



The genus *Wormaldia* (Trichoptera, Philopotamidae) of the Ryûkyû Archipelago, southwestern Japan

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Abstract

Wormaldia collections from the Ryûkyû Archipelago were examined and 10 species including 6 new species were recognized: *W. carinata* (Schmid), *W. okinawaensis* sp. nov., *W. apophysis* sp. nov., *W. tectum* sp. nov., *W. itoae* sp. nov., *W. amamiensis* sp. nov., *W. ishigakiensis* sp. nov., *W. niiensis* Kobayashi, *W. yakuensis* Kobayashi and *W. sp.* Males of all six new species, as well as a male of *W. carinata* and females of *W. carinata*, *W. apophysis*, *W. okinawaensis* and *W. ishigakiensis* are described or redescribed and illustrated. Species compositions of *Wormaldia* were totally different among three regions, northern, central and southern Ryûkyûs.

Key words: caddisflies, new species, description, taxonomy, distribution, endemic species

Introduction

The Ryûkyû Archipelago comprises more than 200 islands stretching at a distance of 1,200 km between Kyûshû, one of the Japanese mainlands, and Taiwan. Because the Ryûkyûs are situated in the transition zone between Palaearctic and Oriental regions, this archipelago has been of great interest to biogeography researchers of various terrestrial and freshwater animal groups (Nishida *et al.* 2003). Rates of endemic species are known to be quite high in vertebrate groups, such as amphibians and terrestrial reptiles (Ohta 1998) and some insect families including Cicadidae (Hemiptera), Scarabaeidae, Cicindelidae, Buprestidae (Coleoptera) and Tephritidae (Diptera) (Kinjo 1986). The archipelago is divided into northern, central and southern Ryûkyûs based on geomorphology and terrestrial fauna. In general, central Ryûkyûs have the highest degree of endemism among these three regions (Toda *et al.* 2003).

Although caddisflies of the Ryûkyûs have not been studied sufficiently, Tanida (1997) compiled a tentative list of caddisfly fauna in central and southern Ryûkyûs and enumerated 44 species, about 70% of which were possibly undescribed. He also reported the high endemism, since 90% of the species in his list being endemic to the Ryûkyûs. Shimura (2010), however, showed some similarity with caddisfly faunas of Yonaguni-jima, which is the southwesternmost island of southern Ryûkyûs and Taiwan. He found 14 species of adult caddisflies, three of which had been recorded in Taiwan and two were suggested to be the same as Taiwanese species.

Among the philopotamid caddisflies Kuhara (2005a, b) recorded two species of *Dolophilodes* and two species of *Wormaldia* from Yaku-shima in northern Ryûkyûs. On the other hand, only *Wormaldia carinata* (Schmid) and unnamed species have been reported from the central Ryûkyûs, and only unnamed species have been recorded from the southern Ryûkyûs (Tanida 1997, Shimura 2010).

I have examined thousands of philopotamid specimens collected in several major islands of Ryûkyû Archipelago and found undescribed and unrecorded species. In this study, I treat only the genus *Wormaldia*. The other genera will be reported in other articles.

Materials and methods

Collections were primarily from Yaku-shima in the northern Ryûkyûs, Amami-ôshima and Okinawa-jima in central Ryûkyûs, and Ishigaki-jima, Iriomote-jima and Yonaguni-jima in southern Ryûkyûs (Fig. 1). I also

examined only one specimen each from Tokuno-shima and Okinoerabu-jima in central Ryûkyûs. T. Ito (TI), H. Nishimoto (HN), F. Nishimoto (FN), R.B. Kuranishi (RK), A. Ohkawa (AO), K. Tojo (KT), Y. Shimura, O.S. Flint Jr. and others provided materials. *Wormaldia* were not found in collections from Iriomote-jima and Yonaguni-jima. Association of male and female is based on specimens collected in copula or similar wing venation within specimens collected together. Male and female genitalia were figured after clearing in hot 10% KOH. Terminology of male genitalia follows that of Kuhara (2005a). Types for newly described species are deposited in the collections of Systematic Entomology, Hokkaidô University, Sapporo (SEHU), the Natural History Museum and Institute, Chiba (CBM) and the National Museum of Natural History, Smithsonian Institution, Washington, D.C. (NMNH) as indicated in the species descriptions. Unless otherwise stated, all specimens are preserved in alcohol.

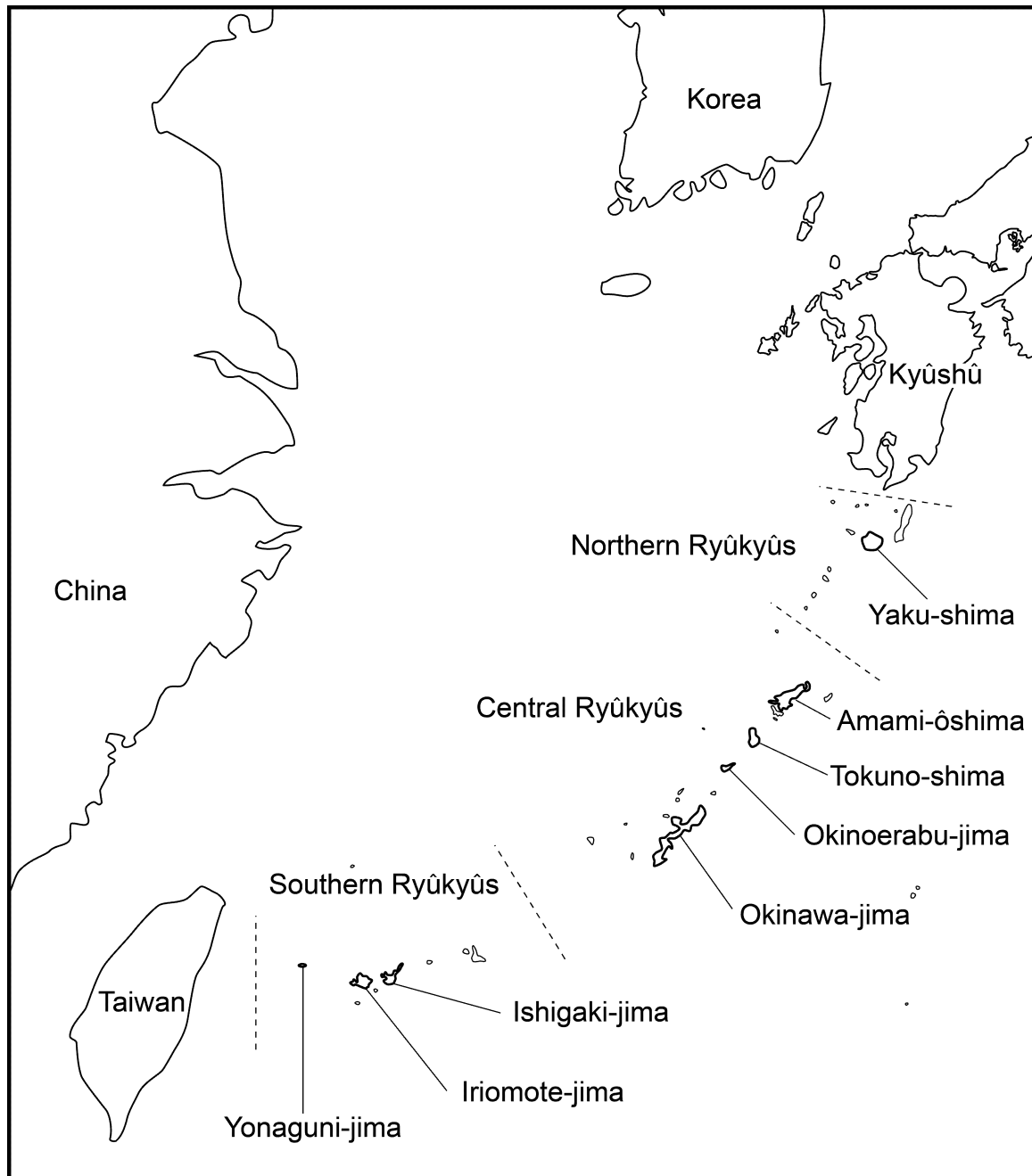


FIGURE 1. Map of the Ryûkyû Archipelago.

Species descriptions and records

Wormaldia carinata (Schmid 1991)

Fig. 2

Doloclanes carinata Schmid 1991: 107 (male) (Type locality: Okinawa-jima, Japan).

