



***Zanna robusticephalica* sp. nov. (Hemiptera: Fulgoromorpha: Fulgoridae) from China, with comments on some ultrastructural characters of the new species**

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Abstract

Zanna robusticephalica sp. nov. (Hemiptera: Fulgoromorpha: Fulgoridae: Zanninae: Zannini), representing the third species of the planthopper genus *Zanna* Kirkaldy, 1902 from China, is described and illustrated from Yunnan in southwestern China. Scanning electron micrographs of the antennal sensilla, rostral apex, hind tarsal segments, gonoplac and wax glands of the new species are provided. The generic diagnostic characters of *Zanna* are redefined and the autapomorphies are proposed to support the monophyly of the genus. A check-list of the Oriental *Zanna* species is included.

Key words: Fulgoroidea, ultrastructure, morphology, pretarsus

Introduction

The fulgorid planthopper genus *Zanna* Kirkaldy, 1902 (Hemiptera: Fulgoromorpha: Fulgoridae) is an Afro-Asian genus and currently includes 36 described species (26 from tropical Africa and 10 from south and southeast Asia) (Metcalf 1947; Lallemand 1959, 1963, 1966; Bourgoïn 2017). The distribution pattern of *Zanna* species shows that the genus probably represents a relatively old and primitive group with much earlier origin within Fulgoridae and supports the view that the southern Asia and Africa shared a closer historical biogeographical relationship and faunal affinity (Schuh & Stonedahl 1986; Liang 1998).

Metcalf (1938) placed *Zanna* in the tribe Zannini of the subfamily Fulgorinae and later moved the genus to the tribe Dictyopharini of the subfamily Dictyopharinae (Metcalf 1946). Lallemand (1959) elevated the level of the tribe Zannini to subfamily rank, e.g. Zanninae and later presented characters of the genus and provided a key for the separation of ten Asian species known in the genus (Lallemand 1963). Urban & Cryan (2009) presented the first preliminary molecular phylogenetic analysis of Fulgoridae based on five genetic loci (18S rDNA, 28S rDNA, histone 3, wingless, and cytochrome oxidase I) and suggested that the genus *Zanna* should be excluded from a monophyletic Fulgoridae. Further investigation is necessary to clear up this taxonomic question.

Two *Zanna* species, *Z. chinensis* (Distant, 1893) (Fig. 1) and *Z. affinis* (Westwood, 1839), were recorded in China. *Z. chinensis* is found in Yunnan, Sichuan, Guangxi, Guizhou, Guangdong, Hainan and Taiwan of southern China (Distant 1906; Chou *et al.*, 1985; Li 1987; Hua 2000). Outside China, this species was also recorded in northeastern India and northern Burma (Distant 1906, 1916). *Z. affinis* was originally described from Nepal and was recorded in Hong Kong by Walker (1851).

During sorting and identifying the Oriental fulgorid species from the material housed in Zoological Museum at the Institute of Zoology of Chinese Academy of Sciences, several specimens of an undescribed *Zanna* species were found. They were collected in the extreme south of Yunnan province in southwestern China and this is the third *Zanna* species known from China.

The purpose of the paper is to describe and illustrate the new species and provide the new ultrastructural characters referring to antennal sensilla, rostral apex, hind tarsal segments, gonoplac and wax glands of the new species. The generic diagnostic characters of *Zanna* are redefined and the autapomorphies of the genus are discussed.



FIGURE 1. *Zanna chinensis* Dist., adult habitus (China: Yunnan, Xishuangbanna).

Materials and methods

Specimens studied. The specimens studied in the course of this work are deposited in the Zoological Museum at the Institute of Zoology, Chinese Academy of Sciences, Beijing, P.R. China (IZCAS).

Preparation. Dry, pinned, museum specimens were used for the description and illustration. The external morphology was observed with a Zeiss Stemi SV 11 optical stereomicroscope (Carl Zeiss, Göttingen, Germany) and particular parts of the body were illustrated with the use of a drawing tube. For the study of the male genital structures, male genital capsule was removed from the abdomen and macerated in cold 10% KOH overnight, then rinsed in distilled H₂O, and finally transferred to glycerol for the examination. Photographs of the specimens were taken with a Nikon Coolpix 5400 digital camera. The digital images were then imported into Adobe Photoshop 8.0 for labelling and plate composition. For scanning electron microscopy (SEM) study of the ultrastructures, dry, pinned museum specimens were used. The voucher specimens were from the Zoological Museum of the Institute of Zoology, Chinese Academy of Sciences, Beijing, P. R. China. The particular parts (e.g. head together with antennae or rostrum) were cut off from the body, transferred to 10% KOH for 1–2 minutes, cleared with 10% KOH, washed in distilled water, mounted on aluminium stubs by double-sided sticky tape, air-dried at room temperature and coated with gold-palladium using a sputter coater. Observations were made with a JEOL 5200LV (Japanese Electronic and Optical Ltd., Tokyo, Japan) scanning electron microscope, operated at accelerating voltages of 10 and 25 kV, respectively.

