



New species and immatures of crane flies of subgenus *Formotipula* Matsumura from Taiwan (Diptera: Tipulidae: *Tipula*)

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Abstract

Taiwanese species of the crane fly subgenus *Tipula* (*Formotipula*) Matsumura, 1916, are reviewed. *Tipula* (*Formotipula*) *argentea*, **new species**, is described and figured. The only other previously known Taiwanese species, *Tipula* (*Formotipula*) *holoserica* (Matsumura, 1916), is redescribed. The external anatomy of the last instar larva and pupa of *T. (F.) holoserica* is described and illustrated, with a brief discussion of the biology of the larva.

Key words: Diptera, *Formotipula*, larva, new species, pupa, Taiwan, *Tipula*, Tipulidae

Introduction

Formotipula was first proposed by Matsumura (1916) as a genus for the type species *Formotipula holoserica*. Alexander (1920) placed *Tipula nigrorubra* (Riedel, 1917) and *Tipula rufomedia* (Edwards, 1916) as synonyms of *Tipula holoserica* (Matsumura, 1916). Edwards (1931) recognized *Formotipula* as a subgenus of *Tipula* Linnaeus and characterized *Formotipula* morphologically by the following features: spur formula is 1–1–2; claws of male toothed; Rs short or of moderate length (1–1.5 times m-cu); M4 arising near middle of discal cell; hairs on branches of M usually few or absent; squama quite bare; thorax nearly bare and uniformly dull black or red; abdomen short, ovipositor always short, fleshy.

Additional characters were recognized for the subgenus in a summary publication on the 18 species of *Formotipula* in Asia (Alexander 1935), and Savchenko (1961) presented a tentative key to the species of *Formotipula* found in the Palaearctic. The diagnostic characteristics, including external sexual characters that separate *Formotipula* from other subgenera, are: body coloration contrasting, black and orange; thorax either chiefly velvety black or a shade of orange or reddish orange; no setae on mesopleura; tibial spur formula 1–1–2; abdomen short, compact; hypopygium strongly tilted upward in male; ovipositor with both cerci and hypovalvae greatly reduced in size, fleshy in female. These characters of the female ovipositor are shared with females in species of *Arctotipula* Alexander, and some species of *Lunatipula* Edwards, but specimens can be easily separated by the tibial spur formula of 1–1–2 in *Formotipula*. The present study has demonstrated that the characters on the male hypopygium and female ovipositor are the most diagnostic features and have been used to characterize this subgenus.

The current Catalogue of the Craneflies of the World (Oosterbroek 2009) placed *Formotipula* as a subgenus of *Tipula* and recognized 27 valid species. *Formotipula* has a predominantly Oriental

distribution and is especially diverse in Southeast Asia. In Taiwan, *Formotipula* is known only by one species, *Tipula (Formotipula) holoserica*, which is recorded throughout the island in lowland and middle elevation wooded habitats (Young & Lin 2005). A second Taiwanese species, *Tipula (Formotipula) argentea*, **new species**, is described below. Both male and female of *T. (F.) holoserica* are redescribed and figured as the original description was overly simplified and imprecise.

The successful rearing of several larvae of *T. (F.) holoserica* into adults from both eggs and field collected larvae allows the present paper to contribute the first complete descriptions and illustrations of the last instar larva and pupa for the subgenus *Formotipula*, as well as additional information regarding the biology of the larvae.

Materials and methods

This study is based on field collected specimens. Specimens were collected and dry-mounted following Byers (1961:677–678). Other specimens were preserved in 70% ethanol. Genitalia preparations were made by soaking the three posterior abdominal segments in cold 10% KOH overnight. They were rinsed with acetic acid and water after removal from KOH, and then stored in glycerin-filled microvials pinned below the corresponding specimens.

Immature stages used for this study were obtained from field-collected mature larvae and by rearing from eggs laid by field-collected adult females. Field-collected larvae were provided with organic debris from the natural habitat, and grown in the laboratory, eventually transforming into pupae and adults in a normal manner. Adult females usually are unwilling to oviposit in the laboratory; but when a gravid female is pinched at the neck region with a pair of fine forceps, she will begin ovipositing and will usually lay all of her eggs in a short period (Young, 1987:217).

Larvae for rearing were housed in a transparent plastic box. Water and organic matter from the natural habitat were mixed and covered the bottom of the box to a depth of 4 cm. The box was set with one end slightly higher than the other, so one fourth of the bottom substrate was damp but not covered with water. Water was sprayed periodically to dampen the soil. Behavior of larvae kept in this situation appeared normal. Commercial turtle food and sweet potato were offered as dietary supplements. Eight larvae were successfully reared to adults from the approximately 45 initial eggs. Methods for preserving larvae and pupae are those of Byers (1961:679).