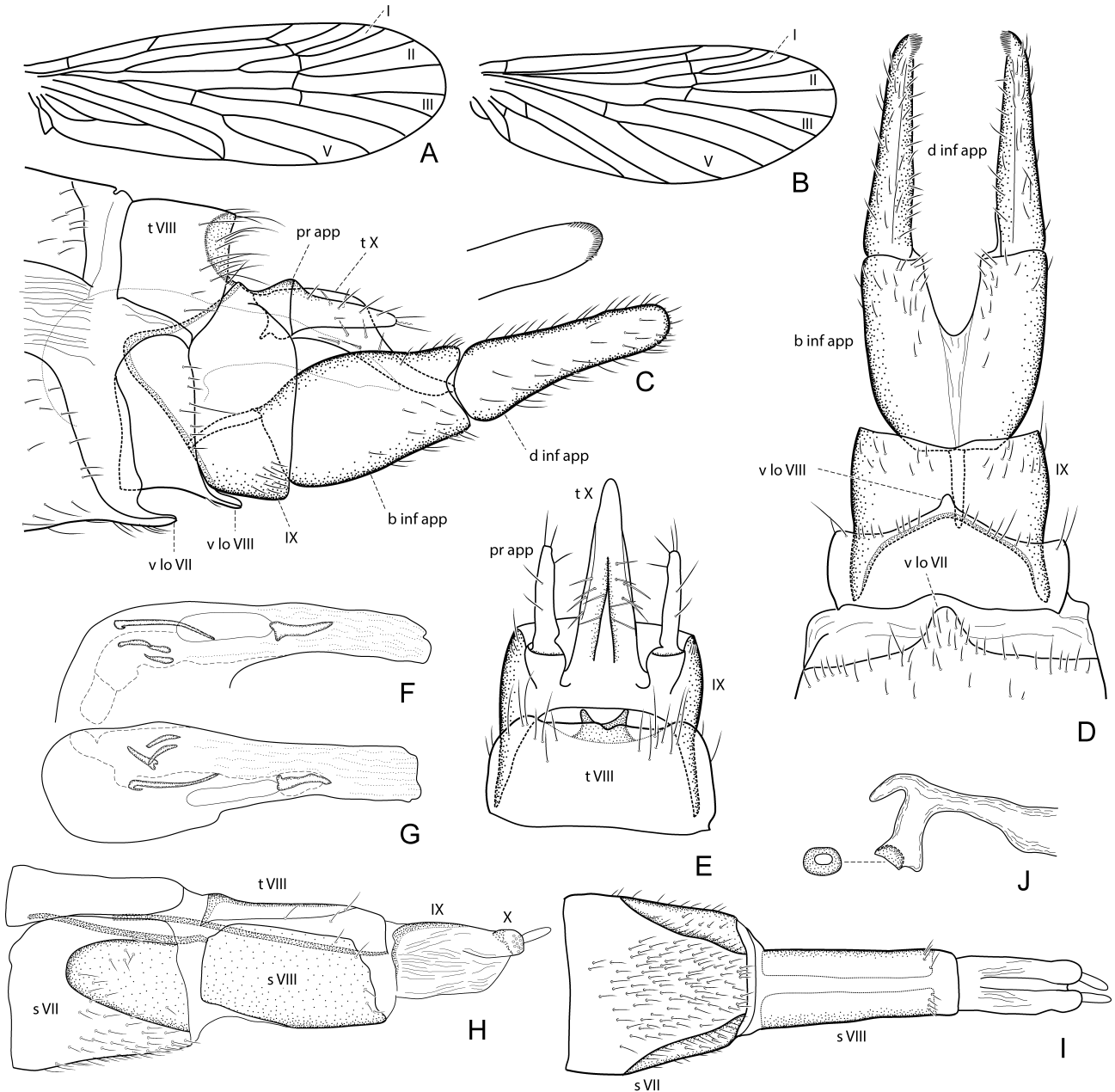


FIGURE 2. *Wormaldia carinata* (Schmid). Wings (A–B): A, forewing; B, hind wing. Male genitalia (C–G): C, lateral, with mesal surface of inferior appendage distal segment; D, dorsal; E, ventral; F, phallus, lateral; G, phallus, dorsal. Female genitalia (H–J): H, lateral; I, ventral; J, vaginal apparatus, lateral. Abbreviations: b inf app = basal segment of inferior appendage, d inf app = distal segment of inferior appendage, pr app = preanal appendage, s VII = sternum VII, s VIII = sternum VIII, t VIII = tergum VIII, t X = tergum X, v lo VII = ventral lobe of sternum VII, v lo VIII = ventral lobe of sternum VIII, IX = segment IX, X = segment X.

Wormaldia carinata (Schmid) has only been reported from the type locality, Okinawa-jima, central Ryūkyūs. New records here include Amami-ōshima, another major island of the central Ryūkyūs. This species is easily distinguished from other Ryūkyū species by a subbasal transverse ridge on the external surfaces of preanal

appendages of male genitalia. The female is described here for the first time and is characterized by lateral concavities of the sternum VIII.

This species was originally described in the genus *Doloclanes* Banks, which was synonymized by Sun and Malicky (2002) under *Wormaldia*.

Adults. Forewing length: male 4.6–5.3 mm (mean = 5.0 mm, n = 6); female 4.5–4.9 mm (mean = 4.5 mm, n = 3). Color (in alcohol): generally blackish brown, legs yellowish. All wings with apical folks I, II, III and V (Fig. 2A, B).

Male genitalia (Fig. 2C–G). See Schmid (1991).

Female genitalia (Fig. 2H–J). Sternum VII with posterior two-thirds of lateral surfaces conspicuously concaved semiellipsoidally. Segment VIII as long as segment VII, longer than tall; tergum moderately sclerotized with strongly pigmented anterior band; sternum longer than tall in lateral aspect, moderately sclerotized laterally with membranous ventromesal region. Segment IX longer than tall, with sclerotized band anteriorly. Vaginal apparatus with ring-like anterior sclerite.

Specimens examined. **Amami-ôshima:** Amami-shi, Naze, Kinsakubaru, 23.iii.1997, FN, 4 males; *ibid.*, 28.iii.1998, FN, 9 males; Amami-shi, Naze, upper reaches of Ôkawa, 9.iv.1993, RK, 9 males; Amami-shi, Sumiyô-chô, 29.iii.1998, FN, 19 males; Amami-shi, Sumiyô-chô, Santarô-tunnel, 30.iii.1998, NH, 3 males; Amami-shi, Sumiyô-chô, upper reaches of Sumiyô-gawa, 18.iv.1993, RK, 3 males; Setouchi-chô, Miyama-gawa, 21.iv.2008, TI, 51 males, 1 female; *ibid.*, 25–26.x.2011, TI, 1 male; Setouchi-chô, Miyama-gawa, small stream, 26.x.2011, TI, 6 males, 1 female; Tatsugô-chô, Toguchi-gawa, 27.iii.1998, NH, 4 males; *ibid.*, 27.iii.1998, NH, 2 males; Uken-son, Kawauchi-gawa, 20.iii.1999, TI and AO, 4 males; *ibid.*, 25.x.2011, TI, 8 males, 1 female; Uken-son, Kawauchi-gawa, el. 50 m, 9.v.2007, TI, 1 male; Uken-son, Tôhatakebashi, 29.iii.1998, FN, 5 males; Uken-son, tributary of Kawauchi-gawa, 25.x.2011, TI, 5 males; Uken-son, Yuwan-dake, 9.v.2007, TI, 10 males, 1 female; Uken-son, Yuwan-gawa, el. 400–600 m, 9.v.2007, TI, 2 males, 3 females; Uken-son, Yuwan-gawa, small stream, 21.iii.1999, TI and AO, 2 males; Uken-son, 29.iii.1998, NH and FN, 15 males; Yamato-son, Materia-no-taki, 29.iii.1998, NH, 2 males; Yamato-son, Yuwan-dake, 29.iii.1998, FN, 6 males; Yamato-son, Yuwan-dake, small stream, 25.x.2011, TI, 2 males. **Okinawa-jima:** Kunigami-son, upper reaches of Benoki-gawa, 27.iii.1997, FN, 5 males; Kunigami-son, upper reaches of Okuma-gawa, 20.v.1993, F, Sato, 3 males; Kunigami-son, upper reaches of Yona-gawa, small stream, 23–25.xi.2010, TI, 4 males; Nago-shi, Genka-kawa, el. 65 m, 8.iv.2011, TI, 16 males, 6 females; Nago-shi, Genka-kawa, Hogen-hashî, 22–24.xi.2010, TI, 11 males, 1 female; Nago-shi, Genka-kawa, madicolous habitat, el. 650 m, 18.iii.2012, TI, 23 males, 3 females; Nago-shi, Haneji, 12.v.1993, F, Sato, 1 male; Nago-shi, middle reaches of Genka-gawa, 5.v.1993, F, Sato, 7 males; Ôgimi-son, upper reaches of Takasato-gawa, 17.iii.2012, TI, 1 male.

Distribution. Japan: central Ryûkyûs (Amami-ôshima, Okinawa-jima).

Wormaldia okinawaensis sp. nov.

Figs. 3, 4.

This new species is somewhat similar to *W. spinosa* Ross 1956 and *W. zhejiangensis* Sun and Malicky 2002 in having a pair of slender posterior process of the tergum VIII, but can be distinguished from these two species by a pair of small triangular lateral projections on tergum X. Examination of the specimen collected in a limestone cave, Ginsuidô, in Okinoerabu-jima and recorded as *W. sp* by Yoshigou *et al.* (2005) confirmed it is this species.

Adults. Forewing length: male 3.7–4.3 mm (mean = 4.0 mm, n = 10); female 3.7–3.9 mm (mean = 3.8 mm, n = 3). Color (in alcohol and pinned specimens): generally blackish brown, legs yellowish. Wing venation as in *W. carinata*.

