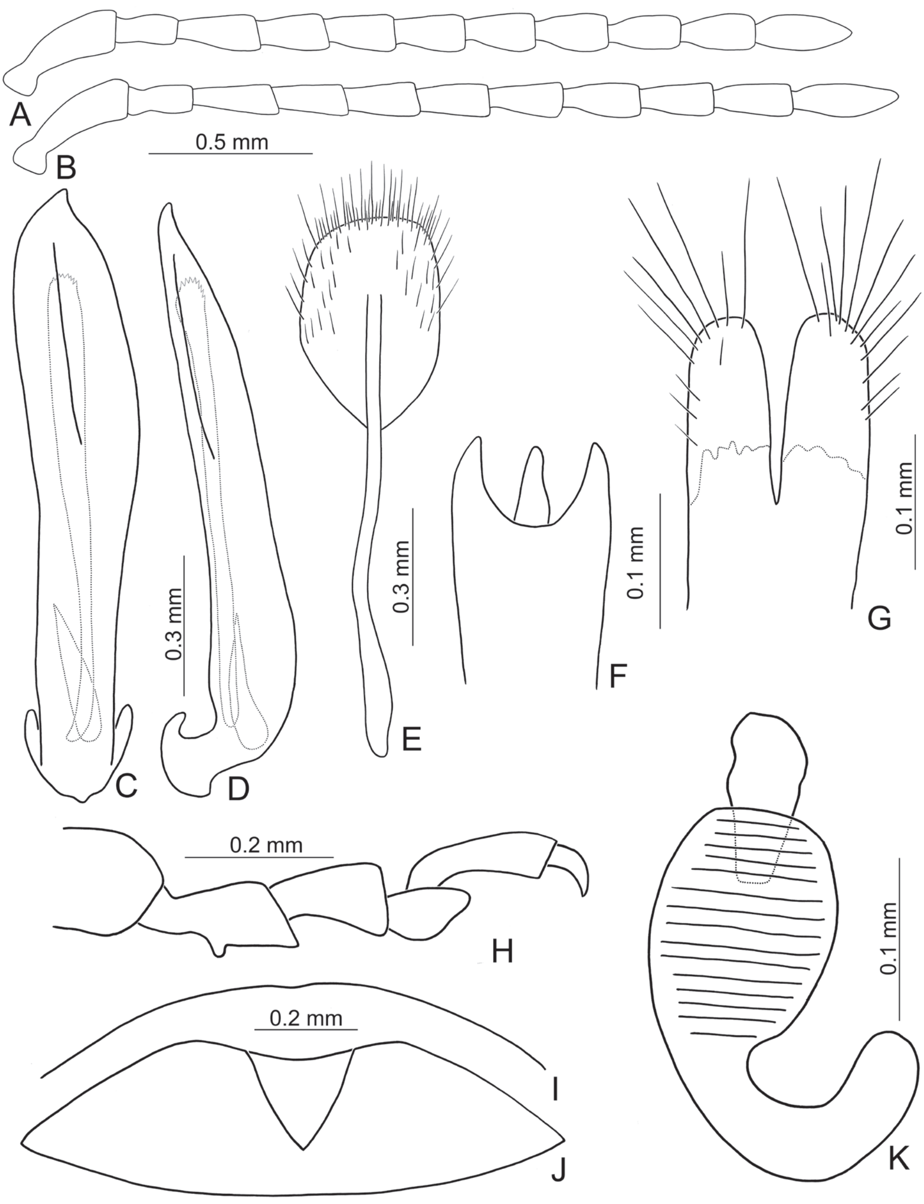

Figure 39. Diagnostic characters of *Pyrrhalta jungchani* sp. nov. **A** antenna, male **B** antenna, female **C** aedeagus, dorsal view **D** ditto, lateral view **E** abdominal ventrite VIII **F** apex of tibia of middle leg, male **G** gonocoxae **H** tarsi of middle leg, male **I** abdominal ventrite V, female **J** abdominal ventrite V, male **K** spermatheca.

interocular space 2.34–2.68 × diameter of eye. Antennae filiform in males (Fig. 39A), length ratios of antennomeres I–XI 1.0: 0.5: 0.6: 0.5: 0.5: 0.5: 0.5: 0.5: 0.6: 0.6: 0.8, length to width ratios of antennomeres I–XI 2.9: 2.1: 2.2: 1.9: 1.9: 1.9: 1.9: 2.0: 2.0:

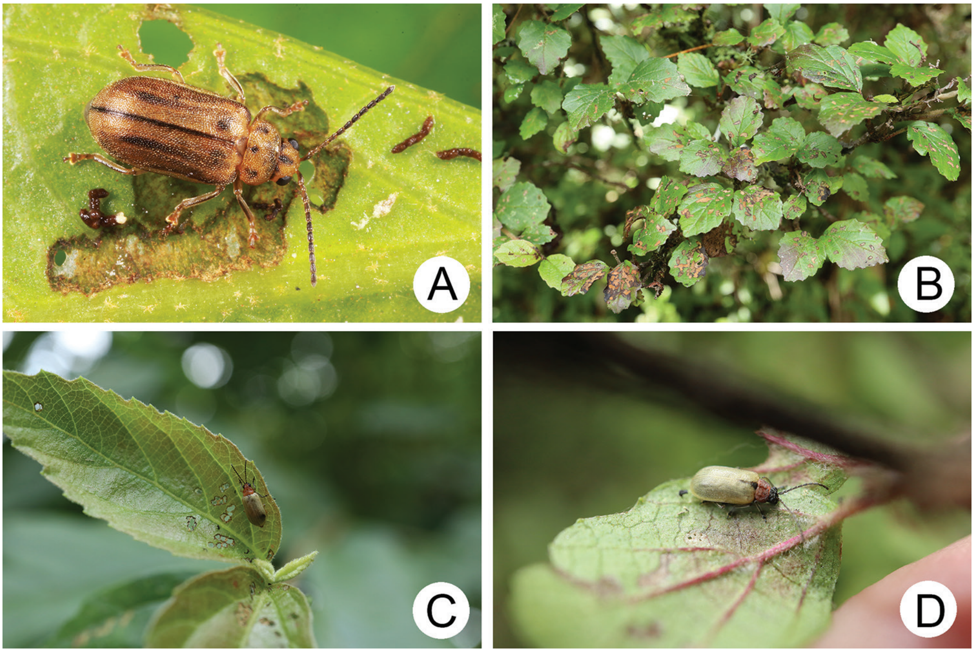

Figure 40. Field photographs of *Pyrrhalta jungchani* sp. nov. and *P. lui* sp. nov. on host plant **A** adult of *P. jungchani* sp. nov. **B** host plant for *P. lui* sp. nov., *Viburnum parvifolium* with feeding marks **C** adult of *P. lui* sp. nov. feeding on leaves of *V. luzonicum* **D** adult of *P. lui* sp. nov.

2.1: 2.7; similar in females (Fig. 39B), length ratios of antennomeres I–XI 1.0: 0.5: 0.6: 0.5: 0.5: 0.5: 0.5: 0.6: 0.5: 0.6: 0.8, length to width ratios of antennomeres I–XI 3.3: 2.2: 2.7: 2.3: 2.2: 2.1: 2.1: 2.4: 2.3: 2.4: 3.3. Pronotum and elytra convex. Pronotum 2.0–2.1 × wider than long, with transverse ridge along apical margin deflexed at antero-lateral angles; disc with reticulate microsculpture, and extremely coarse, dense punctures, with one extremely short seta at each puncture; with median longitudinal and lateral depressions; lateral margins moderately rounded, widest at middle, apical and basal margins slightly concave; anterior and posterior setiferous punctures not erect. Elytra broad, parallel-sided, 1.7 × longer than wide; disc smooth, with extremely coarse and dense punctures, and sparse, extremely short pubescence, usually located between punctures; with indistinct ridges along dark stripes. Apical spur of tibia of middle leg small (Fig. 39F), and tarsomere I modified, axe-shaped in lateral view, narrow basally, and extending to apical 2/3, angles of extended part narrowly rounded in males (Fig. 39H). Aedeagus (Fig. 39C, D) slender in dorsal view, 5.3 × longer than wide, asymmetrically lanceolate, slightly curved at middle, strongly narrowed and recurved near apex, apex narrowly rounded; ostium obliquely longitudinal, covered by a membrane; strongly curved near base in lateral view, recurved near apex, apex narrowly rounded; two endophallic sclerites elongate, primary sclerite 0.8 × as long as aedeagus, with dense teeth along apical margin. Secondar sclerite much shorter, 0.3 × as long as secondary sclerite, apex acute. Only apices of gonocoxae (Fig. 39G) sclerotized, longitudinal, few short setae near base, with six to seven long setae near apex of each gonocoxa. Ventrite VIII (Fig. 39E) well sclerotized, with dense, short setae along lateral and apical area, short and long marginal setae, spiculum long. Receptacle of spermatheca (Fig. 39K) slightly swollen and elongate; pump short and strongly curved; sclerotized proximal spermathecal duct narrow and short. Apical margin of abdominal ventrite V slightly concave medially and with deep depression in males (Fig. 39J); while broadly rounded in females (Fig. 39I).

Remarks. Adults of *P. jungchani* sp. nov. (Fig. 38A), *X. aenescens* (Fairmaire) (Fig. 1D), and *P. lineatipes* (Takei) (Fig. 45G) are easily recognized by the three black spots on the pronota. This new species (Fig. 38C) is most similar to *P. lineatipes* (Fig. 45I) based on the brown elytra with a black stripe arising from the humeral calli and convex pronotum and elytra (entirely metallic green elytra and dorso-ventrally flattened pronotum and elytra in *X. aenescens* (Fig. 1F)). The new species is different from *P. lineatipes* in possessing sparse pubescence and extremely dense elytral punctures (dense pubescence with sparse elytral punctures in *P. lineatipes*), and modified tarsomere I of middle leg in males (Fig. 39H) (normal tarsomere I of middle leg in males of *P. humeralis*). In males of this new species, the aedeagus (Fig. 39C, D) is similar to that of *P. lui* sp. nov. (Fig. 40C, D) with the asymmetrically lanceolate shape and two endophallic sclerites but differs in the recurved apex and shorter secondary endophallic sclerite, 0.3 × as long as primary endophallic sclerite (the straight apex and the longer second endophallic, 0.6 × as long as primary endophallic sclerite, in *P. lui* sp. nov.).

Food plant. adults feed on leaves of *Viburnum odoratissimum* Ker Gawl. (Adoxaceae) (Fig. 40A).

Distribution. The species is widespread at mid-altitudes (1,500–2,500 m) in central and southern Taiwan.

Etymology. Dedicated to Mr Jung-Chan Chen who was the first member of TCRT to collect specimens of this new species.

***Pyrrhalta lui* sp. nov.**

http://zoobank.org/22A6C67A-BA73-46F7-8E0D-A9F092F85B09
Figs 40B–D, 41, 42

Types. ***Holotype*** ♂ (TARI), Taiwan. Hualien: Hahuan Cross-Ridge (合歡越嶺古道), 4.VIII.2018, leg. H.-F. Lu. ***Paratypes.*** 16♂, 7♀ (TARI), same data as holotype; Hualien: 3♀ (TARI), Hutoushan (虎頭山), 21.IV.2018, leg. H.-F. Lu; Kaohsiung: 1♀ (TARI), Chungchihkuan (中之關), 17.IV.2012, leg. L.-P. Hsu; 4♂, 3♀ (TARI), same locality, 12.VI.2015, leg. C.-F. Lee; Miaoli: 1♂ (TARI), Hsuehchien (雪見), 7.VI.2013, leg. W.-B. Yeh; Nantou: 1♂ (TARI), Chingching (清境), 5.III.2007, leg. H.-C. Chen; 1♂ (TARI), Meifeng (梅峰), 2–4.VI.1980, leg. L. Y. Chou & C. C. Chen; 1♀ (TARI), same locality, 24–26.VI.1981, leg. K. S. Lin & W. S. Tang; 1♂ (TARI), Tatachia (塔塔加), leg. 21.VI.2009, leg. C.-F. Lee; Taichung: 1♂, 2♀ (TARI), Kukuan (谷關), 21.III.2014, leg. B.-X. Guo.

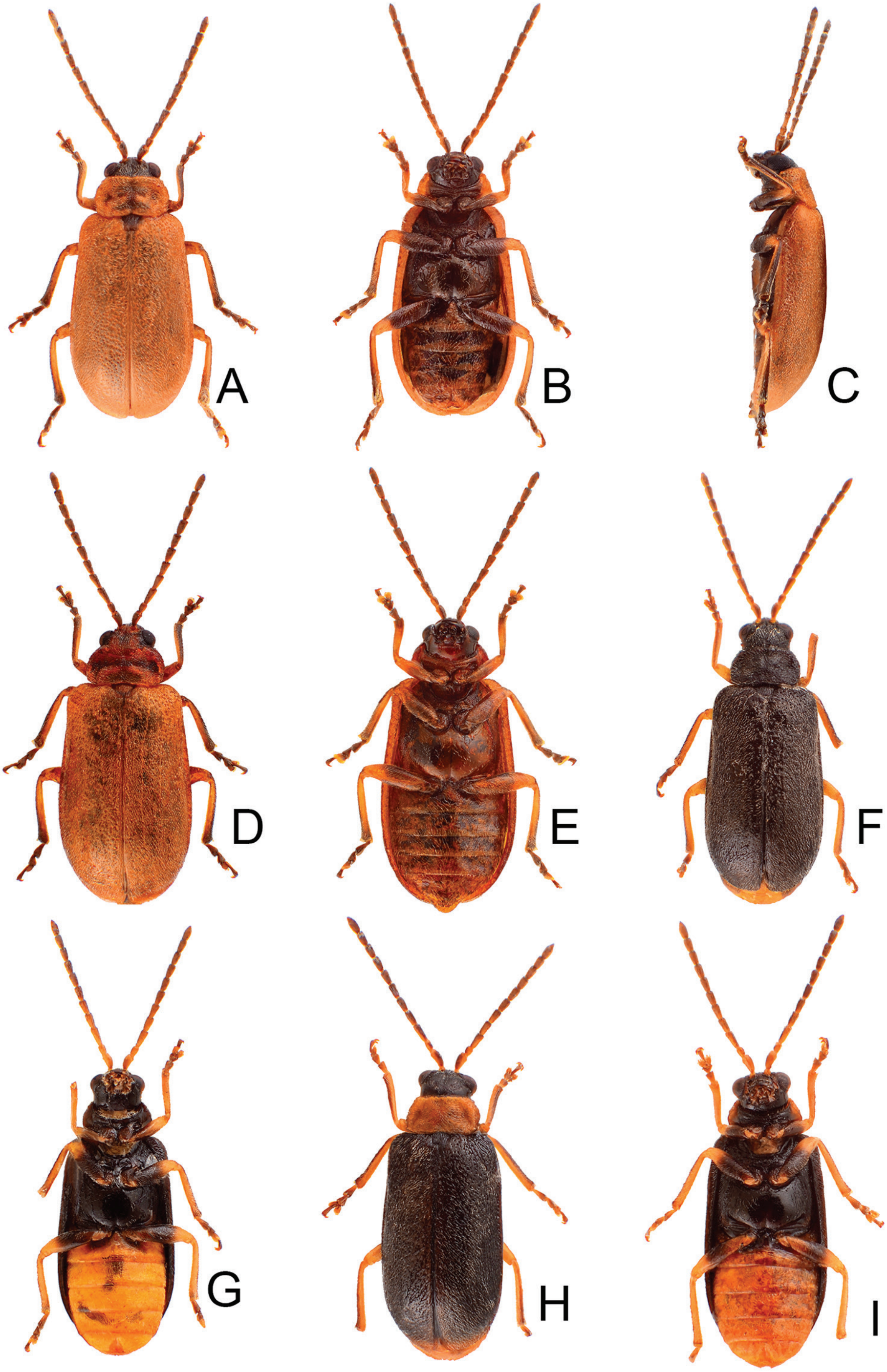

Figure 41. Habitus of *Pyrrhalta lui* sp. nov. **A** male, typical form, dorsal view **B** ditto, ventral view **C** ditto, lateral view **D** female, dorsal view **E** ditto, ventral view **F** male, color variation, dorsal view **G** ditto, ventral view **H** male, color variation, dorsal view **I** ditto, ventral view.

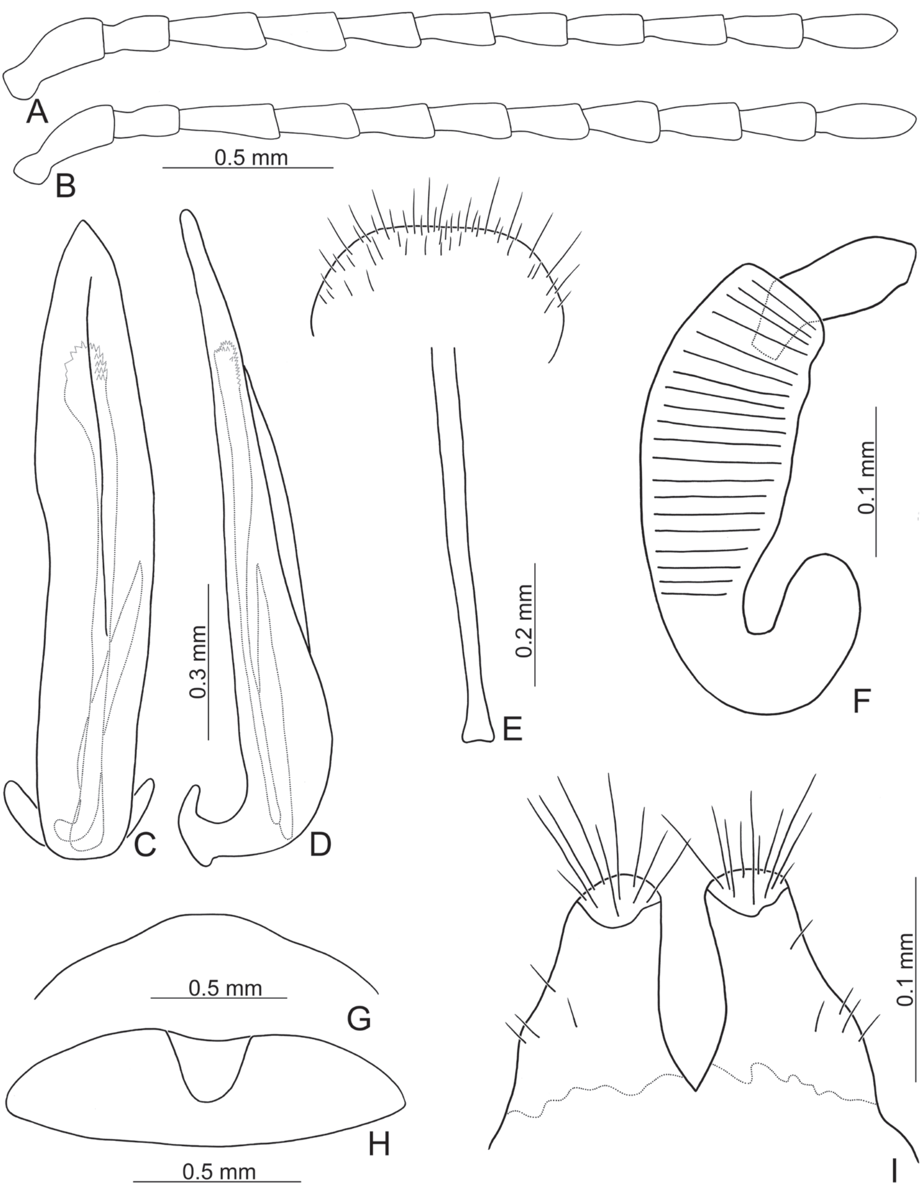

Figure 42. Diagnostic characters of *Pyrrhalta lui* sp. nov. **A** antenna, male **B** antenna, female **C** aedeagus, dorsal view **D** ditto, lateral view **E** abdominal ventrite VIII **F** spermatheca **G** abdominal ventrite V, female **H** abdominal ventrite V, male **I** gonocoxae.

Diagnosis. Elytra relatively narrow, 1.7–1.8 × longer than wide, entirely yellowish brown or black; disc smooth, lacking ridges; with sparse, fine punctures

Description. Length 4.6–5.3 mm, width 2.0–2.4 mm. Body yellow, head and pronotum reddish brown, antenna blackish brown except ventral sides of five basal antennomeres, bases of femora and lateral margins of tibia black; tarsi darker in females (Fig. 41D, E); but head, scutellum, thoracic ventrites, and basal 2/3 of femora black in males (Fig. 41A–C). Eyes small, interocular space 2.55–2.85 × diameter of eye. Antennae filiform in males (Fig. 42A), length ratios of antennomeres I–XI 1.0: 0.6: 0.8: 0.7: 0.7: 0.7: 0.7: 0.7: 0.7: 0.7: 0.8, length to width ratios of antennomeres I–XI 2.6: 1.9: 2.5: 2.1: 2.2: 2.2: 2.4: 2.5: 2.8: 2.4: 2.9; similar in females (Fig. 42B), length ratios of antennomeres I–XI 1.0: 0.6: 0.9: 0.7: 0.7: 0.7: 0.7: 0.7: 0.7: 0.7: 0.9, length to width ratios of antennomeres I–XI 2.7: 2.1: 2.7: 2.2: 2.2: 2.2: 2.2: 2.1: 2.3: 2.1: 3.1. Pronotum and elytra convex. Pronotum 1.8–2.0 × wider than long, with transverse ridge along apical margin deflexed at antero-lateral angles; disc smooth on ridge, but with reticulate microsculpture below ridge, with extremely coarse punctures laterally, smaller medially, with one short seta at each puncture; with median longitudinal and lateral depressions; lateral margins moderately rounded, widest at middle, apical and basal margins slightly concave; anterior and posterior setiferous punctures not erect. Elytra broad, parallel-sided, 1.7–1.8 × longer than wide; disc smooth, with dense, coarse punctures, and extremely dense, short pubescence, some located between punctures. Apical spur of tibia of middle leg absent and tarsomere I not modified in males. Aedeagus (Fig. 42C, D) slender in dorsal view, 6.3 × longer than wide, asymmetrically lanceolate, slightly curved at middle, strongly narrower near apex, apex narrowly rounded; ostium obliquely longitudinal, covered by a membrane; strongly curved near base in lateral view, apex narrowly rounded; two endophallic sclerites elongate, primary sclerite 0.7 × as long as aedeagus, with dense teeth along apical margin. Secondary sclerite much shorter than primary sclerite, 0.6 × as long as primary sclerite, apex acute. Only apices of gonocoxae (Fig. 42I) sclerotized, longitudinal, few short setae near base, with eight to ten long setae near apex on each gonocoxa. Ventrite VIII (Fig. 42E) well sclerotized, with dense short setae along lateral and apical area, with short and long marginal setae, spiculum long. Receptacle of spermatheca (Fig. 42F) slightly swollen and elongate; pump short and strongly curved; sclerotized proximal spermathecal duct narrow and short. Apical margin of abdominal ventrite V slightly concave medially and with deep depression in males (Fig. 42H); broadly rounded in females (Fig. 42G).

Variation. Males of *P. lui* sp. nov. display great variation in color. Some are totally black except for yellowish brown legs and abdomens (Fig. F, G); a few individuals are mainly black but pronota are reddish brown (Fig. 41H, I).

Remarks. Adults of *P. lui* sp. nov. are distinguished within the species group by unicolorous elytra. In males, the aedeagus (Fig. 40C, D) is similar to that of *P. jungchani* sp. nov. (Fig. 39C, D), with an asymmetrically lanceolate shape and two endophallic sclerites. It differs by the straight apex and the longer secondary endophallic sclerite, 0.6 × as long as primary endophallic sclerite (recurved apex and shorter secondary endophallic sclerite, 0.3 × as long as primary endophallic sclerite, in *P. jungchani* sp. nov.).

Food plants. Adults feed on leaves of *Viburnum parvifolium* Hayata (Fig. 40B) and *V. luzonicum* Rolfe (Adoxaceae) (Fig. 40C, D).

Distribution. The species is widespread at mid-altitudes (1,500–2,500 m) in central and southern Taiwan.

Etymology. Dedicated to Mr Hsi-Feng Lu, the member of TCRT who collected most specimens of this new species.

Pyrrhalta shirozui Kimoto, 1969

Figs 38D–I, 43, 44

Pyrrhalta shirozui Kimoto, 1969: 26 (Taiwan); Kimoto and Chu 1996: 57 (catalogue); Kimoto and Takizawa 1997: 300 (key), 374; Beenen 2010: 453 (catalogue); Lee and Cheng 2010: 123 (redescription); Xue and Yang 2010: 129 (catalogue); Takahashi 2012: 324 (specimens at OMNH); Yang et al. 2015: 120 (catalogue).

Pyrrhalta (*Pyrrhalta*) *shirozui*: Wilcox 1971: 89 (catalogue).

Types. ***Holotype*** ♀ (KUEC, by original designation): "(Taiwan) / Sungkang [松崗] / Nantou Hsien [p, w] // 29.VI.[h] 1965 / T. Shirôzu [p, w] // Pyrrhalta / shirozui / Kimoto, n. sp. [h, w] // HOLOTYPE [p, r]". ***Paratype.*** 1♂ (KMNH): "(TAIWAN) / Alishan [阿里山] / Chiai Hsien [p] / 29[h]. VII. 1966 / H. Kamiya leg. [p, w] // Pyrrhalta / shirozui / Kimoto, n. sp. [h, w] // PARATYPE [p, b]".

Other material. Taiwan. Chiayi: 1♂ (TARI), Yushan (玉山), 1.VII.2015, leg. J.-C. Chen; Hualien: 2♀ (TARI) Hahuan Cross-Ridge (合歡越嶺古道), 4.VIII.2018, leg. H.-F. Lu; 1♂ (TARI), Pilu (碧綠), 29.VI.2018, leg. H.-F. Lu; Ilan: 6♂, 3♀ (TARI), Mingchi (明池), 25.V.2008, leg. M.-H. Tsou; 4♂, 2♀ (TARI), same but with "16. VIII.2008"; 1♀ (TARI), Ssuyuan (思源), 11.VIII.2014, leg. J.-C. Chen; 1♂ (TARI), Taipingshan (太平山), 26–28.VII.1983, leg. L. Y. Chou; 1♂, 1♀ (TARI), same locality, 8.VII.2008, leg. H.-J. Chen; 3♂, 6♀ (TARI), same locality, 25.V.2009, leg. C.-F. Lee; 1♂ (TARI), Yingtzuling (鶯仔嶺), 3.VI.2011, leg. Y.-L. Lin; Nantou: 1♀ (TARI), Meifeng (梅峰), 5–9.X.1980, leg. C. C. Chen & C. C. Chien; 1♂, 1♀ (TARI), Nengkaoshan (能高山), 18.X.2011, leg. J.-C. Chen; 1♀ (TARI), Tatachia (塔塔加), 20.VII.2009, leg. S.-F. Yu; 1♀ (TARI), same but with "leg. H. Lee"; 1♀ (TARI), same but with "C.-F. Lee"; 1♂ (TARI), same locality, 21.IX.2009, leg. C.-F. Lee; 3♂♂, 2♀♀ (TARI), Tsuifeng (翠峰), 12–14.IX.1984, leg. K. S. Lin and S. C. Lin; Pingtung: 8♂♂ (TARI), Jinshuiying (浸水營), 12.VIII.2010, leg. J.-C. Chen; 1♀ (TARI), Tahanshan (大漢山), 1.VIII.2009, leg. U. Ong; 1♀ (TARI), same locality, 19.VII.2012, leg. C.-F. Lee; 1♂ (TARI), same locality, 29.VI.2018, leg. Y.-T. Chung; Taichung: 1♂ (TARI), Hassenzan (= Pahsienshan, 八仙山), 4.VI.1942, leg. A. Mutura; 1♂ (TARI), Wuwoweishan (屋我尾山), 5.VI.2012, leg. J.-C. Chen; Taipei: 2♂♂ (TARI), Fengkueitsui (風櫃嘴), 21.X.2007, leg. M.-H. Tsou; 6♂, 3♀ (TARI), Hsiaoyukeng (小油坑), 24.V.2008, leg. M.-H. Tsou; 4♀ (TARI), same but with "12.X.2008"; 9♀ (TARI), same locality and collector, reared from larvae, 21–29.III.2009; 1♀ (TARI), 5.XI.2006, Shihlin (士林), 5.XI.2006, leg. H.-T. Cheng; 2♂, 6♀ (TARI), Yangmingshan (陽明山), 12.V.2007, leg. M.-H. Tsou; 1♀ (TARI), same but with "27.V.2007"; Taitung: 3♂, 1♀ (TARI), Hsiangyang (向陽), 2.VII.2009, leg. S.-F. Yu; 1♀ (TARI), Liyuan (栗園), 19.VI.2013,

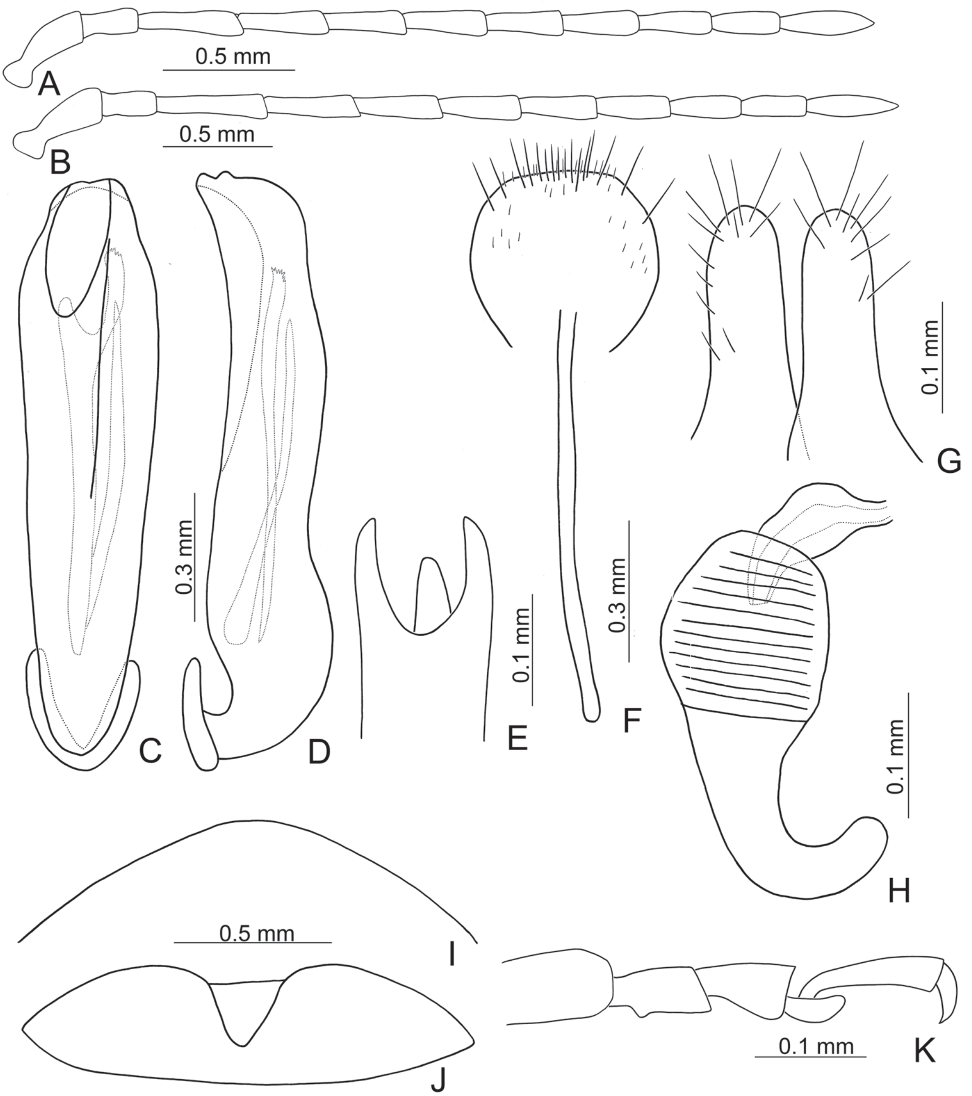

Figure 43. Diagnostic characters of *Pyrrhalta shirozui* Kimoto **A** antenna, male **B** antenna, female **C** aedeagus, dorsal view **D** ditto, lateral view **E** apex of tibia of middle leg, male **F** abdominal ventrite VIII **G** gonocoxae **H** spermatheca **I** abdominal ventrite V, female **J** abdominal ventrite V, male **K** tarsi of middle leg, male.

leg. C.-F. Lee; 1♀ (TARI), Motien (摩天), 23.V.2011, leg. C.-F. Lee; Taoyuan: 4♂, 10♀ (TARI), Lalashan (拉拉山), reared form larvae, 27.IV.2009, leg. C.-F. Lee; 1♂, 9♀ (TARI), same but with “28.V.2009”; 1♀ (TARI), same locality, 15.VII.2009, leg. H.-J. Chen; 1♀ (TARI), Tamanshan (塔曼山), 25.VIII.2008, leg. H. Lee.

Redescription. Length 4.9–6.8 mm, width 2.4–3.4 mm. Body color (Fig. 38D–F) yellowish brown; antennae blackish brown but inner sides of five basal antennomeres yellowish brown; slender black stripe along outer and basal margins of elytra, extending into humeral calli, surrounding scutellum and suture, abbreviated at basal 1/3 or middle, with one additional pair of large black spots inside middle of apical 1/3; legs black, but inner sides of femora and tibiae yellowish brown. Eyes small, interocular space 2.06–2.26 × diameter of eye. Antennae filiform in males (Fig. 43A), length ratios of antennomeres I–XI 1.0: 0.6: 1.1: 0.9: 0.9: 0.9: 0.8: 0.8: 0.8: 0.7: 1.0, length to width ratios of antennomeres I–XI 2.9: 2.2: 4.2: 3.7: 3.4: 3.4: 3.2: 3.1: 3.1: 2.9: 3.9; filiform in females (Fig. 43B), length ratios of antennomeres I–XI 1.0: 0.6: 1.1: 0.9: 0.9: 0.8: 0.8: 0.7: 0.7: 0.7: 0.9, length to width ratios of antennomeres I–XI 2.7: 2.1: 4.4: 3.8: 3.5: 3.3: 3.1: 3.3: 3.2: 3.2: 4.8. Pronotum and elytra convex. Pronotum 2.0 × wider than long, disc smooth; with coarse, dense punctures, and short pubescence; with median longitudinal and lateral depressions; lateral margins rounded, widest at apical 1/3, basal margin truncate, apical margin slightly concave; anterior and posterior setiferous punctures strongly erect. Elytra elongate and broad, parallel-sided, 1.5 × longer than wide; disc smooth, with extremely coarse, dense punctures, and short pubescence. Apical spur of tibia of middle leg small (Fig. 43E), and tarsomere I of middle leg axe-shaped in lateral view, with narrow basal half and expanded apical half in males (Fig. 43K). Aedeagus (Fig. 43C, D) wide in dorsal view, 4.5 × longer than wide, apex asymmetrical, widest at apical 1/6, gradually narrowed toward base, apex rounded but depressed at middle; strongly curved near base in lateral view, slightly and apically curved, apex truncate with a rounded process on left; ostium not covered by membrane; two endophallic sclerites elongate, apex of primary endophallic sclerite with several teeth, 0.6 × as long as aedeagus, with one short branch at apical 1/5, secondary sclerite slightly shorter, 0.8 × as long as the primary endophallic sclerite, apex acute. Only apices of gonocoxae (Fig. 43G) sclerotized and longitudinal, with a number of long setae along lateral and apical margins. Ventrite VIII (Fig. 43F) narrow; disc with several long setae and short setae along apical margin; spiculum long. Receptacle of spermatheca (Fig. 43H) slightly swollen; pump short and strongly curved; sclerotized proximal spermathecal duct wide and short. Apical margin of abdominal ventrite V slightly concave, with deeply rounded depression at middle in males (Fig. 43J); broadly rounded in females (Fig. 43I).

Variation. Some specimens have a black stripe along the entire suture of the elytra (Fig. 38G); some have the black spot separated into two, sometimes connected (Fig. 38H); some have broad black stripe along suture, expanding laterally to connect with black spot (Fig. 38I); many specimens are intermediate between these color patterns.

Remarks. adults of *P. shirozui* Kimoto are easily recognized by the characteristic color patterns on the elytra and sparse, coarse elytral punctures, as well as diagnostic shape of the aedeagus differing from all other species of *Pyrrhalta*.

Host plants. Larvae and adults feed on leaves of *Viburnum formosanum* (Hance) Hayata, *V. foetidum* Wall. var. *rectangulatum* Rehder, *V. integrifolium* Hayata, *V. luzonicum* Rolfe, *V. taitoense* Hayata, and *V. urceolatum* Siebold and Zucc.

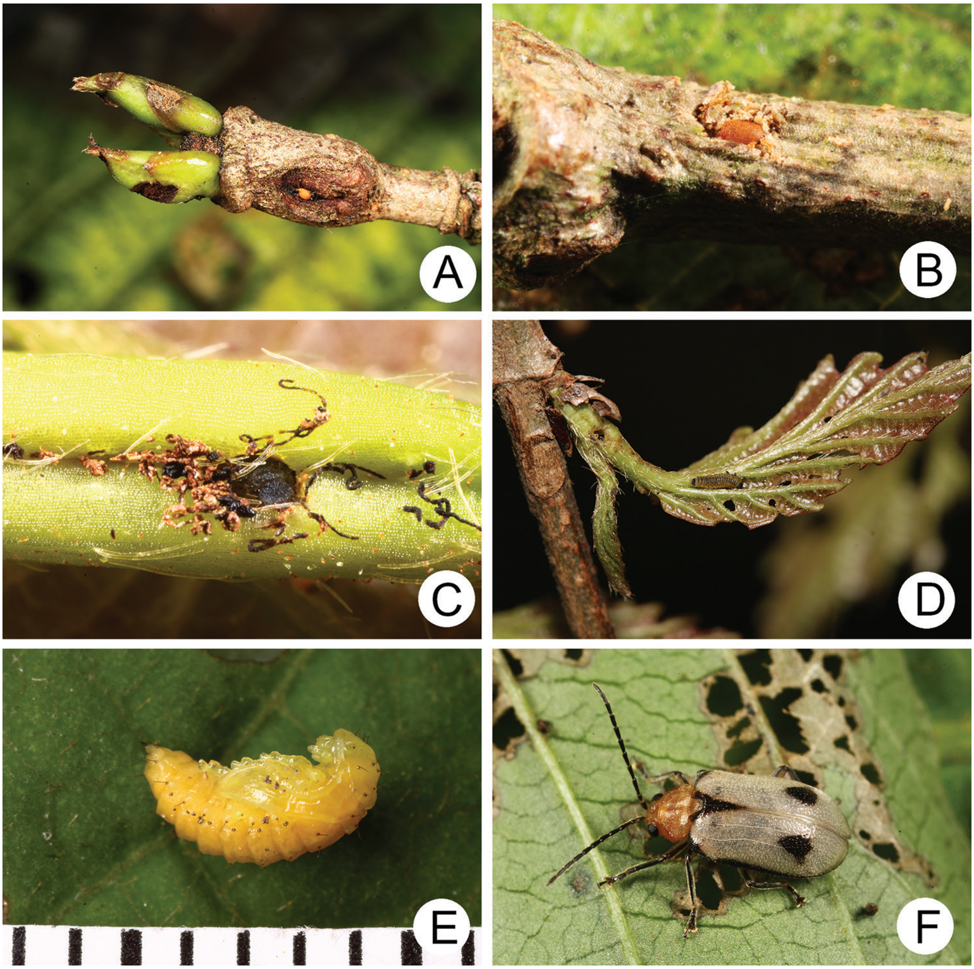

Figure 44. Field photographs of *Pyrrhalta shirozui* Kimoto on host plant **A** egg at crevice of small twig **B** egg at hole prepared by the female **C** Resting site (hole) prepared by larva **D** Larva **E** pupa **F** adult.

Biology. The following life cycle information is based on Mr Mei-Hua Tsou's (TCRT) observations (Lee and Cheng 2010). Females deposited single eggs in crevices of small twigs (Fig. 44A) or a hole prepared by the female (Fig. 44B) during autumn. The larvae hatched when plants sprouted during spring. They prepared a hole as a resting site (Fig. 44C). They exited the hole only when feeding on leaves (Fig. 44D). Larval duration was 14 days. mature larvae burrowed into soil and built underground chambers for pupation. Duration of the pupal stage (Fig. 44E) was 22–28 days. Newly emerged adults appeared during spring and were active (Fig. 44F) during summer and autumn.

Distribution. This species is widespread in lowlands (0–1,500 m) in northern Taiwan and mid-altitudes (1,500–2,500 m) in central Taiwan.