The descriptions are accompanied by drawings of characters found useful in segregating the species. Descriptive terminology follows that of Byers (1961), McAlpine (1981), Gelhaus (1986, 2005), and Young (1999). The following abbreviations are used: **CMNH**, Carnegie Museum of Natural History, Pittsburgh, Pennsylvania, USA; **NCHU**, National Chung Hsing University, Taichung, Taiwan. Specimens studied were deposited in CMNH and NCHU.

Systematics

Formotipula Matsumura

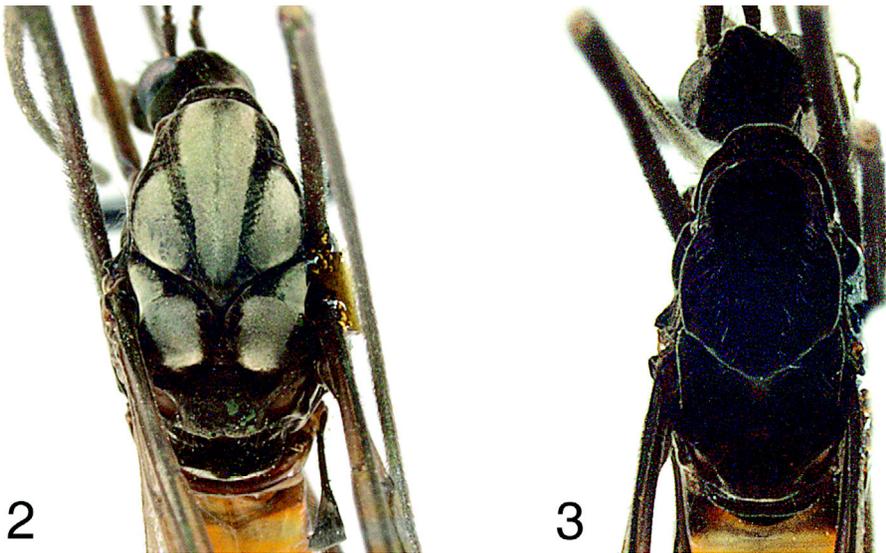
Formotipula Matsumura, 1916, p. 456. Type species *Formotipula holoserica* Matsumura, 1916, by original designation.

Tipula (Formotipula): Edwards, 1931, p. 77; Alexander, 1935, p. 103; Wu, 1940, p.12; Savchenko, 1961, p. 112; Oosterbroek, 2009.

Diagnosis. Antennae 13-segmented. Verticils exceeding segment length. Nasus distinct. Palpi elongate. Mesopleura glabrous. Tibial spur formula 1–1–2. Squama naked. Body coloration contrasting, velvety black or shade of orange or reddish orange (Fig. 1). Male hypopygium strongly tilted upward, with single complex gonostylus. Female ovipositor with short, fleshy cerci and hypovalves.



FIGURE 1. Adult male of *Tipula (Formotipula) holoserica* (Photo by Gaga Lin)



FIGURES 2–3. Dorsal aspect of adult thorax. 2. *Tipula (Formotipula) argentea* new species; 3. *T. (F.) holoserica*.

***Tipula (Formotipula) holoserica* (Matsumura, 1916)**
(Figs. 1, 3–16)

Formotipula holoserica Matsumura, 1916, p. 456.

Tipula holoserica: Alexander, 1920, p. 264.

Tipula rufomedia Edwards, 1916, p. 259. Synonymized by Alexander, 1920, p. 264.

Tipula nigrorubra Riedel, 1917, p. 115. Synonymized by Alexander, 1920, p. 264.

Tipula (Formotipula) holoserica: Alexander, 1935, p. 104; Oosterbroek, 2009.

Diagnosis. This species is known from both sexes; it can be recognized by the distinct velvety black-and-orange body coloration in both sexes and with solid black thoracic dorsum (Fig. 3). The male has tergite 9 broad at base and the outer portion narrowed to a decurved, blackened, acute point.

Description. Based on dry-mounted specimens of both sexes. Body length: Males 12–14 mm; females 14–15 mm. Wing length: 13–15mm.

Head. Entire head and appendages black. Rostrum short, stout, with distinct nasus. Antennae 13 segmented with length 4 mm in males, 3 mm in females; flagellomeres 1–10 basally slightly enlarged, each with four long verticils on basal enlargement.