Male genitalia (Figs. 3A–E, 4). Ventral lobe of sternum VII moderately developed, triangular with round apex in ventral aspect. Tergum VIII not extended posteriorly with posterior margin shallowly incised; pair of processes arising from posteromesal margin, usually fused basally each other, variable in length, long and needle-like in specimens from Okinoerabu-jima and northern part of Okinawa-jima, intermediate, short or lacking in specimens from central part of Okinawa-jima (Fig. 4). Ventral lobe of sternum VIII triangular with round apex in ventral aspect. Segment IX slightly longer than tall, with moderately produced anterolateral margins. Preanal appendages elongate, sinuate in dorsal aspect. Tergum X uniformly tapering to apex in dorsal aspect, with pair of small triangular lateral projection subbasally, bearing about eight strong setae

around midlength. Inferior appendages short; basal segment 1.4 times as long as tall; distal segment shorter than basal segment, somewhat longer than tall, tapering to round apex in lateral aspect, with small spines subapically on mesal surfaces. Phallus membranous, with broad-based cylindrical phallosome. Sclerotized endothelial armature consists of a curved short spine, a sinuate short spine and a rod-like long spine.

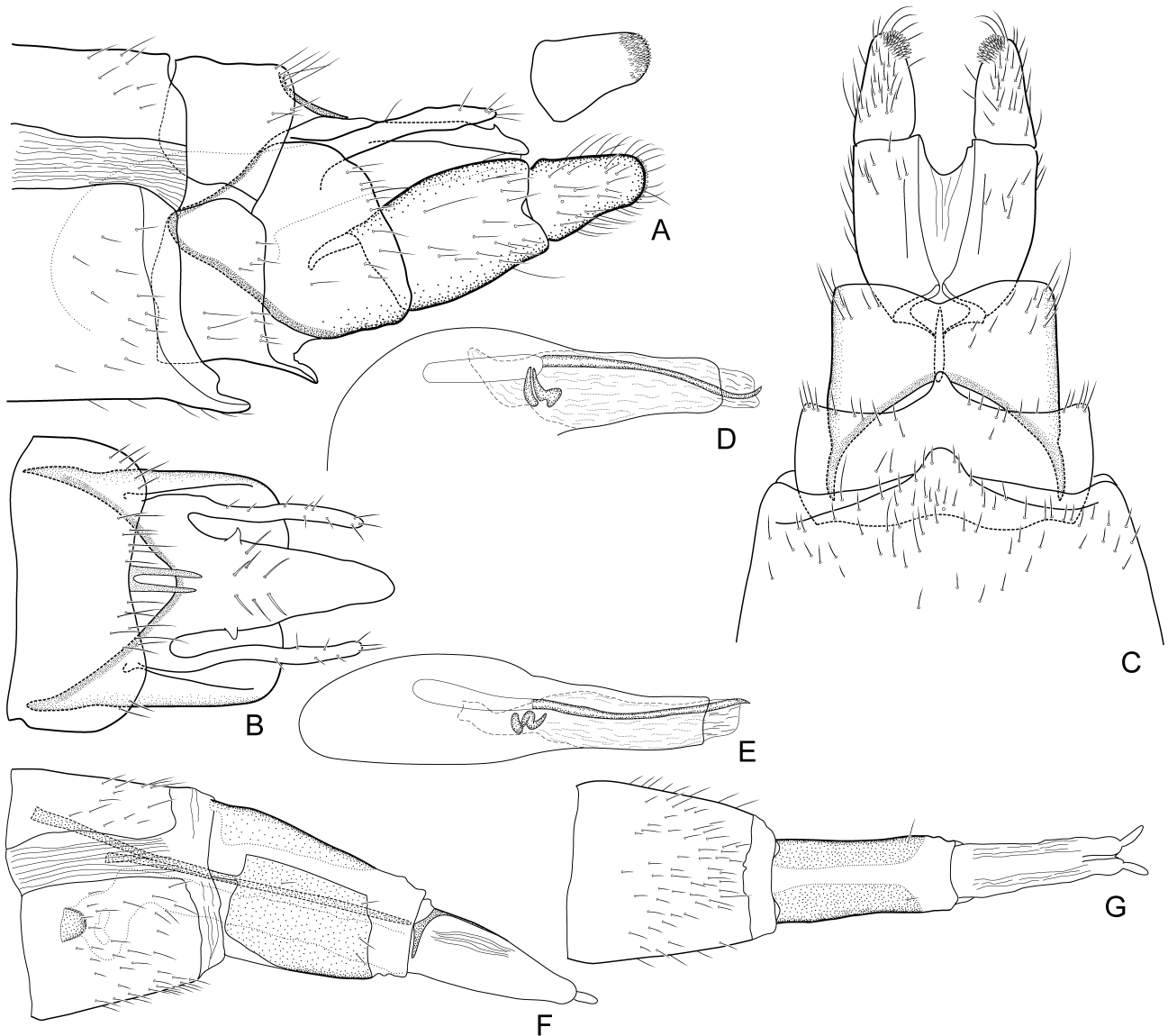


FIGURE 3. *Wormaldia okinawaensis* sp. nov. Male genitalia (A–E): A, lateral, with mesal surface of inferior appendage distal segment; B, dorsal; C, ventral; D, phallus, lateral; E, phallus, dorsal. Female genitalia (F–G): F, lateral; G, ventral.

Female genitalia (Fig. 3F, G). Sternum VII not modified. Segment VIII as long as segment VII, longer than tall; tergum moderately sclerotized, sternum longer than tall in lateral aspect, moderately sclerotized laterally with membranous ventromesal region. Segment IX longer than tall, with anterior sclerotized band. Vaginal apparatus with ring-like anterior sclerite.

Holotype male: Japan: Okinawa-jima: Kunigami-son, upper reaches of Yona-gawa, small stream, 23–25.xi.2010, TI (SEHU).

Paratypes: Okinawa-jima: same data as the holotype, 4 males (2 males: SEHU, 2 males: CBM); Kunigami-son, Hiji-gawa, el. 200 m, 10.iv.2011, TI, 2 males (CBM); Kunigami-son, Hiji-ôtaki, 21.iii.1999, TI and AO, 5 males (SEHU); Kunigami-son, Okuma-gawa, el. 280 m, falls, 26.iii.1997, O. S. Flint, Jr., 5 males, 1 female (pinned, NMNH); Kunigami-son, upper Zatsun-gawa, 27.iii.1997, O. S. Flint, Jr., 6 males, 1 female (pinned, NMNH).

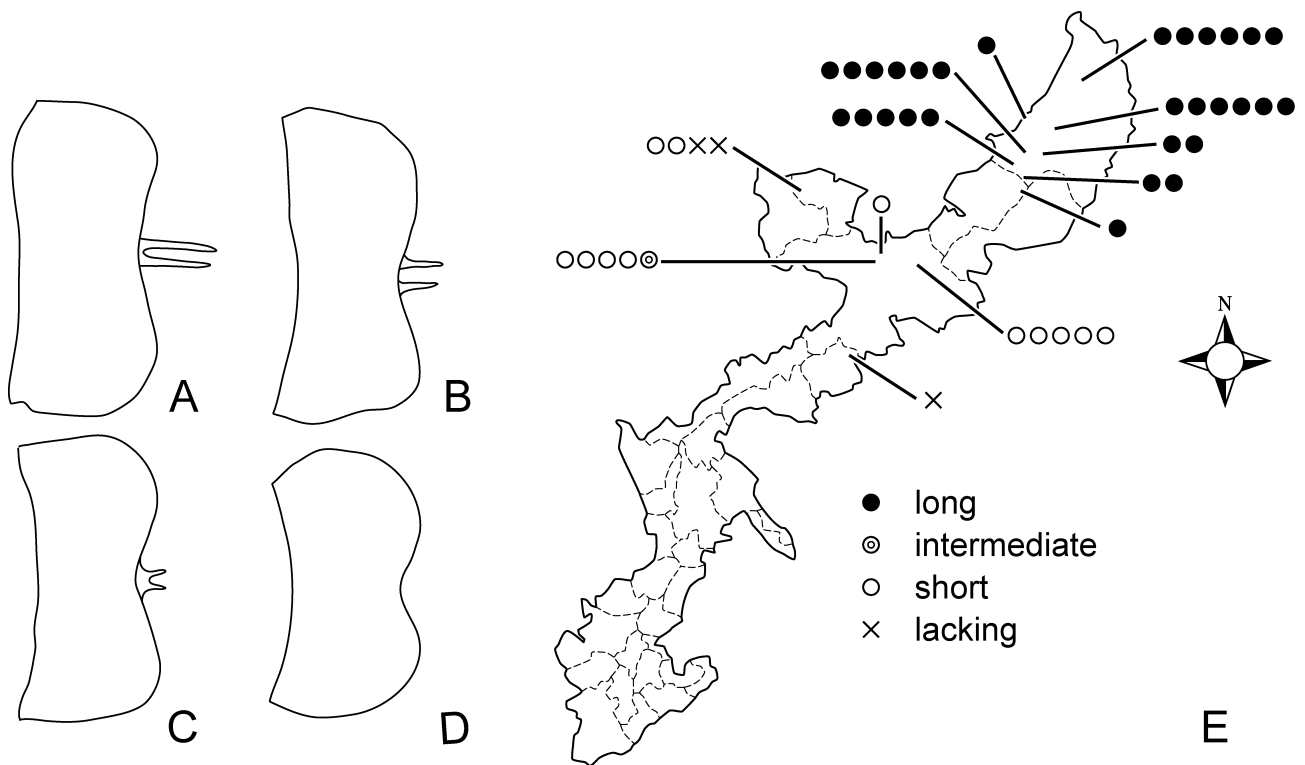


FIGURE 4. Variation of male of *Wormaldia okinawaensis* **sp. nov.** Tergum VIII, dorsal view (A–D): A, long process; B, intermediate process; C, short process; D, lacking process. Distribution map of each type in Okinawa-jima (E). Each circle or cross indicates an individual.