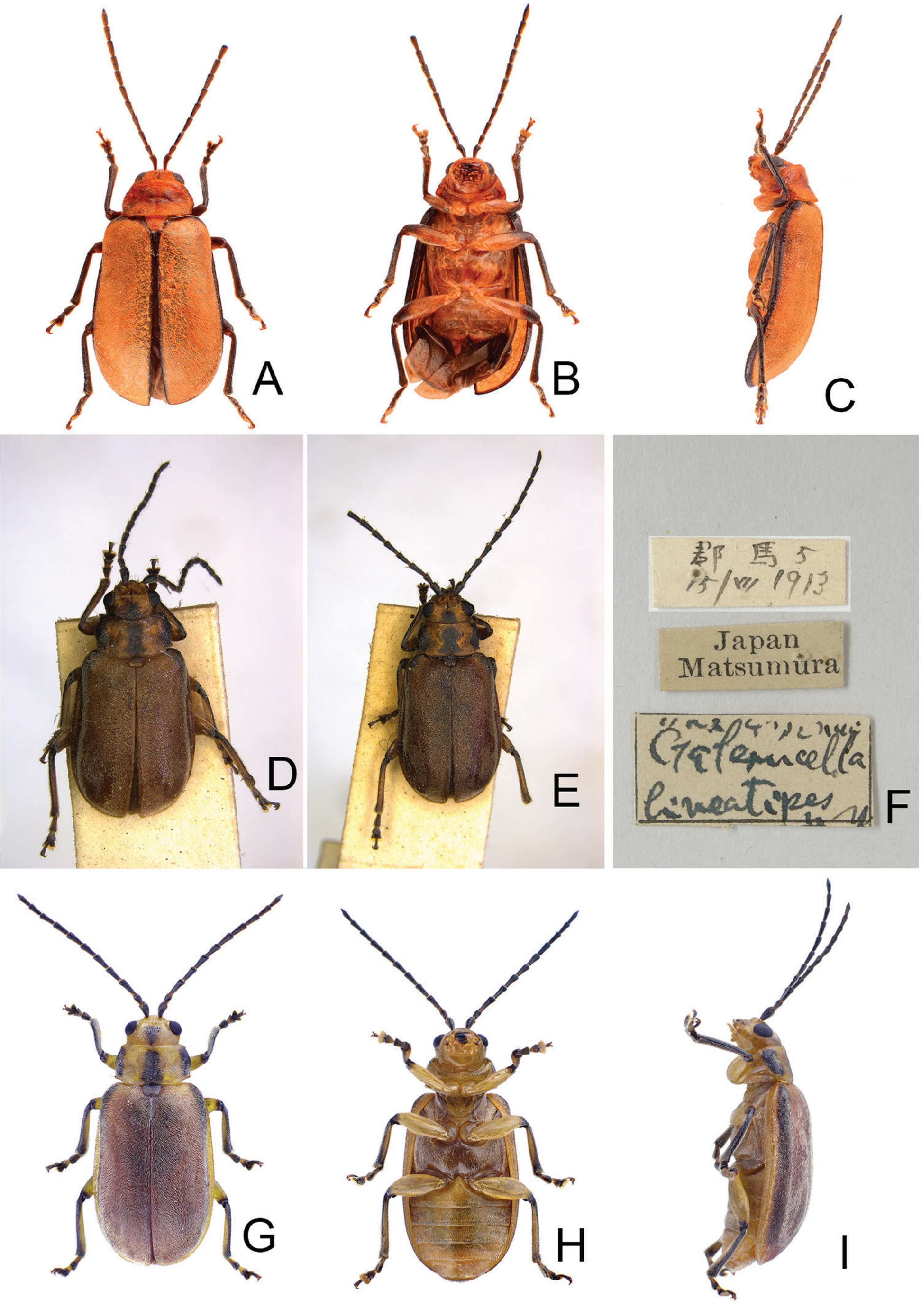

Figure 45. Habitus of *Pyrrhalta kobayashii* Kimoto and *P. lineatipes* (Takei) **A** *P. kobayashii*, female, dorsal view **B** ditto, ventral view **C** ditto, lateral view **D** *P. lineatipes*, lectotype, dorsal view **E** *P. lineatipes*, paralectotype, dorsal view **F** *P. lineatipes*, type labels **G** *P. humeralis*, from Taiwan, female, dorsal view **H** ditto, ventral view **I** ditto, lateral view.

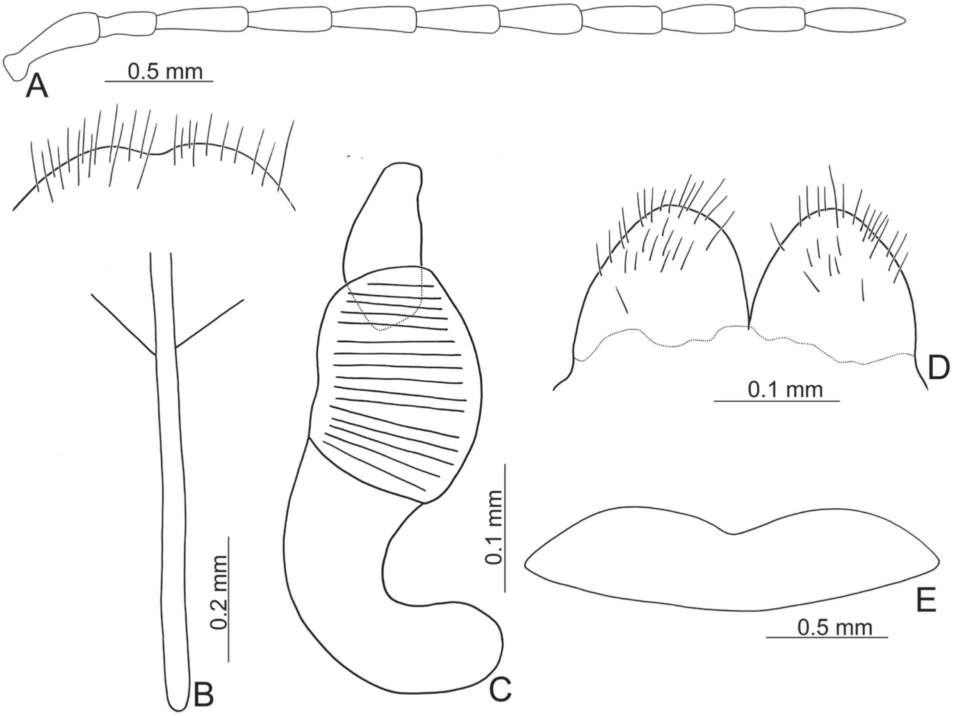

Figure 46. Diagnostic characters of *Pyrrhalta kobayashii* Kimoto, female **A** antenna **B** abdominal ventrite VIII **C** spermatheca **D** gonocoxae **E** abdominal ventrite V.

Pyrrhalta species currently unassigned to any species group

Pyrrhalta kobayashii **Kimoto, 1974**

Figs 45A–C, 46

Pyrrhalta kobayashii Kimoto, 1974: 25; Kimoto and Chu 1996: 56 (catalogue); Kimoto and Takizawa 1997: 301 (key), 373; Beenen 2010: 453 (catalogue); Xue and Yang 2010: 124 (catalogue); Yang et al. 2015: 117 (catalogue).

Types. ***Holotype*** ♀ (OMNH): "Mt. ALI / FORMOSA / 22.VII.1970 / T. KOBAYASHI [p, y] // Pyrrhalta / kobayashii / Kimoto [h, w] // HOLOTYPE [p, r]. ***Paratype.*** 1♀ (KMNH): "(TAIWAN) / Alishan (阿里山) / Chiai Hsien [p] / 29[h]. VII. 1966 / H. Kamiya leg. [p, w] // Pyrrhalta / kobayashii / Kimoto [h, w] // PARATYPE [p, b]".

Other material. Taiwan. Nantou: 1♀ (TARI), Huakang (華岡), 20.VII.2017, leg. J.-C. Chen; Taichung: 1♀ (TARI), Pilu (畢祿), 2.VII.2008, leg. M.-H. Tsou; Taitung: 1♀ (TARI), Hsiangyang (向陽), 12.VII.2012, leg. J.-C. Chen.

Redescription (females). Length 6.2–6.3 mm, width 3.2 mm. Body yellow (Fig. 45A–C); but antennae, lateral margins of elytra (sutures, basal and lateral margins), tibiae, and tarsi black; apices of femora darker. Eyes small, interocular space

2.05–2.09 × diameter of eye. Antennae filiform (Fig. 46A), length ratios of antennomeres I–XI 1.0: 0.5: 0.9: 0.8: 0.8: 0.8: 0.8: 0.8: 0.7: 0.7: 1.0, length to width ratios of antennomeres I–XI 3.2: 2.2: 3.6: 3.3: 3.2: 3.0: 2.9: 2.8: 2.5: 2.9: 4.1. Pronotum and elytra convex. Pronotum 1.8–2.0 × wider than long, with transverse ridge along apical margin deflexed at antero-lateral angles; disc smooth, with coarse punctures laterally, smaller medially; with dense short pubescence, but reduced above ridge, with median longitudinal and lateral depressions; lateral margins moderately rounded, widest at middle, apical and basal margins slightly concave; anterior and posterior setiferous punctures not erect. Elytra broad, parallel-sided, 1.5–1.6 × longer than wide; disc smooth, with dense, fine punctures, and dense, short pubescence, one pubescent seta in each puncture. Gonocoxae (Fig. 46D) apically sclerotized, small, broadly rounded, disc and apical margin with short dense setae. Ventrite VIII (Fig. 46B) transverse, with apical margin depressed at middle, a number of long setae near apical margin, spiculum long. Receptacle of spermatheca (Fig. 46C) slightly swollen and elongate; pump short and strongly curved; sclerotized proximal spermathecal duct narrow and short. Apical margin of abdominal ventrite V moderately concave medially (Fig. 46E).

Remarks. The color pattern of adults of *P. kobayashii* (Fig. 45A) is similar to that of the typical form of *P. discalis* Gressitt & Kimoto (Fig. 31A). The species differs by the more slender antennae, antennomeres IV–X 2.8–3.6 × longer than wide (Fig. 46A) (antennomeres IV–X 1.7–2.4 × longer than wide in *P. discalis* (Fig. 32B)) and relatively narrow elytra, 1.6 × longer than wide (elytra 1.4 × longer than wide in *P. discalis*).

Food plant. Unknown.

Distribution. The species occurs at scattered localities at mid-altitudes (1,500–2,500 m) in central and southern Taiwan.

Pyrrhalta lineatipes **(Takei, 1916), resurrected**

Figs 45G–I, 47, 48A–C

Galerucella lineatipes Takei, 1916: 35 (Japan: Gumma)**.**

Galerucella humeralis Chen, 1942: 17 (China: Guanxi, Liaoning). syn. nov.

Pyrrhalta humeralis: Nakane & Kimoto, 1961: 21 (Japan: Okinawa island); Gressitt and Kimoto 1963: 451 (China: Anhui, Hubei, Fujian, Guandong, Sichuan); Kimoto 1964a: 301 (Japan: Hokkaido, Honshu, Shikoku, Kyushu); Kimoto and Gressitt 1966: 477 (key), 520 (Ryukyus); Kimoto 1969: 28 (Taiwan); Kimoto and Hiura 1971: 15 (Japan); Kimoto 1985: 4 (catalogue); Lee 1990: 81 (larval description, Japan); Jiang 1992: 647 (China: Sichuan); Li 1992: 185 (China: Liaoning); Yang 1993: 332 (China: Hubei); Kimoto and Takizawa 1994: 234 (key), 306 (Japan); Kimoto and Chu 1996: 55 (catalogue); Kimoto and Takizawa 1997: 300 (key), 373; Yang et al. 1997: 865 (China: Sichuan); Wang and Yang 1998: 65 (China: Fujian); Lee and An 2001: 119 (South Korea); Mikhailov and Hayashi 2002: 34 (Sakhalin); Yang 2002: 627 (China: Fujian); Park and Lee 2004: 229

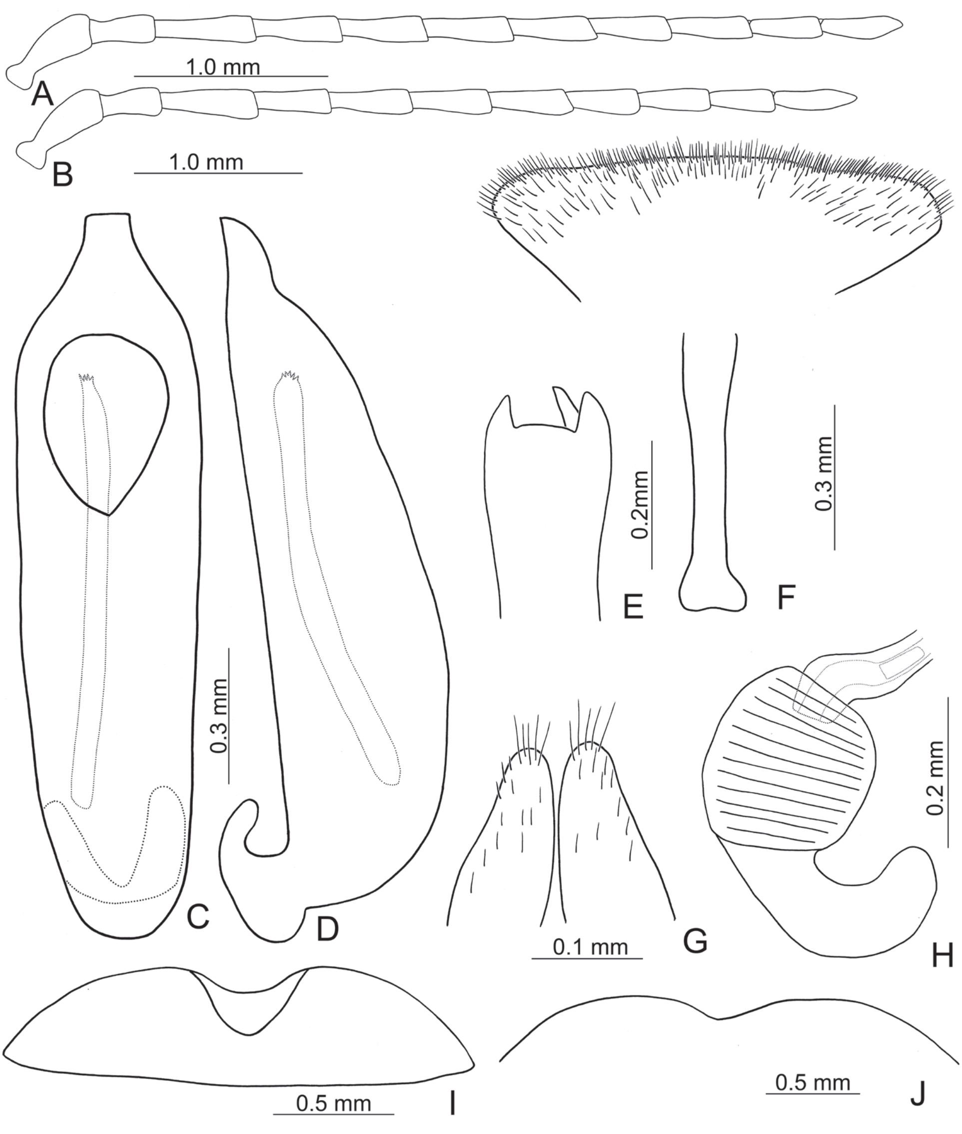

Figure 47. Diagnostic characters of *Pyrrhalta lineatipes* (Takei) **A** antenna, male **B** antenna, female **C** aedeagus, dorsal view **D** ditto, lateral view **E** apex of tibia of middle leg, male **F** abdominal ventrite VIII **G** gonocoxae **H** spermatheca **I** abdominal ventrite V, male **J** abdominal ventrite V, female.

(larval description, Korea); Lee and Ho 2006: 82 (host plants); Wang and Yang 2006: 112 (China: Gansu); Beenen 2010: 452 (catalogue); Xue and Yang 2010: 123 (catalogue); Takahashi 2012: 323; Yang et al. 2015: 117 (China: Helongjiang, Jiangxi, Jilin, Gansu, Shaanxi, Zhejiang, Hunan, Guanxi); Matsumura et al. 2017: 85 (female reproductive system); Cho and An 2020: 22 (catalogue, South Korea).

Pyrrhalta (*Pyrrhalta*) *humeralis*: Wilcox 1971: 86 (catalogue).

Types. *Gallerucella lineatipes*. ***Lectotype*** ♂ (SEHU) (Fig. 45A, C), here designaed: "Japan / Matsumura [p, w] // 群馬 [= Gumma] 5 / 15/VII 1913 [h, on the back of the same card] // Galerucella / lineatipes / n. sp. [h, w]". ***Paralectotype.*** 1♂ (SEHU) (Fig. 45B), same data as holotype. Both specimens glued on separated cards but pined with the same pine originally. Now both are separated and the paratype mounted with copies of the labels.

Galerucella humeralis. Presumably deposited at the IZAS based on the original description (Chen 1942). However, the type seems to be lost (Ruie Nie, pers. comm., 26 Nov 2018).

Other material. China. Fujian: 1♀ (CAS), Shaowu, Tachulan, 14.VII.1946, leg. T. C. Maa; Guangdong: 1♂ (CAS), Taiyong, 5.VIII.1936, leg. K, Gressitt, det. Gressitt and Kimoto, 1961; Heilongjiang: 1♀ (TARI), Dailing (岱岭), 23.VII.1958, leg. S. X. Zhou; Hubei: 1♀ (KMNH), Leong-Ho-Kow to Wang-Ga-Ying, 18.IX.1948, leg. Gressitt & Djou; Japan. Honshu: 1♀ (TARI), Nagano-Ken, Noziri, 10.VIII.1940, leg. T. Nakane; 2♀ (TARI), Yamaguchi, Tokusa, 16.VII.1922, leg. T. Shiraki; Kyushu: 1♂ (TARI), Mt. Korasan (Chikugo), 8.VIII.1934, leg. K. Yamauchi; Sikoku: 2♂, 2♀ (TARI), Kochi-Ken, 7.XI.1935, leg. I. Okubo; Ryukyu Islands: 1♂, 1♀ (CAS), 1♂ (NHMUK), Okinawa I., Nakijin, 26.IV.1964, leg. T. Takara; South Korea. 2♀ (TARI), Suigen, 11.VIII.1936, leg. K. Saito; Taiwan. Hualien: 4♂, 1♀ (TARI), Liyutan (鯉魚潭), 27.VIII.2016, leg. H.-F. Lu; 6♂, 10♀ (TARI), same but with "17.IV.2017"; Nantou: 1♀ (TARI), Meifeng (梅峰), 5–9. X.1980, leg. C. C. Chen & C. C. Chien; Taichung: 2♂ (TARI), Wuleng (武陵), 25.VII.2010, leg. S.-F. Yu; 2♂, 1♀ (TARI), same locality, 13.IX.2010, leg. M.-H. Tsou; 6♂, 9♀ (TARI), same locality, 6.XI.2016, leg. J.-C. Chen.

Redescription. Length 6.0–7.9 mm, width 2.9–4.1 mm. Body color (Fig. 45G–I) yellowish brown; vertex with one longitudinal black spot at middle, antennae blackish brown; pronotum with three large black spots, one spot at center, elongate, extending from near apex to near base; two wide spots along lateral margins; scutellum dark brown or blackish brown; elytra with longitudinal black stripe from humerus to middle; legs yellowish brown, but apices of femora, outer sides of tibiae, and apical 2/3 of tarsi black. Eyes relatively small, interocular space 2.88–2.91 × diameter of eye. Antennae filiform in males (Fig. 47A), length ratios of antennomeres I–XI 1.0: 0.7: 1.1: 0.9: 0.9: 0.9: 0.9: 0.9: 0.9: 0.7: 0.9, length to width ratios of antennomeres I–XI 2.5: 2.4: 3.7: 3.2: 3.2: 3.4: 3.4: 3.4: 3.5: 3.1: 3.7; similar in females (Fig. 47B), length ratios of antennomeres I–XI 1.0: 0.6: 1.0: 0.8: 0.8: 0.8: 0.8: 0.7: 0.7: 0.7: 0.9, length to width ratios of antennomeres I–XI 2.7: 2.1: 3.3: 3.1: 3.2: 3.1: 3.1: 3.1: 3.2: 3.0: 3.8. Pronotum and elytra moderately convex. Pronotum 2.1–2.3 × wider than long, disc with transverse ridge along apical margin deflexed at antero-lateral angles, with dense, extremely coarse punctures, and long pubescence, punctures reduced on ridge; with median longitudinal and lateral depressions; lateral margins medially broadened, apical margin slightly concave, basal margin straight. Elytra elongate, parallel-sided, 1.5–1.6 × longer than wide; disc rough, with sparse fine punctures, and long, extremely dense pubescence. Apical spur of tibia of middle leg small (Fig. 47E), tarsomere I of middle leg not modified in males. Aedeagus (Fig. 47C, D) broad in dorsal view, 4.5 × longer than wide, sides slightly asymmetric, strongly broadened from apex to apical 1/10, slightly narrowed towards base, apex truncate; strongly curved at base in lateral view, moderately broadened from apex to basal 2/5, apex acute; ostium not covered by membrane; single endophallic sclerite long, 0.5 × as long as aedeagus, with several apical small teeth. Gonocoxae (Fig. 47G) longitudinal, base membranous, disc with sparse, short setae, several long setae along apical margin. Ventrite VIII (Fig. 47F) extremely transverse; disc with extremely dense, short setae along apical area; spiculum short. Receptacle of spermatheca (Fig. 47H) very swollen; pump short and strongly curved; sclerotized proximal spermathecal duct wide and short. Apical margin of abdominal ventrite V with rounded depression at middle, followed by shallow notch in males (Fig. 47I); only with shallow depression in females (Fig. 47J).

Remarks. Adults of *P. lineatipes* (Takei) (Fig. 45G), *X. aenescens* (Fairmaire) (Fig. 1D), and *P. jungchani* sp. nov. (Fig. 38A) are easily recognized by the three black spots on the pronota. This species (Fig. 45I) is most similar to *P. jungchani* sp. nov. (Fig. 38C) based on the brown elytra with black stripes arising from humeral calli and convex pronotum and elytra (entirely metallic green elytra and dorso-ventral flattened pronotum and elytra in *X. aenescens* (Fig. 1F)). It differs from *P. jungchani* sp. nov. by the more dense pubescence, sparse punctures on elytra (sparse pubescence and extremely dense punctures on elytra in *P. jungchani* sp. nov.), and normal tarsomere I of middle leg in males (Fig. 39H) (modified tarsomere I of middle leg in males of *P. jungchani* sp. nov. (Fig. 39H)). In addition, the aedeagus (Fig. 47C, D) and abdominal ventrite VIII in females (Fig. 47F) are diagnostic.

Mr. Takei sent specimens to Dr. Matsumura for identification. He wrote a new species name on the identification card, *Galerucella lineatipes* sp. n., but that name was never published. Later, Takei (1916) described this new species collected by him as *Galerucella lineatipes* Mats. (n. sp.). Thus, the correct authorship is Takei. Two types at the SEHU fit the original description well; it is a distinct species that differs from *Galerucella calmariensis* and is regarded as a senior synonym of *P. humeralis*.

Although *Pyrrhalta lineatipes* feed on leaves of *Viburnum* spp., it does not belong to the *P. shirozui* species group due to a number of apomorphies in adults and arrangement of eggs. *Pyrrhalta lineatipes* differs from members of the *P. shirozui* species group with its symmetrical aedeagus (Fig. 47C) lacking a secondary endophallic sclerite (asymmetrical aedeagi (Figs 39C, 42C, 43C) and with the second endophallic sclerite in *P. shirozui* species group), the extremely transverse ventrite VIII in females, and with short speculum (Fig. 47F) (vs. narrow ventrite VIII in females and with long speculum in *P. shirozui* species group (Figs 39E, 42E, 43F), and egg mass on small twigs (Fig. 48A) (the single egg on small twigs in *P. shirozui* (Fig. 44A, B). Interestingly, females of *P. viburni* also deposited egg masses (Hilker 1992) on small twigs as those of *P. lineatipes*, and larvae and adults fed on leaves of *Viburnum* spp., so both might belong to the same species-group.

Host plants. *Viburnum* sp. (Gressitt and Kimoto 1963), *V. odoratissimum* Ker. in Japan (Lee 1990), *V. sargentii* Koehne in the laboratory, Korea (Park and Lee 2004), *V. betulifolium* Batalin (present study), *V. parvifolium* Hayata (present study), *V. taitoense* Hayata (present study), *V. dilatatum* Thunb, *V. awabuki* Koch, *V. opulus*, *V. phlebotrichum*, *V. sieboldii* (Lee and Cho 2006), *Salix* sp. (Gressitt and Kimoto 1963; Lee and Cho 2006; need further confirmation).

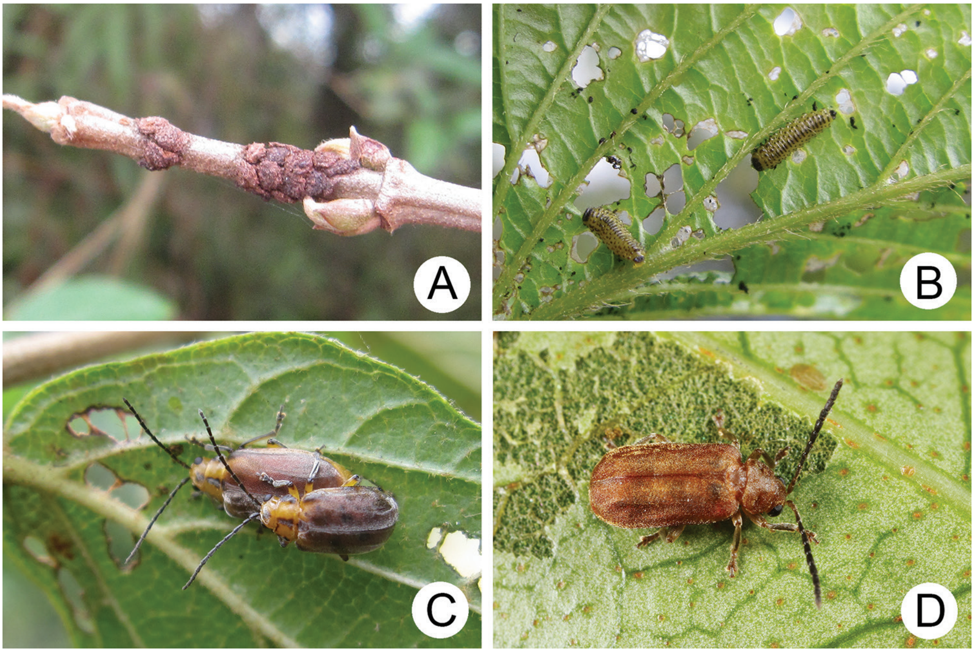

Figure 48. Field photographs of *Pyrrhalta lineatipes* (Takei) and *P. ohbayashii* Kimoto on host plant **A** *P. lineatipes*, egg masses **B** same, third-instar larvae **C** same, adults **D** *P. ohbayashii*, adult.

Biology. The overwintering eggs of *P. lineatipes* were deposited into the twigs of the hostplants (Fig. 48A), *Viburnum* sp., as observed by Mr. His-Feng Lu, 15 November 2016, in Liyutan, eastern Taiwan. Each egg mass was covered with feces and small fragments of chewed plant material. young larvae were found on 5 March of the following year. They were transferred to the laboratory for rearing and fed on leaves. mature larvae (Fig. 48B) burrowed into soil and built underground chambers for pupation. The newly emerged adults crawled out soil (Fig. 48C) April 7.

Distribution. China (Anhui, Fujian, Gansu, Guandong, Guanxi, Helongjiang, Hubei, Hunan, Jiangxi, Jilin, Liaoning, Shaanxi, Sichuan, Zhejian; Yang et al. 2015), Japan (Hokkaido, Honshu, Shikoku, Kyushu; Okinawa island), Korea, Taiwan. It is only found in a few localities from lowlands to mid-altitudes in eastern Taiwan.

Pyrrhalta ohbayashii Kimoto, 1984

Figs 48D, 49A–C, 50

Pyrrhalta ohbayashii Kimoto, 1984: 46; Kimoto 1987: 188 (additional records); Kimoto 1991: 9 (additional records); Kimoto and Chu 1996: 57 (catalogue); Kimoto and Takizawa 1997: 300 (key), 373; Beenen,2010: 453 (catalogue); Xue and Yang 2010: 127 (catalogue); Yang et al. 2015: 119 (catalogue).

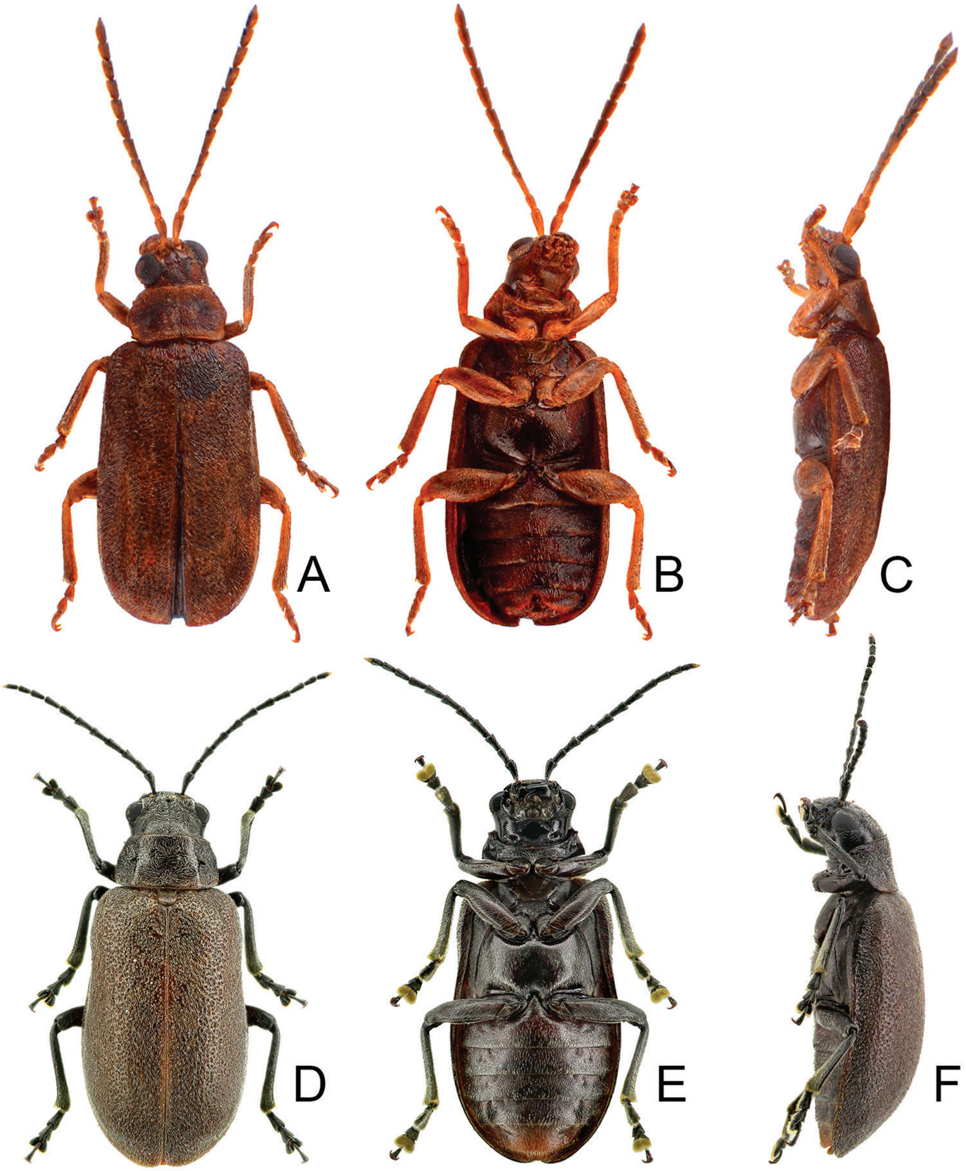

Figure 49. Habitus of *Pyrrhalta ohbayashii* Kimoto and *P. takizawai* Kimoto **A** *P. ohbayashii*, male, dorsal view **B** ditto, ventral view **C** ditto, lateral view **D** *P. takizawai*, female, dorsal view **E** ditto, ventral view **F** ditto, lateral view.

Types. ***Holotype*** ♀ (KUEC, by original designation): "(FORMOSA) / Mt. Lala-shan [拉拉山] / Taoyuan Hsien / 7, V 1982 / N. Ohbayashi leg. [p, w] // Pyrrhalta / ohbayashii / Kimoto, n. sp. [h, w] // HOLOTYPE [p, r] // KU. Type / No. 2438 [p, w]". ***Paratype.*** 1♀ (KMNH): "(FORMOSA) / Mt. Lala-shan [拉拉山] / Taoyuan Hsien /

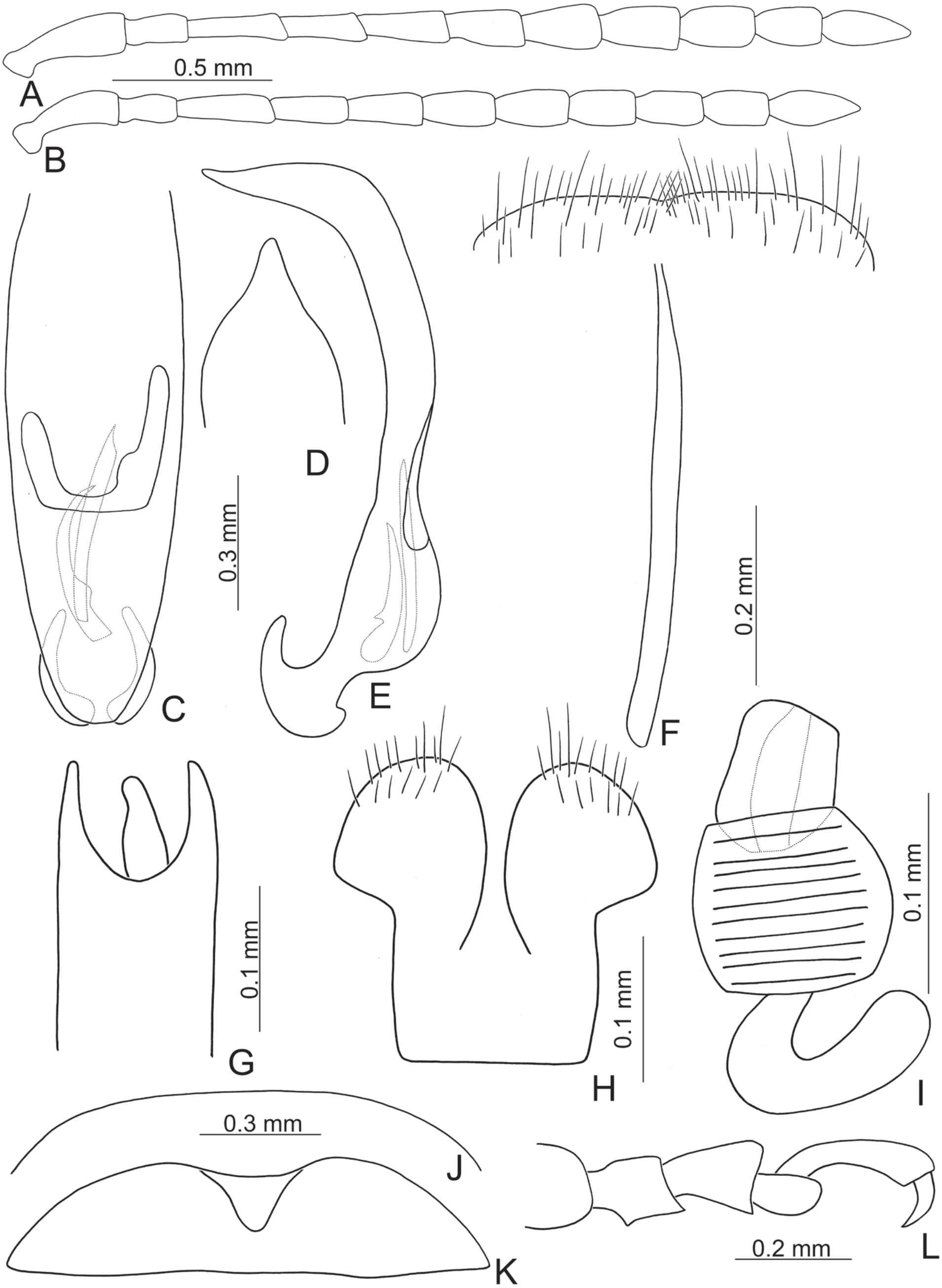

Figure 50. Diagnostic characters of *Pyrrhalta ohbayashii* Kimoto **A** antenna, male **B** antenna, female **C** aedeagus except apex, dorsal view **D** apex of aedeagus, dorsal view **E** aedeagus, lateral view **F** abdominal ventrite VIII **G** apex of tibia of middle leg, male **H** gonocoxae **I** spermatheca **J** abdominal ventrite V, female **K** abdominal ventrite V, male **L** tarsi of middle leg, male.

7, V 1982 / N. Ohbayashi leg. [p, w] // Pyrrhalta / ohbayashii / Kimoto, n. sp. [h, w] // PARATOPOTYPE [p, b]".

Other material. Taiwan. Kaohsiung: 1♀ (KMNH), Tayuenshan, near Liukui (六龜), 5.VI.1989, leg. K. Baba, det. S. Kimoto, 1990; 1♂ (TARI), Tengchih (藤枝), 10.VIII.2013, leg. W.-C. Liao; 1♂ (TARI), same locality, 8.V.2020, leg. Y.-C. Hsu; 1♀ (TARI), Tona trail (多納林道), 5.XI.2016, leg. W.-C. Liao; Pingtung: 1♀ (TARI), Peitawushan (北大武山), 28.V.2014, leg. Y.-T. Chung; 4♀ (TARI), same but with "1.IX.2016"; 1♂, 1♀ (TARI), same but with "30.IV.2017"; 2♀ (TARI), same but with "28.IX.2017"; 3♂, 1♀ (TARI), Shahsi trail (沙溪林道), 20.VII.2017, leg. B.-X. Guo; 5♂, 7♀ (TARI), Taiwu (泰武), 11.IX.2020, leg. Y.-T. Chung; Taipei: 3♂ (TARI), Yingzuling (鶯子嶺), 24.VII.2010, leg. Y.-L. Lin.

Redescription. Length 4.5–4.6 mm, width 1.9–2.1 mm. Body color (Fig. 49A–C) dark brown; antennae black except three basal antennomeres. Eyes large, interocular space 1.77–1.91 × diameter of eye. Antennae filiform in males (Fig. 50A), gradually broadened from antennomere IV, broadest at VII and VIII, then gradually narrowed to apical antennomere, length ratios of antennomeres I–XI 1.0: 0.5: 0.8: 0.7: 0.7: 0.6: 0.6: 0.6: 0.6: 0.6: 0.7, length to width ratios of antennomeres I–XI 3.0: 2.2: 3.5: 3.0: 2.6: 2.0: 1.8: 1.9: 1.8: 1.7: 2.5; similar in females (Fig. 50B), length ratios of antennomeres I–XI 1.0: 0.5: 0.9: 0.7: 0.7: 0.7: 0.7: 0.6: 0.6: 0.6: 0.8, length to width ratios of antennomeres I–XI 3.3: 2.0: 3.5: 2.8: 2.4: 2.1: 2.0: 1.7: 1.9: 1.9: 2.6. Pronotum and elytra convex. Pronotum 1.8–1.9 × wider than long, disc with reticulate microsculpture; with extremely dense, coarse punctures, and short pubescence, with median longitudinal and lateral depressions; lateral margins slightly rounded, widest at middle, apical and basal margin slightly concave; anterior and posterior setiferous punctures slightly erect. Elytra elongate, parallel-sided, 1.7–1.8 × longer than wide; disc with reticulate microsculpture, with sparse, coarse punctures, and short pubescence. Apical spur of tibia of middle leg small (Fig. 50G), and tarsomere I of middle with narrow basal half and small acute process at basal 1/3 in lateral view in males (Fig. 50L). Aedeagus (Fig. 50C–E) broad in dorsal view, 4.2 × longer than wide, broadest at middle, symmetric, apex lanceolate; ostium transverse at apical 1/3, not covered by a membrane; strongly curved near base and at apical 1/5 in lateral view, apex narrowly rounded; two endophallic sclerites small and elongate, primary sclerite straight in lateral view, 0.3 × as long as aedeagus, secondary sclerite curved in lateral view, 0.7 × as long as primary sclerite. Gonocoxae (Fig. 50H) basally connected, short, with a number of long setae near apex. Ventrite VIII (Fig. 50F) with apical area well sclerotized, apical margin truncate but slightly concave at middle, with dense, long setae along apical area, spiculum extremely long. Receptacle of spermatheca (Fig. 50I) very swollen; pump long and strongly curved; sclerotized proximal spermathecal duct wide and short. Apical margin of abdominal ventrite V slightly concave medially and with deep depression in males (Fig. 50K); straight in females (Fig. 50J).

Remarks. Adults of *P. ohbayashii* Kimoto (Fig. 49C) are similar to those of *P. ishiharai* Kimoto (Fig. 34A) and *P. wulaiensis* sp. nov. (Fig. 34D) in possessing longitudinal ridges on the brown elytra, but differ by the narrower elytra, 1.7–1.8 × longer than wide (elytra 1.5 × longer than wide in *P. ishiharai* and *P. wulaiensis* sp. nov.). Gonocoxae are similar to those species of *Xanthogaleruca*. In males of *P. ohbayashii*, the aedeagus is diagnostic; strongly curved at apical 1/3 and the extremely small endophallic sclerites.

Food plant. Adults feed on leaves of *Prunus phaeosticta* var. *phaeosticta* (Hance) Maxim. (Fig. 48D).

Distribution. The species is widespread at lowlands (0–1,500 m) in northern and southern Taiwan.

Pyrrhalta takizawai Kimoto, 1996

Figs 49D–F, 51, 52

Pyrrhalta takizawai Kimoto, 1996: 32; Kimoto and Takizawa 1997: 300 (key), 374; Beenen 2010: 453 (catalogue); Lee and Cheng 2010: 124 (redescription); Xue and Yang 2010: 130 (catalogue); Yang et al. 2015: 121 (catalogue).

Types. ***Holotype*** ♀ (SEHU, by original designation): "Nanshanchi (南山溪) / Nantou, Taiwan / 7,12.VII.1983 / H. Takizawa [p, w] // Pyrrhalta [h] / Det. H. Takizawa [p, w] / Pyrrhalta / takizawai / Kimoto, n. sp. [h] / Det. S. Kimoto, 19 [p, w] // HOLOTYPE [p, r] // 00000000154 / Sys. Ent / Hokkaido Univ. / Japan [SEHU] [p, w]". ***Paratype.*** 1♀ (KMNH): "Nanshanchi / Nantou, Taiwan [p] / 25.VIII [h] 1983 / K. Ra [p, w] // Pyrrhalta / takizawai / Kimoto, n. sp. [h] / Det. S. Kimoto, 19 [p, w] // PARATYPE [p, b] // PHOTO [p, r]".