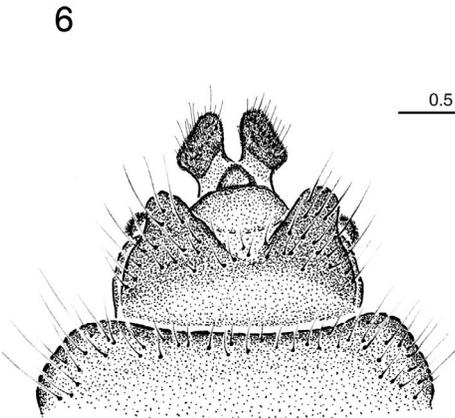
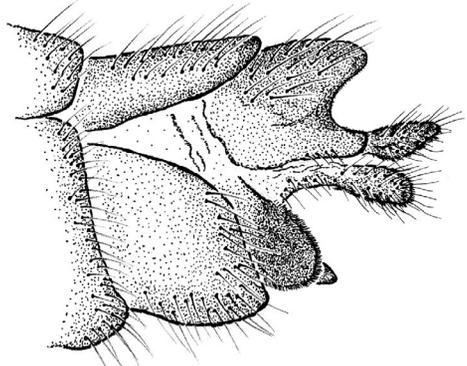
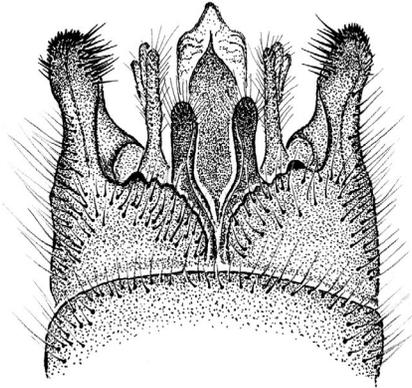
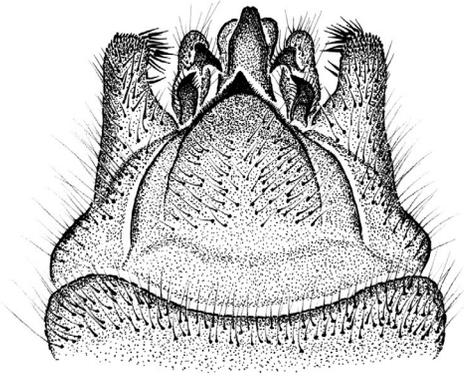
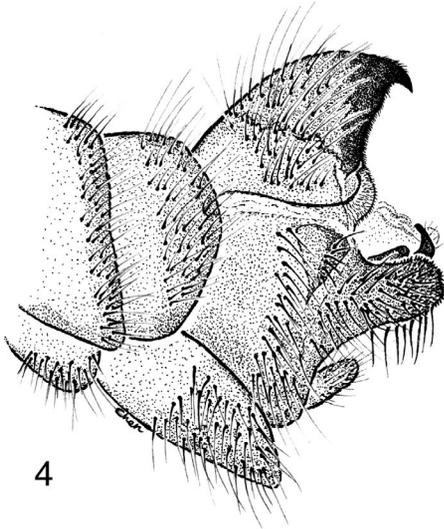
Thorax. Overall velvety black, thoracic dorsum without stripes (Fig. 3). Halteres and legs entirely black. Wings dark, strongly tinged with black. R1+2 preserved; R2 short, perpendicular to R1+2. No setae on mesopleura; setae on notum sparse and erect. Tibial spur formula 1–1–2. Claw toothed. Squama naked.

Abdomen. Short and compact, in male with hypopygium strongly curved upward. Basal segment and all of segments 6 to 9 involving the genitalia of both sexes black; segments 2 to 5 deep orange, with extreme posterolateral angles of tergites 3 to 5 black.

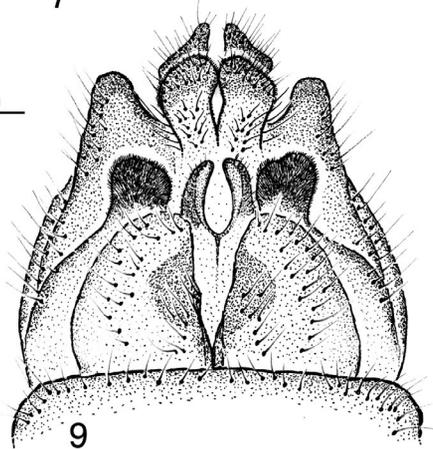
Hypopygium. Male genitalia as in Figs. 4–6. Tergite 8 short, sternite 8 projected caudad beneath sternite 9; tergite 9 and sternite 9 separated; tergite 9 with median region of outer portion narrowed and heavily blackened, the tip turned downward to an acute point (Fig. 4). Basistyle produced caudad into a stout blackened lobe, tip obtuse with abundant short black spines and numerous long black setae (Figs. 5–6). Outer gonostylus absent. Inner gonostylus broad, flattened, with short outer basal lobe tapering into an acute point; beak compressed, slender in dorsal aspect with apical hook directed anteriorly (Fig. 5). Sternite 9 on either side of median area with a small dark rod clothed with long black setae (Fig. 6).