Other specimens examined. **Okinoerabu-jima:** Ginsuidô, 30.iv.2004, H. Yoshigou, 1 male. **Okinawa-jima:** same data as the holotype, 1 male, 1 female; Ginoza-son, Kimbaru-gawa, 26.iii.1997, FN, 1 male; Kunigami-son, Hiji-ôtaki, 21.iii.1999, TI and AO, 1 female; Kunigami-son, upper reaches of Iji-gawa, 4.v.1997, KT, 1 male; Kunigami-son, Yona, Sukuna-gawa, small stream, 22.iii.1999, TI and AO, 1 female; Kunigami-son, Yonaha-dake, 27.iii.1997, FN, 2 males; Nago-shi, Genka-kawa, Hogen-hashî, 22–24.xi.2010, TI, 5 males; Nago-shi, Haneji, 12.v.1993, F, Sato, 1 male; Nago-shi, tributary of Haneji-ôkawa, 11.v.1993, F, Sato, 5 males; Nakijin-son, Shigema-gawa, el. 115 m, 17.iii.2012, TI, 4 males; Ôgimi-son, upper reaches of Takasato-gawa, 17.iii.2012, TI, 1 male; Okinawa-shi, Takiyambaru, 28.iv.1993, F, Sato, 1 female.

Etymology. This specific epithet is named for the island in which the holotype specimen was collected.

Distribution. Japan: central Ryûkyûs (Okinoerabu-jima, Okinawa-jima).

Wormaldia apophysis **sp. nov.**

Fig. 5

This new species is similar to *W. okinawaensis* **sp. nov.** in the structure of male genitalia, but can be distinguished from it by the longer distal segment of inferior appendages.

Adults. Forewing length: male 3.9–4.8 mm (mean = 4.3 mm, n = 8); female 3.5–3.8 mm (mean = 3.6 mm, n = 3). Color (in alcohol) generally blackish brown. Wing venation as in *W. carinata*.

Male genitalia (Fig. 5A–E). Ventral lobe of sternum VII moderately developed, triangular with round apex in ventral aspect. Tergum VIII somewhat extended posteriorly; posterior margin widely incised mesally; mesal process arising from posterior margin, slender, bifurcated at one-third distance from apex, upcurved preapically. Ventral lobe of sternum VIII triangular with round apex in ventral aspect. Segment IX as long as tall, with moderately produced anterolateral margins. Preanal appendages elongate, nearly straight in lateral aspect, weakly curved inward in distal one-third in dorsal aspect. Tergum X tapering to apex in dorsal aspect, with pair of small triangular lateral projections at two-fifths distance from base and small dorsomesal projections subapically, bearing about five strong setae around each lateral projection. Inferior appendages with basal segment 1.7 times as long as tall; distal segment as long as basal segment, tapering to round apex in

lateral aspect, with small spines along apical margin on mesal surfaces. Phallus membranous, with broad-based cylindrical phallosome including invaginated endotheca, with a broad based, bifurcated sclerotized endotheal armature, each branch sigmoid.

Female genitalia (Fig. 5F, G). Sternum VII weakly concaved posterolaterally. Segment VIII slightly longer than segment VII, longer than tall; tergum weakly sclerotized; sternum longer than tall in lateral aspect, moderately sclerotized laterally. Segment IX longer than tall, with anterior sclerotized band, short stick-like internal sclerite positioned between anterior apodemes. Vaginal apparatus with ring-like anterior sclerite.

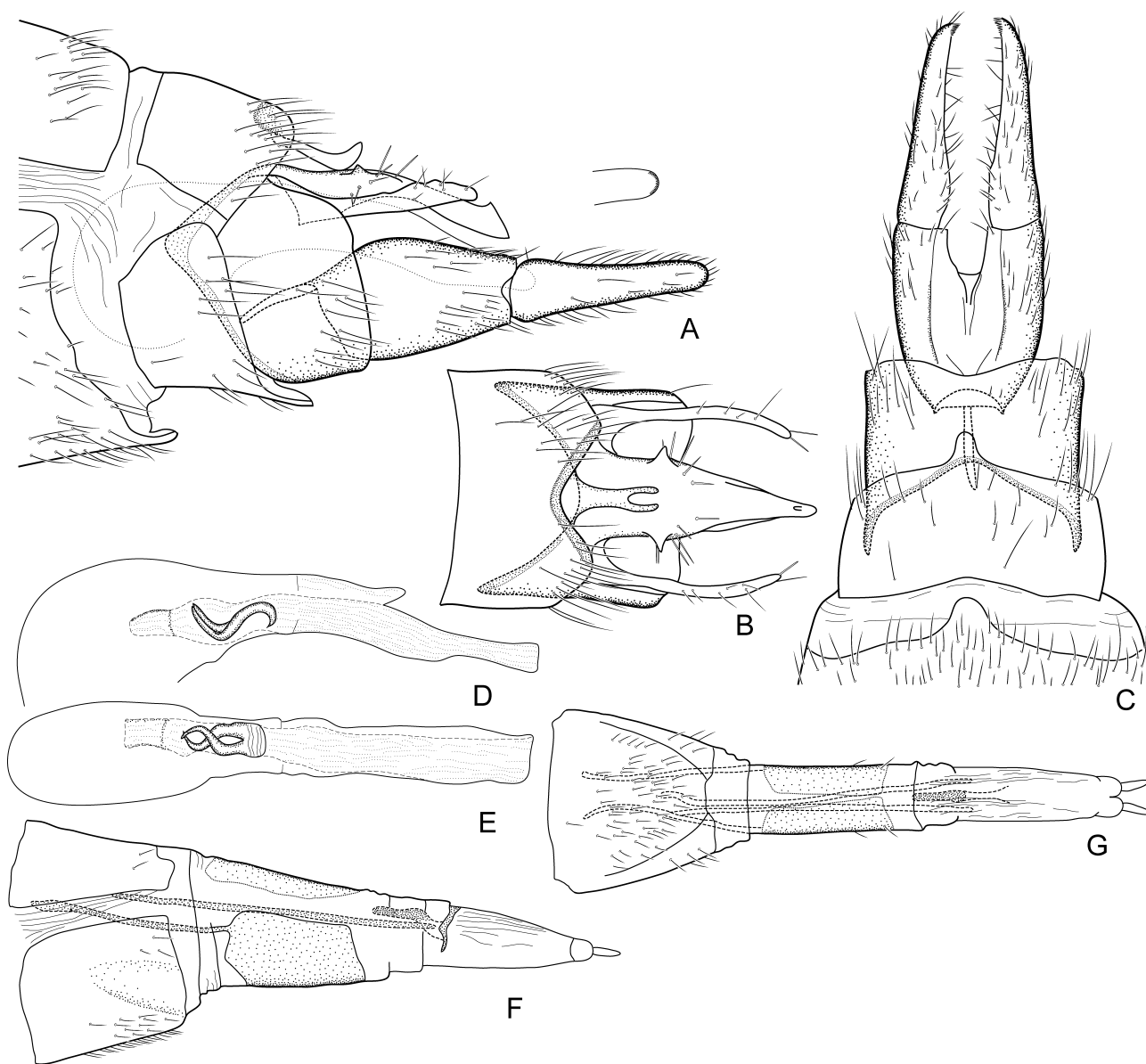


FIGURE 5. *Wormaldia apophysis* sp. nov. Male genitalia (A–E): A, lateral; B, dorsal; C, ventral; D, phallus, lateral; E, phallus, dorsal. Female genitalia (F–G): F, lateral; G, ventral.

Holotype male: Japan: Amami-ôshima: Uken-son, Yuwan-dake, 9.v.2007, TI (SEHU).

Paratypes: Amami-ôshima: same data as the holotype, 7 males (SEHU); Amami-shi, Naze, upper reaches of Ôkawa, 9.iv.1993, RK, 2 males (CBM); *ibid.*, 19.iv.1993, RK, 2 males (CBM); Setouchi-chô, Miyama-gawa, 25–26.x.2011, TI, 1 male (SEHU); Setouchi-chô, Miyama-gawa, small stream, 26.x.2011, TI, 6 males (SEHU); Uken-son, Kawauchi-gawa, 25.x.2011, TI, 5 males (CBM); Uken-son, Yuwan-dake, small stream, 17.iv.1993, RK, 1 male (CBM).

Other specimens examined. Amami-ôshima: Amami-shi, Naze, Kinsakubaru, 23.iii.1997, FN, 3 males; *ibid.*, 28.iii.1998, FN, 8 males; Amami-shi, Naze-asato, 30.iii.1998, NH, 2 males; Amami-shi, Sumiyô-chô,

Santarô-tunnel, 30.iii.1998, NH, 1 male; Setouchi-chô, Miyama-gawa, 21.iv.2008, TI, 1 male; Setouchi-chô, Miyama-gawa, small stream, 25–26.x.2011, TI, 5 males, 1 female; Tatsugô-chô, Toguchi-gawa, 27.iii.1998, NH, 3 males; Uken-son, Tôhatakebashi, 29.iii.1998, FN, 46 males; Uken-son, tributary of Kawauchi-gawa, 25.x.2011, TI, 4 males, 2 females; Uken-son, Yuwan-dake, 9.v.2007, TI, 6 males; Uken-son, Yuwan-gawa, el. 400–600 m, 9.v.2007, TI, 2 males; Uken-son, Yuwan, el. 46 m, 12.v.2014, KT, 3 males; Uken-son, 24.iii.1997, FN, 11 males; *ibid.*, 29.iii.1998, NH, 1 male. **Tokuno-shima:** Amagi-cho, Matsubara, el. 81 m, 13.v.2014, KT, 1 male.