Other material. Taiwan. Hsinchu: 1♂ (TARI), Feifengshan (飛鳳山), 5.III.2009, leg. S.-F. Yu; 1♀ (TARI), Kuanhsi (關西), 21.VI.2009, leg. W.-T. Liu; 4♂, 8♀ (TARI), same locality, 24.VII.2010, leg. H. Lee; 2♂, 1♀ (TARI), Peitelaman (北德拉曼), 26.VI.2008, leg. H. Lee; 1♂ (TARI), Shihlu trail (石鹿古道), 23.VIII.2014, leg. Y.-L. Lin; 1♀ (TARI), Talu trail (大鹿林道), 26.VIII.2012, leg. Y.-L. Lin; 1♂ (TARI), Wufeng (五峰), 17.III.2009, leg. S.-F. Yu; 1♂ (TARI), Tahunshan (大混山), 1.III.2009, leg. M.-H. Tsou; Ilan: 2♂ (JBCB, NMPC), 20 km N of Ilan city, 2.VI.2008, leg. F. & L. Kantner; Pingtung: 1♂ (TARI), Lilungshan (里龍山), 9.IV.2013, leg. J.-C. Chen; 1♂ (TARI), same locality, 24.III.2014, leg. Y.-T. Chung; 1♂ (TARI), same but with "23.III.2016"; 1♂ (TARI), Neiwen (內文), 12.IV.2013, leg. B.-X. Guo; 1♂ (TARI), Shouka (壽卡), 26.IV.2013, leg. Y.-T. Chung; 1♀ (TARI), same but with "13.VI.2013"; 1♀ (TARI), Shuangliu (雙流), 12.IV.2008, leg. Y.-T. Chung; 10♂, 7♀ (TARI), same but with "25.IV.2018"; 1♀ (TARI), Tahanshan (大漢山), 18.VII.2007, leg. S.-F. Yu; 1♀ (TARI), same locality, 6.VIII.2016, leg. Y.-T. Chung; 1♂ (TARI), Tungyuan (東源), 19.II.2007, leg. S.-F. Yu; Taipei: 1♂, 1♀ (TARI), Chiachiuliao (加九寮), 26.IV.2008, leg. H. Lee; 1♂ (TARI), Fushan (福山), 17.VI.2008, leg. S.-F. Yu; 1♀ (TARI), Pinglin (坪林), 17.VII.2010, leg. Y.-L. Lin; 4♂, 2♀ (TARI), Taipei Zoo, 6.VII.2006, leg. Y.-C. Yu; 1♀ (TARI), same but with "20.X.2006"; 3♀ (TARI), same locality, 10.II.2007, leg. S.-F. Yu; 2♂, 2♀ (TARI), same but with "24.V.2007"; 1♂ (TARI), same but with "27.VI.2007"; 2♂, 2♀ (TARI), same but with "19.I.2008"; 1♀ (TARI), same locality, 24.V.2007, leg. M.-H. Tsao; 2♂♂, 1♀ (TARI), same local-

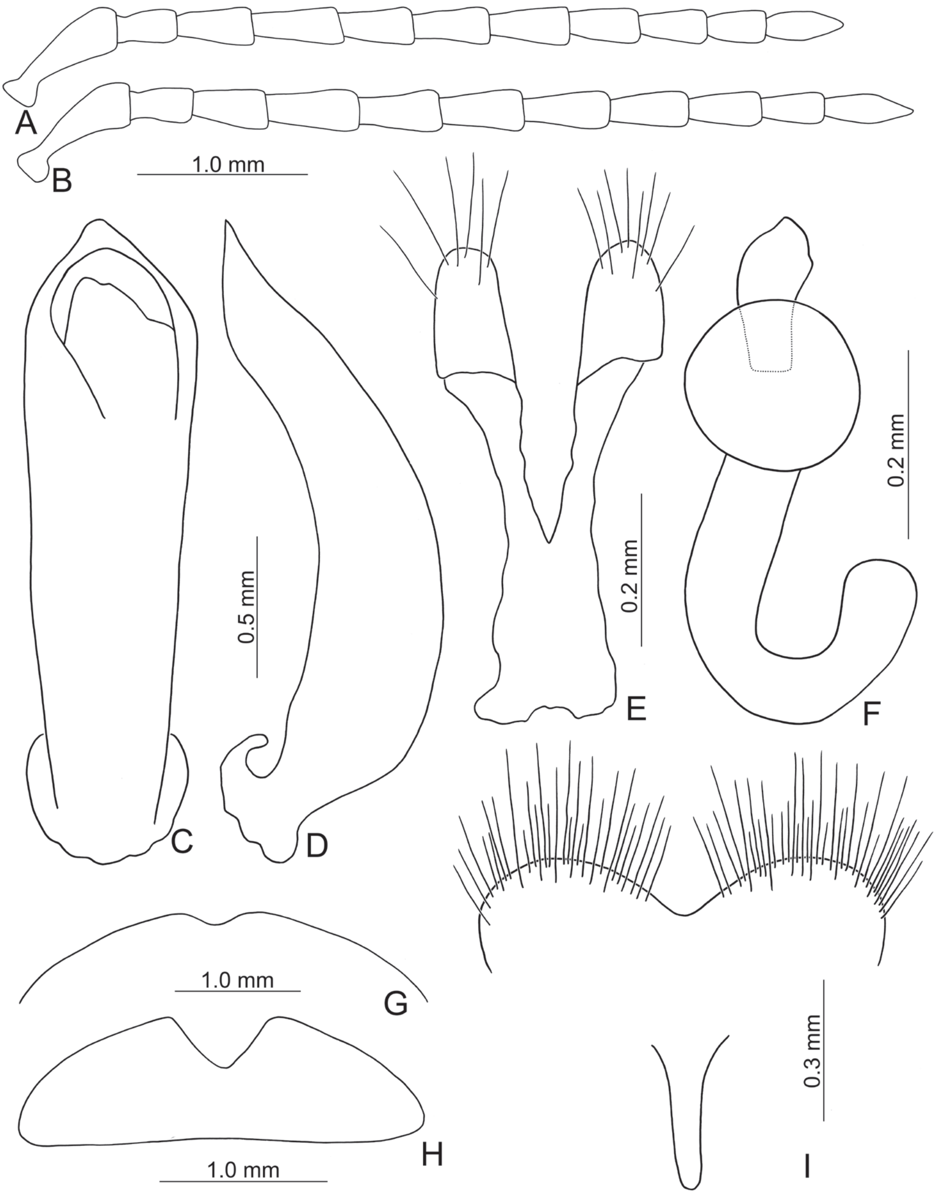

Figure 51. Diagnostic characters of *Pyrrhalta takizawai* Kimoto **A** antenna, male **B** antenna, female **C** aedeagus, dorsal view **D** ditto, lateral view **E** gonocoxae **F** spermatheca **G** abdominal ventrite V, female **H** abdominal ventrite V, male **I** abdominal ventrite VIII.

ity, 10.VII.2007, leg. C.-F. Lee; 4♂ (TARI), Takouhsi (大溝溪), 29.IV.2020, leg. L. Huang; 1♀ (TARI), Yuanshan (鳶山), 22.VIII.2014, leg. S.-F. Yu; Taoyuan: 2♂, 4♀ (TARI), Hsuanyuan (萱源), 21–23.IV.2008, leg. S.-F. Yu; 1♀ (TARI), Lalashan (拉拉山), 4.V.2010, leg. S.-F. Yu; 1♂, 1♀ (TARI), Yongfu (永福), 16.IV.2011, leg. M.-H.

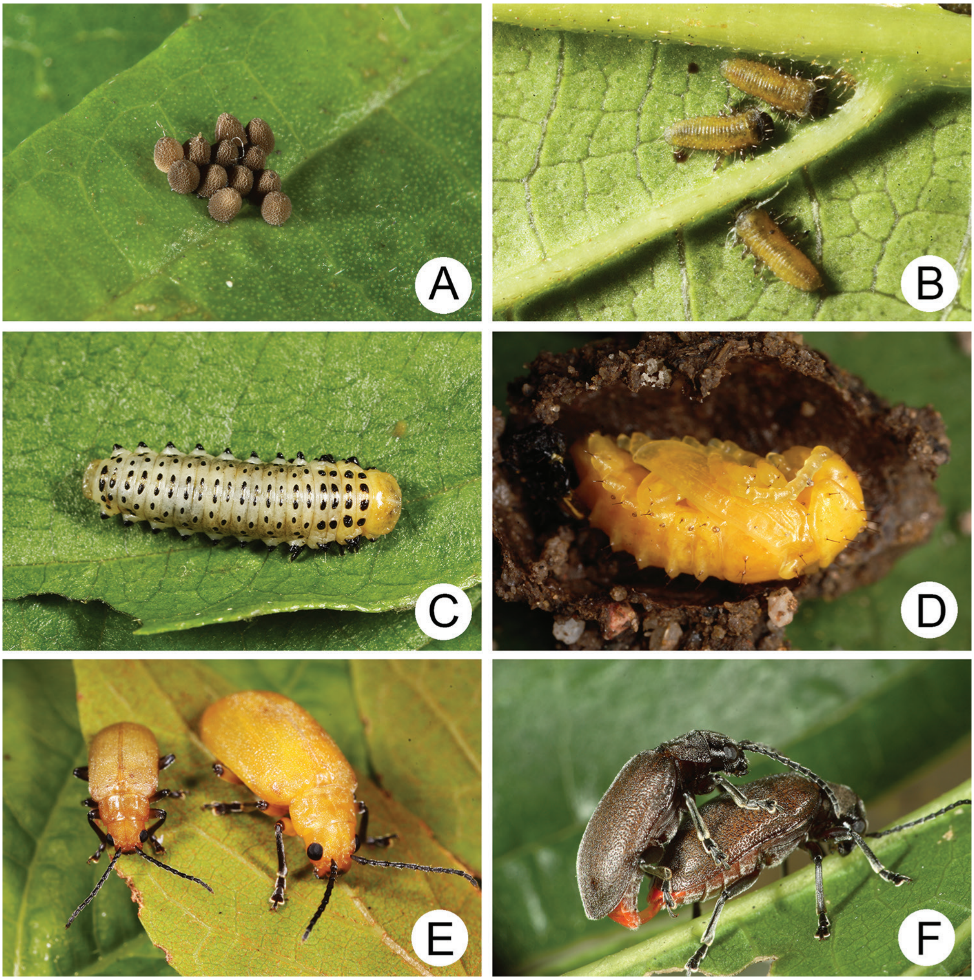

Figure 52. Field photographs of *Pyrrhalta takizawai* Kimoto on host plant **A** egg mass **B** First-instar larvae **C** Third-instar larva **D** pupa **E** young adults **F** older adults.

Tsou; 7♂, 4♀ (TARI), same but with "4.VI.2011"; 1♂, 1♀ (TARI), same but with "14.III.2015".

Redescription. Length 10.4–12.3 mm, width 4.3–5.4 mm. Body dark brown or blackish brown (Fig. 49D–F); antennae, tibiae, tarsi, and apices of femora black; teneral individuals with body yellowish brown. Eyes extremely small, interocular space 2.85–3.42 × diameter of eye. Antennae filiform in males (Fig. 51A; length ratios of antennomeres I–XI 1.0: 0.5: 0.6: 0.7: 0.6: 0.6: 0.6: 0.5: 0.5: 0.5: 0.6, length to width ratios of antennomeres I–XI 2.9: 1.8: 2.0: 2.3: 2.0: 2.0: 2.1: 2.1: 2.0: 1.8: 2.6; similar in females (Fig. 51B), length ratios of antennomeres I–XI 1.0: 0.5: 0.6: 0.7: 0.6: 0.6: 0.6: 0.6: 0.6: 0.5: 0.7, length to width ratios of antennomeres I–XI 2.9: 1.7: 1.8: 2.3: 2.0: 2.1: 2.2: 2.2: 2.0: 2.0: 3.1. Pronotum and elytra convex. Pronotum 1.9–2.0 × broader than long, disc smooth; and with extremely dense, coarse and fine punctures, and short pubescence; with median longitudinal and lateral depressions; lateral margins moderately rounded, widest at apical 1/3, apical and basal margins slightly concave; anterior and posterior setiferous punctures slightly erect. Elytra broad, parallel-sided, 1.6–1.7 × longer than wide; disc smooth, with dense, coarse punctures; and extremely dense short pubescence, some pubescence located between coarse punctures. Apical spur of tibia of middle leg absent, tarsomeres I of front and middle legs enlarged in males. Aedeagus (Fig. 51C, D) broad in dorsal view, 4.0 × longer than wide, broadest at apical 1/6, strongly narrowed from apical 1/6 to apex, apex narrowly rounded, gradually narrowed from apical 1/6 to base; symmetric; ostium covered by a membrane; strongly curved from apical 1/6 to base in lateral view, apex narrowly acute; no endophallic sclerites. Gonocoxae (Fig. 51E) connected at base, irregularly margined, with six to eight long setae near apex of each gonocoxa. Ventrite VIII (Fig. 51I) well sclerotized, apical margin moderately concave at middle, fringed with dense long and short setae; spiculum extremely short. Receptacle of spermatheca (Fig. 51F) very swollen; pump extremely long and strongly curved; sclerotized proximal spermathecal duct wide and short. Apical margin of abdominal ventrite V with deep notch at middle in males (Fig. 51H); shallow notch in females (Fig. 51G).

Remarks. Adults of *P. takizawai* Kimoto are similar to those of *P. igai* Kimoto and *P. meihuai* sp. nov. in having large, brown bodies but differ by the sparse pubescence on the pronotum (vs. dense pubescence on pronotum in *P. igai* and *P. meihuai* sp. nov.), sparse, coarse punctures on elytra (vs. dense, coarse punctures on elytra in *P. meihuai* sp. nov.; sparse, fine punctures on elytra in *P. igai*). The form of the aedeagus, gonocoxae, and female abdominal ventrite VIII are also diagnostic.

Host plant. Larvae and adults feed on leaves of *Celtis sinensis* Pers. (Cannabaceae).

Biology. Adults were collected from Taipei City Zoo, January 19, 2008 and transferred to the laboratory for rearing. Females began to deposit an average of 10–20 eggs in single egg mass (Fig. 52A) during middle March. Larvae hatched in 7 days. The larvae (Fig. 52B) fed on leaves and the larval duration was 14 days. mature larvae (Fig. 52C) burrowed into soil and built underground chambers for pupation. Duration of the pupal stage (Fig. 52D) was 28–30 days. Newly emerged adults (Fig. 52E) were yellowish brown and appeared during spring and were active (Fig. 52F). They became darker during summer and autumn and were inactive during winter.

Distribution. The species is widespread at lowlands (0–1,500 m) in Taiwan.

Key to Taiwanese species of *Xanthogaleruca* and *Pyrrhalta* (*X. aenescens* excluded)

1 Antenna extremely slender, antennomeres III–V more than 3.0 × longer than wide **2**
– Antenna long or stout, antennomeres III–V less than 3.0 × longer than wide **8**
2 Antennae and legs black; elytra yellow with black margins **3**
– Antennae and legs yellowish brown; part of elytra green, or yellowish brown elytra with brown longitudinal stripes **4**

3 Elytra with dense, fine punctures, and black stripes along suture; tibiae entirely black (Fig. 45A–C) .... ***P. kobayashii* Kimoto**

– Elytra with sparse, coarse punctures, black stripes and spots variable; tibiae yellowish brown with lateral margin black (Fig. 38D–I)... ***P. shirozui* Kimoto**

4 Elytra at least partly green, without brown longitudinal stripes **5**

– Elytra yellowish brown, with brown longitudinal stripes (Figs 5G–I, 7C, D) .... ***P. tahsiangi* sp. nov.**

5 Elytra with longitudinal ridges, apically brown **6**

– Elytra smooth, lacking longitudinal ridges, apices green.......... **7**

6 Elytra with coarse punctures and sparse pubescence (Fig. 5A–C) .... ***P. gressitti* Kimoto**

– Elytra with fine punctures and dense pubescence (Fig. 11D–F) .... ***P. viridipennis* Kimoto**

7 Elytra green with yellow lateral margin (Fig. 11A–C)..... ***P. taiwana* Kimoto**

– Elytra green with wide brown band along suture (Figs 5D–F, 9F) .... ***P. houjayi* sp. nov.**

8 Pronotum with three large black spots, one at middle, two laterally.......... **9**

– Pronotum without black spots **13**

9 Body flattened; elytra metallic green (Fig. 1D–F).......... ***X. yuae* sp. nov.**

– Body convex; elytra brown, reddish brown, or dark brown **10**

10 Body reddish brown; elytra with five pairs of black spots, one pair near base, two pairs near middle, two pairs at apical 1/3 (Fig. 23).......... **11**

– Body brown or dark brown, elytra with black stripes at humeral calli........ **12**

11 Antennomere III elongate, 4.5 × longer than wide, apically expanded in males (Fig. 24A); tarsomere I of middle leg modified in males (Fig. 24K).......... ***P. maculata* Gressitt & Kimoto**

– Antennomere III short, 2.7–3.4 × longer than wide, antennomere IV with small tubercle in males (Fig. 25A); tarsomere I of middle leg not modified in males .... ***P. tsoui* Bezděk & Lee**

12 Small species, 4.3–5.0 mm in length; elytra relatively narrow, 1.7 × longer than wide, disc with dense coarse punctures, with one additional pair of longitudinal dark stripes between humeral calli and suture (Fig. 38A–C).......... ***P. jungchani* sp. nov.**

– Large species, 6.0–7.9mm in length; elytra relative broad, 1.5 × longer than wide, disc with sparse fine puncture, lacking longitudinal dark stripes between humeral calli (Fig. 45G–I) .... ***P. lineatipes* (Takei)**

13 Smaller species, less than 6.5 mm in length.......... **14**

– Larger species, more than 6.5 mm in length.......... **21**

14 Elytra with ridges.......... **15**

– Elytra smooth, lacking ridges **17**

15 Elytra with regular dark spots between ridges (Fig. 34A–C) .... ***P. ishiharai* Kimoto**

– Elytra unicolorous, without dark spots.......... **16**

16 Smaller species, 3.3–3.7 mm in length; elytra relatively broad, 1.5 × longer than wide (Fig. 34D–F) ....***P. wulaiensis* sp. nov.**

– Larger species, 4.5–4.6 mm in length; elytra relatively narrow, 1.7–1.8 × longer than wide (Fig. 49A–C) ....***P. ohbayashii* Kimoto**

17 Elytra relatively narrow, 1.7–1.8 × longer than wide, entirely yellowish brown or black, disc with sparse, fine punctures (Fig. 41) .... ***P. lui* sp. nov.**

– Elytra relatively broad, 1.4–1.6 × longer than wide, entirely reddish brown, or yellowish brown with black margin and suture, disc with dense, coarse punctures...**18**

18 Body entirely reddish brown...**19**

– Elytra yellow or partly yellow..**20**

19 Legs reddish brown (Fig. 30A–C); tibia of middle leg with apical spine (Fig. 28G), tarsomere I modified (Fig. 28M), and sides of ventrite V strongly shortened in males (Fig. 28K) ....***P. formosanensis* sp. nov.**

– Legs black (Fig. 30D–F); tibia of middle leg lacking apical spine, tarsomere I not modified, and sides of ventrite V normal in males... ***P. semifulva* (Jacoby)**

20 Elytra entirely yellowish brown (Fig. 15D–F) ....***P. meifena* Kimoto**

– Elytra yellowish brown with black margin and suture, sometimes black band along suture enlarged or with additional transverse black bands (Fig. 31) .... ***P. discalis* Gressit & Kimoto**

21 Larger species, 10.4–12.3 mm; elytra with sparse coarse punctures (Fig. 49D–F) .... ***P. takizawai* Kimoto**

– Smaller species, 7.3–8.7mm; elytra with dense fine punctures...................**22**

22 Body black (Fig. 15A–C) .... ***P. alishanensis* sp. nov.**

– Body brown...**23**

23 Discs of pronotum and elytra with reticulate microsculpture (Fig. 18A–C)... .... ***P. igai* Kimoto**

– Discs of pronotum and elytra smooth, lacking reticulate microsculpture (Fig. 18D–F) .... ***P. meihuai* sp. nov.**

Discussion

The taxonomic relationship of *Pyrrhalta*, *Tricholochmaea*, and *Xanthogaleruca* has been controversial for many decades. Laboissière (1934) proposed *Xanthogaleruca* as a subgenus of *Galerucella* characterized by antennomere III equal or slightly shorter than IV, with the following antennomeres twice as long as wide, and tibiae ridged. Bechyné (1961) listed *Xanthogaleruca luteola* from Afghanistan and implicitly treated *Xanthogaleruca* as a genus. Silfverberg (1974) examined the aedeagi of *X. luteola* (Müller, 1766) and *X. subcoerulescens* (Weise, 1884) and described a comb-shaped internal sclerite. Subsequent authors were not consistent with either genus or subgenus concepts of *Xanthogaleruca*, and it has been treated as a distinct genus (e.g., Beenen 2008, 2010; Beenen and Talpur 2019; Nie et al. 2017; Warchałowski 2003, 2010; Riley et al. 2002, 2003), a subgenus of *Pyrrhalta* (e.g., Wilcox 1965), or a synonym of *Pyrrhalta* (e.g., Wilcox 1971; Yang et al. 2015; Nie et al. 2012; Kimoto and Takizawa 1997).

Tricholochmaea was described by Laboissière (1932) as a subgenus of *Lochmaea* Weise, 1883. However, Gressitt and Kimoto (1963) synonymized *Tricholochmaea* with *Pyrrhalta*. Similar to the situation in *Xanthogaleruca*, the concept of *Tricholochmaea* has not been treated consistently by subsequent authors. It has been regarded as a genus (e.g., Beenen 2010; Warchałowski 2010; Riley et al. 2002, 2003), a subgenus of *Pyrrhalta* (e.g., Wilcox 1965, 1971), or a synonym of *Pyrrhalta* (e.g., Xue and Yang 2010). The characters used to distinguish *Tricholochmaea* and *Pyrrhalta* are superficial, including tibiae with ridges the entire length or with traces only (Warchałowski 2010), or the presence of an asymmetrical aedeagus (Wilcox 1965).

The *Pyrrhalta* genus complex badly requires comprehensive revision based on molecular data of species from the whole distributional area. The revision of Taiwanese species supports inclusion of *Tricholochmaea* as part of the *Pyrrhalta semifulva* species group within *Pyrrhalta*. This species group also comprises maculate species traditionally classified in *Pyrrhalta* (cf. Bezděk and Lee 2019). However, we treat *Xanthogaleruca* as a distinct genus based on the characteristic comb-like sclerite of the aedeagus and apparent phylogenetic distance from *Pyrrhalta* as proposed by Nie et al. (2017a), but the genus-level arrangement presented in this paper should be treated as tentative.

Some characters presumed to be important for generic diagnosis are not supported by the present study. The apical spur of the middle leg in males appears across whole genus and species groups, or in some species within different groups, including *Xanthogaleruca*; *Pyrrhalta gressitti*, *P. tahsiangi* sp. nov., and *P. viridipennis* within the *P. gressitti* species group; *P. maculata*, *P. tsoui*, *P. formosanensis* sp. nov., and *P. ishiharai* within the *P. semifulva* species group; and *P. jungchani* sp. nov. and *P. shirozui* within the *P. shirozui* species group. Some of these species have tarsomere I of the middle leg modified, including *P. tahsiangi* sp. nov. within the *P. gressitti* species group; *P. maculata*, *P. formosanensis* sp. nov., and *P. ishiharai* within the *P. semifulva* species group; *P. jungchani* sp. nov. and *P. shirozui* within the *P. shirozui* species group. Groups based on other morphological characters such as the ratio of length vs. width for each antennomere and elytra; sizes and genitalic characters in both sexes are more diagnostic for sorting species within the genus. Such groupings are corroborated by phylogenetic relationships of host plants and shared feeding behaviors. Members of *Xanthogalerucae* feed on leaves of *Ulmus* species or *Zelkova serrata* (Ulmaceae), those of the *Pyrrhalta gressitti* species group feed on leaves of leaves of *Rhododendron* species or *Vaccinium randaiense* (Ericaceae), those of the *P. meifena* species group feed on leaves of *Acer* species (Sapindaceae), those of the *P. semifulva* species group feed on flowers of *Meliosma rhoifolia* (Sabiaceae) or species of Rosaceae, and those of the *P. shirozui* species group feed on leaves of *Viburnum* species (Adoxaceae). This suggests that information about host plants and feeding behaviors may be helpful in grouping species of *Pyrrhalta*.

Species richness of *Pyrrhalta* may be underestimated based on the following reasons. Most *Pyrrhalta* species are monophagous; for example, four species of the

P. meifena species group feed on *Acer* species (Sapindaceae), of which six species are found in Taiwan (Li and Lo 1993). This suggests 0.66 species of *Pyrrhalta* per species of *Acer*; similarly, five species of the *P. gressitti* species group feed on leaves of one or two species of the genus *Rhododendron* (Li et al. 1998), and 13 species of *Rhododendron* are recorded from Taiwan, suggesting only 0.38 species of *Pyrrhalta* per species of *Rhododendron*.

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RESEARCH ARTICLE

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A new species of *Nemoura* (Plecoptera, Nemouridae) and supplementary description of *Amphinemura cordiformis* from the Nanling Mountains of southern China

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Abstract

Two species of Nemouridae are described and illustrated from the Nanling Mountains of southern China, including a new species, *Nemoura biplatta* **sp. nov.** from Guangxi Zhuang Autonomous Region, and a new regional record species, *Amphinemura cordiformis* Li & Yang, 2006 from Hunan Province. The morphological characteristics of the new species are compared to related taxa and the new images with supplementary description of *A. cordiformis* are also provided.

Keywords

Mangshan National Natural Reserve, Maoershan National Natural Reserve, *Nemoura biplatta* sp. nov.

Introduction

Nemoura Latreille, 1796 and *Amphinemura* Ris, 1902 are the two largest genera of Nemouridae in China. Both of these genera are comprised of approximately 200 valid species known from the Holarctic and Oriental regions (Baumann 1975; Yang et al. 2015; Yang and Li 2018; DeWalt et al. 2020). Currently, more than 40 species of the genus *Nemoura* and nearly 100 species of the genus *Amphinemura* have been recorded from China (Wu 1926, 1938, 1940, 1962, 1973; Sivec 1981; Li and Yang 2005, 2006a, 2006b, 2007a, 2007b, 2008a, 2008b, 2008c, 2008d, 2011; Wang et al. 2006; Du and Wang 2007; Du et al. 2007, 2008; Wang and Du 2008; Li et al. 2012; Ji and Du 2014; Ji et al. 2014; Li et al. 2016, 2018a, 2018b; Chen and Du 2017a, 2017b; Mo et al. 2017, 2019, 2020a, 2020b, 2020c; Qian et al. 2018; Chen 2020).

The Nanling Mountains are located at 24°00'–26°30'N, 110°–116°E and are the boundary of Guangdong province, Guangxi Zhuang Autonomous Region, Hunan province, Jiangxi province, and Fujian province. The mountains are regarded as a priority area for biodiversity conservation, containing 19 wildlife natural reserves, such as Maoershan National Natural Reserve in Guangxi Zhuang Autonomous Region and Mangshan National Natural Reserve in Hunan province (Chen et al. 2015). Historically, two *Nemoura* species were recorded from Maoershan National Natural Reserve, including *N. perforata* Li & Yang, 2006a and *N. cucurbitata* Mo, Wang, Yang & Li, 2020.

Herein, an additional *Nemoura* species, *Nemoura biplatta* sp. nov. from Maoershan National Natural Reserve, is described as new to science and one *Amphinemura* species, *Amphinemura cordiformis* Li & Yang, 2006, is proposed from Guizhou province and it is reported for the first time in Mangshan National Natural Reserve. Detail descriptions, illustrations, and new images of the two species are provided and discussed.

Materials and methods

All examined specimens were collected by hand or net and preserved in 75% ethanol. Terminalia of adults were examined and illustrated using Keyence VHX-5000 system and final images were prepared using Photoshop CS6. All listed specimens are deposited in the Insect Collection of Yangzhou University (**ICYZU**), Jiangsu Province, China. The new species is named after the morphological characteristics of the terminalia.

Results

Nemoura biplatta sp. nov.

http://zoobank.org/813CC274-3443-49FB-8BB9-47394EB48578
Figures 1–7

Type material. ***Holotype***, 1♂, China, Guangxi Zhuang Autonomous Region, Guilin City, Ziyuan County, Maoershan National Natural Reserve, the walkway beside the swamp (Fig. 7), 1945 m, 25°53'37.2624"N, 110°25'25.1544"E, 27.VIII.2020, leg. Huo Qing-Bo (ICYZU). Paratypes, 1♂, 1♀, the same data as the holotype (ICYZU).

Diagnosis.

Description. Adult habitus (Fig. 1): head black, antennae dark brown, pronotum dark brown with rugosities, head slightly wider than pronotum; cervical gills poorly developed, outside lateral cervical sclerites with single small membranous, gill-like

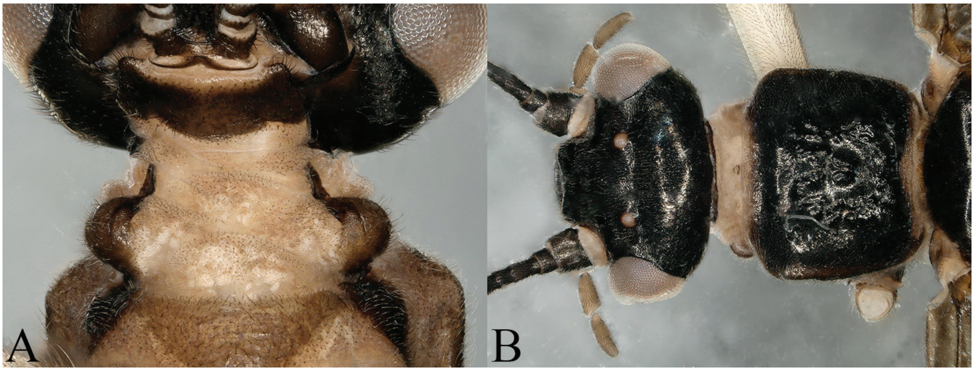

Figure 1. *Nemoura biplatta* sp. nov. male **A** prothorax, ventral view **B** head and pronotum, dorsal view.

nub. Wings subhyaline, infuscate, veins brown. Legs pale brown; abdominal segments brown, terminalia dark brown.

Male (Figs 2–4). Body length 7.5 mm, forewing length 9.0 mm, hindwing length 8.0 mm. Tergum VIII and tergum IX distinctly sclerotized, but median area is less sclerotized, distal margin of tergum IX slightly covering the anterior margin of tergum X, with a mid-anterior notch and a row of long spines extending to the anterior margin of tergum X along the posterior margin (Figs 2, 4). Hypoproct broad basally, and tapering to a thin apex; vesicle large, length approximately 2.5× width. Tergum X distinctly sclerotized at both edges of lateral area, mid-anterior area weaker, median area membranous, with two sclerotized triangular sclerite plates beneath epiproct; apex of sclerite strongly sclerotized and median portion with setae and several black spines, sclerotized band extending to lateral margin from sclerite base (Figs 2, 4). Cercus thick and oval, distinctly sclerotized, length approximately 2× width, gradually tapered toward tip with a long and slender spine, curving forward and inward at apex (Fig. 2A). Epiproct nearly oblong, short and broad; dorsal sclerite with two sclerotized bands forming a pair of nipple-like bulges, near apex with two S-shaped sclerotized arms tapering subapically toward small sharp tip, apex encased by cambered membrane with a small prolonged median sclerite (Fig. 2B, D); ventral sclerite with two stick-like sclerites bearing spines and connected at base forming a mid-posterior projection, basic sclerite sinuous with a lateral knob, partly extending posteriorly and upwards (Figs 3, 4). Paraproct divided into two lobes; outer lobe broad and short, strongly sclerotized with setae; inner lobe short, narrow at base, broader from 2/3 to apex with lateral margin strongly sclerotized (Figs 2–4).

Female (Figs 5, 6). Body length 9.0 mm, forewing length 10.5 mm, hindwing length 8.5 mm. Body coloration and the cervical gills are similar to the male (Fig. 5). Sternum VII definitely produced distally, extending to posterior margin of sternum VIII; pregenital plate rounded and wide, strongly sclerotized with several wrinkles. Sternum VIII with two obvious sclerotized spots and several small spots are dispersed laterally. Sternum IX and sternum X darkly sclerotized (Fig. 6). Paraproct dark brown and broad, cerci short and brownish.

Etymology. The Latin *bi-* and *platta* referring to the paired sclerites present beneath epiproct.

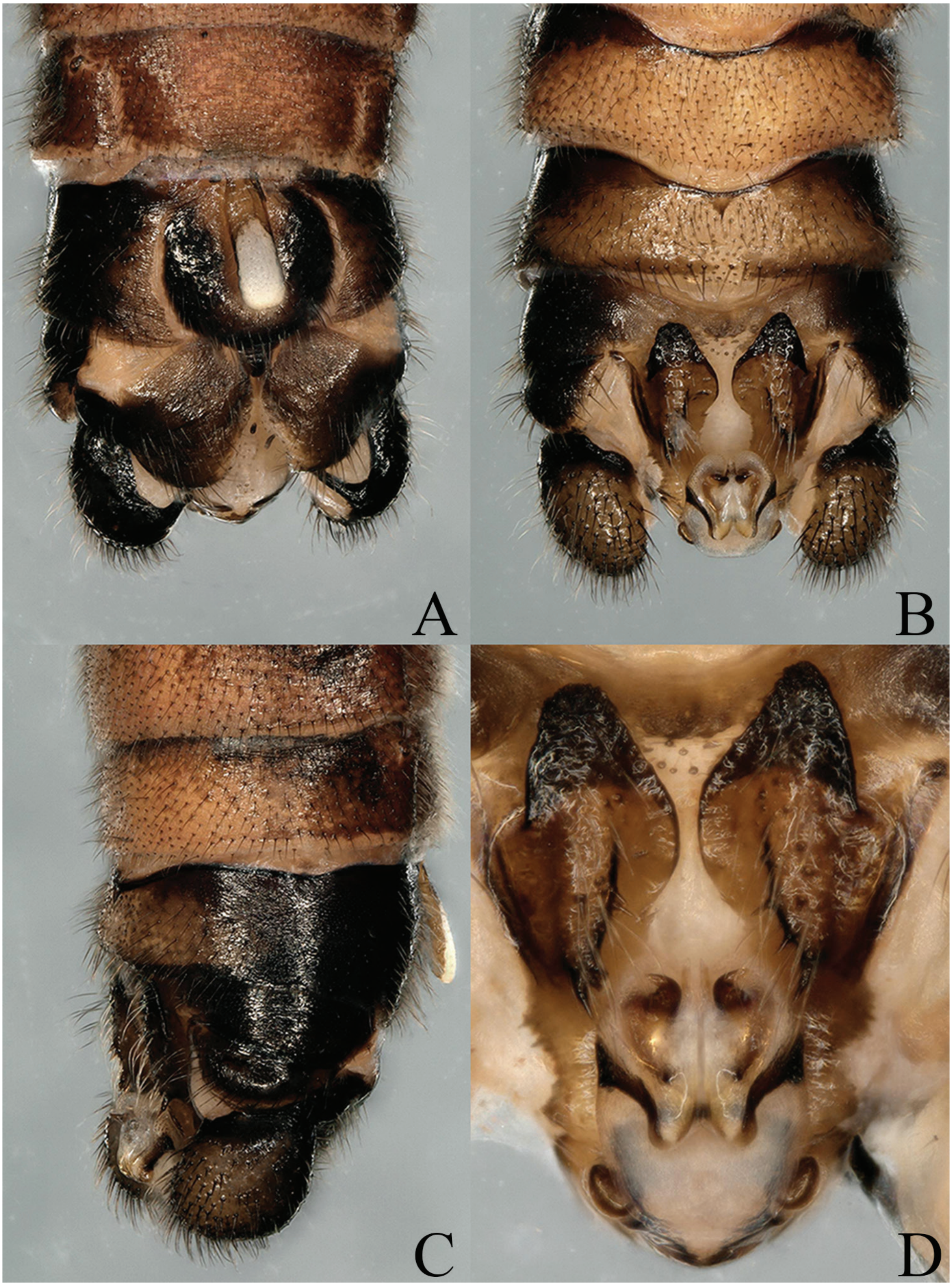

Figure 2. *Nemoura biplatta* sp. nov. male terminalia **A** ventral view **B** dorsal view **C** lateral view **D** epiproct, dorsal view.

Remarks. Regarding to the affinities of the new species, *N. biplatta* belongs to the *cercispinosa* complex proposed by Baumann (1975), whose cerci enlarged and thick, bearing one or more spines at apex. The new species is similar to some of the spe-

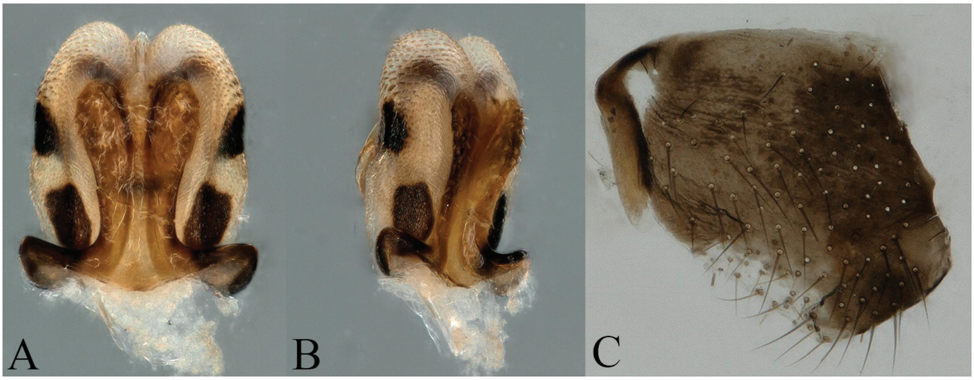

Figure 3. *Nemoura biplatta* sp. nov. male **A** epiproct, ventral view **B** epiproct, lateral view **C** right paraproct, ventral view.

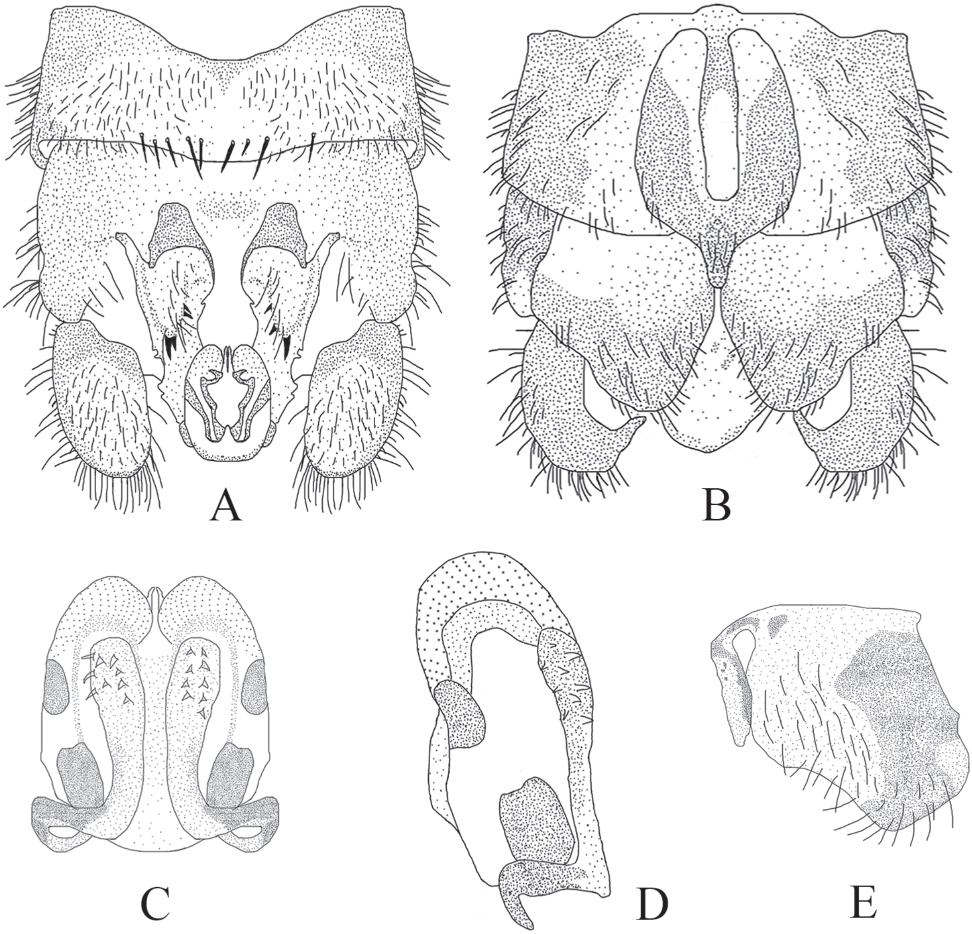

Figure 4. *Nemoura biplatta* sp. nov. male **A** terminalia, dorsal view **B** terminalia, ventral view **C** epiproct, ventral view **D** epiproct, lateral view **E** right paraproct, ventral view.

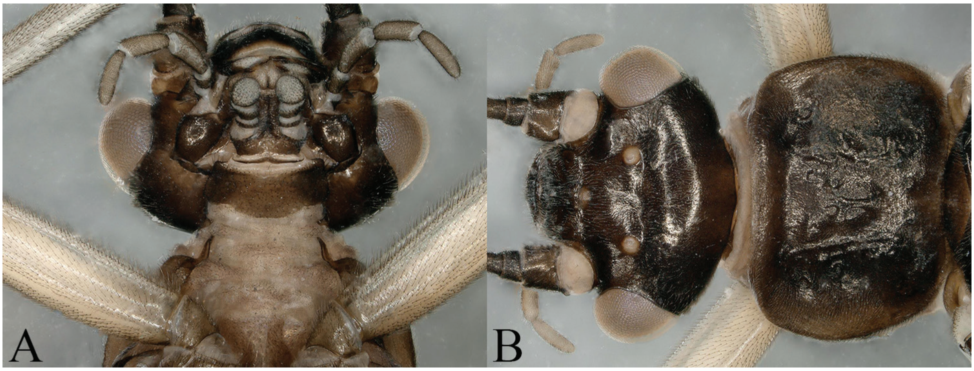

Figure 5. *Nemoura biplatta* sp. nov. female **A** prothorax, ventral view **B** head and pronotum, dorsal view.