Ovipositor. External structures as in Figs. 7–9. Tergite 9 with two rounded, dorsoventrally flattened lobes separated by broadly V-shaped median emargination (Fig. 8). Sternite 9 on either side of median area with a round lobe covered with fine setae (Fig. 9). Cerci short, wide, fleshy, apically rounded. Sternite 10 distinct, nested below cerci. Hypoalves short, sclerotized, sharply pointed (Fig. 7).

FIGURES 4–9. *Tipula (Formotipula) holoserica*. 4. Male hypopygium left lateral aspect; 5. Male hypopygium, dorsal aspect; 6. Male hypopygium, ventral aspect; 7. Female ovipositor, left lateral aspect; 8. Female ovipositor, dorsal aspect; 9. Female ovipositor, ventral aspect.



0.5 mm



Distribution. *Tipula* (*Formotipula*) *holoserica* is known only from Taiwan. The collecting data (Young & Lin 2005) show this species occurs from sea level up to middle elevation (36–2000 m) woodland habitats.

Material examined. TAIWAN: Kaohsiung: Shanping, 640 m, J. Rawlins, C. Young: 23–31 March 1988, 1 ♂; 21–30 April 1988, 2 ♂; 11–20 May 1988, 1 ♂, [CMNH]; Taipei: Wulai, 31 March 1965, C. Yoshimoto, D. Perkins, 1 ♂, 1 ♀ [CMNH]; Sansia: Baichi Mts., 659 m 24°53'38"N, 121°24'17"E, Lingchu Lin, 4 July 2007, 1 ♀; 6 August 2007, 1 ♀; 9 August 2007, 2 ♂, 1 ♀; 19 August 2007, 3 ♂ [CMNH]; Tuchen, Kan-Lu Temple, 27 m, 24°58'22"N, 121°26'54"E, ChenLe Chu, 19 August 2007, 1 ♂, 1 ♀ [CMNH]; Nantou: Huisun Linchang, 730 m, 24°05'21"N, 121°01'51"E, 8 July 2007, Lingchu Lin, 1 ♀ [CMNH].

Remarks. This is the type species of *Formotipula* Matsumura. The distinct, contrasting, velvety black-and-orange body coloration distinguishes this species from all other species in the genus *Tipula*. However, there are several black-and-orange colored crane fly species in other genera of *Ctenophora* Meigen, *Hexatoma* Latreille, *Leptotarsus* Guérin-Méneville, and *Nephrotoma* Meigen in Taiwan. This species can be separated from all aforementioned genera by the strongly tilted upward genitalia in males, and the extremely short ovipositor in females.

The synonymy of *rufomedia* Edwards, 1916, and *nigrorubra* Riedel, 1917, as proposed by Alexander, 1920, is accepted here. The original descriptions of both taxa as well as the figures presented by Edwards for *rufomedia* clearly show that these names are junior synonyms of *holoserica*, and do not pertain to the new species as described below.

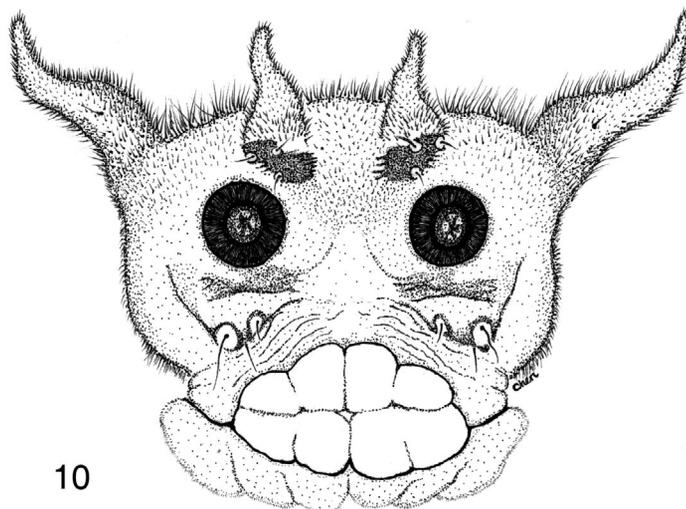
Larval description. Mature fourth (final) instar larva: Body 16–18 mm long and 2.8–3.0 mm wide, body stout and terete, tapering gradually toward both ends. Body dull gray, paler laterally.

Head. Broad, massive, well sclerotized, oval-shaped and slightly depressed, typical head capsule of Tipulinae (Byers 1961, Young 1981, Gelhaus & Young 1991); antennae with cylindrical basal segment, about three times as long as its basal width, slightly tapering apically with apical sensory peg; mandibles bifurcate with distinct, large central tooth, two smaller dorsal teeth, and an additional tooth and hair tuft near base; maxillae with hairy galea and lacinia; hypopharynx with five teeth; hypostomal bridge with one large, acute central tooth and two smaller ones on each side.