Etymology. The specific epithet derived from the Greek "*apophysis*" (process) in reference to the prominent posteromesal process of tergum VIII in male genitalia of this species.

Distribution. Japan: central Ryûkyûs (Amami-ôshima, Tokuno-shima).

***Wormaldia tectum* sp. nov.**

Fig. 6

This new species is characterized by the combination of the following male characteristics: tergum VIII developed posterodorsally nearly overhanging tergum X, segment IX longer than tall and distal segment of inferior appendages constricted at midlength in lateral aspect.

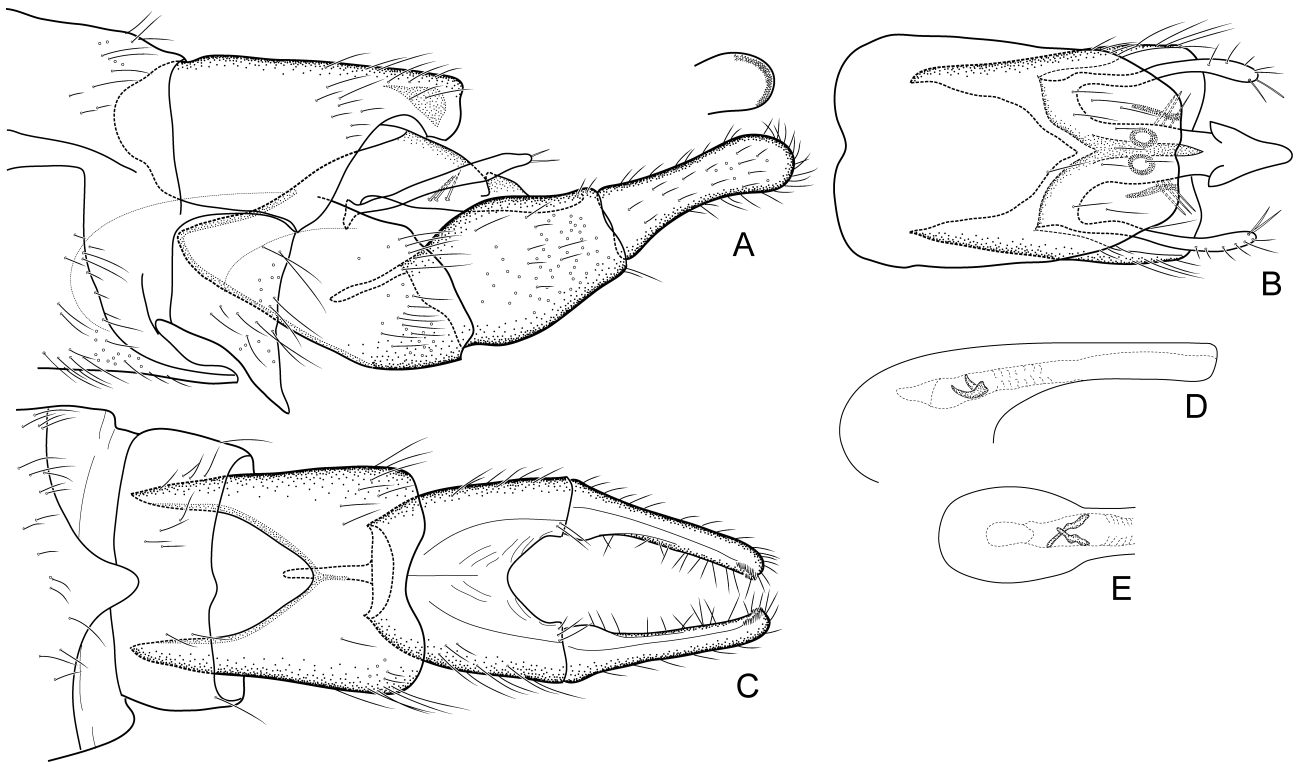


FIGURE 6. *Wormaldia tectum* sp. nov. Male genitalia: A, lateral; B, dorsal; C, ventral; D, phallus, lateral; E, phallus, dorsal.

Adults. Forewing length: male 4.4–4.6 mm (mean = 4.5 mm, n = 3). Color (pinned specimens): generally blackish brown, legs yellowish. Wing venation as in *W. carinata*.

Male genitalia (Fig. 6A–E). Ventral lobe of sternum VII moderately developed, triangular with round apex in ventral aspect. Tergum VIII strongly developed posterodorsally as roof-like extension, covering more than basal half of tergum X; extension tapered in dorsal aspect, bent downward posterolaterally, posterior margin shallowly notched mesally. Ventral lobe of sternum VIII directed ventrad, extended beyond ventral margin of sternum VII. Segment IX longer than tall, anterolateral margins distinctly produced anterad. Preanal appendages slender, directed posterodorsally, weakly curved inward in distal halves. Tergum X tall basally in lateral aspect, narrow, slightly tapering to apex in dorsal aspect, with mesal ridge in basal half and pair of small triangular lateral projections at one-fourth distance from apex, bearing three setae along each side around midlength. Inferior appendages with basal segment 1.4 times as long as tall; distal segment as long as basal segment, constricted at midlength with round apex in lateral aspect, with small spines along apical margin on

mesal surfaces. Phallus membranous, with broad-based cylindrical phallosome including invaginated endothea, with pair of short curved sclerotized endothelial armature.

Female. Unknown.

Holotype male: Japan: Okinawa-jima: Kunigami-son, Yonaha-dake, 27.iii.1997, FN (SEHU).

Paratypes: Okinawa-jima: same data as the holotype, 2 males (1 male: SEHU, 1 male: CBM); Kunigami-son, Yona, upper Yona-gawa, 25.iii.1997, O. S. Flint, Jr., 1 male (pinned, NMNH).

Etymology. The specific epithet derived from the Latin neuter noun "*tectum*" (roof) in reference to the roof-like structure of tergum VIII in male genitalia of the species.

Distribution. Japan: central Ryûkyûs (Okinawa-jima).

***Wormaldia itoae* sp. nov.**

Fig. 7

This new species is similar to *W. fujinoensis* Kobayashi 1980, *W. nabewarina* Kobayashi 1969 and *W. kadowakii* Kobayashi 1980, but can be distinguished from the latter three species by the deep dorsomesal excision of tergum VIII of the male.

Adults. Forewing length: male 4.3–4.6 mm (mean = 4.5 mm, n = 11). Color (in alcohol): generally brown. Wing venation as in *W. carinata*.

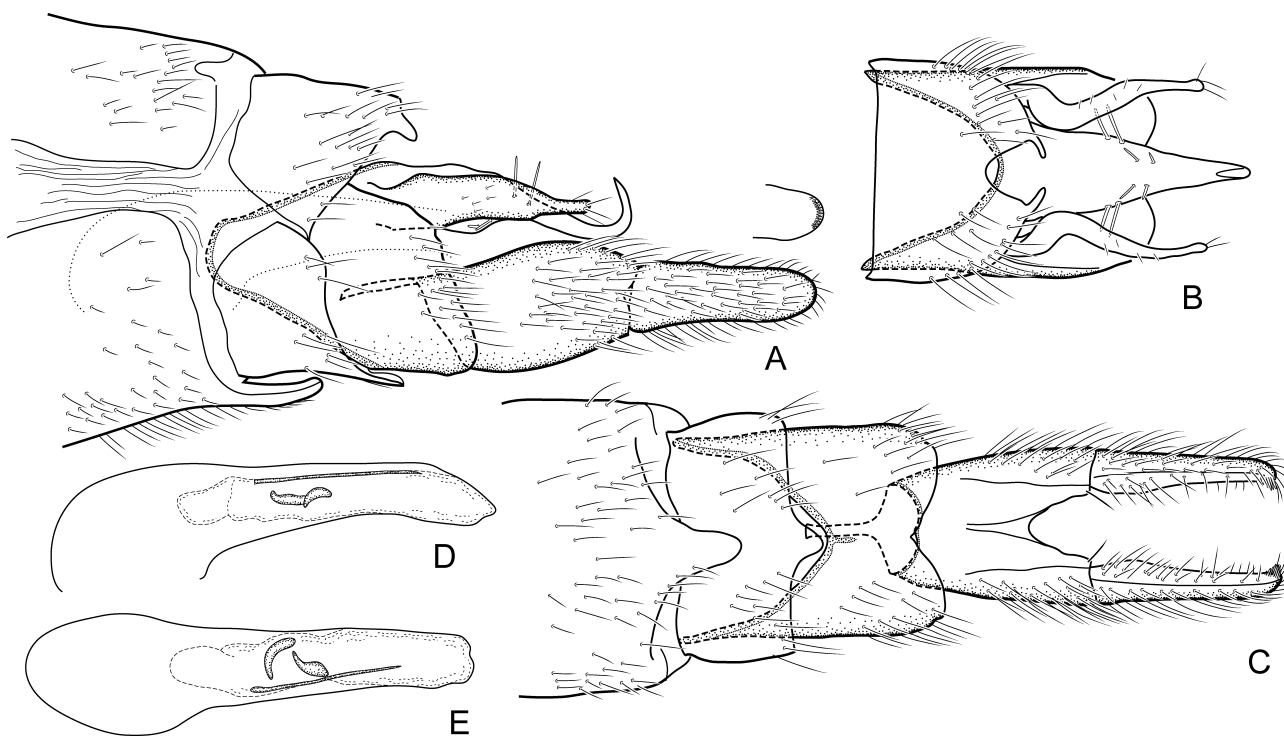


FIGURE 7. *Wormaldia itoae* sp. nov. Male genitalia: A, lateral; B, dorsal; C, ventral; D, phallus, lateral; E, phallus, dorsal.