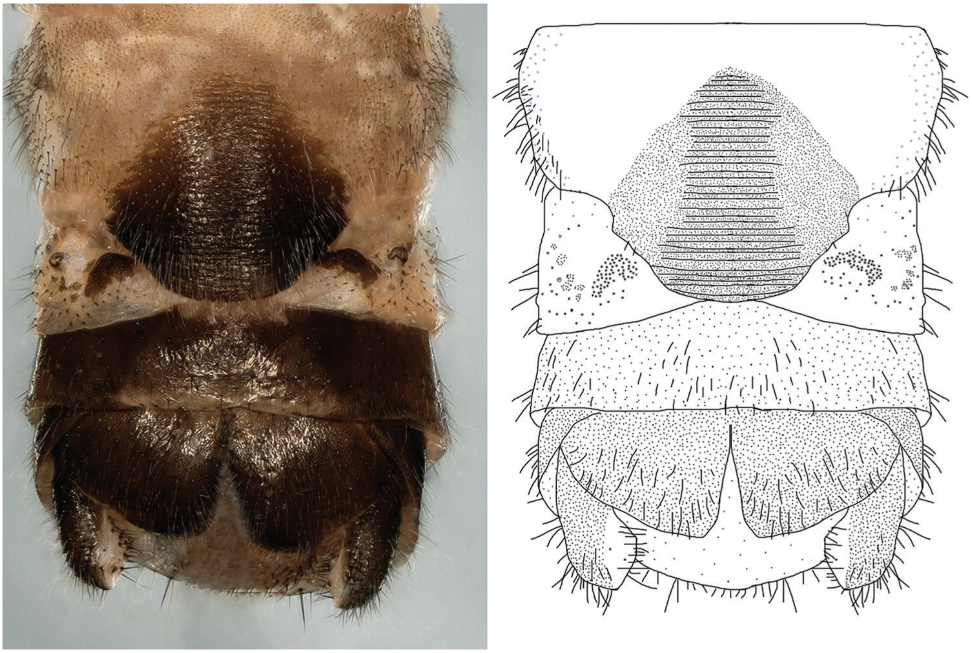

Figure 6. *Nemoura biplatta* sp. nov. female abdomen, ventral view.

cies known from Assam like *N. khasii* Aubert, 1967 and *N. kuhleni* Aubert, 1967 by epiproct and paraproct. However, in *N. khasii* and *N. kuhleni*, the two lateral arms of the epiproct are rounder or heart-shaped, while in *N. biplatta*, the arms are sclerotized and S-shaped with a small sharp tip subapically. The outer lobe of paraproct differ quite slightly in shape. Compared to some Chinese species, the male of *N. biplatta* appears similar to *N. fusiformis* Chen & Du, 2017 and *N. nankinensis* Wu, 1926 from Jiangsu province, particularly in respect of the oblong epiproct. The epiproct ventral sclerite of *N. fusiformis* seems similar to our new species in the pair of prongs at the sides and the sclerotized lateral knob. However, the new species can be easily separated by the pres-

Figure 7. Habitat of *Nemoura biplatta* sp. nov. in China, Guangxi Zhuang Autonomous Region (Maoershan National Natural Reserve). The wet, scrubby habitat of the new species seen from the walkway beside the swamp. (Photograph by Huo Qing-Bo).

ence of the two sclerotized bands on the epiproct dorsal sclerite and the outer lobe of the paraproct without a strongly sclerotized large hook and a sharp process. In terms of *N. nankinensis*, the epiproct dorsal sclerite with a pair of lateral sclerites and the medially crossed grooves are quite similar to the new species, which may be distinguished by the pair of S-shaped sclerites with a sharp tip and the outer lobe of paraproct which is broad and blunt (without being finger-shaped) with a slightly curved apex. Above all, the sclerotized sclerite plate beneath the epiproct make it simple to identify it as a new species.

Amphinemura cordiformis **Li & Yang, 2006**

Figures 8–12

Amphinemura cordiformis: Li & Yang, 2006. Zootaxa 1154: 42.
Amphinemura cordiformis: Wang, Du, Sivec & Li, 2006. Illiesia 2(7): 50.
Amphinemura cordiformis: Yang, Li & Zhu, 2015. Fauna Sinica Insecta 58: 182.
Amphinemura cordiformis: Yang & Li, 2018. Species Catalogue of China. Vol. 2. Animals, Insecta (III), Plecoptera, 8.

Type locality. China, Guizhou Province, Dashahe.

Material examined. 2♂♂, China, Hunan Province, Chenzhou City, Yizhang County, Mangshan National Natural Reserve, Guizizhai (Fig. 12), 1218 m, 24°57'4.896"N 112°55'44.418"E, 3.IX.2020, leg. Huo Qing-Bo (ICYZU); 12♂♂, China, Guizhou Province, Leigong Mountain, Lianhuaping, 1450–1620 m, 17–18.IX.2005, leg. Wang Zhi-Jie (ICYZU).

Distribution. China (Guizhou, Hunan).

Diagnosis.

Description. Adult habitus (Fig. 8): head and antennae dark brown, palpi pale brown, pronotum dark brown with rugosities, head wider than pronotum; two cervical

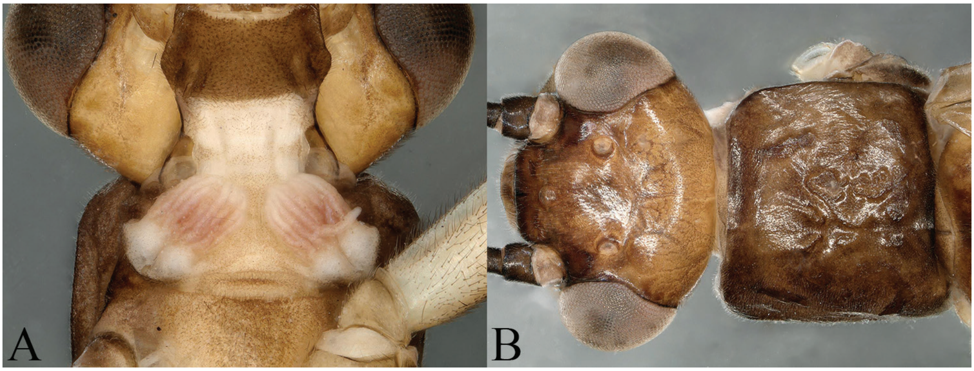

Figure 8. *Amphinemura cordiformis* male **A** prothorax, cervical gills, ventral view **B** head and pronotum, dorsal view.

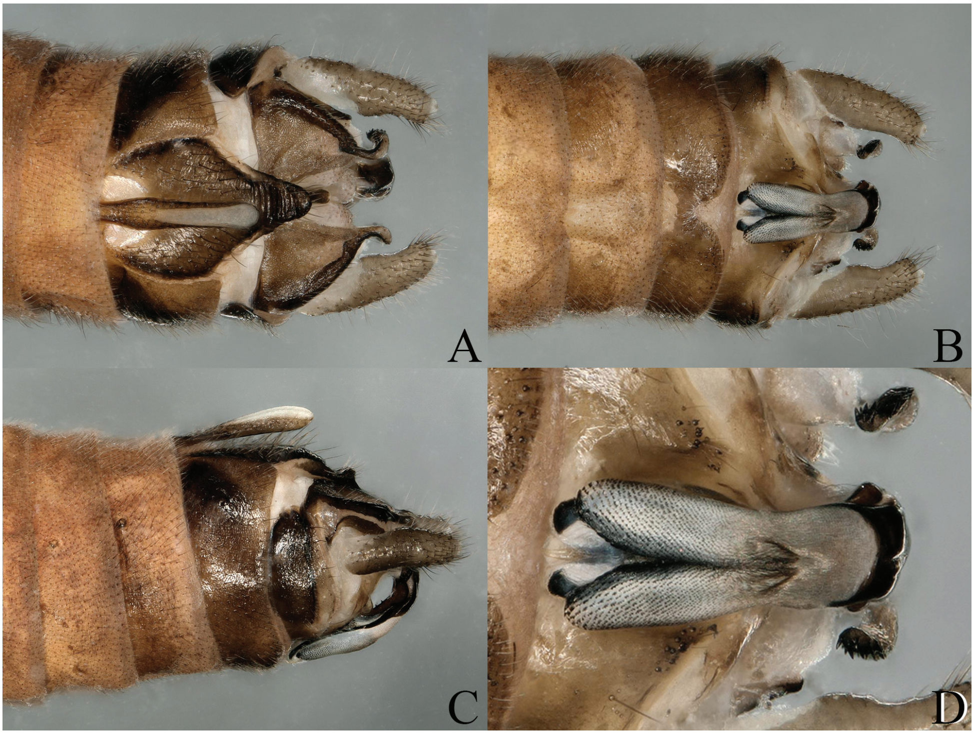

Figure 9. *Amphinemura cordiformis* male terminalia **A** ventral view **B** dorsal view **C** lateral view **D** epiproct, dorsal view.

gills, one on each side of lateral cervical sclerites with two branches, each branch divide into several branches; wing membranes subhyaline, veins brown. Legs pale brown; abdominal segments brown, terminalia darker.

Male (Figs 9–11). Body length 7.0 mm, forewing length 9.5 mm, hindwing length 7.2 mm. Tergum IX sclerotized with a concavity at mid-anterior margin, an

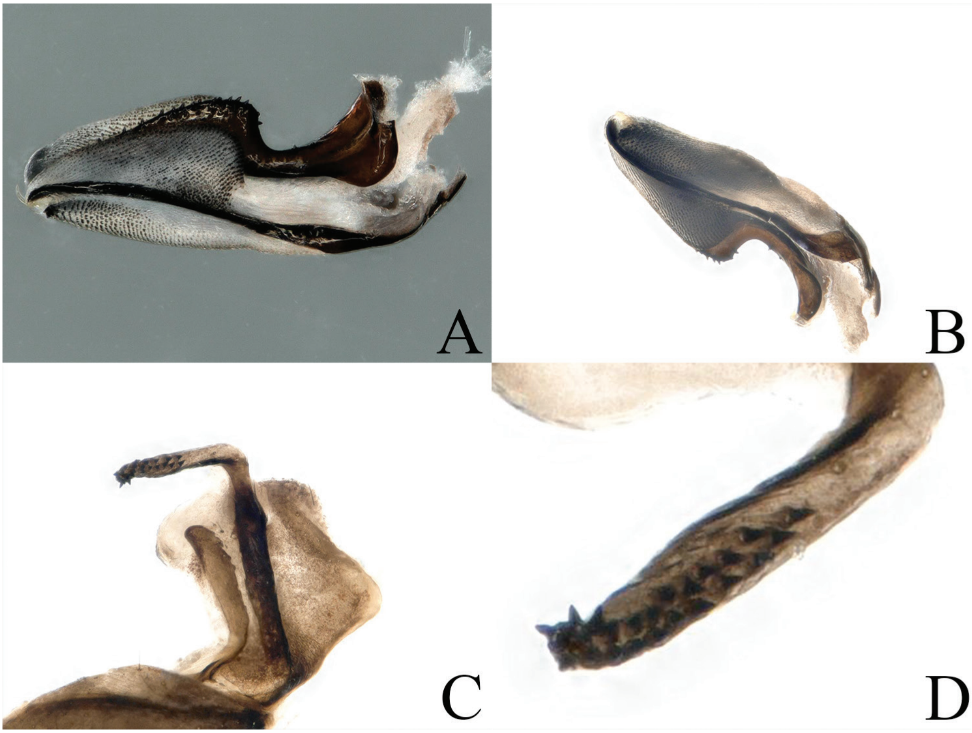

Figure 10. *Amphinemura cordiformis* male **A** epiproct, ventral view **B** epiproct, lateral view **C** right paraproct, ventral view **D** apex of the median right paraproct lobe, ventral view.

inverted V-shaped concavity at mid-posterior margin (Figs 9B, 11A). Hypoproct broad basally, bearing setae and tapering to a thin apex, below apex with an apical nipple; vesicle slender, length approximately 4× of maximum width. Tergum X strongly sclerotized laterally, median area beneath epiproct weakly sclerotized with several black spots ambilaterally, covering sparse long setae (Figs 9, 11). Epiproct slender, split apically with a membranous small ligule; dorsal aspect of epiproct wrapped by two long, oval, apically grooved lobes, jointed at base and divided half-way by distinctly sclerotized along notch, below notch with a pair of V-shaped sclerotized stripes; dorsal sclerite with two slender, lateral sclerites projecting inwards to apex over lobes, forming two teeth-like tips; ventral sclerite entirely sclerotized, constricted basally with two small spines, broadened from half-way forming a subtriangular process with a row of black spines along margin, visible in lateral view; two subtriangular membranous lobes slightly shorter than process, located laterally, surface densely covered with pits (Figs 9–11). Paraproct trilobed; inner lobe weakly sclerotized, large and square, with slender sclerotized stripe along inner margin; median lobe mostly sclerotized, more strongly at base, subapically curved to form right angle, near apex two rows of small black spines, apex rounded with a ring of claw-like spines; outer lobe shorter than median lobe, weakly sclerotized,

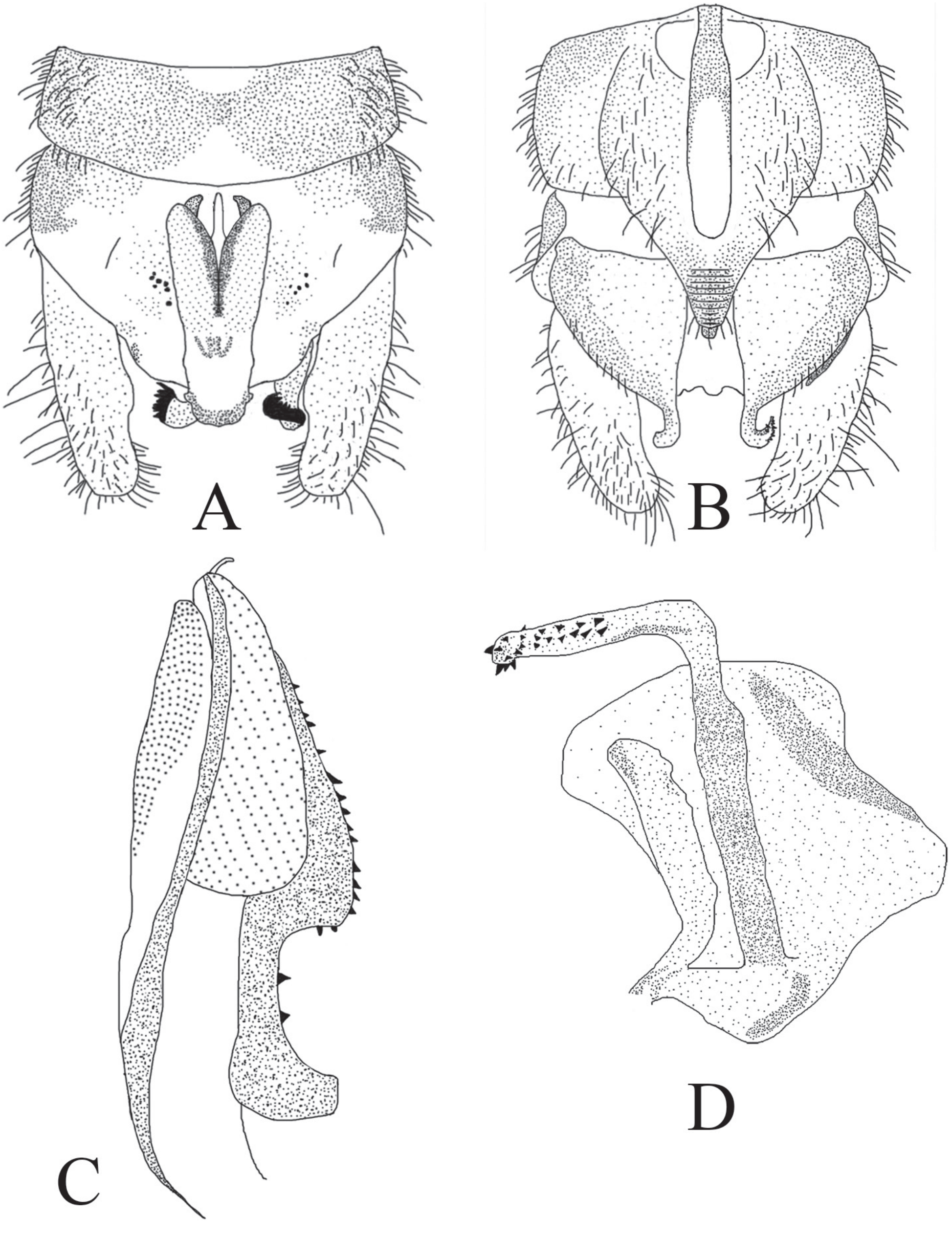

Figure 11. *Amphinemura cordiformis* male **A** terminalia, dorsal view **B** terminalia, ventral view **C** epiproct, lateral view **D** right paraproct, ventral view.

apex rounded and more heavily sclerotized, inner edge with some irregular nicks (Figs 10C, D, 11D).

Remarks. Compared to the specimens described from Guizhou province, the ones from Hunan province present slight discrepancies in males. The Hunan specimens have a pair of V-shaped sclerotized stripes below the notch in the dorsal view of epiproct,

Figure 12. Habitat of *Amphinemura cordiformis* in China, Hunan Province, Mangshan National Natural Reserve, Guizizhai (Photograph by Huo Qing-Bo).

and the ventral sclerite basally bears two small spines, which are obscure in the Guizhou specimens. Additionally, the paraproct outer lobe of the Hunan specimens is thicker, apically rounded, and bears some irregular nicks along the inner edge. The inner lobe has a slender sclerotized stripe along its inner margin and the median lobe bears two rows of spines subapically and a ring of claw-like spines apically whereas the inner lobe is triangular and slightly sclerotized in the Guizhou specimens, and the number and arrangement of the spines near the apex of median lobe are variable. As mentioned above, the enumerated characters probably refer to geographical or individual variability.

Conclusion

The Nanling Mountains, where the two species discovered, including *Nemoura biplatta* sp. nov. from Maoershan National Natural Reserve in Guangxi Zhuang Autonomous Region and *Amphinemura cordiformis* from Mangshan National Natural Reserve in Hunan Province, are a priority area for biodiversity conservation. Although there are similar species exist, the two species documented here are new to science or represent new records based on detailed morphological comparison. Considering the geographical or individual variability of some similar species, molecular methods should be considered to confirm the status of new taxa in the future. Meanwhile, it is expected that more new species of stonefly may be discovered in the Nanling Mountains in the future with additional specimen collection and biodiversity surveys.

Acknowledgements

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Out of the blue: The first record of the genus *Heremites* Gray, 1845 (Squamata, Scincidae) from Pakistan

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Abstract

The genus *Heremites* Gray, 1845 is endemic to the Western Palearctic region, containing morphologically similar species with a not well resolved taxonomy. The genus has a broad distribution from North Africa to Central Asia, with the only known record from northeastern Afghanistan. Three species are currently recognized in the genus with one, *H. septemtaeniatus* (Reuss, 1834), representing populations at the eastern edge of the genus range. During extensive fieldwork, we discovered *H. septemtaeniatus* from northwestern Pakistan and provisionally suggest that this population could be morphologically defined as *H. septemtaeniatus transcaucasicus* (Chernov, 1926). This important contribution to the knowledge regarding the family Scincidae in Pakistan, however, needs further investigation using an integrative approach.

Keywords

Afghanistan, Central Asia, *Mabuya*, morphology, range extension, taxonomy, *Trachylepis*

Introduction

The endemic western Palearctic genus *Heremites* Gray, 1845 was recently resurrected and used for the revised taxonomy of the Middle Eastern lizard members of the *Mabuya* group (Karin et al. 2016). For a long time, members of the present-day genus *Heremites* were lumped into the genus *Trachylepis* Fitzinger, 1843, which now represents only related lizards from Africa and Madagascar (Karin et al. 2016). Based on the results of molecular phylogenetic analyses and morphology, the genus *Heremites* currently represents three species, *H. auratus* (Linnaeus, 1758), *H. septemtaeniatus* (Reuss, 1834), and *H. vittatus* (Olivier, 1804). They ranging from North Africa, through the Middle East and Arabia, to Central Asia (Sindaco and Jeremcenko 2008; Karin et al. 2016). However, this range is not, according to the current knowledge, connected, but is instead disjunct or further divided (Sindaco and Jeremcenko 2008). This range characteristic, together with molecular data suggest, that the current knowledge on these taxa is probably incomplete (cf. Baier et al. 2017; Bahmani et al. 2018). Morphological similarities between the three species and the unclear distribution throughout their range has led to confusion also in the taxonomy. Especially two species, *H. auratus* and *H. septemtaeniatus* are confusing despite their monophyletic position in molecular-based phylogenetic trees and the degree of genetic divergence (Mausfeld and Schmitz 2003; Güçlü et al. 2014; Karin et al. 2016; Bahmani et al. 2018). Some authors thus rank both taxa under the *H. auratus* species complex (Sindaco and Jeremcenko 2008). Moravec et al. (2006), however, restricted the range of *H. auratus* to Turkey and the adjacent Aegean Islands and mentioned *H. septemtaeniatus* as occurring in NE Africa, the Arabian Peninsula, Transcaucasia, Iraq, Iran, and western and southern Turkmenistan (Sindaco and Jeremcenko 2008; Fig. 1). Moravec et al. (2006) also reported *H. septemtaeniatus* for the first time from Afghanistan (Nangarhar Province), although Leviton and Anderson (1970) mentioned possible records from the vicinity of Tajan River at the Iran-Afghan-Turkmen borders (see also Sindaco and Jeremcenko 2008). The only known population of *H. septemtaeniatus* in Afghanistan is a biogeographical mystery, as it is separated from the rest of the genus range by the important barrier (the Hindu Kush Mountains) and desert basins (Sistan). The information presented in Moravec et al. (2006) represents a very important range extension for the genus, with a distribution gap of about 1300 km as the crow flies from localities in central Iran (Šmíd et al. 2014), and ca. 700 km from expected localities in NW Afghanistan or southern Turkmenistan (Sindaco and Jeremcenko 2008; Fig. 1 in this study). The origin of this isolated Afghan population is unknown and it has not been studied. Therefore, the biogeography and possible taxonomical consequences of the isolated eastern Afghan population remain challenging.

According to the current knowledge, the range of *H. septemtaeniatus* from Armenia, northern Iraq through central and northern Iran to eastern Afghanistan represents a subspecies, *H. s. transcaucasicus* (Chernov, 1926). Although the taxonomic status of the subspecies *transcaucasicus* is not clear and some authors refer to it as a subspecies of *H. auratus* (e.g. Leviton et al. 1992; Anderson 1999; Faizi and Rastegar-Pouyani 2006; Rastegar-Pouyani et al. 2008; Faizi et al. 2010; Bahamani et al. 2016; Karin et al. 2016; Bahamani et al. 2018), we here follow Achmedov and Ščerbak (1987) and Moravec et al. (2006) in recognizing it as a subspecies of *H. septemtaeniatus*. However, as is evident from recent molecular studies, the situation is probably more complex (Bahmani et al. 2018) and further molecular and morphological research across the range of the genus is required to resolve the taxonomic ambiguities.

The knowledge of reptile diversity in Pakistan has strikingly increased within the last two decades (e.g., Khan et al. 2021). On the other hand, the species composition, distribution patterns, and natural history of many species are still poorly known (Khan 2006; Masroor 2012). Following by Minton (1966), Khan (2006) adopted Murray (1884) in presenting the record of *Mabuya aurata* (= *H. auratus*) from Sindh, Pakistan as uncertain and dubious. This record is probably an error and the genus *Heremites* had thus previously never been recorded in the country, certainly not in the Sindh Province, which does not offer suitable climatic and habitat preferences for this genus. However, in view of the presence of the genus in one known Afghan locality in the Nangarhar Province (Moravec et al. 2006), distanced several tens of kilometers from the Pakistani border, we expected the possible presence of this genus in Pakistan.

Material and methods

During field surveys in the Khyber Pakhtunkhwa Province, Pakistan, we found a population of lizards of the family Scincidae, identified as members of the genus *Heremites*. Overall, 13 specimens (seven adult males and five adult females [SVL (snout-vent length) ≥ 50 mm], and one juvenile) were collected during several trips between 2013 and 2019. All the specimens were caught by hand, euthanized in a closed vessel with a piece of cotton wool containing ethyl acetate (Simmons 2002) and later permanently fixed in formaldehyde or 70% ethanol. Specimens were deposited in the herpetological collection of the Pakistan Museum of Natural History (**PMNH**) in Islamabad, Pakistan, except one that is in the herpetological collection of the Department of Zoology, Comenius University in Bratislava, Slovakia as (DJ [Daniel Jablonski] 9560).

Morphological characters were taken following the character definitions by Faizi and Rastegar-Pouyani (2006) and Faizi et al. (2010). Measurements were taken with a digital caliper to the nearest 0.1 mm. Measurements of arms, legs, and head were principally taken on the right side of the animal (from the left side if the animal was damaged on the right). Scale counts beneath the fourth toe and finger was taken from both sides. Morphometric characters and scalation data were taken as follows: SVL (snout-vent length, from the tip of snout to the anterior edge of the cloaca); TL (tail length, from the posterior edge of the cloaca to the tip of the tail); HL (head length, the distance between the retroarticular process of the jaw and the snout-tip); HW (head width, the widest part of the head); HH (head height, from the occiput to the underside of the jaws); TrL (trunk length, distance from axilla to groin measured from the posterior edge of the forelimb insertion to the anterior edge of the hindlimb insertion); OD (orbital diameter, the vertical diameter of the orbit); EL (ear length, the longest dimension of the ear opening); DN (distance between nostrils); END (eye-nostril distance, the distance between the anterior corner of the eye and the tip of the snout); EED (eye-ear distance, from the posterior edge of the eye to the anterior corner

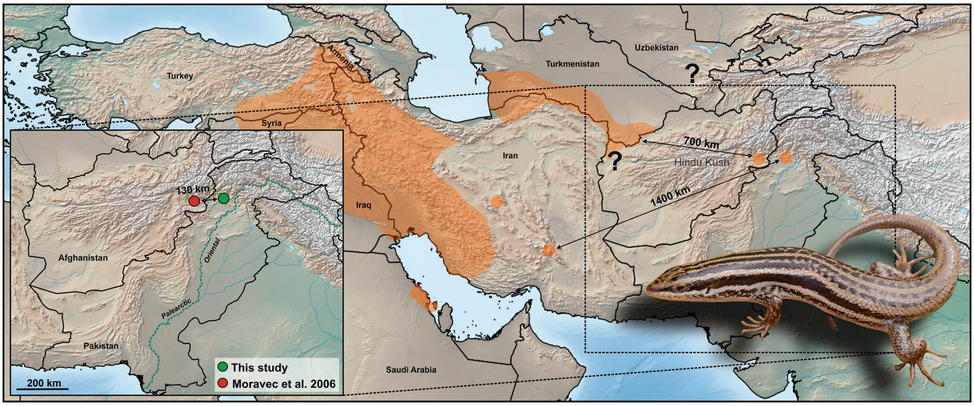

Figure 1. Distribution range of *Heremites septemtaeniatus* highlighted in orange, adopted from Sindaco and Jeremcenko (2008) and Šmíd et al. (2014), and species records from Afghanistan and Pakistan (Moravec et al. 2006; this study). The question marks indicate areas of questionable occurrence of the species from Afghanistan and Uzbekistan (Sindaco and Jeremcenko 2008). The pictured live specimen (DJ 9560) is an individual from Shah Alam Baba, Tehsil Adinzai, Lower Dir district, Khyber Pakhtunkhwa Province, Pakistan.

of the ear); FrW (frontal width); FrL (frontal length); FnW (frontonasal width); FnL (frontonasal length); LorWa (width of anterior loreal); LorWp (width of posterior loreal); IpL (length of interparietal); MnW (width of mental); MnL (length of mental); HLL (hindlimb length, length of femur and crus to tip of fourth toe); FLL (forelimb length, length of humerus and forearm to tip of fourth finger); SL (supralabials); IL (infralabials); SSLE (number of scales between last supralabial and ear opening); EP (ear pectination, number of scales projecting inside the ear opening); PN (pair of nuchals); SAB (scales across the body, number of scales in a single row around the widest part of the body); DSNV (dorsal scales in a row from first nuchal to above level of the vent); VT (ventral transverse, scales counted in a row from chin shields to cloaca); SDL 4thT (subdigital lamellae under 4th toe); SDL 4thF (subdigital lamellae under 4th finger); PN (pair of nuchal scales); SCS (number of supraciliary scales); SC (number of subcaudals from behind vent to tip of tail). Qualitative characters: SOF (contact between the third supraocular and the frontal); PFC (prefrontals in contact or not); PSC (parietal shields in contact or not); KDS (number of keels on dorsal scales); in contact (+), without contact (-). The following data are presented as the ratio between obtained characters: SVL/TL, HL/HW, HW/HH, SVL/TrL, FrW/FrL, FnW/FnL, LorWa/LorWp, MnW/MnL.

For comparison of morphological data, we used data from adult specimens (n = 61), comprised of 48 specimens (belonging to *H. septemtaeniatus transcaucasicus* and *H. s. septemtaeniatus*) from Iran (Faizi and Rastegar-Pouyani 2006), and a single known specimen from Afghanistan (Table 1; Appendix 1). The single museum specimen (adult male, Figs 3 and 5) referred to *H. septemtaeniatus* from Afghanistan (ZFMK-H 9064) was collected on 7 April 1972 in the vicinity of Dar-e-Nur, vic. Shewa (34.5558°N, 70.6073°E), Nangarhar Province (Moravec et al. 2006; Wagner

Table 1. Data comparison of morphological characters of adults (minimum-maximum with mean ± standard deviation) of *Heremites septemtaeniatus* from Pakistan and Afghanistan with those of closely related taxa from Iran (Faizi and Rastegar-Pouyani 2006). All measurements are in mm, abbreviations are defined in the materials and methods section; (NA) data not available.

Characters	*Heremites septemtaeniatus* Pakistan n = 12	*Heremites septemtaeniatus* Afghanistan n = 1	*Heremites s. transcaucasicus* Iran n = 39	*Heremites s. septemtaeniatus* Iran n = 9
Metric data				
SVL	51.7–92.3 (82.9±6.9)	92.0	71.2–96.5 (81.8±6.0)	64.0–84.8 (74.6±6.9)
TL (complete tail n = 7)	68.0–111.7 (97.0±15.7)	105.8	72.0–129.0 (100.5±10.9)	89.7–160.0 (112.6±30.5)
SVL/TL (n = 7)	0.6–1.0	0.9	0.7–1.2	0.5–0.9
HL	11.1–19.0 (16.4±2.2)	16.5	NA	12.1–15.5 (13.7±1.1)
HW	8.2–11.0 (9.7±0.9)	11.0	NA	9.3–12.1 (10.7±0.8)
HL/HW	1.6–1.8	1.5	0.8–1.3	1.2–1.4
HW/HH	1.2–1.4	1.3	1.1–1.5	1.1–1.4
HH	5.8–8.7 (7.5±1.1)	8.1	NA	7.0–9.8 (8.4±0.9)
OD	1.8–3.0 (2.6±0.3)	2.8	1.1–2.8 (1.9±0.4)	1.5–2.1 (1.8±0.2)
EL	1.3–2.4 (1.8±0.3)	2.2	NA	NA
END	3.5–5.1 (4.4±0.5)	4.1	3.3–5.2 (4.2±0.5)	3.4–4.7 (4.1±0.5)
EED	3.6–5.6 (4.9±0.6)	5.0	4.1–5.9 (5.2±0.4)	5.0–6.1(4.9±0.5)
DN	1.7–3.0 (2.2±0.4)	2.5	1.9–3.6 (2.7±0.4)	2.1–3.0 (2.5±0.2)
HLL	24.3–36.1 (31.5±3.9)	35.0	NA	33.7–42.0 (38.6±3.0)
FLL	16.0–26.3 (22.4±2.9)	25.1	NA	21.5–28.0 (25.8±1.9)
TrL	22.8–46.8 (37.0±7.9)	49.1	33.0–51.6 (39.2±4.4)	27.7–40.5 (35.5±4.7)
SVL/TrL	1.8–2.3 (2.0±0.1)	1.9	1.8–2.4	1.9–2.3
FrW/FrL	0.5–0.6 (0.6±0.0)	0.5	NA	NA
FnW/FnL	1.4–2.0 (1.7±0.2)	1.6	NA	NA
LorWa/LorWp	0.5–1.0 (0.7±0.1)	0.5	NA	NA
IpL	2.1–3.0 (2.5±0.0)	3.6	NA	NA
MnW/MnL	1.6–2.0 (1.9±0.1)	1.5	NA	NA
Meristic data				
SL	6–7 (6.9±0.3)	6	NA	NA
IL	7–8 (7.0±0.3)	8	NA	NA
SSLE	3–4 (3.7±0.0)	4	NA	NA
EP	3–5 (4.0±0.6)	5	NA	NA
SAB	35–42 (36.0±2.0)	35	32–40 (36±1.8)	31–36 (32.9±1.5)
DSNV	52–60 (54.8±2.4)	54	NA	NA
VT	62–69 (65.0±2.2)	62	61–72 (66.6±2.8)	64–70 (67.1±2.0)
SDL 4thT	19–23 (21.0±1.1)	19–21	16–22 (18.7±1.6)	14–20 (17.5±1.8)
SDL 4thF	14–16 (14.8±0.7)	10–15	11–16 (14±1.1)	14–21 (15.6±2.2)
PN	1	1	NA	NA
SCS	5	4	NA	NA
SC (n = 7)	72–98 (85.8±9.0)	86	NA	NA
SOF	+	+	NA	NA
PSC	+	+	NA	NA
PFC	9(+), 3 (-)	+	NA	NA
KDS	3	3	3	3

et al. 2016). This specimen represents the nearest record of the species to the presently described specimens of the genus *Heremites* from Pakistan. Morphological data from the Afghan specimen were taken *de novo* in this study and are presented here for the first time (Table 1). The distribution map was prepared using QGIS (2021). Institutional abbreviations for the voucher specimens are as follow: **ZFMK**: Zoologisches

Forschungsmuseum Alexander Koenig, Bonn, Germany; **PMNH**: Pakistan Museum of Natural History, Islamabad, Pakistan; **RUZM**: Razi University Zoological Museum; **MMTT**: Iran National Natural History Museum; **DJ**: Daniel Jablonski (collection at the Department of Zoology, Comenius University in Bratislava, Slovakia).

Results

We report *Heremites septemtaeniatus* for the first time with certainty from the territory of Pakistan, representing the easternmost known distribution limit for the genus (Fig. 1). The first five individuals (PMNH 3474–3478; Fig. 3) were collected and morphologically identified as members of the genus *Heremites* during a field survey by M. Idrees on June 14, 2013. Seven additional specimens (PMNH 3518–3524; Fig. 4) were caught from the same locality on August 22, 2014. Very recently, another specimen (DJ 9560) was collected from the same locality on September 18, 2019 (Figs 1, 3, 5). The locality lies in the rocky habitat near Shah Alam Baba, Tehsil Adinzai, Lower Dir district, Khyber Pakhtunkhwa Province, Pakistan (34.7367°N, 72.1021°E; WGS 84, Fig. 2), at an elevation of 1110 m a.s.l. The collected specimens included both sexes and different age and size stages from juvenile to adults. This suggests that the population is well established and reproducing.

The region where the population was discovered is in the Lower Dir district, which has an average elevation of 1420 m a.s.l. The district is bestowed with three different forest types, i.e., moist temperate, sub-tropical Chir Pine, and sub-tropical broad-leaved. The elevation decreases gradually toward the south along the river Panjkora. The district lies in the temperate zone, where winters are cold with temperatures reaching below the freezing point (-2 °C), while summers are hot and humid due to heavy monsoon rains and with temperature reaching up to 32 °C (Nasrullah et al. 2012; Hidayat et al. 2017). The winter season arrives from mid-November to March and snowfall occurs in the upper parts from December to March. The investigated locality is a hilly area with big rocks that provided basking surfaces and shelter for the observed individuals of *Heremites*. Some of the frequently occurring trees in the study area were *Monotheca buxifolia*, *Eucalyptus camaldulensis*, *Ficus carica*, *Ailanthus altissima*, *Olea ferruginea*, *Morus alba* and *M. nigra*. The most dominant shrubs of the study area were *Dodonaea viscosa*, *Rumex hastatis*, and *Indigofera heterantha*. *Apluda mutica* was the most abundant grass species, followed by *Aristida depressa*, *Setaria viridis*, *Cymbopogan jwarancusa* and *Cynodon dactylon*.

The representative syntopic herpetofauna of the study area was documented and included amphibians [*Allopaa hazarensis* (Dubois & Khan, 1979), *Duttaphrynus melanostictus* (Schneider, 1799), *Firouzophrynus stomaticus* (Lütken, 1864), *Fejervarya* Bolkay, 1915 sp., *Hoplobatrachus tigerinus* (Daudin, 1802), *Sphaerotheca* cf. *breviceps* (Schneider, 1799)], lizards [*Calotes versicolor farooqi* Auffenberg & Rehmann, 1995, *Cyrtodactylus* (Gray, 1827) sp., *Eublepharis macularius* (Blyth, 1854), *Eurylepis taeniolatus* Blyth, 1854, *Hemidactylus* cf. *brookii*

Figure 2. The habitat of *Heremites septemtaeniatus transcaucasicus* near Shah Alam Baba, Tehsil Adinzai, Lower Dir district, Khyber Pakhtunkhwa Province, Pakistan. Overall view of the locality (**A**), detail of the microhabitat (**B**).

Gray, 1845, *Laudakia agrorensis* (Stoliczka, 1872), *L. pakistanica auffenbergi* Baig & Böhme, 1996, *Varanus bengalensis* (Daudin, 1802)], and snakes [*Boiga trigonata* (Schneider, 1802), *Bungarus caeruleus* (Schneider, 1801), *Echis carinatus sochureki*

Figure 3. Dorsal and ventral views of adult specimens of *Heremites septemtaeniatus transcaucasicus* from Pakistan (PMNH 3474–3478 and DJ 9560), together with the only specimen of this species from Afghanistan (Dar-e-Nur, vic. Shewa, ZFMK-H 9064).

Stemmler, 1969, *Eryx johnii* (Russell, 1801), *Naja oxiana* (Eichwald, 1831), *Oligodon arnensis* (Shaw, 1802), *Ptyas mucosa* (Linnaeus, 1758), *Platyceps* cf. *rhodorachis* (Jan in de Filippi, 1865)].

The adult Pakistani specimens (n = 12) exhibited the following morphological characteristics (for details see Table 1): SVL 0.6–1.0 times TL; HL 1.6–1.8 times its width; HW 1.2–1. 4 times its height; SVL 1.8–2.3 times TrL; SVL in males (n = 7) 61.7–92.3 mm, in females (n = 5) 76.6–89.0 mm; TL in males 68.0–111.7 mm, 110.0 mm in females with complete tail; HL in males 11.1–19.0 mm, in females 16.4–18.0 mm; parietals in contact behind interparietal (100% of specimens); third supraocular in contact with the frontal (100%); prefrontals mostly in contact (75%) or

Figure 4. Dorsal and ventral views of adult and juvenile specimens of *Heremites septemtaeniatus transcaucasicus* from Pakistan (PMNH 3518–3524).

separated (25%); 35–42 scales around the widest part of the body; 62–69 ventral scales in transverse rows counted from gular to cloaca; 52–60 dorsal scale rows from first nuchal to above vent; each dorsal scale provided with three keels; olive-brown above, with four longitudinal dark brown stripes on head dorsum, breaking up into rhomboidal spots towards the middle of the back and continuing up to tail base; broad dark stripe, bordered above with white spots, arising from the nostril, passing along upper half of the flank, continuing onto tail; limbs brown with white speckles (see Table 1).

Comparison of morphological data revealed that the Pakistani specimens are conspecific to specimen ZFMK-H 9064 from Afghanistan (Table 1, Figs 3 and 5). Except for slight variations in SCS, SDL 4th F, IL and IpL, the remaining morphological characters of the Pakistani specimens are in agreement with the Afghan specimen. On the

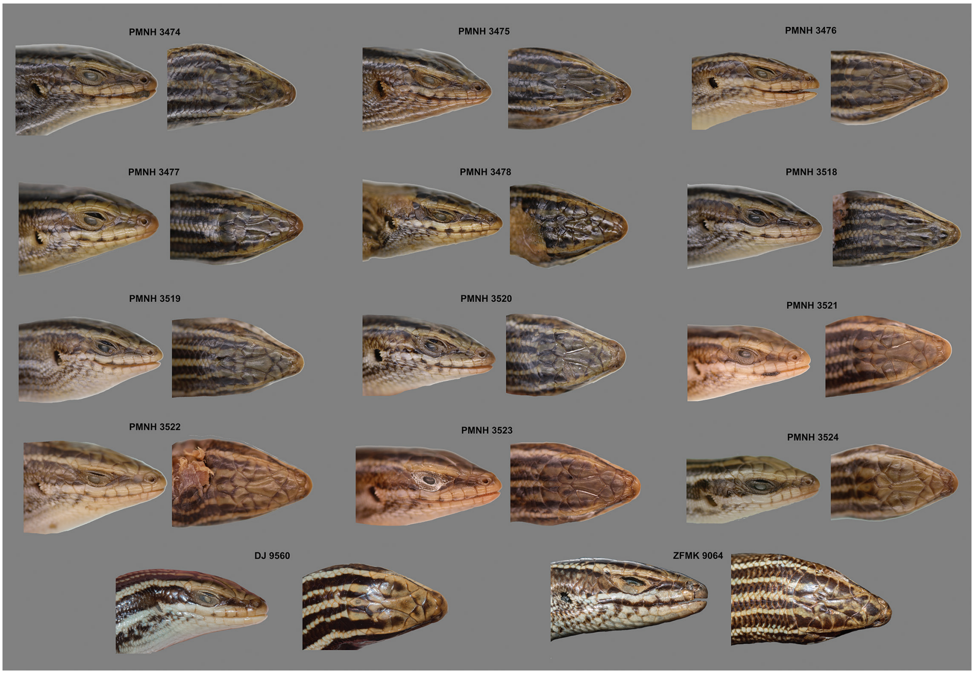

Figure 5. Lateral and dorsal head views of collected specimens of *Heremites septemtaeniatus transcaucasicus* from Pakistan (PMNH 3474–3478, PMNH 3518–3524 and DJ 9560), together with the only specimen of the species from Afghanistan (Dar-e-Nur, vic. Shewa, ZFMK-H 9064).

other hand, specimens assigned to *H. septemtaeniatus* and *H. s. transcaucasicus* from Iran differ from the Pakistani specimens in several characters including HL/HW, HW/HH and SDL 4thT (Table 1). Based on the current knowledge, we are inclined to provisionally place the Pakistani specimens as *H. s. transcaucasicus*, pending further research. Our record of *H. septemtaeniatus* represents the 18th taxon of the family Scincidae from the territory of Pakistan (Masroor 2012).