Thorax. All segments densely covered with fine, short microscopic hairs appressed to body. Macrosetae short, placement on thoracic segments same as that on abdominal segments (Figs. 11–12).

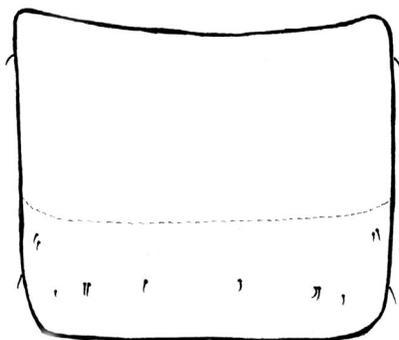
Abdomen. All segments covered with short, brownish, transverse rows of microscopic hairs; macrosetae darker; all setae except L4 situated on posterior annuli; L4 situated on anterior annulus. Setae D1–D3 short; D4 the shortest, D5 and D6 lighter and finer, situated above D4 (Fig. 11); seta V1 the shortest, and V2–V5 slightly longer (Fig. 12); setae L1 and L2 absent, L3 and L4 short. D2, D3 and V2, V3 surrounded by dark clusters of macroscopic hairs.

Spiracular disc. Surrounded by six subequal lobes (Fig. 10); dorsal and lateral lobes conical, dorsal lobes one half length of lateral lobes, lateral lobes dorsolateral; dorsal and lateral lobes unsclerotized with microscopic hairs, one dark macrosetae on posterior surface of each lateral lobe, two thirds length from lobe tip; dark brown irregular sclerite near base of each dorsal lobe, three visible macrosetae on sclerotization, with pale area surrounding their bases; ventral lobes roughly triangular in dorsal aspect, with subacute tip, basal width one and one half times length; sclerotization on inner surface of each ventral lobe, darker below spiracles and lighter apically, tip of ventral lobes each with three visible macrosetae; spiracles circular; marginal band black; anal opening transverse with four equal sized anal papillae.

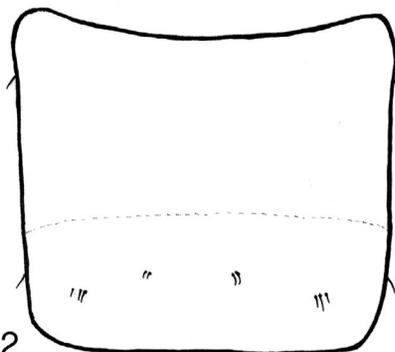


10

0.5 mm



11

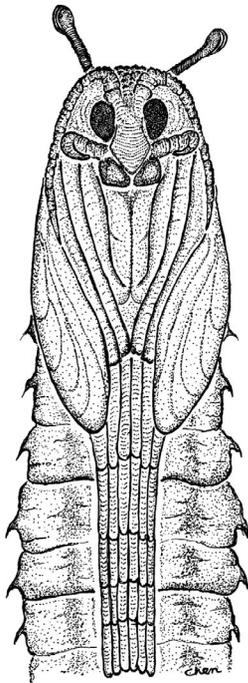


12

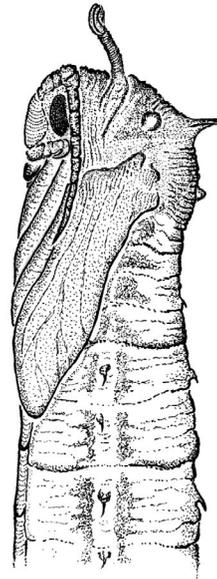
FIGURES 10–12. *Tipula (Formotipula) holoserica* larva. 10, Terminal abdominal segment, posterior view showing spiracular disc and anal papillae; 11, Abdominal macrosetal arrangements, abdominal segment 6, dorsal view, anterior end at top; 12, Abdominal segment 6, ventral view.

Remarks. Larvae of *Tipula (Formotipula) holoserica* can be readily and consistently keyed to other taxa in existing keys, in part to couplet 9 (*Nephrotoma*) in the key for the larvae of Malaysian Tipulinae (Young, 2004), or in part to couplet 17 (*Beringotipula*) in the key for the larvae of North American *Tipula* (Gelhaus, 1986). *T. (F.) holoserica* superficially resembles species in *Nephrotoma* Meigen, as well as several of the most terrestrial subgenera of genus *Tipula* Linnaeus: *Beringotipula* Savchenko, *Pterelachisus* Rondani, *Trichotipula* Alexander, *Vestiplex* Bezzi, and *Lunatipula* Edwards (in part). Specifically these share the following morphological characters: border of setae around spiracular lobes reduced or absent; sclerotization on dorsal and lateral lobes reduced or absent; anal papillae reduced in number and size. The distinctive difference of *T. (F.) holoserica* from

the above subgenera is the absence of the sclerotization associated with the lateral lobes, and it can easily separated from *Nephrotoma* by the absence of transverse welts on the prothoracic dorsum.