Male genitalia (Fig. 7A–E). Ventral lobe of sternum VII strongly developed, triangular with round apex in ventral aspect. Tergum VIII somewhat extended posteriorly; posterior margin deeply excised mesally; arm-like short processes arising from both side corners of excision, directed posteromesad. Ventral lobe of sternum VIII triangular with round apex. Segment IX longer than tall, anterolateral margins distinctly produced anterad. Preanal appendages relatively thick, tapering to apex in lateral aspect, sinuate in dorsal aspect. Tergum X triangular in dorsal aspect, apical part acutely curved dorsad, bearing two pairs of strong lateral setae and two pairs of strong setae dorsolaterally near midlength. Inferior appendages with basal segment 1.7 times as long as tall; distal segment as long as basal segment, slightly tapering to round apex in lateral aspect, with small spines along apical margin on mesal surfaces. Phallus membranous, with broad-based cylindrical phallosome. Sclerotized endothelial armature consists of two curved short spines and a rod-like long spine.

Female. Unknown.

Holotype male: Japan: Yaku-shima: Kamiyaku-chô, tributary of Miyanoura-gawa, 10.v.2006, TI (SEHU).

Paratypes: Yaku-shima: same data as the holotype, 5 males (3 males: SEHU, 2 males: CBM); Yaku-chô, Harumaki, 20.vii.1998, RK, 1 male (CBM).

Other specimens examined. **Yaku-shima:** Kamiyaku-chô, Shirataniunsuikyô, 9.v.2006, TI, 2 males.

Etymology. The specific epithet named after T. Ito, who collected the holotype specimen.

Distribution. Japan: northern Ryûkyûs (Yaku-shima).

Wormaldia amamiensis sp. nov.

Fig. 8

The male of this new species is perhaps most similar to that of *W. bilamellata* Sun 1997, but differs from it by segment IX whose anterolateral margins are somewhat angularly produced and endotheca without sclerotized armature. It also somewhat resembles those of *W. niiensis* Kobayashi 1985 and *W. gabriella* (Banks 1930) but can be easily distinguished from them by tergum X whose apex is not upcurved. Moreover, the ventral lobe of sternum VII weakly tapers to the apex in this species, but in *W. bilamellata*, *W. niiensis* and *W. gabriella* it is constricted basally in ventral aspect.

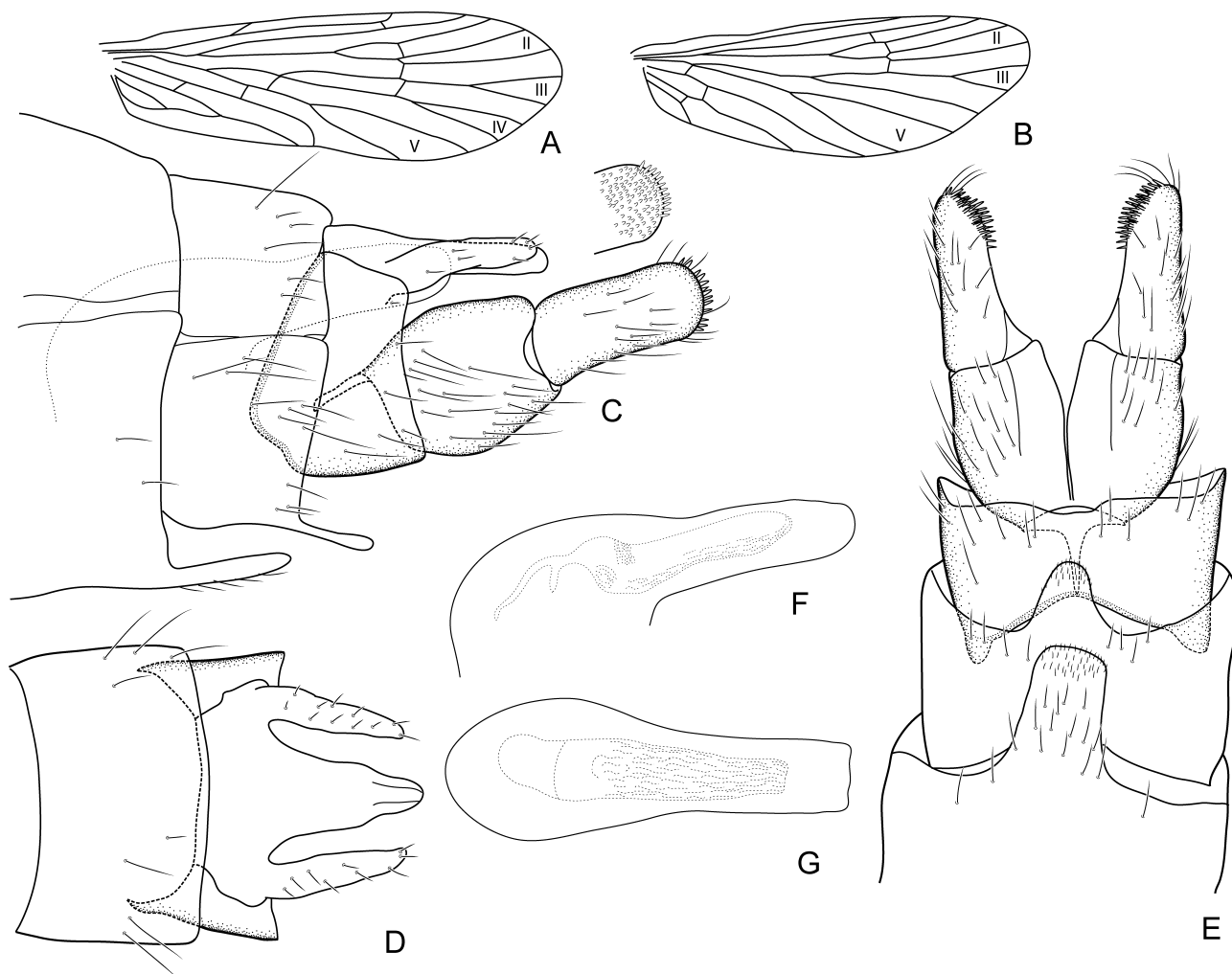


FIGURE 8. *Wormaldia amamiensis* sp. nov. Wings (A–B): A, forewing; B, hind wing. Male genitalia (C–G): C, lateral, with mesal surface of inferior appendage distal segment; D, ventral; E, dorsal; F, phallus, lateral; G, phallus, dorsal.

Adults. Forewing length: male 3.7–4.5 mm (mean = 4.2 mm, n = 10). Color (in alcohol): dorsum of head and thorax brown, all wings light brown. Forewings with apical folks II, III, IV and V (Fig. 8A). Hind wings with apical folks II, III, and V (Fig. 8B).

Male genitalia (Fig. 8C–G). Ventral lobe of sternum VII strongly developed, weakly tapering to blunt apex in ventral aspect. Tergum VIII not modified, with nearly straight posterior margin. Ventral lobe of sternum VIII moderately long, triangular with round apex in ventral aspect. Segment IX shorter than tall, anterolateral margins somewhat angularly produced anterad. Preanal appendages finger-like, nearly straight in dorsal aspect, almost as long as tergum X. Tergum X tapering to apex in dorsal aspect, without projections and strong setae. Inferior appendages short; basal segment slightly longer than tall; distal segment as long as basal segment, twice as long as tall, nearly parallel sided in lateral aspect, with small spines on apical third of mesal surfaces. Phallus membranous, with broad-based cylindrical phallosome and invaginated endotheca without sclerotized endothecal armature.

Female. Unknown.

Holotype male: Japan: Amami-ôshima: Uken-son, Kawauchi-gawa, 29.iii.1998, NH (SEHU).

Paratypes: Amami-ôshima: same data as the holotype, 2 males (CBM); Yamato-son, Yamatohama, upper reaches of Yamato-gawa, 15.v.2014, KT, 3 males (SEHU).

Other specimens examined. **Amami-ôshima:** Amami-shi, Sumiyô-chô, Kamiya, 12.v.2014, KT, 2 males; Uken-son, Kawauchi-gawa, el. 50 m, 9.v.2007, TI, 1 male; Yamato-son, Yamatohama, upper reaches of Yamato-gawa, 15.v.2014, KT, 3 males.

Etymology. This specific epithet is named for its distribution in Amami-ôshima.

Distribution. Japan: central Ryûkyûs (Amami-ôshima).

Wormaldia ishigakiensis sp. nov.

Fig. 9

The male of this new species is very similar to that of *W. gressitti* Ross 1956, especially in the shape of the segment IX and the basal segment of inferior appendages but can be distinguished from it by the following characteristics: In dorsal aspect, the apex of tergum X of *W. ishigakiensis* is narrow, but that of *W. gressitti* is broadly rounded and relative length of the distal to basal segment of inferior appendages of *W. ishigakiensis* is somewhat larger than that of *W. gressitti*; sclerotized endothecal armature consists of two rod-like spines and a small sclerite in *W. ishigakiensis*, but a sinuate slender rod in *W. gressitti*. In Ryûkyûs this is the only species whose discoidal cell in both wings is short and the tips of R1 and R2 are fused in the hind wings.