Discussion

Information about geographic distributions are essential for understanding the biogeography, evolution, ecology of species and for enabling their effective conservation, especially at the margins of their ranges. Our first record of the genus *Heremites* for Pakistan extends the known range of the genus from the Afghan locality (see Moravec et al. 2006) by ca. 130 km as the crow flies to the east, ca. 700–800 km from localities in NW Afghanistan and Turkmenistan (Sindaco and Jeremcenko 2008), and ca. 1.400 km from the central Iranian localities (Anderson 1999; Šmíd et al. 2014; Fig. 1 in this study). The present Pakistani locality lies approximately only 70 km from the border between the Palearctic and Oriental biogeographical regions [see Palearctic-Oriental transition zone in Sindaco and Jeremcenko (2008; Fig. 1)]. Our record is thus a biogeographically very important range extension and another example of a West Palearctic reptile with a wide area of distribution reaching close proximity to the Oriental Region. For example, a similar pattern can be observed in *Laudakia caucasia* (Eichwald, 1831), *Natrix tessellata* (Laurenti, 1768), or *Macrovipera lebetinus* (Linnaeus, 1758) (Khan 2006; Sindaco and Jeremcenko 2008; Mebert et al. 2013; Sindaco et al. 2013; Jablonski and Masroor 2020). On the other hand, a similar distribution pattern can be observed in scincid lizards from the Oriental Region, as is well known for the genus *Eutropis* Fitzinger, 1843, which extends from SE Asia to Afghanistan (Karin et al. 2016; Wagner et al. 2016; Jablonski et al. 2019).

We suggest that the populations from Pakistan and Afghanistan should be tentatively ranked under *H. septemtaeniatus transcaucasicus* despite the fact that recent works (Faizi and Rastegar-Pouyani 2006; Rastegar-Pouyani et al. 2008; Arakelyan et al. 2011; Nasrabadi et al. 2017) treated the taxon *transcaucasicus* as a subspecies of *H. auratus*. Moravec et al. (2006) examined the type series of *H. septemtaeniatus* and *H. auratus* and pointed out differences in several morphological characters. These authors mentioned that the third supraocular is in contact with the frontal shield in *H. septemtaeniatus* while such contact is lacking in *H. auratus*. The third supraocular is also usually in contact with the frontal in *H. s. transcaucasicus* (Chernov 1926: 64) and thus, placement of *transcaucasicus* under the *H. septemtaeniatus* instead of *H. auratus* is justified. While describing *Mabuya transcaucasica*, Chernov (1926) did not provide information on the contact of the parietals. Nevertheless, the parietals are said to be in contact in *Heremites vittatus* while separated from each other in *H. septemtaeniatus* and *H. auratus* (Anderson 1999). Both *septemtaeniatus* and *transcaucasicus* exhibit an almost identical dorsal coloration and pattern by having four longitudinal dark brown stripes, breaking up into spots or disappearing on the posterior back. *Heremites auratus*, on the other hand, has two longitudinal rows of large, more or less rectangular dark spots on the dorsum. All specimens examined in the present study have parietals that are in narrow contact and thus, our specimens deviate in this character from what is typically characterized for the nominate species *septemtaeniatus* or its subspecies *transcaucasicus* (Anderson 1999: 274). Similarly, the subspecies *transcaucasicus* was described to have the prefrontals in contact so that the frontonasal does not come in contact with the frontal (Chernov 1926). On the contrary, the prefrontals are not in contact in *H. auratus* (Anderson 1999). Arrangement of prefrontals is, however, variable in the specimens at hand. In PMNH 3474–76, 3518–3519, 3520–3521, 3523–3524, the prefrontals are in contact and thus prevent the contact of the frontonasal with the frontal. On the other hand, PMNH 3522, 3477–3478, and ZFMK-H 9064 exhibit prefrontals which are separated so that frontonasal comes in contact with the frontal.

The disjunct distribution pattern of our *H. septemtaeniatus* together with its morphological differences from the known forms of the genus necessitate further research.

It will be especially challenging to study DNA data to find out if the most probably isolated Hindu Kush population of *Heremites* has a relict distribution or even it belongs to an unknown taxon.

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Appendix 1.

Material used for the morphological comparison of *Heremites septemtaeniatus* from Iran (Faizi & Rastegar-Pouyani 2006).

Heremites s. transcaucasicus

RUZM 001–005, West Azarbaijan Province, vicinity of Turkey border, Ghotur on the road between Lighwan and Sefideh khan (38.5833°N, 45.0333°E); RUZM 006–009, West Azarbaijan, Bukan, on the road to Mahabad (36.5333°N, 46.1666°E); RUZM

010–013, Kurdistan Province, Baneh, on the road to Saghez (35.9666°N, 35.9666°E); RUZM 014–020, Kurdistan Province, Marivan, on the road to Saghez (Sarshiv road), 35.3666°N, 45.2333°E); RUZM 021–029, Kurdistan Province, Sarvabad, (35.2833°N, 46.3500°E); RUZM 030–034, Kermanshah Province, on the road to Eslam Abad-e- Gharb, (34.3166°N, 47.1166°E); RUZM 035–039, Kermanshah Province, on the road to Paveh, Kawat, (34.9166°N, 46.4500°E).

Heremites s. septemtaeniatus

MMTT 1704, Khuzestan Province, Izeh; MMTT 1705, Khuzestan Province, East coast of Dez river; MMTT 1757, Khuzestan Province, Izeh; RUZM 050, Fars Province, Firouz Abad; MMTT 1841, Khuzestan, Ramhormoz; MMTT 1874, Khuzestan, Darkhuvin; MMTT 2116, Khuzestan, 20 Km S.W. Izeh; RUZM 051–52, Fars Province, Dashte Arjan.

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RESEARCH ARTICLE

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Describing the hidden species diversity of *Chaetozone* (Annelida, Cirratulidae) in the Norwegian Sea using morphological and molecular diagnostics

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Abstract

Using molecular markers and species delimitation analyses, a high diversity of bi-tentaculate Cirratulidae was discovered from the North-East Atlantic. Five new species are described: *Chaetozone pseudosetosa* **sp. nov.**, *Chaetozone quinta* **sp. nov.**, *Chaetozone barentsensis* **sp. nov.**, *Chaetozone monteverdii* **sp. nov.**, and *Chaetozone chambersae* **sp. nov.** Several morphogroups are also described, even though the presence of cryptic diversity prevented naming of individual species. For each species presented, a molecular diagnostic is given from the universal barcode COI and, when available, the D1–D2 domains of the 28S rRNA. This increases the number of species in *Chaetozone* in northern European waters from ten to at least 17 species, the exact number of species remaining uncertain as taxonomic issues with older names remain unresolved.

Keywords

Continental shelf, cryptic species, integrative taxonomy, new species, North-East Atlantic, Norway, polychaetes

Introduction

Marine benthic environments in the North Sea and shelf areas in the Norwegian Sea are said to be among the best-studied areas in the world (Nygren et al. 2018). However, recent biodiversity surveys and projects aiming at mapping species occurrences, and environmental monitoring have shown that there is still more to explore and surprises to be unveiled. New species are still being discovered and described (Kongsrud et al. 2011; Nygren and Pleijel 2011; Bakken et al. 2014; Nygren et al. 2018; Capa et al. 2019), and studies of faunal characteristics (Oug et al. 2017) and distribution patterns (Eilertsen et al. 2018) show novelties not previously reported.

Polychaete worms belonging to Cirratulidae Ryckholt, 1851 are common in a diversity of marine substrates and can reach high densities, as high as up to 10.000 specimens per m^2 in quantitative samples (Hily 1987). Therefore, they are of ecological importance and among the frequently encountered organisms in environmental monitoring. However, they show few intra-specific morphological differences and, because of this, they are known to be a taxonomic challenge and difficult to identify (e.g., Blake 1996, 2018).

The genus *Chaetozone* Malmgren, 1867, according to the latest diagnosis, is characterised, among other features, by having prominent acicular spines in noto- and neuropodia that in posterior segments arise in fascicles from elevated podial lobes or membranes that in some species almost encircle the posterior segments (Blake 2019). In Europe, a total of ten *Chaetozone* species have been reported: *C. setosa* Malmgren, 1867; *C. caputesocis* (Saint-Joseph, 1894); *C. carpenteri* McIntosh, 1911; *C. zetlandica* McIntosh, 1911; *C. corona* Berkeley & Berkeley, 1941; *C. vivipara* Christie, 1984; *C. gibber* Woodham & Chambers, 1994; *C. christiei* Chambers, 2000; *C. jubata* Chambers & Woodham, 2003; *C. elakata* Blake & Lavesque, 2017. However, the identity and generic position of some of these species (e.g., *C. caputesocis*, *C. zetlandica* and *C. vivipara*) need to be assessed, as descriptions are vague (Petersen 1999; Blake and Lavesque 2017; Le Garrec et al. 2017).

In biodiversity assessments and monitoring surveys, Norwegian *Chaetozone* specimens are mainly sorted into four lots, named *C. setosa*, *C. jubata*, *C. christiei*, and *C. zetlandica*. But a recent study, aiming to address the species diversity of bi-tentaculate cirratulids, combining morphological examination and species delimitation analyses of DNA sequence data of the North-East Atlantic showed that total species richness had been overlooked (Grosse et al. 2020). A total of 14 *Chaetozone* species (Fig. 1), understood to be separately evolving metapopulation lineages (De Queiroz 2007), was recovered (Grosse et al. 2020). Three different scenarios for these recovered species based on DNA sequence data were identified: 1) species that unequivocally matched the diagnosis of a nominal species (like the case of *Chaetozone setosa*); 2) species that matched the diagnosis of a species complex (e.g., *C. zetlandica*); 3) species that did not match any of the currently available *Chaetozone* species or species complex diagnoses, suggesting they are undescribed.

We provide a molecular diagnosis for each species/species complex/morphogroup as several of the species presented are, at least for now, only distinguishable through DNA analyses. Molecular diagnostic characters allow the description of cryptic species in the absence of observable morphological diagnostic characters (Churchill et al. 2014; Delić et al. 2017; Teixeira et al. 2020). This is important when we know that many species discovered through molecular species delimitation analyses remain undescribed and thus unavailable for further studies (Pante et al. 2015).

In this study, we describe five new species: *Chaetozone pseudosetosa* sp. nov., *Chaetozone quinta* sp. nov., *Chaetozone barentsensis* sp. nov., *Chaetozone monteverdii* sp. nov. and *Chaetozone chambersae* sp. nov. We also describe three morphogroups, containing cryptic species and/or that cannot be linked to an existing name or described as new species as yet.

Material and methods

Material examined, study area and morphological observations

Nearly 100 specimens were examined in detail, and morphological comparisons were made between them and with descriptions in the literature. Most specimens have DNA vouchers previously assigned to species via DNA analyses (Grosse et al. 2020). The molecular species assignments (Fig. 1) were used as a fixed reference to differentiate between intra- and inter-specific variations in morphological characters. Most specimens were stained with Shirlastain A solution (SDL International LTD), and some of them with methylene blue. Selected specimens were examined by SEM at the University of Bergen, Norway. For morphological observations, specimens were studied with stereo and compound microscopes. Not all species recovered by Grosse et al. (2020) are formally described here, as for some species not enough specimens were available (and/or in good enough condition) to produce a description.

Specimens used in this study are deposited in the collections of the University Museum of Bergen, University of Bergen (**ZMBN**) and NTNU University Museum (**NTNU-VM**) (Bakken et al. 2020). Specimens are mainly from cruises and surveys covering areas in the Barents Sea, the Norwegian coast and shelf, the North Sea, and the Skagerrak. Several of these surveys are from projects studying polychaete diversity such as POLYSKAG (polychaetes in coastal waters of Skagerrak), BIOSKAG 2 (deep environments of the Skagerrak), PolyNor (polychaetes in the Norwegian Sea), PolyPort (polychaetes in Norwegian harbours), UNIS 2007 and UNIS 2015 (University Center in Svalbard) cruises, and monitoring surveys along the Norwegian coastline. Type specimens were made available by the Swedish Natural History Museum (**SMNH**), the National Museums of Scotland (**NMSZ**), and the British Museum (Natural History, **BMNH**).

Molecular information

The datasets were the same as the complete *Chaetozone* COI and 28S datasets of Grosse et al. (2020). The list of specimens with GenBank accession numbers are available in Suppl. material 1. Alignments of COI and 28S sequences are available in Fasta format as Suppl. materials 2, 3 respectively. Acquisition of DNA sequences was as follows: several parapodia, a few branchiae or the posterior segments were removed for DNA extraction from 306 specimens. Tissue samples from 95 specimens were sent to the Canadian Center for DNA Barcoding, Biodiversity Institute of Ontario, University of

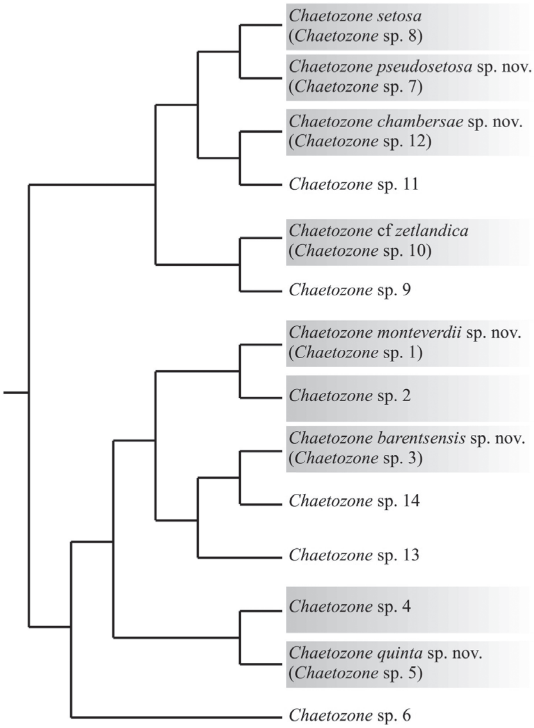

Figure 1. Cladogram of the different species present in Norway, after Grosse et al. (2020). The species treated in this paper are highlighted in grey.

Guelph, Guelph, Ontario, for sequencing forward and reverse strands with the primer pairs polyLCO/polyHCO or ZplankF1_t1/ZplankR1_t1 (Table 1). Tissue samples from another 211 specimens were processed at the NTNU University Museum as follows. Tissues were placed into 50 µL of QuickExtract (Epicentre) and heated at 65 °C for 60 minutes followed by 3 minutes at 95 °C in a thermo-shaker at 300 rpm. These DNA extractions were diluted in 200 µL of elution buffer (10 mM Tris-Cl, pH 8.5). Amplification of the target DNA fragments was done by Polymerase Chain Reaction (PCR). PCR mixtures contained 1.4 µL of DNA template, 0.30 µL of each primer, and 10 µL of RedTaq 1.1× MasterMix 2.0 mM MgCl2 (VWR) for a final reaction volume of 12 µL. The different pairs of primers used (jgLCO1490/jgHCO2198, CirrCOIF/CirrCOIR, or polyLCO/polyHCO for COI; and 28SC1'/28SD2 for 28S) and the PCR thermal cycling profiles are shown in Table 1. 1.5 µL of each PCR product was run for 45 minutes on a 1% agarose gel electrophoresis containing SYBR safe (Invitrogen) for DNA detection and visualised using GeneSnap from SynGene software (Version 6.08, Cambridge, UK). PCR products providing neat bands of expected size were purified with illustra ExoProStar 1-Step (GE Healthcare, Litlle Chalfont, UK). Cycle sequencing was performed on both strands by Eurofins Genomics DNA Sequencing Department (Ebersberg, Germany). Forward and reverse reads were merged into consensus sequences using Geneious 11.0.5 (https://www.geneious.com).

Table 1. PCR Primers: The different primer pairs used to amplify the markers used in this study and their respective cycles.

Region	Name	Length	Source	Sequence 5'-3'		Cycle
COI	jgLCO1490	~650 bp	(Geller et al. 2013)	TITCIACIAAYCAYAARGAYATTGG	34x	3 min 96 °C
	jgHCO2198		(Geller et al. 2013)	TAIACYTCIGGRTGICCRAARAAYCA		60 s 95 °C
						60 s 48 °C
						60 s 72 °C
						6 min 72 °C
	CirrCO1F	~650 bp	(Weidhase et al. 2016)	TTTTTCTACTAACCATAAAGACATTG	34x	60 s 96 °C
	CirrCO1R		(Weidhase et al. 2016)	CCGAGGAAGTGTTGAGGGA		60 s 94 °C
						60 s 53 °C
						60 s 72 °C
						5 min 72 °C
	polyLCO	~650 bp	(Carr et al. 2011)	GAYTATWTTCAACAAATCATAAAG	5x	60 s 96 °C
	polyHCO		(Carr et al. 2011)	TAMACTTCWGGGTGACCAAARAATCA		40 s 95 °C
						40 s 46 °C
						60 s 72 °C
					35x	40 s 94 °C
						40 s 51 °C
						60 s 72 °C
						7 min 72 °C
	ZplankF1_t1	~650 bp	(Prosser et al. 2013)	tTCTASWAATCATAARGATATTG	29x	60 s 95 °C
	ZplankR1_t1		(Prosser et al. 2013)	TTCAGGRTGRCCRAARAATCA		40 s 94 °C
						40 s 51 °C
						60 s 72 °C
						5 min 72 °C
28S	28SC1	D1-D2	(Le et al. 1993)	ACCCGCTGAATTTAAGCAT	29x	60 s 96 °C
	28SD2	~750 bp	(Le et al. 1993)	TCCGTGTTTCAAGACGG		30 s 95 °C
						60 s 62 °C
						60 s 72 °C
						7 min 72 °C

COI sequences were aligned using MUSCLE (Edgar 2004) implemented in Aliview 1.25 (Larsson 2014). 28S D1-D2 sequences were aligned with MAFFT 7 online version (Katoh et al. 2017) with the algorithm Q-INS-i, that considers the secondary structure of RNA, using the 200PAM/k=2 scoring matrix and a gap penalty of 1.53. The COI and 28S alignments are available in Suppl. materials 2, 3 respectively. COI p-distances were calculated using MEGA 10.0.5 (Kumar et al. 2018).

The online version of DeSignate (Hütter et al. 2020) was used to find diagnostic molecular characters for each species. Diagnostic characters for a species are defined as positions in the alignments where the nucleotides of this species are uniform, but different from the rest of the species in the alignment (Davis and Nixon 1992; DeSalle et al. 2005). DeSignate is able to find two types of diagnostic characters: single positions, or a duo of positions that are diagnostic as a combination but not individually. The positions in this duo, called combined characters by the software's authors, can be separated by a number of other positions. We chose to select only combined characters made by adjacent positions, which are in effect a short sequence of two bases. Therefore, a k-window of 2 was used for both datasets. For each species, the positions given for diagnostic characters are that of the alignments given in Supplementary Material 2 (COI) and 3 (28S).

Systematic account

Genus *Chaetozone* Malmgren, 1867

Chaetozone Malmgren, 1867: 96; Chambers 2000: 589–591; Blake 2015: 504–507; Blake 2018: 69; Blake 2019: 170–171.

Type species. *Chaetozone setosa* Malmgren, 1867 by monotypy.

Diagnosis (emended). Prostomium blunt to conical, peristomium short to elongate, usually lacking eyespots, with a pair of small nuchal slits or depressions at posterior edge; with a single pair of grooved dorsal tentacles arising from posterior edge of peristomium, or sometimes more posterior on an achaetous anterior segment, or rarely an anterior chaetiger. First pair of branchiae arising from an achaetous segment or chaetiger 1; or sometimes with first two pairs of branchiae on a single anterior segment. Branchiae laterally ciliated in distal half. Body usually expanded anteriorly, rarely with middle or posterior body segments beaded or moniliform; narrowing posteriorly or posterior end often expanded. Chaetae include capillaries on most chaetigers and sigmoid acicular spines in neuropodia and notopodia; capillary chaetae typically smooth or with sparse to dense fibrillation, fibrils generally homogeneously spread or grouped on one side of the blade, rarely arranged in concentric rings; some species with long, natatory-like capillaries, sometimes limited to gravid individuals; spines typically concentrated in posterior segments, forming distinct cinctures with spines carried on elevated membranes; cinctures with few to many spines sometimes encircling entire individual posterior segments, accompanied with none to many alternating capillaries; bidentate spines sometimes present in juveniles or occasionally accompanying unidentate spines in ventral most position of far posterior chaetigers of adults. Pygidium a simple lobe, disk-like, or with long, terminal cirrus.

Remarks. Based on observations from SEM images from several species in this study, the presence of cilia on the branchiae (Fig. 2) is added to the previously emended diagnosis (Blake 2019).

Chaetozone setosa Malmgren, 1867

Figures 3, 4

Chaetozone setosa Malmgren, 1867: 96, Pl. 14, fig. 84 (in part); Petersen 1999: 111; Chambers 2000: 589–591, fig. 1 (in part); Blake 2015: 504–507, figs 1, 2.
Chaetozone sp. 8 Grosse et al. 2020: fig. 4.

Type locality. Isfjord, Svalbard, Norway, 55 m depth.

Material examined. ***Lectotype*:** Svalbard • 1 ind.; Isfjord; 06 Jun. 1864; 55 m; SMNH 1493-03. ***Paralectotypes*:** Svalbard • 172 ind.; same data as for holotype; SMNH 1493-04–175. **Other material examined.** Svalbard • 7 ind.; 78.14872°N, 13.12559°E; 13 May 2015; 243 m; ZMBN125766–125769, 125837–125838, 129637; • 2 ind.;

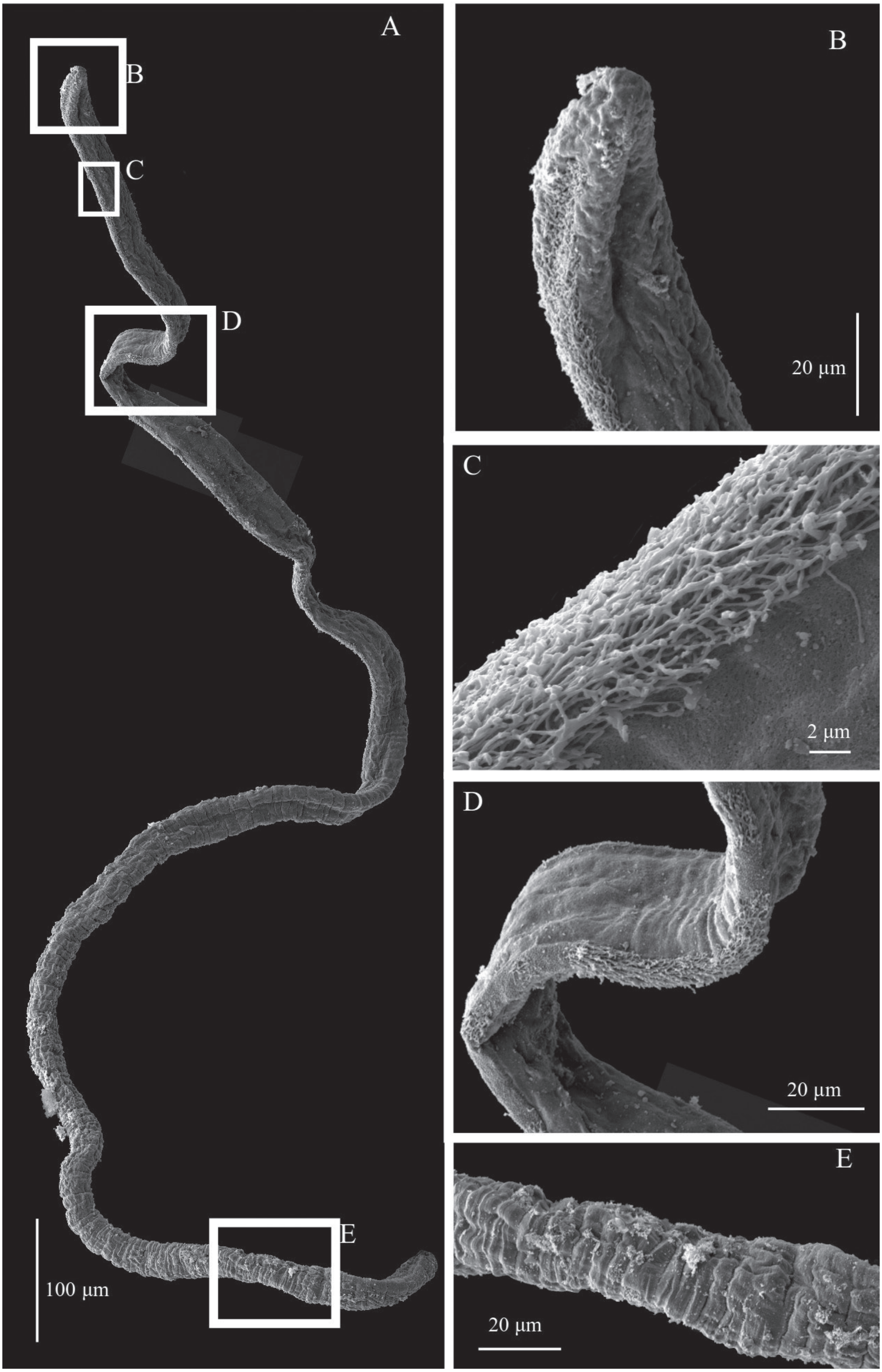

Figure 2. SEM of branchial anatomy, specimen ZMBN125776 (*Chaetozone* sp. 4) **A** whole branchia **B** detail of distal end **C** detail of lateral cilia **D** detail of distal half morphology **E** detail of proximal half morphology.

79.55130°N, 11.22970°E; 30 Aug. 2007; 91 m; ZMBN125815–125816 • 2 ind.; 78.32855°N, 15.14712°E; 07 May 2015; 266 m; ZMBN125811, ZMBN125813 • 2 ind.; 79.70829°N, 18.17362°E; 10 May 2015; 407 m; ZMBN125817–125818 • 1 ind.; 79.68089°N, 11.13989°E; 09 May 2015; 180 m; ZMBN125770 • 1 ind.; 79.58854°N, 18.63483°E; 10 May 2015; 242 m; ZMBN125812. – Barents Sea • 1 ind.; 71.61528°N, 32.99719°E; 9 Aug. 2013; 305 m; ZMBN125764.

Diagnosis. Peristomium with two large distinct annulations and dorsal crest; dorsal tentacles on posterior margin of peristomium; first pair of branchiae on distinct segment 1 (achaetous); posterior segments developed in full cinctures with up to 20–26 spines per parapodia (Figs 3, 4) (based on Blake 2015).

Molecular diagnosis. COI: 220: G. 28S: 545–546: AC (based on 36 COI sequences and 19 28S sequences).

Distribution. Barents Sea, Svalbard, White Sea, ~ 80–400 m depth.

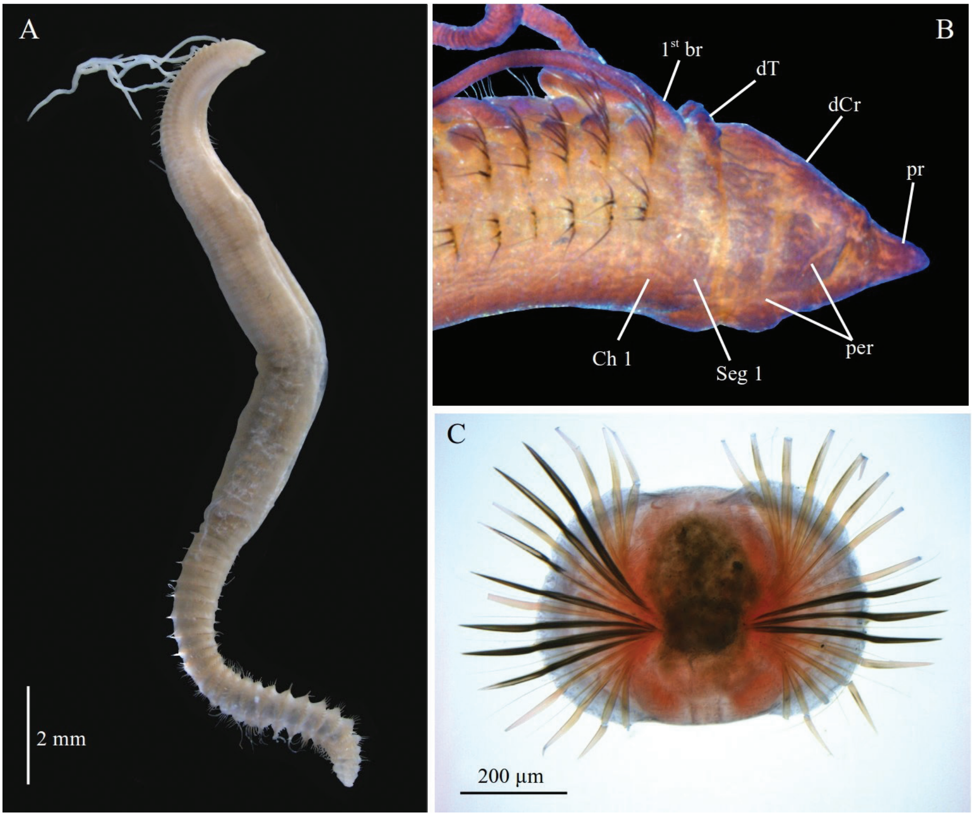

Figure 3. *Chaetozone setosa* **A** lectotype SMNH 1493-03, in lateral view **B** paralectotype SMNH 1493-04–175, anterior end in lateral view, stained with Shirlastain A **C** paralectotype SMNH 1493-04–175, cross section of modified posterior segments. Abbreviations: br, branchiae; Ch, chaetiger; dCr, dorsal crest; dT, dorsal tentacle; per, peristomium; pr, prostomium; Seg, segment.

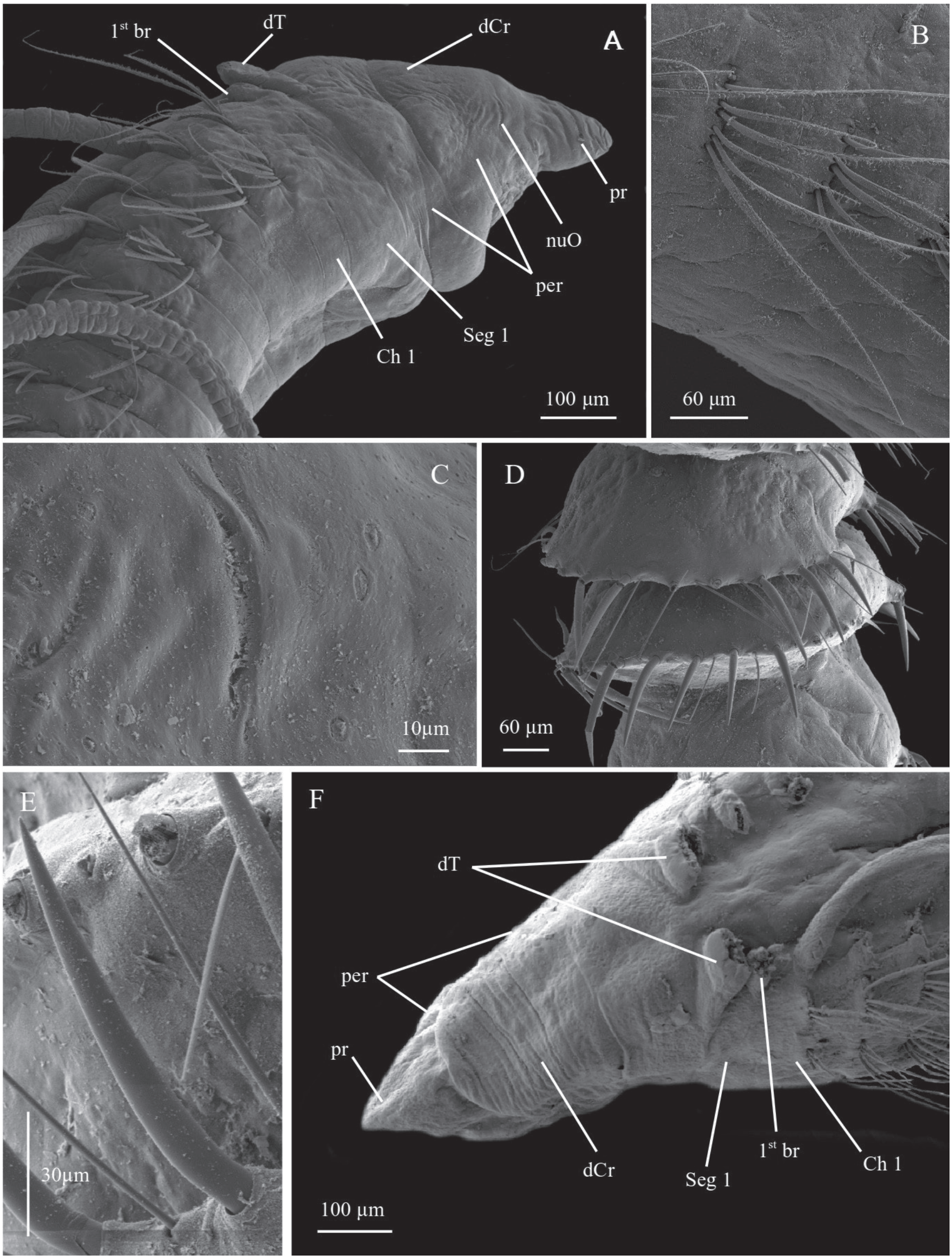

Figure 4. *Chaetozone setosa* **A** ZMBN125817, SEM of anterior end in lateral view **B** ZMBN125768, SEM of anterior neuropodia in lateral view **C** ZMBN125817, SEM of nuchal organ, specimen **D** SEM of posterior cinctures in lateral view, specimen ZMBN125817 **E** ZMBN125817, SEM of neuropodial spine **F** ZMBN129637, SEM of anterior end in dorsal view. Abbreviations: br, branchiae; Ch, chaetiger; dCr, dorsal crest; dT, dorsal tentacle; per, peristomium; pr, prostomium; Seg, segment.

Remarks. A lectotype (Fig. 3A) and 172 paralectotypes from Svalbard were designated by Petersen (1999), from which a thorough redescription and illustrations were provided by Blake (2015). As many early described polychaete species, *C. setosa* has been reported from all around the world (Chambers 2000; Oug et al. 2014), before being restricted to the Arctic and subarctic areas in northern Europe (Blake 2015), which corresponds to the area covered by Malmgren's type series: Spitsbergen (Svalbard), Finnmark (northern Norway) and Bohüslan (western Sweden). Specimens were recently collected from the type locality in Svalbard, as well as other areas along Northern Europe, including from the localities given in Malmgren. Genetic analyses revealed the presence of two distinct, yet morphologically identical species (Fig. 1): one present in Svalbard, the Barents Sea, and the White Sea (Fig. 1; *Chaetozone* sp. 8), and the other present in the Norwegian Sea, the North Sea, and the Skagerrak (Fig. 1; *Chaetozone* sp. 7) (Grosse et al. 2020). The former species included specimens collected at the type locality of *C. setosa*, consequently interpreted as members of the type species of *Chaetozone*. The other one is described herein and named *C. pseudosetosa* sp. nov. This species is morphologically identical to *Chaetozone pseudosetosa* sp. nov., described below. Methylene blue stains the peristomium with transversal bands of varying intensity, as well as anterior segments and posterior cinctures also with transversal bands, mostly ventrally (Blake 2015). *Chaetozone pseudosetosa* sp. nov. shows a similar pattern. Genetic distance in the COI marker between *Chaetozone setosa* and other congeners in the area mostly ranges from 20% to 25%, except for a minimum of 8% divergence with *C. pseudosetosa* sp. nov. (Table 2).

***Chaetozone pseudosetosa* sp. nov.**

http://zoobank.org/8CAA7808-CB69-4983-874D-19A5FF982EFF
Figures 5, 6

Chaetozone sp. 7 Grosse et al. 2020: fig. 4.

Type locality. Drøbak, Oslofjorden, south of Storskjær, Norway, 31 m depth.

Material examined. ***Holotype*:** Oslofjorden, Norway • 59.6562°N, 10.6081°E; 20 Oct. 2014; 31 m; ZMBN125756. ***Paratypes*:** Oslofjorden, Norway • 3 ind.; 59.6444°N, 10.6192°E; 21 Oct. 2014; 106 m; NTNU- VM74516–74518 • 1 ind.; 59.05485°N, 10.250467°E; 29 May 2011; 70 m; NTNU-VM74514 • 1 ind.; 59.89017°N, 10.75551°E; 20 Sep. 2018; 12 m; NTNU-VM76534 • 1 ind.; 59.89731°N, 10.73703°E; 20 Sep. 2018; 8 m; NTNU-VM76547. – North Sea • 1 ind.; 59.28789°N, 5.32506°E; 08 Jun. 2014; 76 m; ZMBN125790 • 1 ind.; 59.02985°N, 5.44881°E; 10 Jun. 2014; 59 m; ZMBN125789 • 3 ind.; 60.269686°N, 5.197750°E; 26 Jul. 2014; 120 m; NTNU-VM74525–74526, 74528 • 1 ind.; 59.76022°N, 5.49682°E; 08 Jun. 2014; 40 m; ZMBN125787 • 1 ind.; 60.90389°N, 7.16813°E; 17 Nov. 2012; 115 m; ZMBN125795 • 1 ind.; 58.24753°N, 6.53673°E; 03 Feb. 2016; 155 m; ZMBN125824 • 1 ind.; 60.60332°N, 5.09513°E; 6 Mar. 2017; 94 m;

Table 2. COI p-distances between and within Norwegian *Chaetozone* species. The number of base differences per site from averaging over all sequence pairs within each group are shown. Species described and discussed in this paper are denoted with an “°”.

	***Chaetozone monteverdii* sp. nov.° (*Chaetozone* sp. 1)**	***Chaetozone* sp. 2°**	***Chaetozone barentsensis*° (*Chaetozone* sp. 3)**	***Chaetozone* sp. 4°**	***Chaetozone quinta*° (*Chaetozone* sp. 5)**	***Chaetozone pseudosetosa* sp. nov.° (*Chaetozone* sp. 7)**	***Chaetozone setosa*° (*Chaetozone* sp. 8)**	***Chaetozone* sp. 9°**	***Chaetozone cf zetlandica*° (*Chaetozone* sp. 10)**	***Chaetozone* sp. 11**	***Chaetozone chambersae* sp. nov.° (*Chaetozone* sp. 12)**	***Chaetozone* sp. 13**	***Chaetozone* sp. 14**
Chaetozone monteverdii sp. nov.° (*Chaetozone* sp. 1)	0.0019	0.2372	0.2470	0.2677	0.2532	0.2572	0.2452	0.2400	0.2350	0.2268	0.2194	0.2343	0.2557
Chaetozone sp. 2°	0.2372	0.0048	0.2627	0.2674	0.2840	0.2718	0.2625	0.2667	0.2669	0.2466	0.2447	0.2444	0.2737
Chaetozone barentsensis° (*Chaetozone* sp. 3)"	0.2470	0.2627	0	0.2356	0.2364	0.2490	0.2328	0.2559	0.2508	0.2459	0.2389	0.1587	0.0953
Chaetozone sp. 4°	0.2677	0.2674	0.2356	0.0015	0.0950	0.2705	0.2594	0.2472	0.2405	0.2457	0.2410	0.2496	0.2353
Chaetozone quinta° (*Chaetozone* sp. 5)	0.2532	0.2840	0.2364	0.0950	0	0.2553	0.2620	0.2458	0.2314	0.2568	0.2585	0.2508	0.2379
Chaetozone pseudosetosa sp. nov.° (*Chaetozone* sp. 7)	0.2572	0.2718	0.2490	0.2705	0.2553	0.011	0.0889	0.2090	0.2079	0.1737	0.1889	0.2299	0.2556
Chaetozone setosa° (*Chaetozone* sp. 8)	0.2452	0.2625	0.2328	0.2594	0.2620	0.0889	0.004	0.2045	0.2041	0.1701	0.1949	0.2214	0.2369
Chaetozone sp. 9	0.2400	0.2667	0.2559	0.2472	0.2458	0.2090	0.2045	0.0033	0.1069	0.1931	0.1988	0.2486	0.2553
Chaetozone cf *zetlandica*° (*Chaetozone* sp. 10)	0.2350	0.2669	0.2508	0.2405	0.2314	0.2079	0.2041	0.1069	0.0014	0.1994	0.1994	0.2492	0.2581
Chaetozone sp. 11	0.2268	0.2466	0.2459	0.2457	0.2568	0.1737	0.1701	0.1931	0.1994	0.0061	0.1088	0.2219	0.2594
Chaetozone chambersae sp. nov.° (*Chaetozone* sp. 12)	0.2194	0.2447	0.2389	0.2410	0.2585	0.1889	0.1949	0.1988	0.1994	0.1088	0.0053	0.2225	0.2463
Chaetozone sp. 13	0.2343	0.2444	0.1587	0.2496	0.2508	0.2299	0.2214	0.2486	0.2492	0.2219	0.2225	0.0008	0.1694
Chaetozone sp. 14	0.2557	0.2737	0.0953	0.2353	0.2379	0.2556	0.2369	0.2553	0.2581	0.2594	0.2463	0.1694	0.0102

The number of base differences per site from averaging over all sequence pairs within each group are shown. Species described and discussed in this paper are denoted with an “°”.