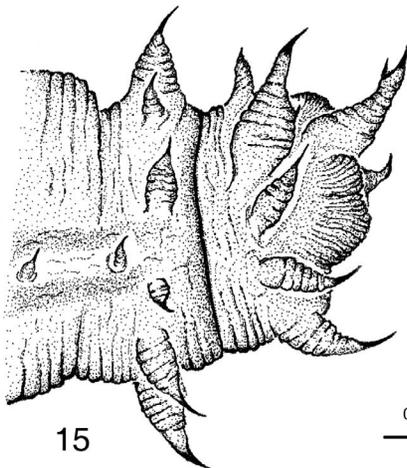


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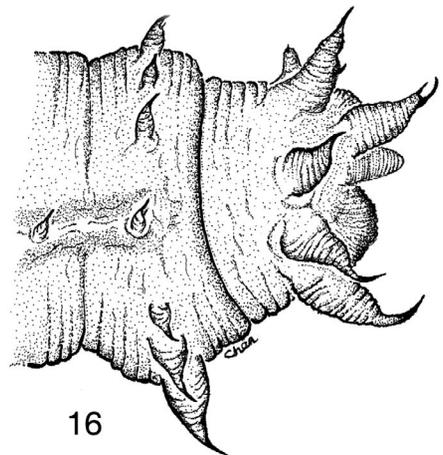


14

1 mm



15



16

0.5 mm

FIGURES 13–16. *Tipula (Formotipula) holoserica* pupa. 13. Ventral aspect; 14. Lateral aspect; 15. Male terminal segments, lateral aspect; 16. Female terminal segments, lateral aspect.

Pupal description. Male: length 16–17 mm, width 2.8–3.0 mm. Female: length 18–19 mm, width 3.8–4.0 mm. Body coloration overall light yellowish brown, slightly darker on tarsal sheaths.

Head. Antennal sheath slightly expanded at base (Fig. 13), apex of sheath reaching about one third length of mesothoracic tibia. Paired short, wrinkled ridges between bases of antennal sheaths. Maxillary palpal sheath short, its apex recurved, reaching sheath of prothoracic femur (Fig. 14).

Thorax. Respiratory horn 1.2–1.3 mm in length, with slightly curved and minute annulations along entire length, apex enlarged and rounded. Dorsum of thorax densely wrinkled with two pairs of protuberant lobes (Fig. 14), larger pair above wing base, smaller pair near wing base. Wing sheaths reaching slightly over middle length of abdominal segment 2. Sheaths of fore, middle, and hind tarsi in transverse alignment, reaching slightly over middle of posterior edge of abdominal segment 4.

Abdomen. Segments 2–7 with well-defined anterior and posterior annuli; three hooked spines on each side on segments 3–7; two spines on anteroventral margins and eleven spines along posteroventral margins of segments 5–7; two spines on anteriodorsal margins and thirteen spines along posteriodorsal margins of segments 3–7. Terminal segments (8–9 in male, 8–10 in female) with six pairs of elongated spines in female (Fig. 16), and seven pairs in male (Fig. 15); in female four pairs directed dorsally, two pairs directed ventrally; spines directly anterior to genital sheaths with two hooks apically; in male, an additional pair of spines at the base of genital sheaths curved dorsad; female with distinct cercal sheath.

Remarks. The pupa of *T. (F.) holoserica* is recognizable as belonging in Tipulinae by the wrinkles on the thoracic cuticle and the spines along the posterior margins of the abdominal segments (Gelhaus and Young, 1995). It can be distinguished from other Tipulinae by the presence of two pairs of protuberant lobes on the thoracic dorsum. The short length of the respiratory horns of the pupa is probably associated with its terrestrial habitat.

Biology. The larvae were collected in three different localities: Taipei County, Kan-Lu Temple in Tuchien, 234 m, 24°57'13"N, 121°27'17"E; Taipei County, Da-chine Mountains in His-chih, 434 m, 25°02'58"N, 121°40'09"E in April and May of 2007; and in Chiayi County, Fen-chi-hu, 1405 m, 23°30'11"N, 120°41'42"E in March of 2009. All three collecting sites are shaded woodland habitats. Larvae were collected in wide ranges of terrestrial microhabitats from outer layers of decayed logs, under mosses, to beneath leaf litter and soil in woodlands. Other species occurring in similar habitats were several species of *Tipula* (*Lunatipula*), *T. (Pterelachisus)* and *Nephrotoma*.