Adults. Forewing length: male 4.0 mm (n = 1); female 4.4–4.8 mm (mean = 4.6 mm, n = 3). Color (in alcohol) generally light brown. Forewings with apical forks I, II, III, IV and V (Fig. 9A). Hind wings with I, II, III and V (Fig. 9B). Discoidal cell short in all wings. Hind wings R1 short, fused to R2 near edge.

Male genitalia (Fig. 9C–H). Ventral lobe of sternum VII strongly developed, narrow with round apex in ventral aspect. Tergum VIII strongly developed posterodorsally as roof-like extension, strongly tapering to posterior margin in dorsal aspect. Ventral lobe of sternum VIII strongly developed ventrocaudad, narrow and triangular with subacute apex in ventral aspect. Segment IX slightly longer than tall, subtriangular in lateral aspect; anterolateral margins distinctly produced anterad; posteroventral margin developed ventrad, with small ventromesal process. Preanal appendages slender and nearly straight in lateral aspect; mesal margins with excisions in basal halves in dorsal aspect. Tergum X tapering to narrow apex with constriction near midlength in dorsal aspect, with dorsal projection subbasally. Inferior appendages with basal segment twice as long as tall, each with small triangular process on dorsomesal surface; distal segment slightly shorter than basal segment, slightly curved downward in lateral aspect, with small spines on mesal surfaces subapically; inner margins with acute expansions subapically in ventral aspect. Phallus membranous, with broad-based cylindrical phallosome. Sclerotized endothecal armature consists of two rod-like spines and a small sclerite.

Female genitalia (Fig. 9I, J). Sternum VII bearing strong hook-like mesal process in anterior one-third, which is directed posteroventrad in lateral aspect. Segment VIII as long as segment VII, as long as tall in lateral aspect; tergum and sternum not separate. Segment IX longer than tall, with sclerotized band anteriorly. Vaginal apparatus with ring-like anterior sclerite.

Holotype male: Japan: Ishigaki-jima: Nagura, Hokusui, Nagura-gawa, tributary, el. 9 m, 11–13.iv.2011, TI (SEHU).

Other specimens examined. **Ishigaki-jima:** same data as the holotype, 2 females (CBM); Nagura, Hokusui, Nagura-gawa, el. 9 m, 11–12.iii.2009, TI, 1 female (SEHU).

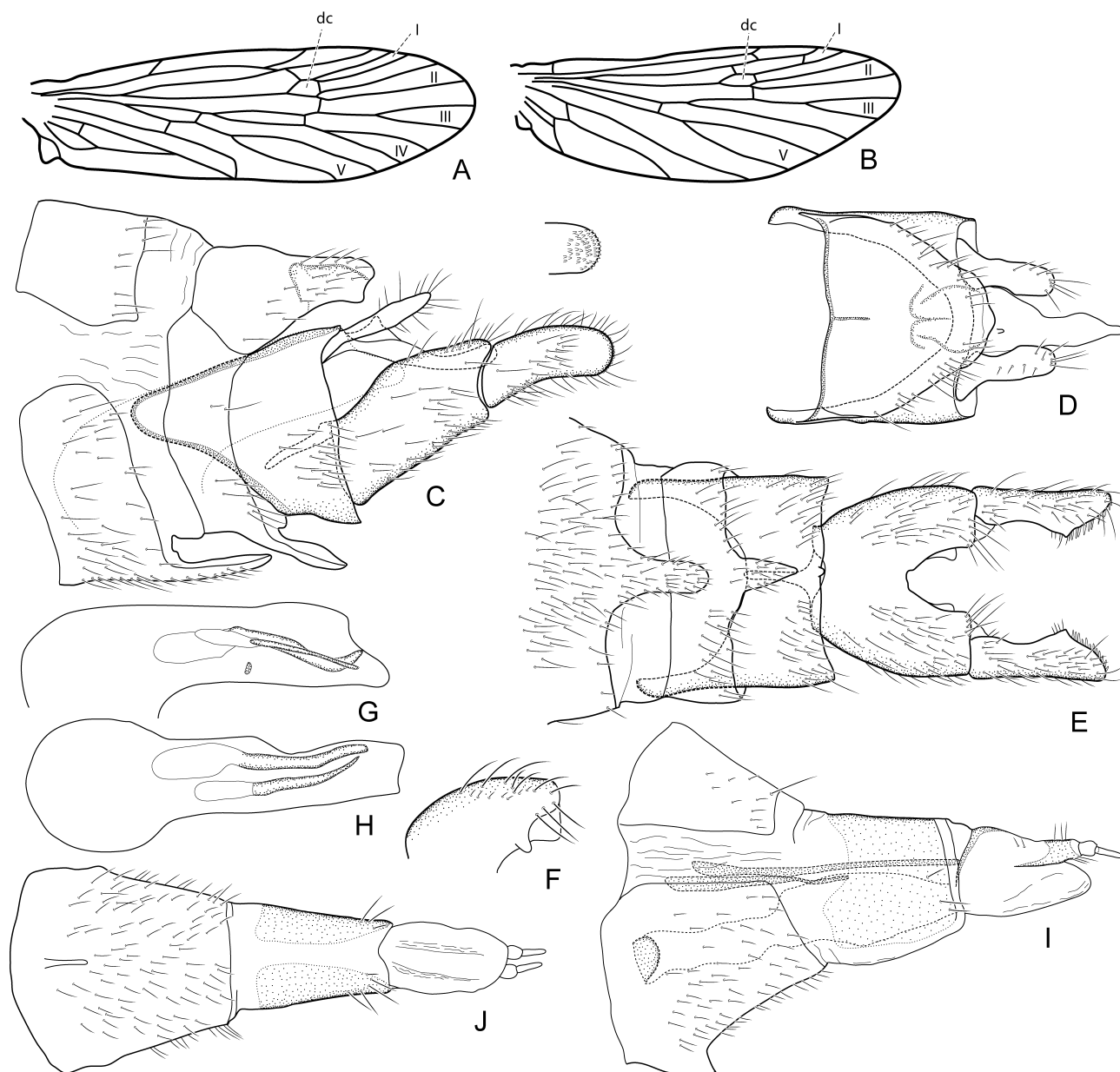


FIGURE 9. *Wormaldia ishigakiensis* sp. nov. Wings (A–B): A, forewing; B, hind wing. Male genitalia (C–H): C, lateral, with mesal surface of inferior appendage distal segment; D, dorsal; E, ventral; F, basal segment of right inferior appendage, dorsal; G, phallus, lateral; H, phallus, dorsal. Female genitalia (I–J): I, lateral; J, ventral. Abbreviation: dc = discoidal cell.

Etymology. This specific epithet is named for its distribution in Ishigaki-jima.

Distribution. Japan: southern Ryūkyūs (Ishigaki-jima).

***Wormaldia yakuensis* Kobayashi 1980**

Wormaldia (*Wormaldia*) *yakuensis* Kobayashi 1980: 102 (male) (Type locality: Yaku-shima, northern Ryūkyūs, Japan); Kuhara 2005a, 233 (male).

This species was originally described from Yaku-shima, northern Ryūkyūs and was recently redescribed with additional specimen records from this island (Kuhara 2005a). The following additional specimens have been examined.

Additional specimens examined. **Yaku-shima:** Kamiyaku-chō, Nagata, small stream, 10.v.2006, TI, 5 males; *ibid.*, 25.ix.2003, N. Kuhara, 3 males; Kamiyaku-chō, Seibu, small stream, 10–11.v.2006, TI, 2 males;

Kamiyaku-chô, Shirataniunsuikyô, 9.v.2006, TI, 1 male; *ibid.*, 9.v.2006, TI, 1 male; Kamiyaku-chô, tributary of Miyanoura-gawa, 10.v.2006, TI, 1 male; Yaku-chô, Onoaida, Onoaida-gyokô, 17.iv.2003, A. Ishizuka, 1 male; Yaku-chô, Yodogawagoya-shita, el. 1360 m, 10.vii.1992, T. Ogata, 1 male.

Distribution. Japan: Kyûshû, northern Ryûkyûs (Yaku-shima).

Wormaldia niiensis Kobayashi 1985

Wormaldia (Wormaldia) niiensis Kobayashi 1985, 9, male (Type locality: Nii, Tsushima, Japan); Kuhara 2005a, 237 (male).

Wormaldia coreana Kumanski 1992, 56, male (Type locality: Mt. Kumgang, Kangweon-do, North Korea); Ivanov 1997, 47, male, female; synonymized by Kuhara (2005a).

Kuhara (2005a) redescribed this species and recorded it from Yaku-shima, northern Ryûkyûs. No additional specimens were examined during the current study.

Distribution. Japan: Hokkaidô, Honshû, Shikoku, Kyûshû, northern Ryûkyûs (Yaku-shima), Tsushima. North Korea, Russia (South Primorye).

Wormaldia sp.

This is a probable undescribed species collected in Yaku-shima, northern Ryûkyûs and has also been found in Honshû and Shikoku, Japanese mainlands (Kuhara unpublished). I will describe it in another paper on *Wormaldia* of Japanese mainlands.

Material examined: Japan: Yaku-shima: Kamiyaku-chô, Shirataniunsuikyô, 9.v.2006, TI, 1 male; Kamiyaku-chô, tributary of Miyanoura-gawa, 10.v.2006, TI, 1 male.