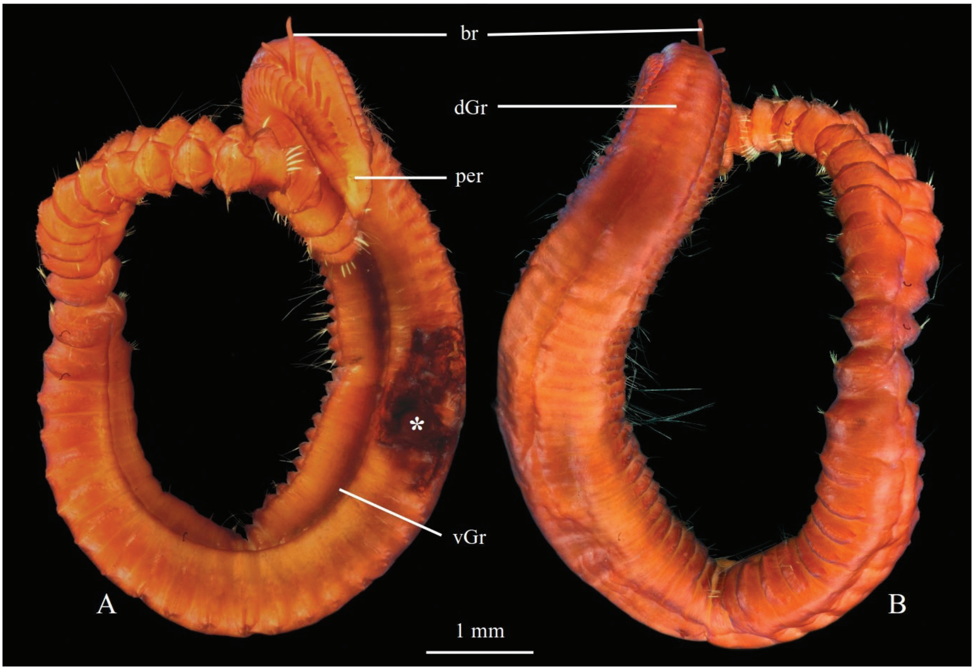

Figure 5. *Chaetozone pseudosetosa* sp. nov., holotype ZMBN125756 **A** holotype in ventral view, stained with Shirlastain A **B** holotype in dorsal view, stained with Shirlastain A. Abbreviations: br, branchiae; dGr, dorsal groove; per, peristomium; vGr, ventral groove; a star (*) indicates where parapodia were removed for DNA analyses.

ZMBN125780. – Norwegian Sea • 1 ind.; 63.44753°N, 10.62730°E; 07 Feb. 2018; 77 m; NTNU-VM74602 • 1 ind.; 63.437891°N, 10.50624°E; 04 Sep. 2018; 4 m; NTNU-VM75900. – Barents Sea • 1 ind.; 70.262°N, 31.083833°E; 16 Apr. 2014; 126 m; NTNU-VM74499. – Sweden • 2 ind.; 58.866667°N, 11.1°E; 2005; 70 m; ZMBN129641, 129647 • 2 ind.; 58.8°N, 11.1°E; Nov. 2018; 60 m; ZMBN129643, ZMBN129644.

Diagnosis. Peristomium with two large distinct annulations and dorsal crest; paired tentacles on posterior margin of peristomium; first branchiae on distinct segment 1 (achaetous); posterior segments developed in full cinctures with up to 20–26 spines per parapodia (Figs 5, 6).

Molecular diagnosis. COI: 223: C; 471–472: CA; 349–350: TT (based on 45 COI sequences).

Description. A medium to large species, holotype incomplete, with 78 segments (70–106), 16.5 mm long (12–20 mm), up to 1.2 mm wide (Fig. 5). Colour in ethanol white to light tan. Body elongate, wider in midbody segments, narrowing anteriorly and posteriorly; circular to oval in cross section. Anterior first 15–20 segments 5–6 × wider than long, progressively lengthening 3 × longer posteriorly (Fig. 5). Thin, shallow dorsal groove from segment 10–15. Distinct ventral groove along most of body (Fig. 5).

Prostomium short, long as two third of peristomium, conical to triangular, tapering to rounded anterior tip, without annulations; eyespots absent; nuchal organs as narrow slits at posterior margin of prostomium (Fig. 6A, B). Peristomium as long as wide, with two large rings of similar length, distinct laterally, weakly distinct or invisible dorsally on dorsal crest; dorsal crest little to well developed, covering all peristomium, slightly overlapping prostomium anteriorly, extending posteriorly between dorsal tentacles, up to anterior margin of chaetiger 1 (Fig. 6A, B). Dorsal tentacles arising from posterior margin of peristomium, well separated (Fig. 6A, B). First pair of branchiae arising from segment 1 (achaetous), posterior to dorsal tentacles (Fig. 6A, B). Second pair of branchiae arising from chaetiger 1, dorsally and slightly posterior to notopodia. Subsequent branchiae similarly placed. Branchiae or branchial scars on most chaetigers until development of cinctures.

Parapodia as low mounds or ridges in anterior and middle segments, progressively developing into high, elevated membranes and into complete cinctures from segment 63 (50–85) (Figs 5, 6C, F). 6–11 short capillaries per neuro- and notopodia throughout, smooth; 2–4 long natatory-like capillaries per notopodia from segment 20 or 21 to 70–72, up to 1.5 × longer than body width, smooth (Fig. 6E). 8–13 spines per neuro- and notopodia, from segment 42–54 in neuropodia and segment 46–54 in notopodia, unidentate, sigmoid, rarely slightly crossing dorsally in posterior cinctures (Fig. 6C, D, F). Alternating capillaries usually between all spines, of similar length of longer than spines.

Pygidium with terminal anus and with small rounded ventral lobe (Fig. 6G).

Methylene blue staining pattern. A moderately distinctive pattern. Methyl blue stains the peristomium lightly in transversal bands. Dorsum does not stain. Transversal lines of dark blue dots are present along anterior segments, more or less dense but never strong, not covering the whole length of the segments, creating a light stripe pattern anteriorly. Rows of dark blue dots also present on most mid and posterior parapodia, not conspicuous and only lateral in midbody segments.

Etymology. This species is named *pseudosetosa* because it looks identical to *C. setosa* and has been identified as such until now.

Remarks. Although this species is morphologically indistinguishable from *C. setosa*, it is a distinct species, and thus we felt it was important to name it. Cryptic species are important to take into account (Nygren 2014), which is difficult to do if they are not named, do not have a type, and are not diagnosed either morphologically or molecularly. In the absence of diagnostic morphological characters to distinguish it from *C. setosa*, molecular diagnostic characters can be of help (Nygren and Pleijel 2011; Parapar et al. 2020). In particular, *C. setosa* is known as a bioindicator and distinguishing between *C. setosa* and *C. pseudosetosa* sp. nov. can be important in that regard.

Chaetozone pseudosetosa sp. nov. COI distance with other species in the area mostly ranges from 20% to 25%, with a minimum of 8% with *Chaetozone setosa* (Table 2).

Distribution. Norwegian coast and shelf, Skagerrak, North Sea, 4–160 m depth. One specimen is recorded from Finnmark, which means it may be sympatric with *C. setosa* in this area.

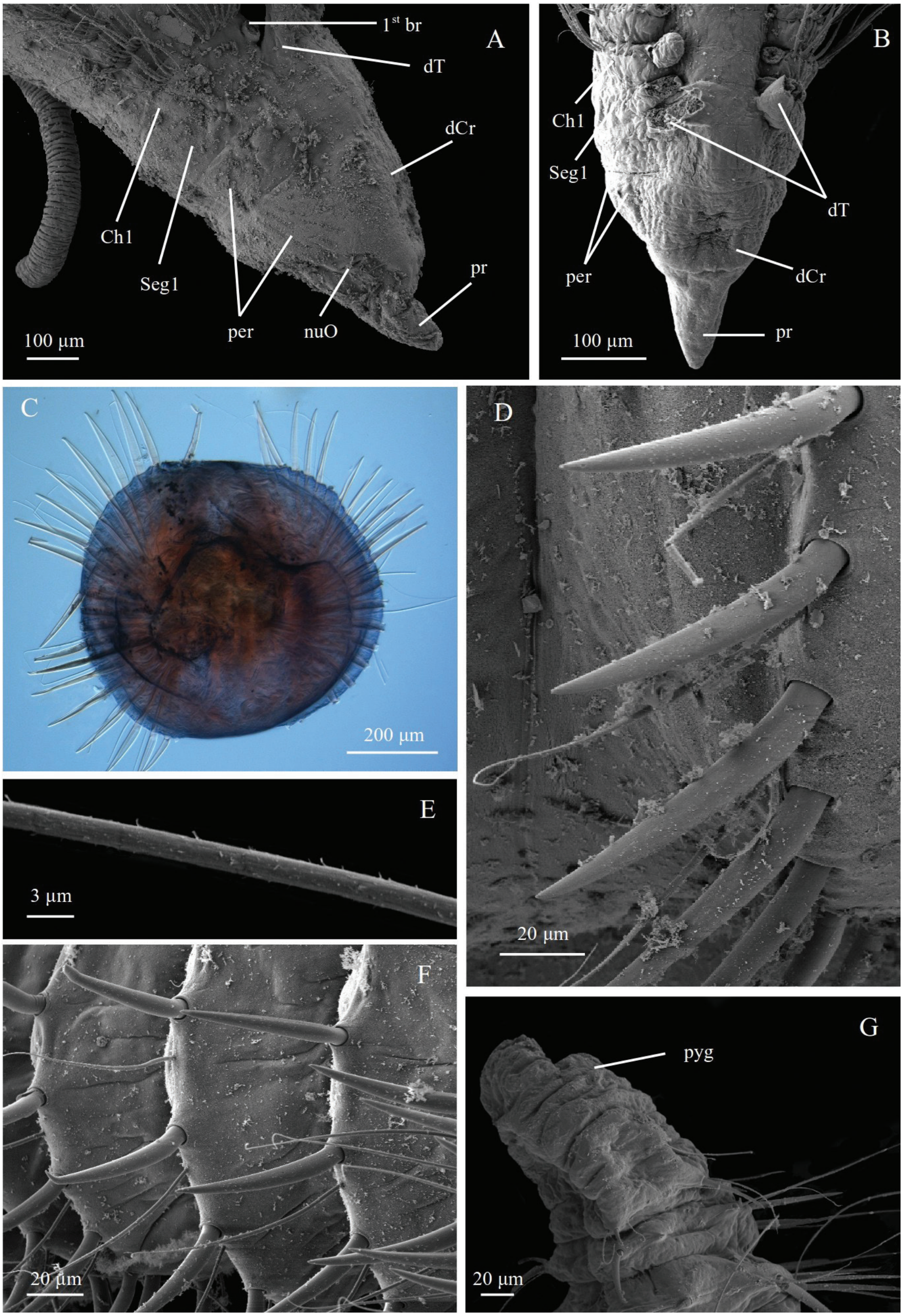

Figure 6. *Chaetozone pseudosetosa* sp. nov. **A** paratype ZMBN125780, SEM of anterior end in lateral view **B** paratype ZMBN129644, SEM of anterior end in dorsal view **C** paratype NTNU-VM74602, cross section of posterior segment **D** paratype ZMBN125780, SEM neuropodial spines **E** paratype ZMBN129644, SEM of notopodial capillary **F** Paratype ZMBN129644, SEM of posterior neuropodia **G** paratype ZMBN129643, SEM of pygidium. Abbreviations: br, branchiae; Ch, chaetiger; dCr, dorsal crest; dT, dorsal tentacle; nuO, nuchal organ; per, peristomium; pr, prostomium; pyg, pygidium; Seg, segment.

***Chaetozone quinta* sp. nov.**

http://zoobank.org/12A6B992-A58C-42C5-9F71-5F6FCC3DD350
Figure 7

Chaetozone sp. 5 Grosse et al. 2020: fig. 4.

Type locality. Søra Kjerringasundet, east of Sotra, Bergen, 75 m depth.

Material examined. ***Holotype*:** North Sea • 1 ind.; 60.32652°N, 5.14085°E; 02 Sep. 2014; 75 m; ZMBN125802. ***Paratypes*:** North Sea • 1 ind.; 61.04889°N, 4.9723°E; 15 Jul. 2015; 161 m; ZMBN125777 • 1 ind.; 60.50728°N, 5.00028°E; 30 Nov. 2015; 66 m; ZMBN125807. **Other material examined.** North Sea • 3 ind.; 60.355133°N, 5.168967°E; 10 Apr. 2018; 92 m; ZMBN138610–138612.

Diagnosis. Prostomium ventrally bi-annulated; peristomium short and without annulations; wide ventral groove; paired tentacles and first branchiae on segment 1 (achaetous); posterior segments developed in incomplete cinctures bearing 9–11 spines per parapodia (Fig. 7).

Molecular diagnosis. COI: 446: T; 475: G; 539: T; 548: T; 607: G; 349–350: GG; 361–362: AG; 486–487: TA (based on 2 COI sequences).

Description. A medium species, holotype incomplete, 61–70 segments, 6–8 mm long, 0.6–1 mm wide. Colour of ethanol preserved specimens white to light tan. Body elongate, narrowing progressively anteriorly, 2–3 × wider at anterior third than at anterior end. Round in cross section anteriorly, widening progressively to a flatten oval at anterior third. Anterior segments 5 × higher and wider than long. Midbody segments 10 × wider and 5 × higher than long. Posterior segments 2.5 × higher and 3 × wider than long. Thin shallow dorsal groove, best visible anteriorly. Wide shallow ventral groove along entire body (Fig. 7C).

Prostomium longer than peristomium, conical, tapering to rounded anterior tip; with ventrally and laterally distinct posterior annulation above mouth, as long as segment 1; eyespots absent; nuchal organs simple slits at posterior margin of prostomium, above posterior annulation (Fig. 7A). Peristomium short, as long as segment 1 ventrally, as long as two segments dorsally, without annulations, overlapping with prostomium anteriorly (Fig. 7A). Dorsal tentacles arising from segment 1 (achaetous), well separated (Fig. 7A). First pair of branchiae arising from segment 1, immediately behind tentacles (Fig. 7A). Segment 1 longer than chaetiger 1, achaetous, weekly bi-annulated (Fig. 7A). Second pair of branchiae arising from chaetiger 1, dorsal and slightly posterior to parapodia (Fig. 5A). Subsequent branchiae similarly placed. Branchiae or branchial scars present on most chaetigers until development of cinctures.

Parapodia as low mounds or ridges in anterior and middle segments, developing into relatively low incomplete cinctures from segment 45–50, arising on each side but not completing over venter and dorsum. Five or six short capillaries in neuropodia throughout, in notopodia from development of spines, smooth; 5–7 medium capillaries in notopodia, from chaetigers 1–29, twice as long as neuropodial capillaries, smooth; one or two long capillaries in notopodia from segment 12 to 27–29, smooth (Fig. 7D).

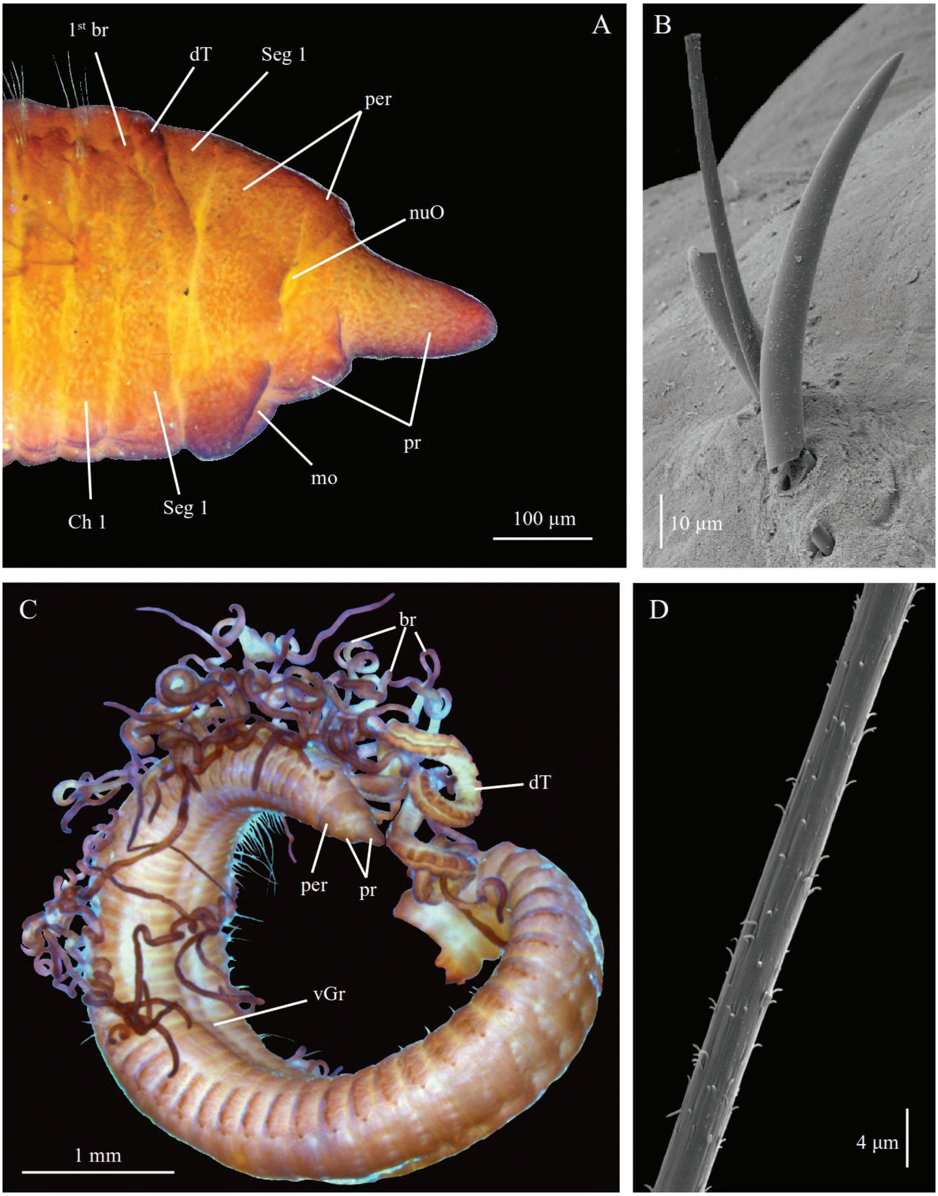

Figure 7. *Chaetozone quinta* sp. nov. **A** ZMBN138610, anterior end in lateral view, stained with Shirlastain A **B** paratype ZMBN125807, SEM of neuropodial spine **C** holotype ZMBN125802 in lateral view, stained with Shirlastain A **D** paratype ZMBN125807, SEM of capillary chaetae. Abbreviations: br, branchiae; Ch, chaetiger; dT, dorsal tentacles; mo, mouth; nuO, nuchal organ; per, peristomium; pr, prostomium; Seg, segment; vGr, ventral groove.

Five or six spines per neuropodia from segment 27–29, four or five spines per notopodia from segments 31 or 32, unidentate, short, rather spread out (Fig. 7B). Alternating capillaries between most spines except ventralmost, slightly longer than spines.

Pygidium with terminal anus and with a short, rounded ventral lobe.

Methylene blue staining pattern. Prostomium except tip, peristomium and sides of segment 1 retain a dark blue stain, while rest of body does not stain.

Etymology. *Quinta* is the cardinal adjective for fifth in the feminine nominative singular, as this species has always been "*Chaetozone* sp. 5". It is also named with a thought for a friend and colleague who is named after the same number.

Remarks. This species is easily distinguished from other species of *Chaetozone* in Norwegian waters by its distinct bi-annulated prostomium, short peristomium, and segment 1 (achaetous) bearing both tentacles and first branchiae. For other species of *Chaetozone* in the area, prostomium is always simple. The methylene blue staining pattern is also unique and easily recognisable, with most of prostomium except the distal tip, peristomium and sides of segment 1 retaining a dark blue pattern, unlike the rest of the body.

Chaetozone quinta sp. nov. COI distance with other species in the area mostly ranges from 23% to 28%, with a minimum of 9% with *Chaetozone* sp. 4 (Table 2).

Distribution. Norwegian coast and shelf, ~ 60–160 m depth.

***Chaetozone barentsensis* sp. nov.**

http://zoobank.org/5A4E27EE-59D3-48E9-9F89-2C061FCDDDDF
Figure 8

Chaetozone sp. 3 Grosse et al. 2020: fig. 4.

Type locality. Barents Sea, 337 m depth.

Material examined. ***Holotype*:** Barents Sea • 1 ind.; 71.056°N, 29.655667°E; 21 Apr. 2014; 337 m; NTNU-VM74492. ***Paratypes*:** Barents Sea • 7 ind.; 71.056°N, 29.655667°E; 21 Apr. 2014; 337 m; NTNU-VM74493–74498, ZMBN129638 • 2 ind.; 71.187833°N, 28.943167°E; 23 Apr. 2014; 380 m; NTNU-VM74489, ZMBN129639. – North Sea • 1 ind.; 60.173°N, 5.003°E; 22 Apr. 2011; 6 m; ZMBN95707.

Diagnosis. Dorsal tentacles on distinct segment 1 (achaetous); first branchiae on indistinct segment 2 (achaetous); approximately 22 short, flat spines per parapodia in posterior segments (Fig. 8).

Molecular diagnosis. COI: 158: A; 214: G; 518: A; 283–284: CT; 289–290: TA. 28S: 37: A; 419: T; 457: A; 461: A; 462: A; 510: C (based on 13 COI sequences and 3 28S sequences).

Description. A small species, holotype complete, 40–48 segments, 4–5 mm long, 0.25 mm wide (Fig. 8A). Colour in ethanol white to light grey. Body elongate, without any distinct enlargement, rather round in cross section, slightly flattened in posterior half. Anterior segments 4 × higher than long. Posterior segments 2 × higher than long. Dorsal groove over posterior half. Ventral ridge along entire body.

Prostomium as long as peristomium, 2 × longer than high, conical, without annulations; eyespots absent; nuchal organs simple slits at posterior margin of prostomium (Fig. 8B). Peristomium short, as long as two anterior segments, sometimes appears partially divided in two annulations, one anterior to mouth and one bearing

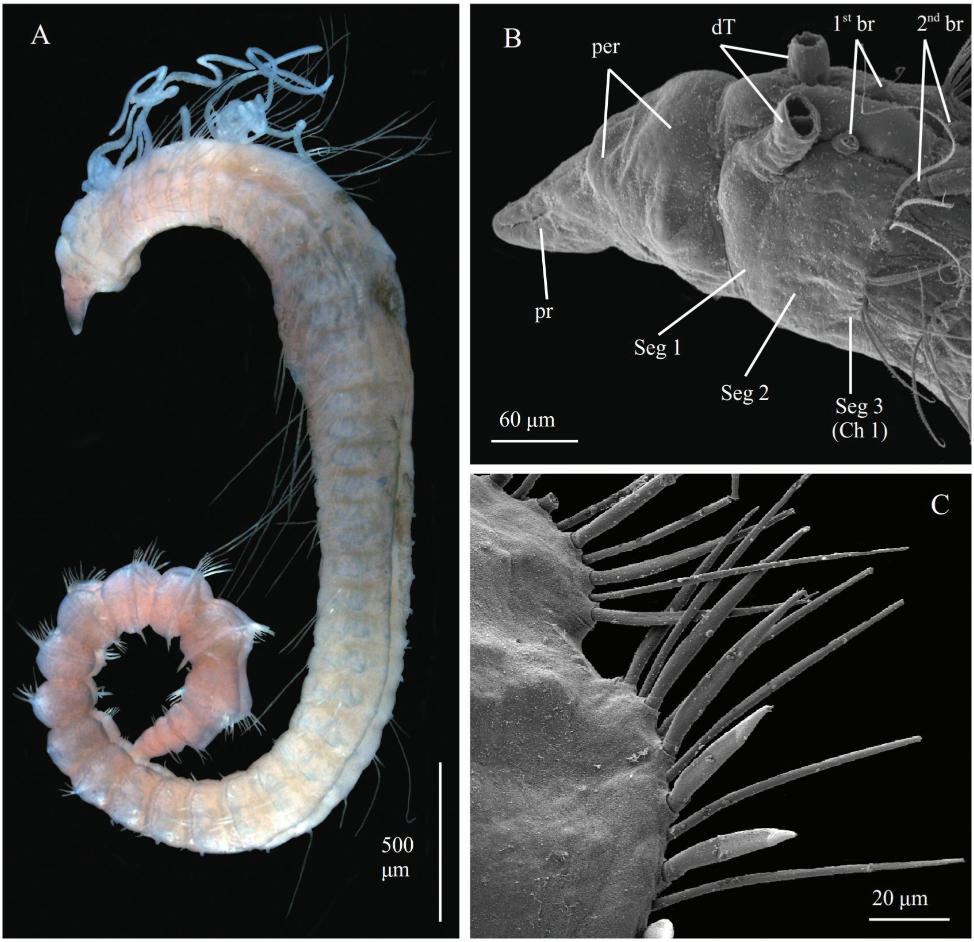

Figure 8. *Chaetozone barentsensis* sp. nov. **A** holotype NTNU-VM74492 in lateral view, stained with Shirlastain A **B** paratype ZMBN129638, SEM of anterior end in lateral view **C** paratype ZMBN129639, SEM of posterior notopodia. Abbreviations: br, branchiae; Ch, chaetiger; dT, dorsal tentacles; per, peristomium; pr, prostomium; Seg, segment.

mouth (Fig. 8B). Dorsal tentacle arising from segment 1 (achaetous), well separated. Segment 1 achaetous, distinct from peristomium (Fig. 8B). First pair of branchiae arising from segment 2 (achaetous), aligned with dorsal tentacles and second pair of branchiae (Fig. 8B). Segment 2 achaetous, often indistinct from segment 1 and chaetiger 1 (Fig. 8B). Second pair of branchiae arising from chaetiger 1, dorsal to notopodia (Fig. 8B). Subsequent branchiae similarly placed. Branchiae or branchial scars present on most chaetigers until development of cinctures.

Parapodia as low mounds or ridges in anterior and middle parts, progressively developing into elevated membrane and into complete cinctures around segment 25–37 (Fig. 8A). Thirteen smooth short capillary chaetae present in all chaetigers 2–4 long chaetae in anterior notopodia, up to several times body width. 22 spines from segment 24–28 in neuropodia and segment 25–29 in notopodia, short, slightly curved, dorsalmost spines thin and rounded in cross section, gradually flattening and widening towards most lateral positions (Fig. 8C). Alternating capillaries present between all spines, longer than spines (Fig. 6C).

Pygidium with terminal anus and with a small rounded ventral lobe.

Methylene blue staining pattern. No particular pattern. Prostomium and peristomium retains slightly more stain than rest of body.

Etymology. The name comes from the Barents Sea, where the species was found.

Remarks. *Chaetozone barentsensis* sp. nov. is similar in general appearance to *C. setosa*, which is found in the same area, although it is smaller (up to 5 mm vs. 3 cm for *C. setosa*) and differs, in particular, in the position of its tentacles which arise from the first achaetous segment vs. posterior margin of the peristomium for *C. setosa*, the presence of a ventral ridge instead of a groove, and the shape of its spines which are significantly shorter than that of *C. setosa*.

Chaetozone barentsensis sp. nov. COI distance with other species in the area mostly ranges from 23% to 26%, with a minimum of 9% with *Chaetozone* sp. 14 (Table 2).

Distribution. *Chaetozone barentsensis* sp. nov. is found in the Barents Sea, ~ 400 m depth. One specimen was found on the Norwegian coast outside Bergen at 6 m depth.

Chaetozone monteverdii **sp. nov.**

http://zoobank.org/0B70368F-1A73-41DA-8A98-DCA3F2ACAC24
Figures 9, 10

Chaetozone sp. 1 Grosse et al. 2020: fig. 4.

Type locality. Norwegian Sea, north-west of Bergen, 280 m depth.

Material examined. ***Holotype*:** Norwegian Sea • 1 ind.; 61.37705°N, 2.11215°E; 31 May 2014; 280 m; ZMBN98250. ***Paratypes*:** North Sea • 1 ind.; 59.56729°N, 5.21568°E; 26 Apr. 2017; 328 m; ZMBN125786 • 1 ind.; 62.35117°N, 6.16178°E; 21 Jul. 2012; 243 m; ZMBN125783 • 1 ind.; 60.2593°N, 5.13703°E; 13 Jun. 2017; 248 m; ZMBN116562 • 2 ind.; 59.99°N, 5.35°E; 27 Jun. 2007; 250 m; NTNU-VM74506, ZMBN129648.

Comparative material. *Chaetozone jubata*: Paratypes: Faroe-Shetland channel • 2 ind.; 61.5.57°N, 2.4093°W; Jul. 1996; 710 m; NMSZ.1999.237.4–5.

Diagnosis. Prostomium fused with peristomium, giving the anterior end a drop-like appearance; dorsal tentacles on segment 1 (achaetous), first pair of branchiae on segment 2 (achaetous); ventral ridge; long capillary chaetae on expanded anterior with fibrils arranged in distinctive transversal rows, numerous, long, broad and flat spines on high complete cinctures (Figs 9, 10).

Molecular diagnosis. COI: 97: G; 110: C; 145: C; 199: G; 232: 277: G; C; 281: G; 282:T; 356: C; 363: T, 459: T; 485: G, 515: A; 530: T; 564–565: CC, 37–38: TA. 28S: 58: A; 69: T; 440: A; 416–417: CT; 453–454: CT; 454–455: TG; 460–461: GC (based on ten COI sequences and 13 28S sequences).

Figure 9. *Chaetozone monteverdii* sp. nov., Holotype ZMBN98250 in lateral view.

Description. A large species, holotype incomplete, 56 segments (51–56), 20 mm long (14–25 mm), 1.5 mm wide. (Fig. 9). Body elongate, larger anteriorly, narrowing towards the anterior end and in posterior half, oval to flattened oval in cross section anteriorly, round in cross section posteriorly. Anterior segments narrow and crowded, 5 or 6 × higher and wider than long, lengthening and enlarging progressively after first 10–15 segments to 2 × higher than long in posterior segments. Thin, shallow dorsal groove over first 10–15 segments. Prominent ventral ridge along anterior half of body.

Prostomium as long as peristomium, conical, blunt, fused with peristomium, without annulations; eyespots absent; nuchal organs simple slits on posterior margin of prostomium (Fig. 10A). Peristomium short, as long as three segments, without

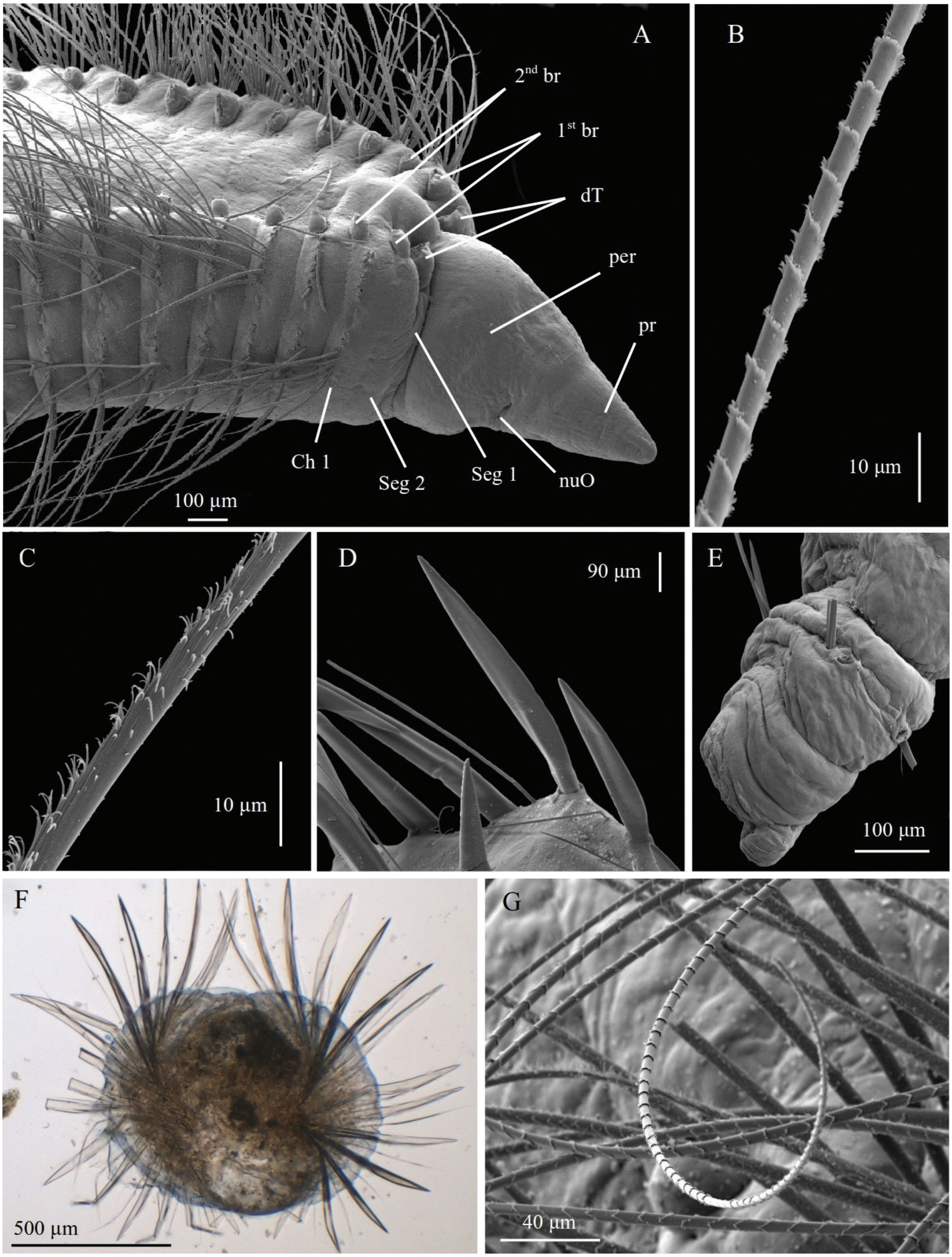

Figure 10. *Chaetozone monteverdii* sp. nov. **A** paratype ZMBN125786, SEM of anterior end in lateral view **B** paratype ZMBN125786, SEM of long segmented notopodial capillary **C** paratype ZMBN125786, SEM of smooth notopodial capillary **D** paratype ZMBN129648, SEM of notopodial spine **E** paratype ZMBN129648, SEM of pygidium in lateral view **F** paratype ZMBN116562, cross section of posterior segment **G** paratype ZMBN129648, SEM of long segmented notopodial capillary. Abbreviations: br, branchiae; Ch, chaetiger; dT, dorsal tentacles; nuO, nuchal organ; per, peristomium; pr, prostomium; Seg, segment.

annulations, overlapping segment 1 posteriorly, in large specimens much narrower than first segments giving whole head a characteristic “drop shape” clearly set off from rest of body (Fig. 10A). Dorsal tentacles on segment 1 (achaetous), well separated (Fig. 10A). Segment 1 achaetous, not completing dorsally, in large specimens, wider than peristomium but not as wide as segment 2 (achaetous) which can cover it on the side so that it is only “facing forward” (Fig. 10A). First pair of branchiae arising from segment 2 (achaetous) (Fig. 10A). Small dorsal crest over segments 1–4 in some specimens. Second pair of branchiae arising from chaetiger 1, dorsal to notopodia (Fig. 10A). Subsequent branchiae similarly placed (Fig. 8A). Branchiae or branchial scars present on most chaetigers until development of cinctures.

Parapodia as low mounds or ridges in anterior segments, progressively developing into elevated membranes and into complete cinctures around segment 38–43, with deep constrictions between the segments (Figs 9, 10F). 7–12 short capillary chaetae in anterior notopodia, approximately 12 in anterior neuropodia, smooth basally and with thin, dense fibrils along one edge from middle (Fig. 10C). Approximately seven very long capillary chaetae in notopodia from chaetiger 3 or 4 up to chaetiger 25, segmented, each segment like a cylinder diagonally cut in cross section with thin fibrils along the edge, difficult to see with light microscopy but obvious with SEM (Fig. 10B, G). 12–16 spines per neuropodia from segment 29–32, 12–14 per notopodia from segment 29–34, long, with a broad flattened elongated leaf shaped blade, slightly folded along its length, longer in notopodia, often crossing over dorsum (Fig. 10D, F). Alternating capillary chaetae between all spines, as long or shorter than spines (Fig. 10D, F).

Pygidium with terminal anus and with a small rounded ventral lobe (Fig. 10E).

Etymology. This species is named after Claudio Monteverdi, an Italian composer, author of the operatic scena ‘Il combattimento di Tancredi e Clorinda’, amongst other pieces.

Methylene blue staining pattern. No strong pattern. Some dark stained dots appear after differentiation on the pygidium, the posterior side of some parapodia, and the underside of some segments.

Remarks. The size and volume of the prostomium, peristomium and the first segments varies in some specimens, which do not exhibit the characteristic “drop-shaped” head and enlarged anterior segments shown on Figures 9, 10, or sometimes only slightly. The prostomium and peristomium are, however, always fused and the arrangement of the dorsal tentacles and first pairs of branchiae is always the same, with dorsal tentacles on segment 1 (achaetous) and first pair of branchiae on segment 2 (achaetous).

This species is similar to *C. jubata* in the general appearance, presence of long chaetae (several times the body width) along the anterior part of the body (from approximately the 2nd–4th chaetigers to approximately the 25th for both species), and the distinctive ample posterior cinctures with big characteristic leaf shaped spines. *Chaetozone jubata* was described as having the tentacular palps originating dorsally from the posterior margin of the third peristomial ring. On the two paratypes of *C. jubata* examined, the peristomial rings are difficult to distinguish and there seems to be either a last, short peristomial ring or an achaetous segment between the tentacular palps and chaetiger 1, on which no branchiae was found. In *Chaetozone mon-*

teverdii sp. nov. we interpret the tentacular palps as originating from a first achaetous segment, which is very distinct from the peristomium. *Chaetozone monteverdii* sp. nov. also differs from *C. jubata* in the nature of the long chaetae (segmented in *C. monteverdii* sp. nov.), the size of the specimens (up to 8 mm reported for *C. jubata* and 20 mm for *C. monteverdii* sp. nov.), the presence of a ventral ridge (a groove in *C. jubata*) and the number of short capillary chaetae in anterior parapodia (5–10 in *C. jubata* and 19–24 in *C. monteverdii* sp. nov.). *Chaetozone monteverdii* sp. nov. is readily distinguished from most other species of *Chaetozone* in the area by the complete fusion of prostomium and peristomium and its distinctive drop-like head shape (in most specimens), the long capillary chaetae restricted to the anterior part of the body, and the amplitude of the posterior cinctures, along with the size and number of spines fully or nearly encircling them. However, it is very similar to *Chaetozone* sp. 2 and *Chaetozone* sp. 4 (in this paper), from which it is so far only distinguished by the nature of the long capillary chaetae, which present fibrils arranged in transversal rows unique to this species, and the presence of a ventral ridge instead of a ventral groove. *Chaetozone monteverdii* sp. nov., *Chaetozone* sp. 2, and *Chaetozone* sp. 4 are all found in the same geographic area (Norwegian coast and shelf) and in the same range of depths (~ 200–600 m).

Chaetozone monteverdii sp. nov. COI distance with other species in the area ranges from 22% to 26% (Table 2).

Distribution. Norwegian coast and shelf, offshore and in the fjords, south of the Trondheimsfjord, ~ 200–300 m depth.

Chaetozone chambersae sp. nov.

http://zoobank.org/F973A1E3-5203-40B4-8C7B-173620CFA091
Figure 11

Chaetozone sp. 12 Grosse et al. 2020: fig. 4.

Material examined. ***Holotype*:** North Sea • 1 ind.; 58.274250°N, 2.644216°W; 18 Jul. 2008; 56 m; NTNU-VM74546. ***Paratypes*:** North Sea • 3 ind.; 51.354333°N, 2.796667°E; 14 Sep. 2010; 22 m; NTNU-VM74486–74487, ZMBN129642 • 1 ind.; 57.777177°N, 2.905357°W; 17 Jul. 2008; 37 m; NTNU-VM74537 • 1 ind.; 51.352833°N, 2.862°E; 14 Sep. 2010; 18.9 m; NTNU-VM74483 • 1 ind.; 51.3575°N, 2.8041°E; 14 Sep. 2010; 21.5 m; NTNU-VM74485.

Comparative material. *Chaetozone christiei*: Holotype: North Sea • 1 ind.; Nov. 1982; 55.32°N, 1.36°W; NMSZ.1998. 122. Paratypes: North Sea • 2 ind.; Nov. 1982; 55.32°N, -1.36°W; NMSZ.1998.123.

Diagnosis. Dorsal and ventral grooves along the body; paired tentacles on the posterior margin of the peristomium; first branchiae between peristomium and first chaetiger, beside tentacles; capillary chaetae short and thick; 13–16 spines per parapodia in posterior segments (Fig. 11).