Tipula (Formotipula) argentea new species

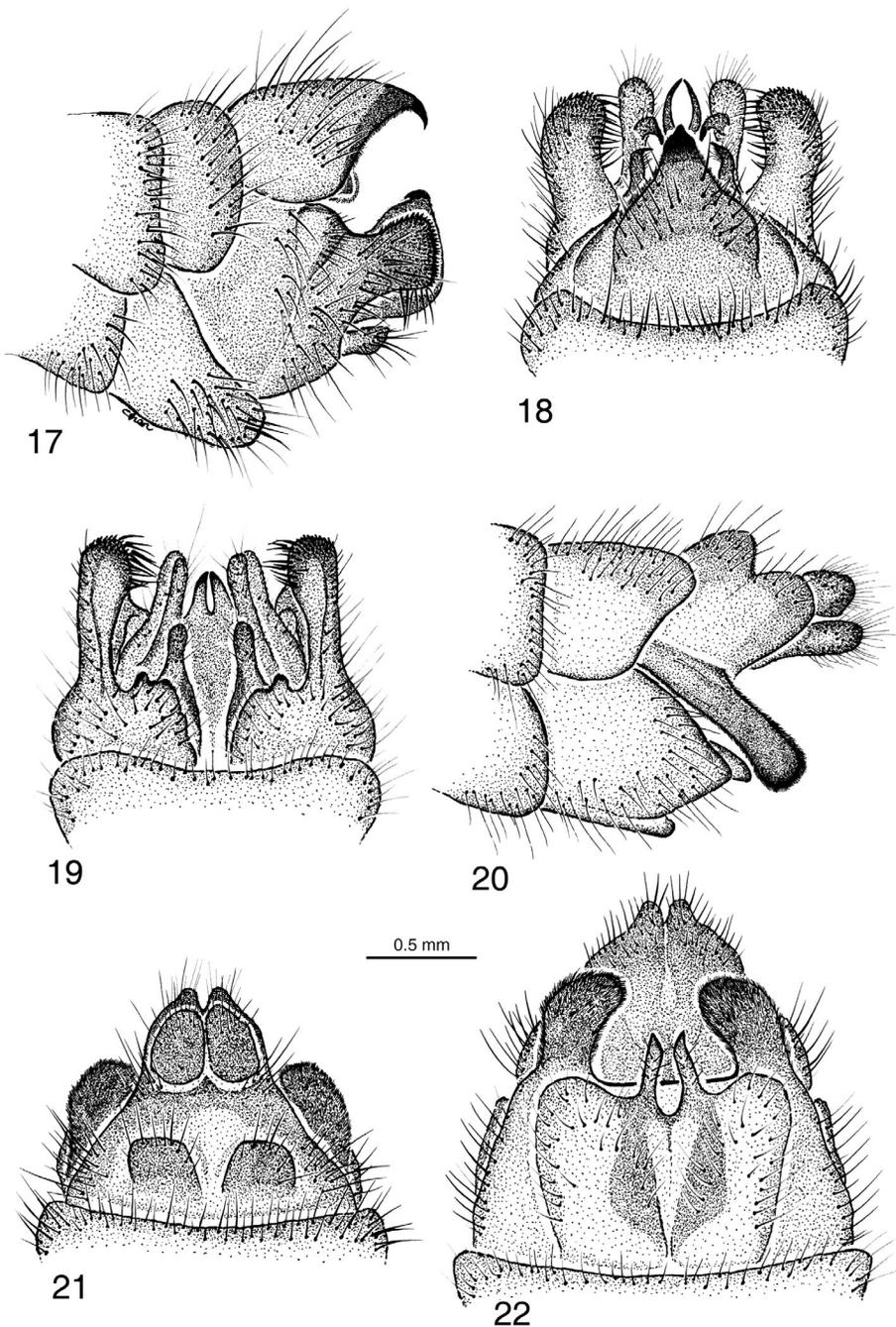
(Figs. 2, 17–22)

Diagnosis. This species is known from both sexes. It is most similar to *T. (F.) holoserica*, but differs in its slightly larger body size and the distinctive silvery stripes on the thoracic dorsum (Fig. 2).

Description. Based on dry-mounted specimens of both sexes. Body length: Males 14–15 mm; females 15–18 mm. Wing length: 17–18 mm.

Head. Entire head and appendages black. Rostrum short, stout with distinct nasus. Antennae 13 segmented with length 4.5 mm in males, 3.5 mm in females; flagellomeres 1–10 basally slightly enlarged, each with 4 long verticils on basal enlargement.