Discussion

A total of 10 *Wormaldia* species were found in the Ryûkyû Archipelago during this study (Table 1). While 3 or 4 species with more than 50 specimens in total have been collected from each of 3 islands (Yaku-shima in northern Ryûkyûs and Amami-ôshima and Okinawa-jima in central Ryûkyûs) only 4 specimens of a single species, *Wormaldia ishigakiensis* were found in the southern Ryûkyûs. Although there might be additional undiscovered species, density and diversity of *Wormaldia* in the southern Ryûkyûs would be quite low, as more than 600 philopotamid specimens collected in various seasons have been examined from the southern Ryûkyûs including Iriomote-jima, Ishigaki-jima and Yonaguni-jima.

TABLE 1. Distribution of *Wormaldia* species on islands in southern, central and northern Ryûkyûs.

Species	S. Ryûkyû	C. Ryûkyû				N. Ryûkyû	Japanese mainlands*
	Ishigaki-jima	Okinawa-jima	Okinoerabu-jima	Tokuno-shima	Amami-ôshima	Yaku-shima	
<i>W. ishigakiensis</i>	+						
<i>W. tectum</i>		+					
<i>W. okinawaensis</i>		+	+				
<i>W. carinata</i>		+			+		
<i>W. apophysis</i>				+	+		
<i>W. amamiensis</i>					+		
<i>W. itoae</i>						+	
<i>W. yakuensis</i>						+	+
<i>W. niiensis</i>						+	+
<i>W. sp.</i>						+	+

*More species have been recorded in Japanese mainlands (Kuhara 2005).

Species composition of *Wormaldia* are totally different among 3 regions of the Ryûkyûs; each species is distributed within only a single region. In addition, even in the central Ryûkyûs, species composition of *Wormaldia* differs between two major islands, Amami-ôshima and Okinawa-jima. Only *W. carinata* is distributed on both islands, the remaining four species were found on only one of the two islands, although *W. okinawaensis* and *W. apophysis* were also collected on other islands that are located between the two major islands. A similar tendency is found in the genus *Lepidostoma* (Lepidostomatidae), which is one of the most intensively studied group of caddisflies in Ryûkyûs (Ito 2005). Three, four and two *Lepidostoma* species have been recorded in northern, central and southern Ryûkyûs respectively, with each species being distributed within a single region and only one species being distributed in both the major islands of central Ryûkyûs.

All *Wormaldia* species of the northern Ryûkyûs, except *W. itoae*, are also distributed on the Japanese mainlands, whereas each species of the central and southern Ryûkyûs is endemic to its own region of the Ryûkyûs. This is consistent with the boundary between the Oriental and Palaearctic regions that is said to exist between Yaku-shima and Amami-ôshima (Toda *et al.* 2003). Although *W. itoae* is an endemic species to northern Ryûkyûs, it appears to be closely related to Japanese mainland species including *W. fujinosensis*, *W. nabewarina* and *W. kadowakii*.

The only species in the southern Ryûkyûs, *W. ishigakiensis* is supposed to be closely related to *W. gressitti* described from Guangdong Province, continental China, which is located west of Taiwan, because of their great similarity in male genitalia and sharing the same wing venation. The Taiwanese species, *W. ulmeri* Ross also shares the same wing venation with *W. ishigakiensis*, whereas there is no known close relative in the central Ryûkyûs, as all species there have different venation from *W. ishigakiensis*.

Meanwhile in the central Ryûkyûs, *W. amamiensis* resembles *W. niiensis*, which is distributed in the northern Ryûkyûs and more northern regions, as well as *W. bilamellata*, which is distributed in Henan Province, continental China. They have similar male genitalia shape and the same wing venation, suggesting that they may be close relatives. In southern Ryûkyûs, on the other hand, there is no similar species to *W. amamiensis*. The other four species in the central Ryûkyûs have no possible close relatives in either the southern or northern Ryûkyûs. They might be relict species as has been suggested in some endemic animal species in the central Ryûkyûs (Kinjo 1986, Ota 1998; Yamada *et al.* 2002). Phylogenetic analysis involving species from the Ryûkyûs and surrounding regions may assist understanding their present distributions.

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References

- Banks, N. (1930) New neuropteroid insects from the United States. *Psyche*, 37, 223–233.
<http://dx.doi.org/10.1155/1930/12828>
- Ito, T. (2005) Checklist of the family Lepidostomatidae, Trichoptera, in Japan 2. In: Tanida, K. & Rossiter, A. (Eds.), *Proceedings of the 11th International Symposium on Trichoptera*. Tokai University Press, Kanagawa, pp. 199–206.
- Ivanov, V.D. (1997) Fam. Philopotamidae. In: Lehr, P.A. (Ed.), *Key to the insects of Russian Far East. Vol. 5. Part 1. Trichoptera and Lepidoptera*. Dal'nauka, Vladivostok, pp. 46–51. [in Russian]
- Kinjo, M. (1986) Nansei-shotô no konchû-sô (Insect fauna of Nansei Islands). In: Kimoto, S. (Ed.), *Nihon no konchû-chirigaku: Hen'isei to shubunka wo megutte (Insect biogeography of Japan: variability and speciation)*. Tokai University Press, Tokyo, pp. 85–91. [in Japanese]
- Kobayashi, M. (1969) Four new species of Trichoptera from Japan. *Bulletin of the Kanagawa Prefectural Museum*, 1, 17–22 + 2 pls.
- Kobayashi, M. (1980) A revision of the family Philopotamidae from Japan (Trichoptera: Insecta). *Bulletin of the Kanagawa Prefectural Museum*, 12, 85–104 + 8 pls.
- Kobayashi, M. (1985) On the Trichoptera from the Island of Tsushima, with seven new species (Insecta). *Bulletin of the Kanagawa Prefectural Museum*, 16, 7–22.
- Kuhara, N. (2005a) A review of *Wormaldia* McLachlan (Trichoptera: Philopotamidae) in Japan, with redescription of eight species. In: Tanida, K. & Rossiter, A. (Eds.), *Proceedings of the 11th International Symposium on Trichoptera*. Tokai University Press, Kanagawa, pp. 229–244.
- Kuhara, N. (2005b) Taxonomic revision of the genus *Dolophilodes* subgenus *Dolophilodes* (Trichoptera: Philopotamidae) of

- Japan. *Entomological Science*, 8, 91–107.
<http://dx.doi.org/10.1111/j.1479-8298.2005.00104.x>
- Kumanski, K. (1992) Studies on Trichoptera of Korea (North). III. Superfamily Hydropsychoidea. *Insecta Koreana*, 9, 52–77.
- Nishida, M., Shikatani, N. and Shokita, S. (Eds.) (2003) *The flora and fauna of inland waters in the Ryukyu Islands*. Tokai University Press, Tokyo, 572 pp. [in Japanese]
- Ohta, H. (1998) Geographic patterns of endemism and speciation in amphibians and reptiles of the Ryukyu Archipelago, Japan, with special reference to their paleogeographical implications. *Researches on Population Ecology*, 40, 189–204.
<http://dx.doi.org/10.1007/BF02763404>
- Ross, H.H. (1956) *Evolution and classification of the mountain caddisflies*. The University of Illinois Press, Urbana, 213 pp.
- Schmid, F. (1991) Quelques Philopotamides orientaux nouveaux ou peu connus (Trichoptera, Annulipalpia). *Beaufortia*, 42, 89–107.
- Shimura, N. (2010) Collection record of Ephemeroptera, Plecoptera and Trichoptera from Yonaguni-Island, the westernmost part of Japan. *Hyōgo Freshwater Biology*, 61/62, 45–54. [in Japanese]
- Sun, C. (1997) Notes on six new species of Trichoptera (Insecta: Mecopteroidea). *Entomotaxonomia*, 19, 289–296. [in Chinese with English summary]
- Sun, C. & Malicky, H. (2002) 22 new species of Philopotamidae (Trichoptera) from China. *Linzer Biologische Beiträge*, 34, 521–540.
- Tanida, K. (1997) Trichoptera fauna of the Ryukyu Islands: taxonomic and ecological prospects. In: Holzenthal, R.W. & Flint, O.S. Jr. (Eds.), *Proceedings of the 8th International Symposium on Trichoptera*. Ohio Biological Survey, Columbus, pp. 445–451.
- Toda, M., Shokita, S. & Nishida, M. (2003) Ryūkyū-rettō no seibutsu-sō no rekishiteki naritachi (Origin of flora and fauna of Ryūkyū Islands). In: Nishida, M., Shikatani, N. & Shokita, S. (Eds.), *The flora and fauna of inland waters in the Ryukyu Islands*. Tokai University Press, Tokyo, pp. 25–32. [in Japanese]
- Yamada, F., Takaki, M. & Suzuki, H. (2002) Molecular phylogeny of Japanese Leporidae, the Amami rabbit *Pentalagus furnessi*, the Japanese hare *Lepus brachyurus*, and the mountain hare *Lepus timidus*, inferred from mitochondrial DNA sequences. *Genes & Genetic Systems*, 77, 107–116.
<http://dx.doi.org/10.1266/ggs.77.107>
- Yoshigou, H., Tamura, H., Iwao, M. & Shimada, N. (2005) The cave fauna of Okinoerabu-jima Island, Amami group, Ryukyu islands, Japan. *Miscellaneous Report of the Hiwa Museum for Natural History*, 44, 37–59 + 5pls. [in Japanese with English abstract]