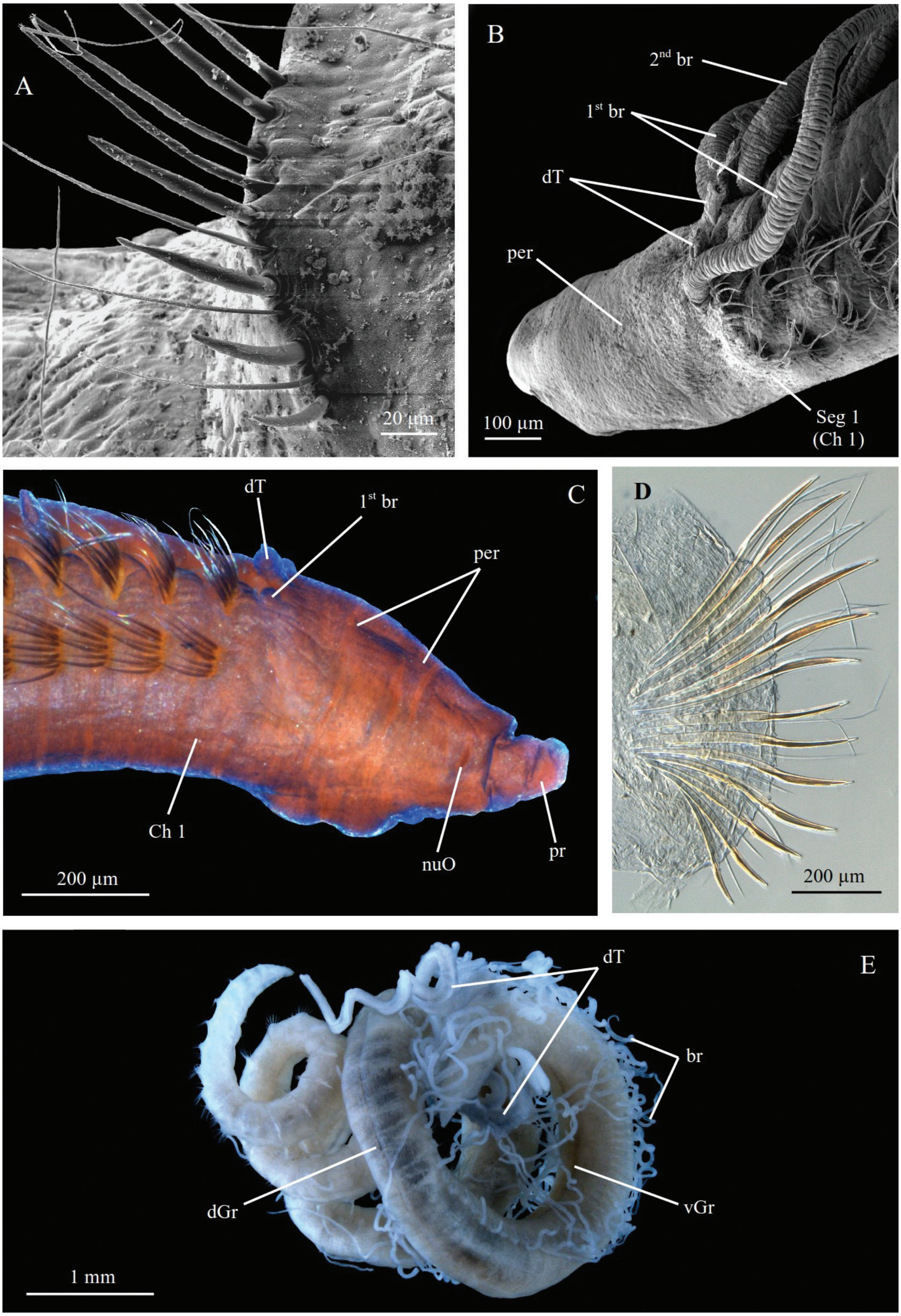

Figure 11. *Chaetozone chambersae* sp. nov. **A** paratype ZMBN129642, SEM of posterior neuropodia **B** paratype ZMBN129642, SEM of anterior end in dorso- lateral view **C** paratype NTNU-VM74486, anterior end in lateral view **D** paratype D NTNU-VM74487,cross section of posterior parapodia **E** holotype NTNU-VM74546 in dorso-lateral view. Abbreviations: br, branchiae; Ch, chaetiger; dT, dorsal tentacles; nuO, nuchal organ; per, peristomium; pr, prostomium; Seg, segment.

Molecular diagnosis. COI: 163: C; 517: G; 512–513: GG. 28S: 89: C; 638: T (based on 17 COI sequences and 10 28S sequences).

Description. A medium species, holotype complete, 124 segments (84–129), 10 mm long (7.5–14) (Fig. 11E). Colour in ethanol white to light tan. Body elongate, narrowing anteriorly and posteriorly, round in cross section, dorsum and venter rounded. Anterior and midbody segments 5–6 × wider than long. Posterior segments 1.5 × wider than long. Thin, shallow dorsal groove along most of body. Faint to distinct ventral groove along most of body.

Prostomium long like two third of peristomium, conical, blunt; eyespots absent; nuchal organs simple slits at posterior margin of prostomium. Peristomium as long as four or five segments, rarely with two distinct annulations, of approximately equal size, partially fused with chaetiger 1 posteriorly. Dorsal tentacles arising from the posterior margin of peristomium, well separated (Fig. 11B, C). First pair of branchiae arising between peristomium and chaetiger 1, just beside dorsal tentacles (Fig. 11B, C). Second pair of branchiae arising from posterior margin of chaetiger 1, dorsal to notochaetae (Fig. 11B). Subsequent chaetigers with branchiae similarly placed. Branchiae or branchial scars present on most chaetigers until development of cinctures.

Parapodia as low mounds or ridges in anterior and middle segments, progressively developing posteriorly into elevated membranes and into incomplete cinctures around segment 90, arising laterally and dorsally, not developing ventrally (Fig. 11A, D). Approximately 20 capillary chaetae per anterior parapodia, short, smooth, thick, and sometimes darkly pigmented in anterior chaetigers (Fig. 11C). Seven or eight spines per neuropodia from segment 43–60, 6–8 in spines per notopodia from segment 46–67, short, unidentate, pointy, slightly curved, transparent (Fig. 11A, D). Alternating capillaries between most spines, rarely two between two spines, thin, up to three times longer than the spines in notopodia (Fig. 11A, D).

Pygidium with terminal anus and with a small triangular ventral lobe.

Etymology. This species is named after Dr Susan Chambers, for her work on European cirratulids.

Remarks. This species is similar to *C. christiei* in general appearance and in having low, incomplete cinctures with short spines, although it has a few more spines per parapodia than *C. christiei*. *Chaetozone chambersae* sp. nov. differs from *C. christiei* in the position of the first pair of branchiae, which are on the posterior margin of the peristomium, beside the tentacular palps, rather than on the first chaetiger. *Chaetozone chambersae* sp. nov. differs from *C. setosa* notably in the absence of a first achaetous segment and fewer, shorter spines.

Chaetozone chambersae sp. nov. is found in British waters, from where many European Cirratulidae species are described. Particular care should be used when identifying cirratulids from this area because of the presence of several undescribed species (Christie 1985; Chambers 2000), the presence of variability in the type material of some species (e.g., *C. christiei*) and the revelation of a much higher diversity that expected in this group (Grosse et al. 2020). It will be important to get better understanding of the British fauna using DNA-based methods.

Chaetozone chambersae sp. nov. COI distance with other species in the area generally ranges from 18% to 25% with a minimum at 10% with *Chaetozone* sp. 11 (Table 2).

Distribution. North Sea, northeast of Scotland, and off Belgium, from ~ 20 to 60 m depth.

Chaetozone cf. zetlandica McIntosh, 1911

Figures 12, 13

Chaetozone zetlandica McIntosh, 1911: 171; Southern, 1914: 115, pls 12, 13, fig. 29A–K.
Caulleriella zetlandica: Day, 1967: 507; Woodham and Chambers 1994: 311 figs 2, 4.
Heterocirrus zetlandica: Fauvel 1927: 99, fig. 34i–n.
Chaetozone sp. 10 Grosse et al. 2020: fig. 4.

Material examined. Norwegian Sea • 1 ind.; 60.54973°N, 5.22897°E; 20 Apr. 2017; 37 m; ZMBN125779 • 2 ind.; 60.17295°N, 5.00315°E; 24 Apr. 2014; 6 m; ZMBN125819–125820 • 1 ind.; 60.51035°N, 5.19158°E; 30 Nov. 2015; 32 m; ZMBN125808 • 1 ind.; 60.173°N, 5.003°E; 23 Apr. 2014; 6 m; ZMBN95386 • 1 ind.; 63.43206°N, 10.37709°E; 07 Sep. 2018; 5 m; NTNU-VM76410 • 1 ind.; 59.97547°N, 5.73998°E; 19 Sep. 2018; 10 m NTNU-VM76478 • 1 ind.; 60.3188833°N, 5.2552833°E; 12 Sep. 2019; 48 m; NTNU-VM76407 • 1 ind.; 60.39426°N, 5.30989°E; 10 Sep. 2018; 4.5 m; NTNU-VM76409.

Comparative material. *Chaetozone zetlandica*: Holotype: Shetland • 1 ind.; Jul. 1867; 170 m; BMNH 1921.5.1.3232.

Diagnosis. All segments narrow, of approximately the same length; red eyespots; peristomium dorsally rounded; paired tentacle on incomplete segment 1 (achaetous); first branchiae on segment 1 (achaetous); posterior end flattened, posterior chaetigers with low, incomplete cinctures (Figs 12, 13).

Molecular diagnosis. 28S: 636: T; 675: T (based on 9 COI sequences and 4 28S sequences).

Description. A large species, 130–154 segments, up to 22 mm long, 3 mm wide, 2 mm high. Body elongate, slightly widening after the middle before narrowing and flattening in posterior quarter, round–oval in cross section anteriorly. Anterior and midbody segments approximately all the same length, all very short, approximately 10 × higher than long, lengthening progressively to 6 × wider than long in posterior segments. Thin dorsal groove in midbody; large ventral groove (Figs 12, 13E).

Prostomium short, one third of peristomium, conical, blunt, without annulations; red eyespots around the nuchal organs; nuchal organs simple slits at posterior margin of prostomium (Fig. 13B). Peristomium short, long as five segments, higher than long, dorsum rounded, two annulations of approximately equal length, second one shorter ventrally and extending dorsally posteriorly between dorsal tentacles (Fig. 13B). Dorsal tentacles arising from segment 1 (achaetous), clearly separated (Fig. 13A, B). First pair of branchiae beside or directly posterior to paired tentacles, on segment 1 (achaetous) (Fig. 13A, B). Second

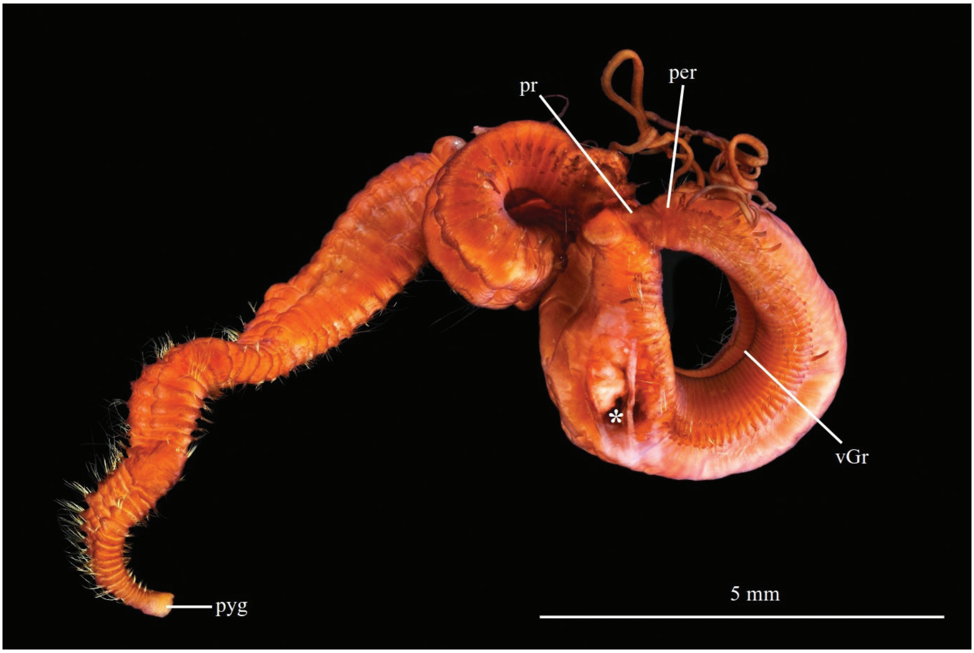

Figure 12. *Chaetozone* cf. *zetlandica*. NTNU-VM76410 in dorso-lateral view, stained with Shirlastain A. Abbreviations: per, peristomium; pr, prostomium; pyg, pygidium; vGr, ventral groove; an asterisk (*) indicates where the parapodia were removed for DNA analyses.

pair of branchiae on chaetiger 1, just above notopodia. Subsequent branchiae similarly placed. Branchiae or branchial scars on all chaetigers including posterior cinctures.

Parapodia as low mounds or ridges in anterior and midbody chaetigers, progressively developing into elevated membrane and into incomplete cinctures around segment 120, encircling only the sides of posterior segments (Figs 12, 13C, E–G). 11–15 Smooth short thick capillary chaetae in neuropodia in anterior and midbody chaetigers, in notopodia along entire body, arranged in two rows in anterior segments (Fig. 13A, D). Smooth short thin chaetae in neuropodia and notopodia in midbody and posterior segments, alternating with thick capillaries in midbody segments, alternating with spines in posterior segments. 7–10 pointed acicular spines in posterior neuropodia from segment 100 (Fig. 13C, F). 7–9 long capillary tipped spines in posterior notopodia from segment 110 (Fig. 13F). Alternating capillaries between all spines (Fig. 13F).

Pygidium with terminal anus, long, cylindrical, with a short ventral lobe and dorsal mound overlapping last two chaetigers (Fig. 13G).

Methylene blue stain. No particular pattern. Prostomium and peristomium stain a bit darker than rest of body, except for a band joining nuchal organs dorsally, and dorsum barely shows any stain.

Remarks. The specimens examined resemble the fragment of the holotype of *Chaetozone zetlandica*. *Chaetozone zetlandica* was described from a unique posterior fragment that is in poor condition and lacks most chaetae. One neuropodium is

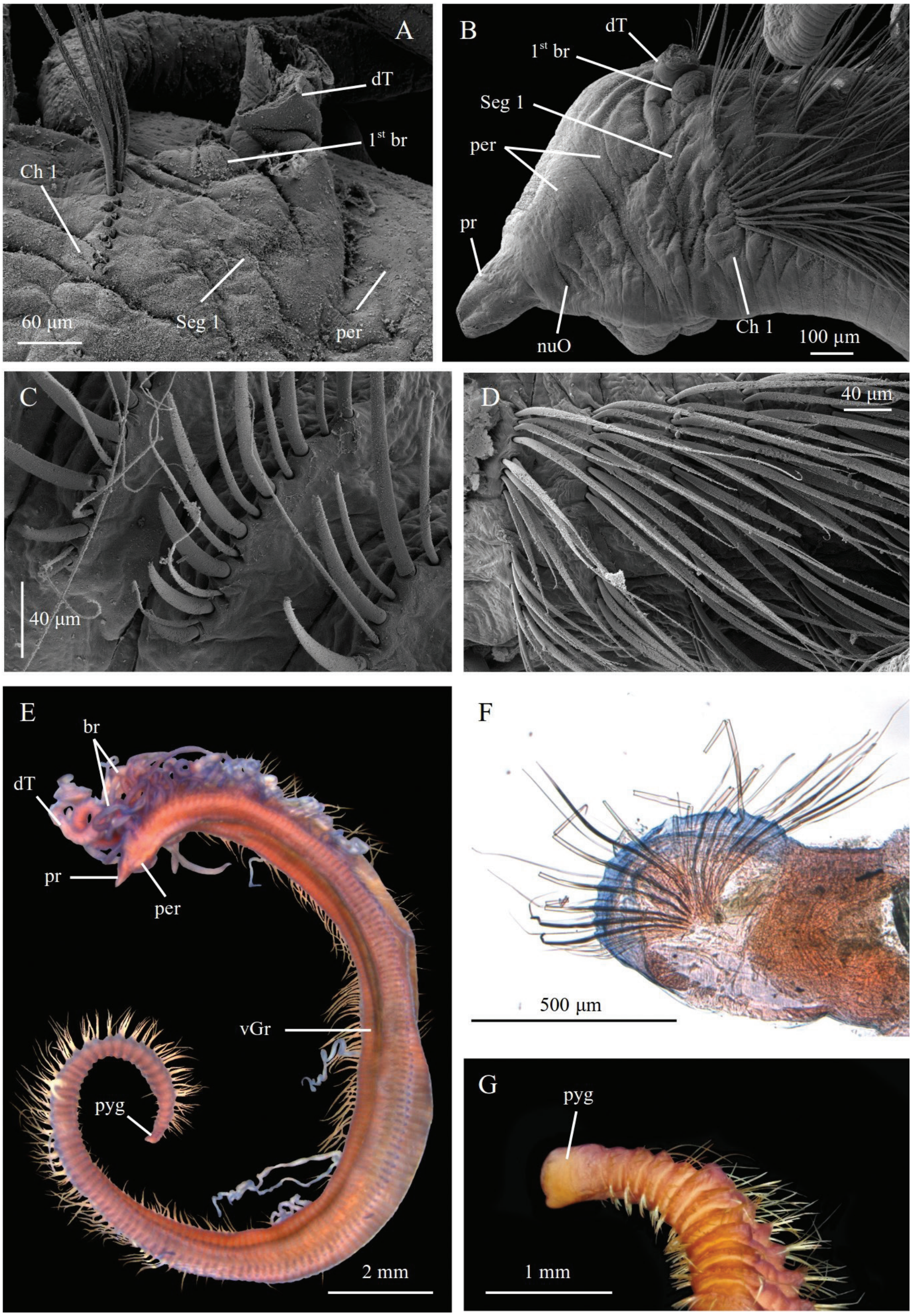

Figure 13. *Chaetozone* cf. *zetlandica* **A** ZMBN125808, SEM of dorsal tentacle and first branchiae **B** ZMBN125808, SEM of anterior end in lateral view **C** ZMBN125808, SEM of neuropodial posterior spines **D** ZMBN125808, SEM of anterior parapodia and capillary chaetae **E** ZMBN125820 in lateral view, stained with Shirlastain A **F** ZMBN95386, cross section of posterior parapodia **G** NTNU-VM76410, pygidium in lateral view, stained with Shirlastain A. Abbreviations: br, branchiae; Ch, chaetiger; dT, dorsal tentacles; nuO, nuchal organ; per, peristomium; pr, prostomium; Seg, segment.

complete and shows unidentate spines arranged in a distinct armature on an elevated membrane. Nothing could be seen from the notopodia. Southern (1914) described a number of complete specimens from Scotland he identified as *C. zetlandica* based on the original fragment from McIntosh (1911). Woodham and Chambers (1994) also examined material from Scotland that they attributed to this species but placed it in the genus *Caulleriella*. They formed this new combination because they did not see any spines in the notopodia and observed some bidentate spines in the neuropodia of small specimens. They did show, however, what they called "awl-shaped" capillary chaetae, as thick as the acicular spines, but longer, and indeed terminating into thin capillary instead of having a blunt tip. These "awl-shaped" capillary chaetae are also shown arranged in a distinct armature, with alternating capillary chaetae on an elevated membrane. As Blake (2018) states, the chaetae of *Caulleriella* are not arranged in cinctures and as the "awl-shaped" capillary chaetae of this species might indeed just be spines, *Caulleriella zetlandica* is strongly suspected to be *Chaetozone zetlandica*. Woodham and Chambers (1994) provided a detailed redescription from a quantity of specimens they also compared to the fragment holotype. Specimens examined in our study mostly confirm to their description. Where they describe the dorsal tentacles as arising from a third peristomial annulation, we describe the dorsal tentacles of our material as arising from segment 1 (achaetous), which is a difference in interpretation rather than a difference in morphology. Woodham and Chambers also describe the first pair of branchiae as arising from the first chaetiger, but their SEM pictures show that it either arise at the anterior of this chaetiger (in addition to a second pair placed posteriorly on the same chaetiger), or from the third peristomial annulation. This last interpretation would be similar to the description we make of our material. However, this possible variation in the position of branchiae cannot be confirmed until more specimens are available.

The specimens described herein are also very similar to *Chaetozone* sp. 9 from Grosse et al. (2020), a species not described here as only two specimens were available. New observations from ongoing work indicate a third genetic clade in this complex. Either of these lineages could be *C. zetlandica*. This is why the species described here as *Chaetozone* sp. 10 is referred with reservations. Although available descriptions in the literature are detailed (Southern 1914; Woodham and Chambers 1994), results presented here show the presence of putative cryptic species that at present cannot with certainty be attributed to the name McIntosh (1911) had available specimens for his original description. We suggest this is solved by examining specimens representing all genetic lineages and assigning the name *C. zetlandica* to one of them. Moreover, due to the condition of the holotype and the un-informativeness of the original description, the validity of the name *Chaetozone zetlandica* may need to be re-assessed in the future.

The COI distance between *Chaetozone* cf. *zetlandica* and *Chaetozone* sp. 9 is 10% (Table 2). COI distances with other species in the area vary between 19% and 26% (Table 2).

Distribution. Norwegian coast and shelf, ~ 5–40 m depth.

***Chaetozone* sp. 2 and sp. 4**

Figure 14

Chaetozone sp. 2 Grosse et al. 2020: fig. 4.
Chaetozone sp. 4 Grosse et al. 2020: fig. 4.

Material examined. *Chaetozone* sp. 2: Norwegian Sea • 1 ind.; 61.42736°N, 7.47479°E; 18 Nov. 2012; 332 m; ZMBN125800 • 1; 62.48183°N, 4.46550°E; 10 Mar. 2012; 211 m; ZMBN125823 • 1 ind.; 61.0501°N, 5.40055°E; 03 May 2017; 1236 m; ZMBN117820 • 1 ind.; 62.482°N, 4.466°E; 03 Oct. 2012; 213 m ZMBN94537 • 1 ind.; 61.11299°N, 5.14124°E; 22 Jul. 2012; 354 m; NTNU-VM74503. *Chaetozone* sp. 4: Norwegian Sea • 3 ind.; 61.42736°N, 7.47479°E; 18 Nov. 2012; 332 m; ZMBN125796–125798 • 1 ind.; 61.21307°N, 5.03809°E; 14 Jul. 2015; 379 m; ZMBN125776 • 1 ind. ; 64.804°N, 10.111°E; 08 Oct. 2013; 378 m; ZMBN94483 • 1 ind.; 62.06827°N, 5.03811°E; 20 Jul. 2012; 334 m; ZMBN125781 • 2 ind.; 61.11299°N, 5.14124°E; 22 Jul. 2012; 360 m; NTNU-VM74500, 74507.

Comparative material. *Chaetozone jubata*: Paratypes: Faroe-Shetland channel • 2 ind.; 61.5.57°N, 2.4093°W; Jul. 1996; 710 m; NMSZ.1999.237.4–5.

Diagnosis. Prostomium fused with peristomium, giving the head a drop-like appearance; dorsal tentacles arising from segment 1 (achaetous), first pair of branchiae arising from segment 2 (achaetous); ventral groove; long capillary chaetae on expanded anterior, numerous long, broad flat spines on high complete cinctures (Fig. 14). No particular methylene blue staining pattern.

Molecular diagnosis. *Chaetozone* sp. 2: COI: 130: G; 173: A; 202: T; 244: C; 293: C; 295: T; 309: G; 310: C; 395: G; 434: G; 454: T; 460: G; 470: G; 471: T; 477: C; 490: C; 302–303: AC; 564–565: CG. 28S: 408: A; 415: C; 416: A; 445: A; 571: C; 454–455: AG; 460–461: TC; 691–692: AA; 704–705: TC. (based on 8 COI sequences and 4 28S sequences) *Chaetozone* sp. 4: COI: 122: T; 487: G; 574: G (based on 10 COI sequences).

Remarks. These considerably distinct molecular lineages but morphologically identical species, *Chaetozone* sp. 2 and *Chaetozone* sp. 4, are morphologically similar to *C. monteverdii* sp. nov. It is clear from the molecular analyses that they are different species from *C. monteverdii* sp. nov. Moreover, they are distinguished from *C. monteverdii* sp. nov. by having smooth long chaetae instead of segmented long chaetae, and a ventral groove instead of a ridge. Nevertheless, while none of the specimens of these two species examined present enlarged first segments, the condition present in *Chaetozone* spp. 2 and 4 could fit within the intra-specific variation documented in *C. monteverdii* sp. nov. The prostomium and peristomium in *Chaetozone* sp. 4 may also appear more distinctly separated than in the other species (Fig. 9). *Chaetozone* spp. 2 and 4 resemble *C. jubata*. However, they differ in the relative position of the paired tentacles and first pair of branchiae. It will be necessary to examine more specimens of each species, including of *C. jubata*, to investigate the intra-specific diversity in each group before confirming that neither *Chaetozone* sp. 2 nor *Chaetozone* sp. 4 are *C. jubata*.

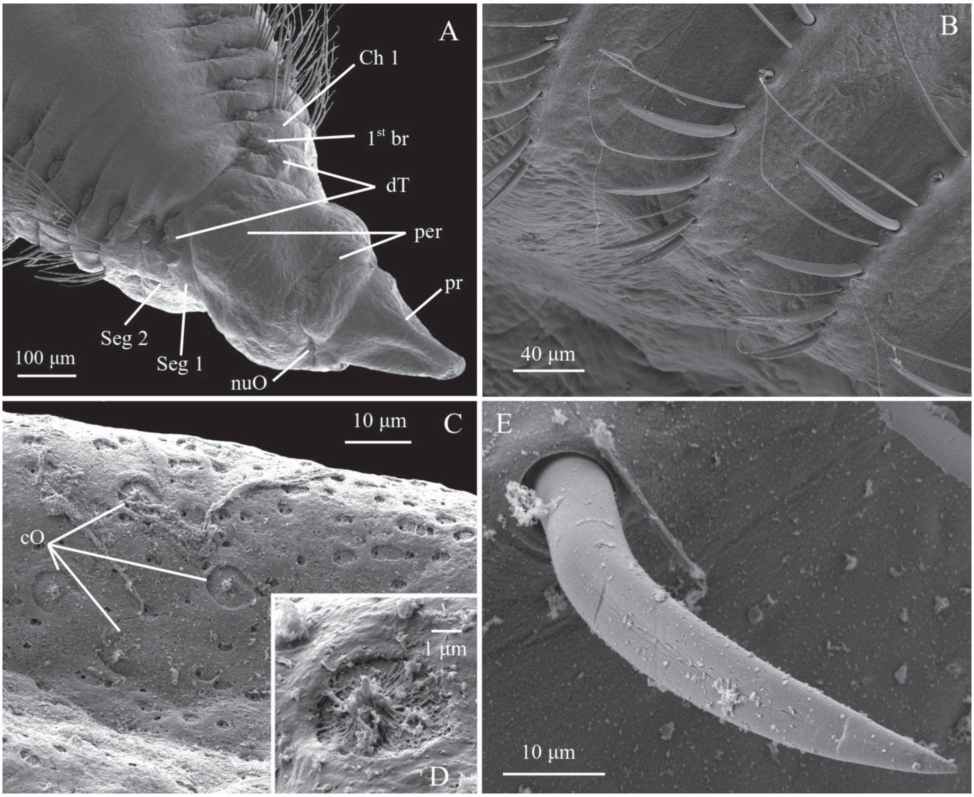

Figure 14. *Chaetozone* sp. 4. **A** ZMBN125798, SEM of anterior end in dorsal view **B** ZMBN125776, SEM of posterior spines **C** ZMBN125798, SEM of peristomium epidermis **D** ZMBN125798, SEM of ciliated organ **E** ZMBN125776, SEM of neuropodial spine. Abbreviations: br, branchiae; Ch, chaetiger; cO, ciliated organ; dT, dorsal tentacles; nuO, nuchal organ; per, peristomium; pr, prostomium; Seg, segment.

The COI distance between *Chaetozone* sp. 2 and *Chaetozone* sp. 4 is 26% (Table 2). COI distances with other species in the area generally varies between 22% and 27%, with minimum at 9% between *Chaetozone* sp. 4 and *Chaetozone quinta* sp. nov. (Table 2).

Distribution. Norwegian coast and shelf, offshore and in the fjords, where they occupy a wide range of depths from ~ 200 m to 1200 m depth.

Discussion

While molecular studies are of major importance in species discovery, they too rarely lead to formal species descriptions (Pante et al. 2015). This is particularly the case when dealing with cryptic species: distinct species understood as separately evolving metapopulation lineages but morphologically identical (Fišer et al. 2018). However, even though they may not be morphologically diagnosable within a species complex, these species should be named and described. A way to do this is to provide molecular diagnostic characters along the morphological diagnosis (e.g., Churchill et al. 2014; Delić et al. 2017; Parapar et al. 2020; Teixeira et al. 2020). In a recent paper, analyses of DNA sequence data delimited a number of *Chaetozone* lineages compatible with the concept of species (understood as separately evolving metapopulation lineages (De Quieroz 2007)) (Grosse at al. 2020). In the present study, five of these are described as new, two are assigned to known species, and two are documented but not formally described. The diagnoses include both morphological and molecular characteristics.

Software currently available allow us to retrieve two types of molecular diagnostic characters: single bases or pairs of bases that together are diagnostic even if they may not be individually. While the software DeSignate (Hütter et al. 2020) makes it possible to create these pairs, or combined characters, by combining bases from any position in the alignment, we chose to include only pairs made by adjacent bases in species diagnosis. One reason is that it simplifies later usage. Another reason is that when allowing any distance within the bases, as many as 344 pairs were found in COI for *Chaetozone pseudosetosa* sp. nov. While molecular diagnostics typically include a few up to a couple of hundred single positions (e.g., Johnson et al. 2015; Teixeira et al. 2020), and all are potentially relevant, such a number is not manageable when describing a species or identifying it.

To be considered diagnostic, the same character state must be present for all specimens of a species, and absent from all other species (Davis and Nixon 1992; DeSalle et al. 2005). This leads to two considerations: the number of species involved in the analyses for comparison (reference group), and the number of sequences from the target species (query group). The more species (and the more sequences per species) there are in the reference group, the more chances are that at a given position in the alignment, at least one species possesses the same character state as the query group. This in turn means decreasing the chances of finding diagnostic characters, especially single bases. However, there is a trade-off, as with an important reference group, the diagnostic characters found in the query group are also more reliable, as we have more confidence in their uniqueness. Here we chose to use the complete *Chaetozone* COI dataset, including species not present in the North Atlantic and not discussed in this paper. The more sequences there are in the query group, the better overview we have of the intra-specific diversity. This once again means that there are less chances of finding diagnostic characters, but that the characters found will be more reliable. There have been several approaches to this issue, from describing species using molecular diagnostic characters based on a single individual and sequence (Jörger and Schrödl 2013), to limiting analyses and decisions to species with more than three sequences (Teixeira et al. 2020) and to pleading for wide datasets (Dayrat 2005). Here, *Chaetozone setosa* and *Chaetozone pseudosetosa* sp. nov. are the species for which there are most sequences, and have very few molecular diagnostic characters, but these should prove reliable. Although only two COI sequences were available from *Chaetozone quinta* sp. nov., we still included molecular diagnostic characters. However, some of these characters may not be diagnostic anymore when more specimens are sequenced, and more intraspecific diversity is known.

Another obstacle to the description of cryptic diversity within a species complex is the lack of sequenced material from type specimens or from specimens from type localities (see also Oug et al. 2014; Grosse et al. 2020), including that of other possible old and synonymised names, which is the first step to be able to assign existing taxon names to species, as it would allow comparing new sequences with these. The best procedure would be to sequence type material, but this is generally not possible as types are in most cases old specimens curated in museum collections, often fixed in formaldehyde, and with degraded DNA. *Chaetozone setosa*, and *C. pseudosetosa* sp. nov. are true cryptic species fitting the description of *C. setosa* but having distinct lineages (8% average p-distance in COI). Only the fact that recent material was available from the type locality of *C. setosa* made it possible to use this existing name for one lineage and give a new name to the other. However, several new species remain undescribed because there are several candidates for existing names. This is the case of *Chaetozone* cf. *zetlandica* in this study. In addition to this species, two other lineages are known from DNA analyses (approximately 10% average p-distance in COI) that could fit the description of *C. zetlandica*. However, *C. zetlandica* was described from Scotland, at a location from where no material is available for DNA sequencing at the moment.

Future addition of new specimens will contribute to knowledge of species groups, their geographical distribution, and possibly elucidate their morphological characteristics. In the meantime, molecular diagnostics can be of great help, in particular to identify cryptic species. Being among the most common and abundant groups of annelids in marine benthic environmental monitoring, knowledge of cirratulids and especially *Chaetozone* represents a step forward in understanding marine biodiversity.

Detailed knowledge of genetic diversity aggregated in described and defined morphogroups, although presently not named, is an advancement in understanding marine biological diversity. Genetic diversity is a compositional level in structural and functional diversity (Cochrane et al. 2016), has impact and is applicable in environmental monitoring and baseline studies in, for example, conservation planning and management. Genetic, as well as morphological, taxonomic diversity is fundamental in applying environmental DNA techniques to environmental monitoring. Thus, an overview of defined genetic groups and described morphogroups is important.

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Supplementary material 1

Specimens data

Authors: Maël Grosse, María Capa, Torkild Bakken

Data type: Collection data, Accession numbers

Explanation note: For all specimens and sequences used in this study, this file gives collection data and GeneBank/BOLD accession numbers.

Link: https://doi.org/10.3897/zookeys.1039.61098.suppl1

Supplementary material 2

COI alignment

Authors: Maël Grosse, María Capa, Torkild Bakken

Data type: DNA sequences

Explanation note: Contains all the COI sequences used in this study.

Link: https://doi.org/10.3897/zookeys.1039.61098.suppl2

Supplementary material 3

28S sequences

Authors: Maël Grosse, María Capa, Torkild Bakken

Data type: DNA sequences

Explanation note: Contains all 28S sequences used in this study.

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High endemicity in aquatic dance flies of Corsica, France (Diptera, Empididae, Clinocerinae and Hemerodromiinae), with the description of a new species of *Chelipoda*

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Abstract

All known records of aquatic dance flies (Empididae, Clinocerinae: 21 species; Hemerodromiinae: eight species) from the island of Corsica (France) are summarized, including previously unpublished data and data on the newly described species *Chelipoda puschae* Ivković, Perović & Grootaert, **sp. nov.** This species was collected during the "La Planète Revisitée Corsica 2019" survey and represents the first description of a new species in the genus *Chelipoda* from the European–Mediterranean region in more than 180 years. A key to European species of *Chelipoda* is provided. Including the new species, five species are recorded from Corsica for the first time: *Dolichocephala malickyi* Wagner, 1995, *Dolichocephala oblongoguttata* (Dale, 1878), *Dolichocephala ocellata* (Costa, 1854), *Chelifera subangusta* Collin, 1961, and *Hemerodromia unilineata* Zetterstedt, 1842. The new species is described and illustrated, and new records of aquatic dance flies from Corsica are given, with new data on 17 species in eight different genera. At present, 29 species of aquatic dance flies are known from Corsica, with 10 species endemic to the island.

Keywords

Distribution, Empididae, endemicity, new species, Our Planet Reviewed expedition

Introduction

The island of Corsica is situated in the Tyrrhenian Sea, about 170 km south of mainland France, about 90 km west of Italy, and separated from Sardinia by the Strait of Bonifacio. Mountains cover about two-thirds of the island, forming a single chain that runs in a north–south direction. Corsica is one of the most important centres of endemism for freshwater invertebrates in Europe (Giudicelli 1975; Ketmaier and Caccone 2013). In terms of its area of about 8700 km^2, the concentration of endemic species on Corsica is one of the highest in Europe, with most of the endemic species located in spring brooks and streams at higher altitudes (Giudicelli 1975).

The aquatic Empididae (Hemerodromiinae and Clinocerinae) of Corsica have previously been studied on a number of occasions (Becker et al. 1910; Vaillant 1965, 1982; Wagner 1995). Becker et al. (1910) and Vaillant (1965, 1982) described, in total, three new species of aquatic dance flies from the island. Pusch (1996) provided the most detailed study of the Clinocerinae of Corsica, describing six new species. At present 23 species of aquatic dance flies are known from Corsica (Becker et al. 1910; Vaillant 1964, 1981; Wagner 1995; Pusch 1996), with nine endemics (Yang et al. 2007).

Both larval and adult aquatic Empididae are predators, mainly feeding on smaller aquatic dipterans such as Chironomidae, Simuliidae, and Psychodidae (Vaillant 1952, 1967; Harkrider 2000; Werner and Pont 2003; Ivković et al. 2007; Ivković and Plant 2015). Adult Hemerodromiinae are easily distinguished from adult Clinocerinae by their raptorial forelegs. They live and hunt in riparian vegetation, whereas adult Clinocerinae are primarily found on the surface of emergent wet stones or in moss mats (Ivković et al. 2007; Sinclair 2008).

Distribution and biodiversity studies are crucial for an understanding of the drivers of biodiversity hotspots (Ivković and Plant 2015; Schmidt-Kloiber et al. 2017). Regional distribution and biodiversity surveys are important for defining the biogeographic distribution of certain species or genera. They also contribute to the study of the various factors that influence changes in biodiversity and that subsequently affect the species conservation status (Meyer and Wagner 2011; Ivković et al. 2013a, 2017, 2020; Shamshev and Ivković 2020).

In this paper, we present new records of aquatic dance flies from Corsica (France) and also describe a new species. Detailed distribution data are presented, all resulting from the examination of specimens collected at 26 sites, sampled during the "La Planète Revisitée Corsica 2019" survey in June 2019.

Materials and methods

New specimen records

This paper is largely based on data and specimens obtained during the "La Planète Revisitée Corsica 2019" survey (http://laplaneterevisitee-corse.mnhn.fr/fr/participantsvolet-terrestre-2019). This 6th section of the large-scale biodiversity programme "La Planète Revisitée" or "Our Planet Reviewed" was organized solely by the French National Museum of Natural History (MNHN, Paris). Its primary aim is to rehabilitate taxonomic work that focuses on the largely neglected components of global biodiversity, i.e. invertebrates (both marine and terrestrial). The Corsica survey started in the spring of 2019 and will be concluded during 2021. It has entailed a number of blitz visits of one or two weeks to particular areas, and traps that were operational throughout the season. At the end of June 2019, a team of 10 French and two Belgian researchers conducted fieldwork in the Alta Rocca region in the south, and the Tartagine valley in the north. They employed a large number of sampling techniques including Malaise traps, pan traps of different colours, polytraps, light traps, pitfall traps, and Lindgren funnel traps. Sweep nets and hand collecting were also used. Between June 23 and 26, 2019, 17 sites at four different research locations in the Alta Rocca area (southern Corsica) were selected for pan trap sampling by Marc Pollet. At three locations, four sampling sites were operational and at the main research location, Campu di Bonza (BO), a fifth sampling site was added. In nearly all sampling sites the same sampling strategy was applied: five blue, five yellow and five white pan traps were installed at soil surface level, in five 3-coloured trap sets. They were filled to two-thirds full with a light formalin solution (<5%) and detergent to lower the surface tension. All traps were operational for four consecutive days (27–30 June 2019). A total of 258 pan traps were in operation during this period. In addition, at each of the sampling sites (and also at other places in each location), flies were collected by sweep net and by hand (with a small polymer jar). All specimens included in the present paper were retrieved from the pan trap and sweep net samples, and from the hand collecting.

All sampling sites were georeferenced while sampling. The names of taxa reflect current nomenclature and classifications (Sinclair 1995; Yang et al. 2007). Species of *Wiedemannia* mentioned herein are not assigned to subgenus, as the subgenera do not represent monophyletic groups and are therefore considered invalid (Ivković et al. 2019). The literature used for identification included Engel (1939, 1940), Vaillant (1965, 1982), Wagner and Horvat (1993), Wagner (1995), and Pusch (1996).

Records are listed for each species. A list of sampling sites with latitude, longitude, altitude, and collecting method is presented in Table 1, and a map showing the positions of the georeferenced sampling sites is also provided (Fig. 1). The collected aquatic dance flies were preserved in 75% ethanol solution (EtOH). For identification purposes, in some cases male terminalia were macerated in hot 85% lactic acid, dissected, and stored in 75% ethanol along with the specimen in the same tube. All specimens listed in the Material examined sections were collected by Anja De Braekeleer, Claire Villemant, and Marc Pollet. Taxonomic diversity is considered at the level of subfamily, genus, and species. Label data for primary types are cited in full, with original spelling, punctuation, and dates. This study is based on material housed in the following institutions: National Museum of Natural History, Paris, France (**MNHN**); Royal Belgian Institute of Natural Sciences, Brussels, Belgium (**RBINS**); col. M. Ivković, University of Zagreb, Croatia (**UZC**); and Canadian

Table 1. List of sampling sites in Corsica during the "La Planète Revisitée Corsica 2019" survey. MSW = random sweep netting, SW = visual sweep netting, HC = collecting by hand, BPT = blue pan traps, YPT = yellow pan traps, WPT = white pan traps.