Thorax. Overall velvety black, scutum with three distinct silvery stripes (Fig. 2); central stripe broad, with dark, narrow median line; lateral stripes extended from pseudosutural fovea to posterior edge of scutum, interrupted in mid-length by transverse suture. Halteres and legs entirely black.



FIGURES 17–22. *Tipula (Formotipula) argentea* new species. 17. Male hypopygium, left lateral aspect; 18. Male hypopygium, dorsal aspect; 19. Male hypopygium, ventral aspect; 20. Female ovipositor, left lateral aspect; 21. Female ovipositor, dorsal aspect; 22. Female ovipositor, ventral aspect.

Wing dark, strongly tinged with black. R1+2 preserved, R2 short, perpendicular, R1+2 three times length of R2. No setae on mesopleura; setae on notum sparse and erect. Tibial spur formula 1-1-2. Claw toothed. Squama naked.

Abdomen. Short and compact, in male with hypopygium strongly curved upward. Basal segment and all of segments 6 to 9 involving the genitalia of both sexes black.

Hypopygium. Male genitalia as in Figs. 17–19. Tergite 8 short, sternite 8 projected caudad beneath sternite 9; tergite 9 and sternite 9 separated; tergite 9 with median region of outer portion narrowed and heavily blackened, the tip turned downward to an acute point (Fig. 17). Basistyle produced caudad into a stout blackened lobe, the tip obtuse with abundant short black spines and numerous long black setae (Fig. 19). Outer gonostylus absent. Inner gonostylus broad, flattened, with short outer basal lobe tapering into an acute point; beak compressed, slender in dorsal aspect, with apical hook directed anteriorly (Fig. 18). Sternite 9 on either side of median area with a small dark rod clothed with long black setae (Fig. 19).

Ovipositor. External structures as in Figs. 20–22. Tergite 9 with two small, rounded, dorsoventrally flattened lobes separated by broad median emargination (Fig. 21). Sternite 9 on either side of median area with an elongated lobe covered with fine setae (Fig. 22). Cerci short, wide, fleshy, apically rounded. Sternite 10 distinct, nested below cerci. Hypovalves short, sclerotized, sharply pointed (Figs. 20).

Distribution. *Tipula (Formotipula) argentea* is known only from Taiwan. The collecting data show this species occurs from sea level up to middle elevation (1906 m) wooded habitats.

Type material. Holotype ♂, deposited NCHU. VERBATIM LABEL DATA: “Taiwan: Taichung Co. Li-Shan 1906m 24-15-23N 121-14-59E 21May2007 Shih H Ding”/ “Holotype *Tipula (Formotipula) argentea* Young”. Paratypes (2): Taiwan: same data as holotype 1 ♀ [NCHU]; Taipei, Sijhih, DaJian Mts. 311 m 25°03'14"N 121°40'22"E 02Mar2008 Linchu Lin, 1 ♀ [CMNH].

Etymology. The species-group name is based on the Latin adjective *argenteus*, of or pertaining to silver, after the silvery-colored stripes on the thoracic dorsum.

Remarks. This new species appears to be most closely related to the only other Taiwanese species, *T. (F.) holoserica*. The male genitalia are somewhat similar in both species with the large ninth tergite that narrowing posteriorly into an acute point. Females of both species have short, fleshy ovipositors, but can be easily separated by the smaller dorsal lobes and longer ventral lobes in the new species. The most distinctive character of the new species is the silvery stripes on the thoracic dorsum.

Discussion

The diverse crane fly fauna of Taiwan and its relationships to that of other regions is of great interest but poorly understood. Geographical distributions of most tipulid species in Taiwan are inadequately documented. No surveys of crane flies have been conducted in the island, and only a limited number of specimens are available for examination. Based on the current known distribution of the subgenus *Formotipula* (Oosterbroek, 2009), a tentative hypothesis can be offered that Taiwanese *Formotipula* represents a component of Oriental rather than Palaearctic origin, although the Catalogue of the Craneflies of the World listed Sichuan and Yunnan provinces in China after Palaearctic region.

The achievement of rearing *T. (F.) holoserica* also provides much needed information increasing awareness of immature stages of crane fly taxa in the Southern Hemisphere. Several of the larval and pupal characters show close correlation with terrestrial life ways and habitats (Young & Hynes 2003) and also support the placement of *Formotipula* among the more advanced lineages within Tipulinae.

Acknowledgments

All immature specimens used in this study were collected by Chenle Chu and Lingchu Lin, and the adult male image was taken by Gaga Lin in Taiwan. I would like to thank them for their assistance in gathering data in the field, as well as with rearing in the laboratory. Thanks are due to Robert L. Davidson and John E. Rawlins for suggestions on a draft of this manuscript; and to Pjotr Oosterbroek and two anonymous reviewers for their comments.

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