ID	Location	Coolecting date	Latitude / Longitude	Altitude (m)	Type of method
	Zicavo, Ponte di Valpine				
1	Zicavo, Ponte di Valpine, at waterfall in riverbed	25.vi.2019	41°52'29.0"N, 09°08'04.7"E	1264	SW
2	Zicavo, Ponte di Valpine, near small waterfall in riverbed	29.vi.2019	41°52'28.0"N, 09°08'05.8"E	1271	HC
3	Zicavo, Ponte di Valpine, in splash zone of rocks in riverbed	25.vi.2019	41°52'27.9"N, 09°08'06.1"E	1270	HC
4	Zicavo, Ponte di Valpine, on dry rocks and on seeps on rocks in riverbed	29.vi.2019	41°52'27.6"N, 09°08'06.8"E	1277	HC
5	Zicavo, Ponte di Valpine, on rocks in riverbed	25–29.vi.2019	41°52'27.4"N, 09°08'06.5"E	1282	BPT, YPT
6	Zicavo, Ponte di Valpine, on rocks in riverbed	25–29.vi.2019	41°52'27.0"N, 09°08'08.3"E	1283	BPT, YPT
7	Zicavo, Ponte di Valpine, on rocks in riverbed	25.vi.2019	41°52'26.7"N, 09°08'08.0"E	1287	SW
8	Zicavo, Ponte di Valpine, at seep on beech forest slope	25–29.vi.2019	41°52'26.3"N, 09°08'08.4"E	1286	YPT
9	Zicavo, Ponte di Valpine, on rocks on beech forest slope	25–29.vi.2019	41°52'26.1"N, 09°08'09.0"E	1298	WPT
	Serra di Scopamène, Castellu d'Ornucciu				
10	Serra di Scopamène, Castellu d'Ornucciu, in higher Alnus forest	26–30.vi.2019	41°49'58.6"N, 09°09'26.1"E	1580	YPT
11	Serra di Scopamène, Castellu d'Ornucciu, in shady sites along stream in pozzine landscape	26–30.vi.2019	41°50'00.5"N, 09°09'27.6"E	1568	YPT, WPT
	Zonza, Samulaghia				
12	Zonza, Samulaghia, on rocks at small waterfall on stream	24.vi.2019	41°46'08.07"N, 09°13'22.86"E	1116	SW
13	Zonza, Samulaghia, canopied seep along the road at edge of forest	24.vi.2019	41°46'07.23"N, 09°13'20.92"E	1093	MSW
14	Zonza, Samulaghia, sapinière forest (soil surface)	24–28.vi.2019	41°45'48.61"N, 09°13'47.56"E	1363	YPT
15	Zonza, Samulaghia, on dry rocks near seep in sapinière forest	24–28.vi.2019	41°45'42.30"N, 09°13'39.01"E	1208	BPT, YPT, WPT
16	Zonza, Samulaghia, sapinière forest	24–28.vi.2019	41°45'42.13"N, 09°13'43.06"E	1267	YPT
17	Zonza, Samulaghia, in dry sapinière forest	24–28.vi.2019	41°45'41.78"N, 09°13'39.52"E	1209	YPT
18	Zonza, Samulaghia, on rocky seep in Sapinière forest (edge of forest)	24–28.vi.2019	41°45'40.1"N, 09°13'32.9"E	1231	YPT
19	Zonza, Samulaghia, seep on rocks in sapinière forest	28.vi.2019	41°45'40.1"N, 09°13'32.9"E	1188	HC
20	Zonza, Samulaghia, marshy seep in dry sapinière forest	24–28.vi.2019	41°45'39.6"N, 09°13'37.2"E	1244	BPT, YPT, WPT, MSW
21	Zonza, Samulaghia, on low vegetation in marshy seep in sapinière forest	24.vi.2019	41°45'39.3"N, 09°13'36.8"E	1243	MSW
	Serra di Scopamène et Sorbollano, Campu di Bonza				
22	Serra di Scopamène et Sorbollano, Campu di Bonza, on banks of river in oak forest	23–27.vi.2019	41°46'28.3"N, 09°07'26.9"E	845	BPT, YPT, WPT
23	Serra di Scopamène et Sorbollano, Campu di Bonza, on gravelly muddy seep in deciduous forest	23–27.vi.2019	41°46'21.5"N, 09°07'15.8"E	920	BPT
24	Serra di Scopamène et Sorbollano, Campu di Bonza, on gravelly muddy seep in deciduous forest	23–27.vi.2019	41°46'21.4"N, 09°07'16.2"E	935	YPT
25	Serra di Scopamène et Sorbollano, Campu di Bonza, edge of oak forest	27.vi.2019	41°46'09.55"N, 09°07'32.83"E	919	YPT
26	Serra di Scopamène et Sorbollano, Campu di Bonza, clearing in oak forest	23.vi.2019	41°46'03.08"N, 09°07'28.58"E	911	SW

National Collection of Insects, Ottawa, Canada (**CNC**). Terminology for adult structures primarily follows Cumming and Wood (2017). The femoral formula is taken from Plant (2009). Homologies of the male terminalia follow those of Sinclair and Cumming (2006) and Plant (2009).

Data analysis

A list of species was compiled from all specimen data collected during this survey and from all available literature data (Table 2). The distribution range of the species

Table 2. List of aquatic dance flies (Diptera: Empididae, Clinocerinae, Hemerodromiinae) of Corsica, with a summary of their distribution range. Species recorded here for the first time from Corsica are listed with "*".

Species	Distribution range
Clinocerinae	
Clinocera appendiculata (Zetterstedt, 1838)	European
Clinocera nigra Meigen, 1804	West Palaearctic
Clinocera stagnalis (Haliday, 1833)	Holarctic
Clinocerella gereckei (Wagner & Horvat, 1993)	Corsica (France), Sardinia (Italy)
Clinocerella wagneri (Pusch, 1996)	Corsica (France)
Dolichocephala guttata (Haliday, 1833)	European
**Dolichocephala malickyi* Wagner, 1995	Mediterranean (Tunisia, Spain, Corsica (France))
**Dolichocephala oblongoguttata* (Dále, 1878)	European
**Dolichocephala ocellata* (Costa, 1854)	European-Mediterranean
Kowarzia barbatula (Mik, 1880)	South European
Kowarzia bipunctata (Haliday, 1833)	European-Mediterranean
Kowarzia cataractae (Pusch, 1996)	Corsica (France)
Kowarzia schnabli Becker, 1910	Corsica (France)
Kowarzia tibiella (Mik, 1880)	Central European
Wiedemannia ariolae Pusch, 1996	Corsica (France)
Wiedemannia bravonae Pusch, 1996	Corsica (France)
Wiedemannia corsicana Vaillant, 1964	Corsica (France)
Wiedemannia czernyi (Bezzi, 1905)	Mediterranean (Corsica (France), Greece, Italy)
Wiedemannia kallistes Pusch, 1996	Corsica (France)
Wiedemannia martini Pusch, 1996	Corsica (France)
Wiedemannia rhynchops (Nowicki, 1868)	Central European
Hemerodromiinae	
Chelifera barbarica Vaillant, 1981	Mediterranean (Algeria, France (Corsica), Greece (Dodecanese Is.))
Chelifera corsicana Vaillant, 1981	Corsica (France)
Chelifera precatoria (Fallén, 1816)	European
**Chelifera subangusta* Collin, 1961	European
Chelipoda albiseta (Zetterstedt, 1838)	European
Chelipoda vocatoria (Fallen, 1816)	European
**Chelipoda puschae* Ivković, Perović & Grootaert, sp. nov.	Corsica (France)
**Hemerodromia unilineata* Zetterstedt, 1842	European

was constructed by assembling information from species lists by Becker et al. (1910), Vaillant (1965, 1982) Wagner (1995), Pusch (1996), Chvála (2012), and Yang et al. (2007). The zoogeographic categorization of species was conducted according to Vigna Taglianti et al. (1999).

Results

Taxonomy

Chelipoda puschae Ivković, Perović & Grootaert, sp. nov.

http://zoobank.org/2F661C1D-B83B-47D7-831B-B1B0444579F7
Figures 2–4

Type locality. France, Corsica, Zonza, Samulaghia, in dry sapinière forest, 41°45'41.78"N, 09°13'39.52"E

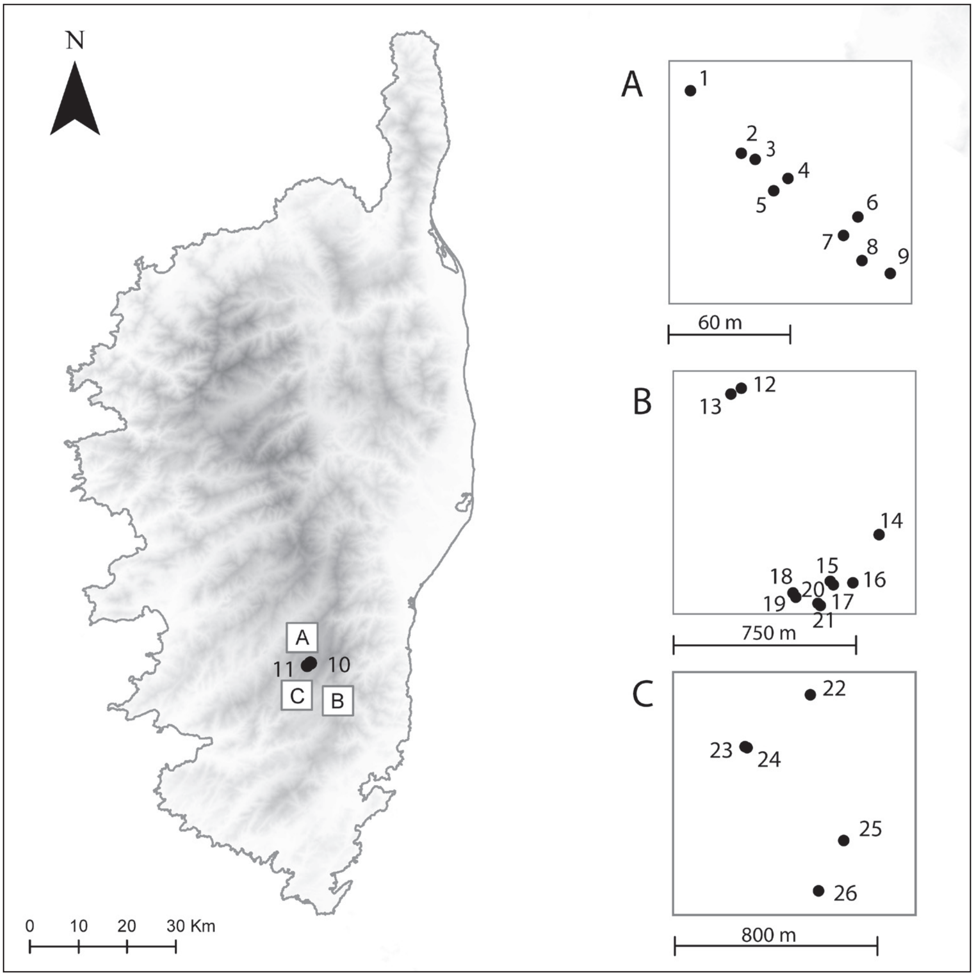

Figure 1. Sampling sites on Corsica (France) as part of the "La Planète Revisitée Corsica 2019" expedition, where aquatic Empididae were encountered during June 2019 (See Table 1 for codes) **A** Zicavo, Ponte di Valpine **B** Zonza, Samulaghia **C** Serra di Scopamène et Sorbollano, Campu di Bonza; 10, 11: Serra di Scopamène, Castellu d'Ornucciu; detailed position of sampling sites 10 and 11 not given in separate box.

Type material. ***Holotype*** • 1 ♂, labelled: "FRANCE, CORSICA; FR-COR/2019/096 (sample code); La Planète Revisitée – MNHN Corsica / 2019; Zonza, Samulaghia; in dry sapinière forest; 41°45'41.78"N, 09°13'39.52"E; 24–28.vi.2019; M. Pollet leg."; HOLOTYPE/*Chelipoda pusche* Ivković, Perović & Grootaert" (MNHN, in 80% ethanol). ***Paratypes*** same data as holotype (• 10 ♂♂, 10 ♀♀, MNHN; • 63 ♂♂, 29 ♀♀, UZC; • 45 ♂♂, 14 ♀♀; RBINS; • 55 ♂♂, 24 ♀♀, CNC).

Additional material. See section with all other records of aquatic empidids.

Diagnosis. Small, slender brown species with black head, darker median stripe on thorax and yellow legs; upper lobe of cercus slightly curved and pointed; subepandrial process sharply projecting anteriorly, rather slim and straight.

Figure 2. Male (not holotype) of *Chelipoda puschae* Ivković, Perović & Grootaert, sp. nov.

Description. Male (Figs 2, 3) Body length (based upon 10 specimens): 2.6–2.9 mm; wing length: 2.6–2.9 mm. Head black, with strong black setae, including 2 ocellar setae, outer vertical setae and 4 postocular setae, other setae fine and paler; patch of fine setae posterior of mouth. Mouthparts dark yellow. Eyes black, almost touching below antenna. Antennae, scape, and pedicel yellow, pedicel twice as long as scape; postpedicel light brown, twice as long as pedicel. Arista-like stylus light brown, about 4× as long as postpedicel.

Sternum yellow, with dark yellow pleura and light brown scutum. Dark brown longitudinal stripe in centre of scutum dorsally broadening towards pronotum and scutellum. Setae on scutum black, with 2 pairs of acrostichal setae, middle pair stronger, posterior pair rather fine and close to scutellum. One anterior pair and one posterior pair of dorsocentral setae, both long and strong. Three notopleural setae, upper posterior rather strong, others smaller and thinner. One pair of strong, marginal scutellar setae.

Legs light yellow, with tarsomeres 4 and 5 darker. Fore coxa with 2 basal setae, upper longer and stronger than lower. Fore tibia slightly longer than fore coxa, distinctly inflated. Femoral formula of fore leg (based upon 10 specimens): 6 anteroventral spines (range 5 or 6), 27 anteroventral denticles (range 23–28), 13 posteroventral denticles (range 10–14), 7 posteroventral spines (range 5–8) and 1 basal spine. All spines dark brown, denticles black. Tibia of a foreleg almost as long as femur.

Wing membrane transparent, veins light brown. Squamae with black fringe. Halter pale brown.

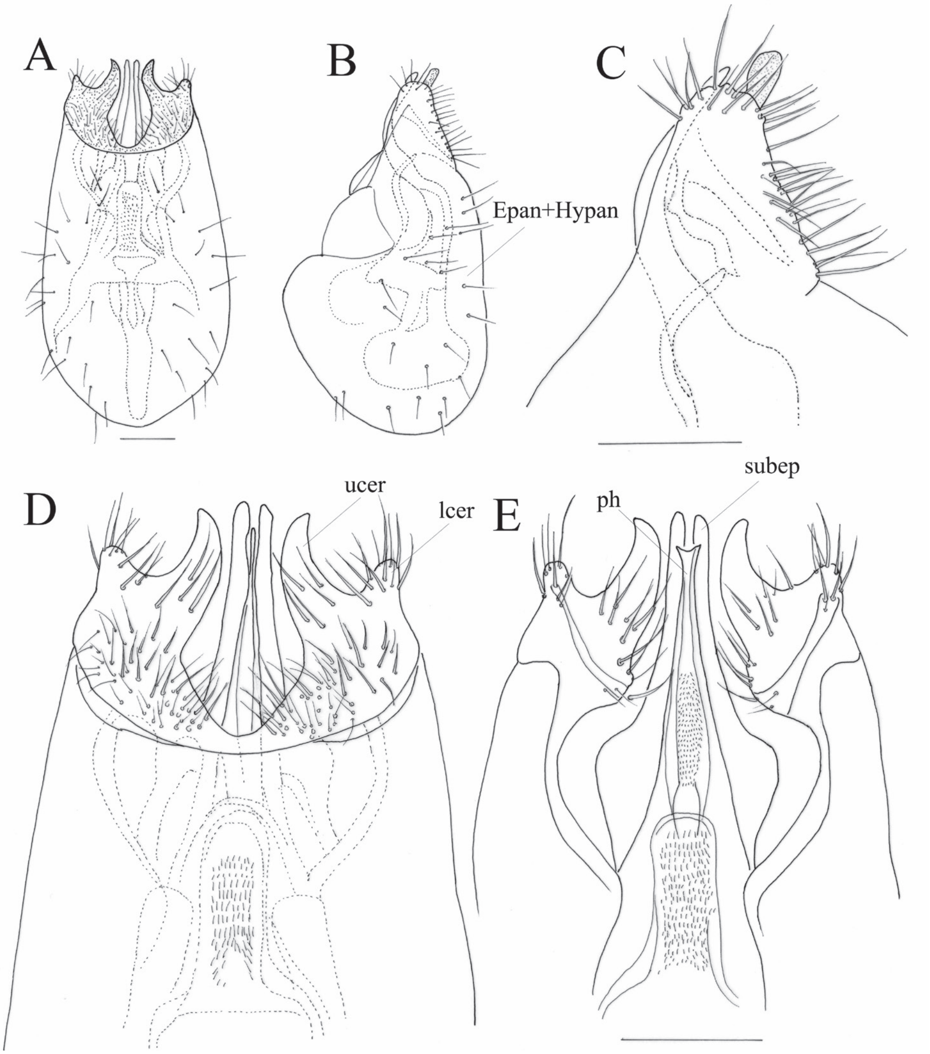

Figure 3. Male terminalia of *Chelipoda puschae* Ivković, Perović & Grootaert, sp. nov. **A** ventral view **B** lateral view **C** lateral view **D** ventral view **E** dorsal view **C–E** show details of the apex. Abbreviations: Epan+Hypan, fused epandrium and hypandrium; lcer, lower lobe of cercus; ucer, upper lobe of cercus; subep, subepandrial process; ph, phallus. Scale bars: 0.1 mm.

Abdominal tergites and sternites brown, tergites darker than sternites, with short setae, dark on tergites, paler on sternites.

Male terminalia (Fig. 3): blackish, darker on upper lobe of cercus, visible part of phallus yellowish. Epandrium and hypandrium fused, rather rounded in lateral view, bearing scattered small dark setae. Left and right lamellae separated by unpigmented densely micropilose membrane. Cercus fused with epandrium +

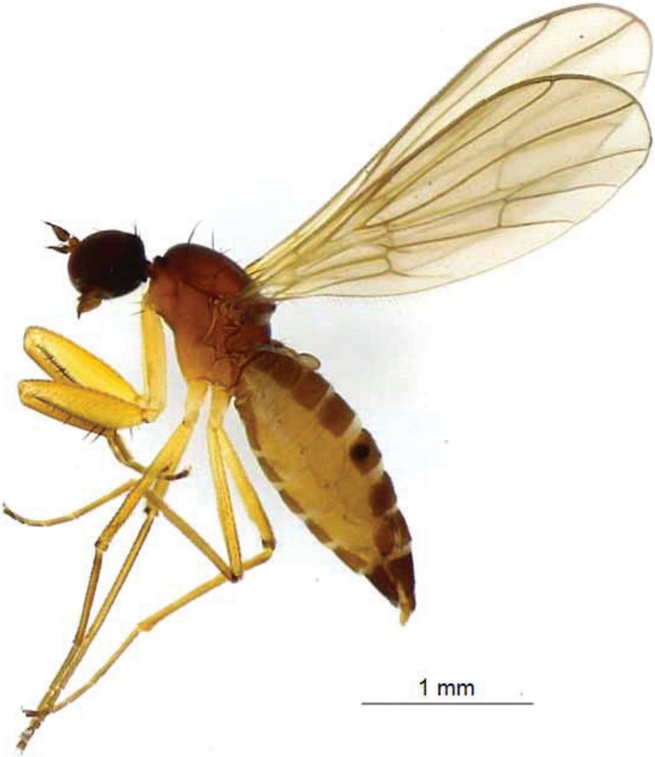

Figure 4. Female of *Chelipoda puschae* Ivković, Perović & Grootaert, sp. nov.

hypandrium, forked, upper lobe of cercus slightly curved and pointed. Subepandrial process sharply projecting anteriorly, rather slim and straight. Phallus apically slender, yellowish.

Female. (Fig. 4) Similar to male, except: antenna darker; femoral spines longer and stronger.

Etymology. The species is named after the German entomologist Martina Pusch, who described six species of Empididae (Clinocerinae) from Corsica.

Remarks. At present, this species is only known from Corsica. It was collected at each of the four localities and eight of the 17 sampling sites investigated during the "La Planète Revisitée Corsica 2019" survey, ranging from open pozzine landscapes to riverbanks in dry oak forests between 845 m and 1,580 m. *Chelipoda puschae* sp. nov. clearly prefers pine forest (sapinière) (Fig. 5) over the other biotopes sampled, with over 96% of the 387 specimens collected here. Within this forest, the species was collected in greatest numbers at a dry rocky site, where its abundance was over five times as high as in the other more humid sampling sites in the same location. Over 97% of all specimens in the pine forest were retrieved from yellow pan traps, and less than 3% from white and blue pan traps.

Figure 5. The pine forest (sapinière) at Zonza, Samulaghia, in southern Corsica, investigated 24–28 June 2019 as part of the "La Planète Revisitée Corsica 2019" survey.

Key to males of European species of *Chelipoda*

1	Epandrium + hypandrium with dorsal claw like appendage pointing downwards; cercus in lateral view small and triangular .... ***Chelipoda vocatoria* (Fallén)**
–	Epandrium and hypandrium rather rounded, without appendages; cerci forked (Fig. 3A–E)... ***Chelipoda puschae* sp. nov.**
–	Cerci rectangular or rhomboidal, with or without elongate dorsal appendage....**2**
2	Cerci elongate in lateral view, with strong dorsal appendage bearing 3 distal teeth-like projections .... ***Chelipoda inexpectata* Tuomikoski**
–	Cerci rhomboidal in lateral view, with inner lobes pointing towards one another in dorsal view.................................. ***Chelipoda albiseta* (Zetterstedt)**

New records of aquatic Empididae (Clinocerinae & Hemerodromiinae) from Corsica (France)

The following format is used for the distribution data: Material examined: number of males (♂) and/or females (♀), locality and location name, description of sampling site, collection date or period, collecting method (sampling site ID, see Table 1). Species recorded for the first time for Corsica (France) are indicated with "*" in front of the species names. A full list of sampling sites is given in Table 1.

Subfamily Clinocerinae

Clinocera nigra Meigen, 1804

Material examined. • 1♂; Zicavo, Ponte di Valpine, on dry rocks and on seepages on rocks in riverbed; 29.vi.2019; HC (4).

Remarks. Previously reported by Becker et al. (1910) and Pusch (1996).

Clinocerella wagneri (Pusch, 1996)

Material examined. • 1♂; Serra di Scopamène et Sorbollano, Campu di Bonza, on gravelly muddy seepage in deciduous forest; 23–27.vi.2019; BPT (23).

Remarks. Recorded and described by Pusch (1996).

**Dolichocephala malickyi* Wagner, 1995

Material examined. • 1♀; Serra di Scopamène, Castellu d'Ornucciu, in shady sites along stream in pozzine landscape, 26–30.vi.2019, WPT (11).

Remarks. This is the first tentative record of this species for Corsica. Although the wing pattern corresponds exactly to that in Wagner (1995), as this is a female, the identification is not 100% certain. We thus await the discovery of the corresponding male.

**Dolichocephala oblongoguttata* (Dale, 1878)

Material examined. • 1♂; Zicavo, Ponte di Valpine, on rocks in riverbed; 25–29.vi.2019; YPT (5) • 1♂, 1♀; Zicavo, Ponte di Valpine, on rocks in riverbed; 25–29.vi.2019; YPT (6) • 1♂; Serra di Scopamène, Castellu d'Ornucciu, in shady sites along stream in pozzine landscape; 26–30.vi.2019; YPT (11) • 1♂; Zonza, Samulaghia, canopied seepage along road at edge of forest; 24.vi.2019; MSW (13).

Remarks. This is the first record of this species for Corsica. Becker et al. (1910) reported *Dolichocephala guttata* (Haliday, 1833), but this record is doubtful as the wing patterns of both species are almost identical and females are indistinguishable. Unfortunately, there is no information on how many specimens of each sex were collected by Becker et al. (1910). As *D. guttata* and *D. oblongoguttata* can be easily confused and/or mixed, the occurrence of *D. guttata* in Corsica needs to be confirmed.

**Dolichocephala ocellata* (Costa, 1854)

Material examined. • 1♀; Serra di Scopamène, Castellu d'Ornucciu, in shady sites along stream in pozzine landscape; 26–30.vi.2019; YPT (11) • 4♂; Serra di Scopamène et Sorbollano, Campu di Bonza, on banks of river in oak forest; 23–27.vi.2019; BPT (22) • 1♂, 1♀; same data, WPT (22) • 1♂; same data, YPT (22).

Remarks. This is the first record of this species for Corsica. Pusch (1996) reported a female of the *D. ocellata* group and we here confirm this record with male and female specimens.

Kowarzia bipunctata (Haliday, 1833)

Material examined. • 1♂; Zonza, Samulaghia, on dry rocks near seepage in sapinière forest, 24–28.vi.2019, BPT (15).

Remarks. Previously reported by Pusch (1996).

Kowarzia cataractae (Pusch, 1996)

Material examined. • 2♂; Zonza, Samulaghia, on dry rocks near seepage in sapinière forest; 24–28.vi.2019; BPT (15).

Remarks. Recorded and described by Pusch (1996).

Kowarzia schnabli Becker, 1910

Material examined. • 1♂; Zicavo, Ponte di Valpine, on rocks in riverbed; 25–29.vi.2019; BPT (5) • 1♂; Zonza, Samulaghia, on rocks at small waterfall on stream; 24.vi.2019; SW (12) • 2♂; Zonza, Samulaghia, on dry rocks near seepage in sapinière forest; 24–28.vi.2019; BPT (15) • 1♂; Zonza, Samulaghia, marshy seepage in dry sapinière forest (20); 24–28.vi.2019; BPT (20).

Remarks. This endemic species was described in Becker et al. (1910) and also collected by Pusch (1996).

Kowarzia tibiella (Mik, 1880)

Material examined. • 1♂; Zonza, Samulaghia, on dry rocks near seepage in sapinière forest; 24–28.vi.2019; BPT (15) • 4♂, 4♀; Zonza, Samulaghia, seepage on rocks in sapinière forest; 28.vi.2019; HC (19).

Remarks. Previously reported by Vaillant (1964) and again by Pusch (1996).

Wiedemannia corsicana Vaillant, 1964

Material examined. • 1♂; Zicavo, Ponte di Valpine, on rocks in riverbed; 25.vi.2019; SW (7).

Remarks. Described and recorded for the first time by Vaillant (1964), and also collected by Pusch (1996).

Wiedemannia czernyi (Bezzi, 1905)

Material examined. • 2♂, 6♀; Zicavo, Ponte di Valpine, at waterfall in riverbed; 25.vi.2019; SW (1) • 2♂, 9♀; Zicavo, Ponte di Valpine, on dry rocks and on seepages on rocks in riverbed; 29.vi.2019; HC (4).

Remarks. This species was previously reported by Wagner (1995) and Pusch (1996). This species was reported in Becker et al. (1910) as *Röederia longipennis* Mik, 1880, which was subsequently synonymized with *Wiedemannia zetterstedti* (Fallén, 1826). However, this is likely a misidentification since the latter species does not occur in this part of Europe and there are substantial taxonomic misidentifications in the *Wiedemannia zetterstedti* "group". A taxonomic revision of this group of sibling species is ongoing and hopefully the taxonomic status of all species in this complex will be resolved in the near future.

Wiedemannia martini Pusch, 1996

Material examined. • 1♂, 3♀; Zicavo, Ponte di Valpine, near small waterfall in riverbed; 29.vi.2019; HC (2) • 7♂,4♀; Zicavo, Ponte di Valpine, in splash zone of rocks in riverbed; 25.vi.2019; HC (3) • 1♂, 1♀; Zicavo, Ponte di Valpine, on dry rocks and on seepages on rocks in riverbed; 29.vi.2019; HC (4) • 1♂, Serra di Scopamène, Castellu d'Ornucciu, in shady sites along stream in pozzine landscape; 26–30.vi.2019; YPT (11).

Remarks. Recorded and described by Pusch (1996).

Subfamily Hemerodromiinae

Chelifera corsicana Vaillant, 1981

Material examined. • 1♂; Serra di Scopamène et Sorbollano, Campu di Bonza, edge of oak forest; 27.vi.2019; YPT (25).

Remarks. Vaillant (1981) collected and described this species on the basis of a single male. Our specimen represents the second finding of this species.

Chelifera precatoria (Fallén, 1815)

Material examined. • 1♂; Zicavo, Ponte di Valpine, on rocks in riverbed; 25–29.vi.2019; YPT (6) • 2♂, 2♀; Serra di Scopamène, Castellu d'Ornucciu, in shady sites along stream in pozzine landscape; 26–30.vi.2019; YPT (11) • 1♂,1♀; Zonza, Samulaghia, on dry rocks near seepage in sapinière forest; 24–28.vi.2019; YPT (15) • 1♂, 1♀; Zonza, Samulaghia, on rocky seepage in sapinière forest (edge of forest); 24–28.vi.2019; YPT (18).

Remarks. Reported previously by Becker et al. (1910).

**Chelifera subangusta* Collin, 1961

Material examined. • 1♂; Zicavo, Ponte di Valpine, at seepage on beech forest slope; 25–29.vi.2019; YPT (8) • 2♂; Zonza, Samulaghia, marshy seepage in dry sapinière forest; 24–28.vi.2019; BPT (20) • 4♂, 16♀; Serra di Scopamène et Sorbollano, Campu di Bonza, on gravelly muddy seepage in deciduous forest; 23–27.vi.2019; BPT (23) • 1♂, 2♀; Serra di Scopamène et Sorbollano, Campu di Bonza, on gravelly muddy seepage in deciduous forest; 23–27.vi.2019; YPT (24).

Remarks. This is the first record of this species from Corsica.

**Chelipoda puschae* Ivković, Perović & Grootaert, sp. nov.

Material examined. •4♂, 1♀; Zicavo, Ponte di Valpine, at seepage on beech forest slope, 25–29.vi.2019; YPT (8) • 1♂, Zicavo, Ponte di Valpine, on rocks on beech forest slope; 25–29.vi.2019; WPT (9) • 2♂, 1♀; Serra di Scopamène, Castellu d'Ornucciu, in higher Alnus forest; 26–30.vi.2019; YPT (10) • 3♂, 2♀; Zonza, Samulaghia, canopied seepage along the road at edge of forest; 24.vi.2019; MSW (13) • 11♂, 3♀; Zonza, Samulaghia, sapinière forest (soil surface); 24–28.vi.2019; YPT (14) • 4♂, 2♀; Zonza, Samulaghia, on dry rocks near seepage in Sapinière forest; 24–28.vi.2019; WPT (15) • 28♂, 15♀; same data; YPT (15) • 18♂, 6♀; Zonza, Samulaghia, sapinière forest; 24–28.vi.2019; YPT (16) • 174♂, 77♀; Zonza, Samulaghia, in dry sapinière forest; 24–28.vi.2019; YPT (17) • 17♂, 14♀; Zonza, Samulaghia, on rocky seepage in sapinière forest (edge of forest); 24–28.vi.2019; YPT (18) • 1♂,1♀; Zonza, Samulaghia, marshy seepage in dry sapinière forest; 24–28.vi.2019; BPT (20) • 1♂, 1♀; same data; WPT (20) • 2♂, 1♀; same data; MSW (20) • 17♂, 23♀; same data; YPT (20) • 7♂, 6♀; Zonza, Samulaghia, on low vegetation in marshy seepage in sapinière forest; 24.vi.2019; MSW (21) • 5♂; Serra di Scopamène et Sorbollano, Campu di Bonza, on banks of river in oak forest; 23–27.vi.2019; YPT (22).

Remarks. See species description above.

**Hemerodromia unilineata* Zetterstedt, 1842

Material examined. • 1♂; Serra di Scopamène et Sorbollano, Campu di Bonza, on banks of river in oak forest; 23–27.vi.2019; YPT (22) • 1♂, Serra di Scopamène et Sorbollano, Campu di Bonza, on gravelly muddy seepage in deciduous forest; 23–27.vi.2019; YPT (24) • 1♂; Serra di Scopamène et Sorbollano, Campu di Bonza, clearing in oak forest; 23.vi.2019; SW (26).

Remarks. This is the first record of this species from Corsica.

Species richness and assemblage composition

So far, 29 species of aquatic empidids are recorded from Corsica, France (Table 2). New data on 16 species (12 Clinocerinae and four Hemerodromiinae) and one new hemerodromiine species, *Chelipoda puschae* sp. nov., were retrieved from samples collected at 26 sites during the "La Planète Revisitée Corsica" survey in June 2019 (Fig. 1; Table 1). The subfamily Clinocerinae is represented by 21 species (72%), in five genera: *Clinocera* Meigen (3 species), *Clinocerella* Engel (2 species), *Dolichocephala* Macquart (4 species), *Kowarzia* Mik (5 species), and *Wiedemannia* Zetterstedt (7 species). The subfamily Hemerodromiinae is represented by eight species (28%), in three genera: *Chelifera* Macquart (4 species), *Chelipoda* Macquart (3 species), and *Hemerodromia* Meigen (1 species) (Table 2). The clinocerine genus *Wiedemannia* is the most species-rich (24% of the total number of aquatic empidids on the island), followed by *Kowarzia* (17%) and the genera *Dolichocephala* (14%) and *Chelifera* (14%) (Fig. 6).

The proportion of endemic species of aquatic empidids in Corsica, i.e. species that have so far only been found in Corsica and that are believed to occur only there, is

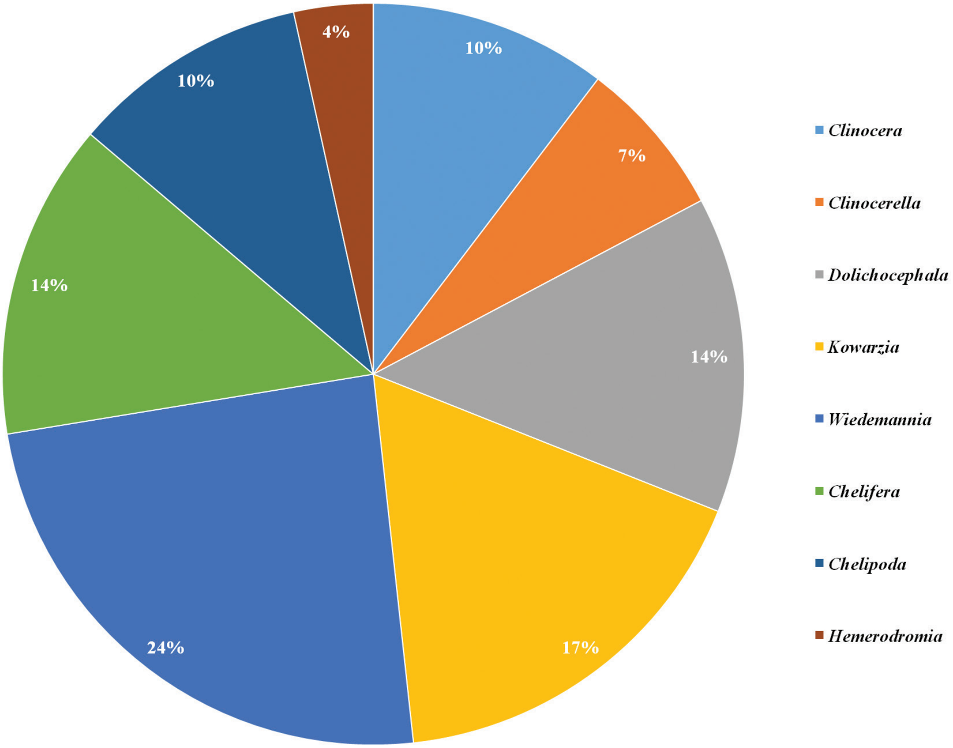

Figure 6. Species richness of aquatic Empididae genera (Diptera: Empididae, Clinocerinae, Hemerodromiinae) on Corsica (total number of species: *Clinocera* – 3 species; *Clinocerella* – 2 species; *Dolichocephala* – 4 species; *Kowarzia* – 5 species; *Wiedemannia* – 7 species; *Chelifera* – 4 species; *Chelipoda* – 3 species; *Hemerodromia* – 1 species).

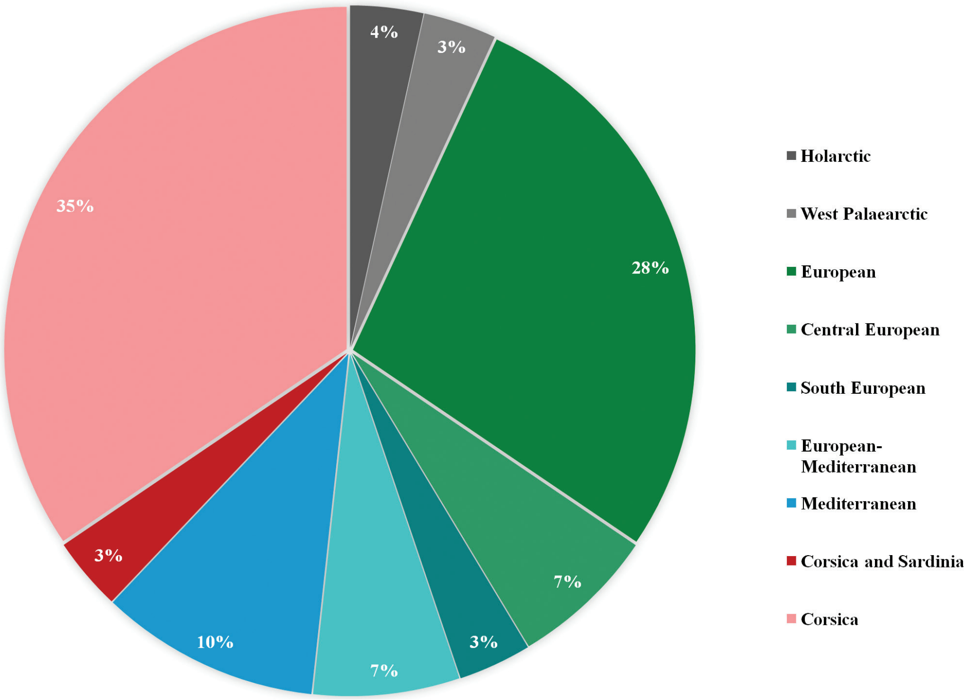

Figure 7. Zoogeographic classification of aquatic empidid species (Diptera, Empididae, Clinocerinae and Hemerodromiinae) currently known from Corsica.

35% (10 species discussed here). In addition, *Clinocerella gereckei* (Wagner & Horvat, 1993) also occurs on Sardinia (Italy). Among Corsican species, 28% are widespread European species, 7% are Central European. A single South European species is recorded, *Kowarzia barbatula* (Mik, 1880). *Dolichocephala ocellata* (Costa, 1854) and *Kowarzia bipunctata* (Haliday, 1833) are considered European–Mediterranean (7% of species discussed here), while *Dolichocephala malickyi* Wagner, 1995, *Wiedemannia czernyi* (Bezzi, 1905), and *Chelifera barbarica* Vaillant, 1981 are Mediterranean species (10% of all species). *Clinocera nigra* Meigen, 1804 is a Western Palaearctic species and *Clinocera stagnalis* (Haliday, 1833) a Holarctic species (Fig. 7).

Discussion

Ten (35%) of the aquatic Empididae recorded from Corsica thus far are considered strictly endemic to the island, and slightly over 40% of the Corsican aquatic empidids are known from other parts of Europe as well (all through Europe, Central Europe, or Southern Europe). The remaining 25% of the species are either widely distributed (Holarctic, Western Palaearctic) or are confined to the Mediterranean area. We compared our list of Corsican species with the existing records of species in Becker et al.

(1910), Vaillant (1965, 1982) Wagner (1995), Pusch (1996), Chvála (2012), and Yang et al. (2007). The following six species were not previously recorded from Corsica and represent the first published records: *Dolichocephala malickyi* Wagner, 1995, *D. oblongoguttata* (Dale, 1878), *D. ocellata* (Costa, 1854), *Chelifera subangusta* Collin, 1961, *Hemerodromia unilineata* Zetterstedt, 1842, and *Chelipoda puschae* Ivković, Perović & Grootaert, sp. nov. Moreover, this is the first description of a species of *Chelipoda* from the European–Mediterranean region for more than 180 years.

Of the two subfamilies, the Clinocerinae have a greater species richness in Europe, especially in mountainous areas (Vaillant 1982; Horvat 1995; Ivković et al. 2012, 2013a, 2013b, 2014, 2017, 2020). This agrees with the pattern observed in Corsica and might be explained by the central mountain chain on the island. Likewise, *Wiedemannia* represents the most speciose genus, both in Corsica and on the continent. By contrast, *Chelifera* is usually the second most species-rich genus (Meyer and Wagner 2011; Ivković et al. 2013a, 2013b, 2017, 2020), but in Corsica it is replaced by *Kowarzia*. A higher diversity of *Kowarzia* is usually only present in mountain regions (Ivković et al. 2014).

The aquatic Empididae fauna of Corsica is composed of exclusively Western Palaearctic taxa with the exception of *Clinocera stagnalis* (Haliday, 1833), which is the most widespread Holarctic clinocerine (also known from North America, North Asia, and North Africa) (Sinclair 2008). Most of the Corsican species are restricted to the Central European or Mediterranean regions. However, 10 of the species encountered in Corsica are strictly confined to the island and can therefore be termed endemic. Only five species are shared with the island of Sardinia (Wagner and Horvat 1993; Wagner 1995). We believe that the current species list is far from complete. Indeed, there has not yet been a comprehensive study of Corsica and all of its freshwater habitats. Furthermore, sampling efforts during the "La Planète Revisitée" were restricted to a short period in late spring and only samples from pan traps and sweep net collecting were examined. Some obvious genera such as *Bergenstammia* and *Phaeobalia* are currently absent from the list. Species in these genera are usually found on the continent only above 1,000 m a.s.l., and as most of Corsica is montane, it is our belief that more species, including more endemics, are likely to be found in Corsica. Most endemic freshwater insect species in Corsica are restricted to higher altitudes (500–1,900 m) (Giudicelli 1975). The influence of altitude and isolation on biodiversity processes is more marked in Corsica, with 30 peaks exceeding 2,000 m, than in, for example, Sardinia where the highest mountain is only 1,830 m. This could explain, in part, why Corsica has a seemingly higher overall species richness than Sardinia, including aquatic empidids (only nine species), even though Sardinia is almost triple the size of Corsica (Giudicelli 1975; Chvála 2012). When it comes to aquatic empidids, we have to bear in mind that they may have been collected only sporadically in Sardinia, mostly as a side catch during inventories of other aquatic groups (Wagner 1984, 1995; Wagner and Horvat 1993). Comparisons between the aquatic empidid faunas of Corsica and Sardinia must therefore be made with the utmost caution. However, the greater species richness in Trichoptera, a group with a similar ecological profile to aquatic empidid flies, also suggests a richer fauna in Corsica, with more endemic species in Corsica than in Sardinia (Giudicelli 1975). In addition, most endemics are found at higher altitudes in Corsica than at lower altitudes (Giudicelli 1975). Katmaier and Caccone (2013) have stated that Corsica is faunistically impoverished when compared to continental resources. Our results, on the contrary, suggest otherwise as the number of aquatic empidids is quite high, especially considering the limited sampling efforts. It has been assumed that most of the endemic species that now occur in Corsica have differentiated from ancestors on the Iberian Peninsula (Katmaier and Caccone 2013). In aquatic empidids, however, this might not be the case, as most of the species present are shared with Central and Southern Europe and only a minority is shared with the Iberian Peninsula, but detailed morphological and/or genetic studies could confirm or reject this assumption. It is postulated that during the Messinian Salinity Crisis, the Mediterranean Sea almost completely dried up and a number of freshwater species reached Corsica through an area of braided rivers present all over the Mediterranean and connecting Corsica to the European continent (Katmaier and Caccone 2013).

To conclude, we hope that this paper will assist in the understanding of our present-day knowledge of the aquatic empidids of Corsica and will provide a starting point for further, more detailed and comprehensive studies, as well as additional studies in Sardinia where the aquatic dance fly fauna is poorly known.

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