Morphological terminology. Morphological terminology largely follows that of Kramer (1950) and Lallemand (1963), and antennal sensilla follows that of Lewis & Marshall (1970) and Marshall & Lewis (1971). The following abbreviations are used in the text, BL: body length (from apex of cephalic process to the tip of forewings); HL: head length (from the apex of the cephalic process to the posterior margin of vertex); HW: head width (including eyes); FWL: forewing length.

Taxonomy

Order Hemiptera Linnaeus, 1758

Suborder Fulgoromorpha Evans, 1946

Superfamily Fulgoroidea Latreille, 1807

Family Fulgoridae Latreille, 1807

Subfamily Zanninae Lallemand, 1959

Tribe Zannini Metcalf, 1938

Genus *Zanna* Kirkaldy, 1902

Pyrops Amyot et Audinet-Serville, 1843: 491; Atkinson, 1885: 139; Distant, 1906: 179; Li, 1987: 330.

Zanna Kirkaldy, 1902: 47; Melichar, 1903: 13; Metcalf, 1947: 246; Lallemand, 1963: 90; Chou et al., 1985: 113; Nagai & Porion, 1996: 27; Hua, 2000: 96. Type species: *Fulgora tenebrosa* Fabricius, 1775. Replacement name for *Pyrops* Amyot et Audinet-Serville, 1843 nec *Pyrops* Spinola, 1839.

Revised generic diagnosis. Members of *Zanna* can be distinguished from other Fulgoridae genera by the combination of the following characters: body distinctly narrow, slender and elongate, usually pale brownish ochraceous, without colorful markings, usually thickly and prominently spotted in black (Figs 1, 2, 3A–D); head distinctly produced into a very long cephalic process, which is longer than abdomen and more than twice as long as pronotum and mesonotum combined; cephalic process relatively robust, hexagonal, gently narrowing from base to apex, somewhat upturned at apex in lateral view (Figs 1, 2A–D, 3A–D); vertex very elongate, lateral margins weakly ridged with carinae being slightly zigzagged, with faint median carina (Figs 1, 2A, 2B, 3A, 3B); frons distinctly elongate, with lateral margins weakly ridged with carinae being slightly zigzagged, with slightly zigzagged submedian carinae, without median carina (Figs 2C, 3C); antennae with pedicel relatively short, subbulbose, fully covered with sensory plaque organs over entire surface (Figs 4, 5A–D); forewings narrow and elongate, almost entirely reticulate, inner marginal areas overlapping at tips; hind tibiae with 5–7 lateral spurs; metatarsomes I and II covered with a pad of dense setae ventrally (Figs 6E, 6F); gonoplac in female adults with basal inner area strongly and densely pilose (Figs 7, 8A, 8B); anal tube in female adults expanded, nearly cardiform in ventral aspect (Figs 8B, 8C), densely covered with long, whitish wax threads ventrally (Fig. 8A), its ventral surface covered with numerous fine hexagonal wax gland units (Fig. 8D), each hexagonal unit bearing a long seta coming from center (Fig. 8B–D) and numerous very tiny wax gland pores on surface (Fig. 8E–H).

Monophyly of *Zanna*. Currently there are about 143 described genera of Fulgoridae (Bourgoin 2017), however, the monophyly of most genera has not been examined cladistically. The wax-secreting plates in the adults of most fulgorid species are located on the abdominal tergites VI–VIII (O'Brien & Wilson 1985). However, the anal tube in the female adults of the *Zanna* species is expanded and nearly cardiform in ventral aspect and the wax gland pores are located on the ventral surface of the modified anal tube (see description under *Z. robusticephalica* sp. nov. below). The very similar wax gland plates are also found in some species of the other fulgoroid families, namely Flatidae, Lophopidae, Ricaniidae and Nogodinidae (Lucchi & Mazzoni 2004; Liang, unpublished data), however, these similarities seem to be the results of parallel developments. In addition, the prolongation of the head into elongate and hexagonal cephalic process (Figs 1, 2A–D, 3A–D), forewings with inner marginal areas overlapping at tips (Figs 1, 2F, 3A); gonoplac in female adults with basal inner area being strongly and densely pilose (Figs 7, 8A, 8B) and the metatarsomeres I and II being covered with a pad of dense setae ventrally (Figs 6E, 6F) are found only in *Zanna* species. These distinct characters appear to be good autapomorphies of *Zanna* that support the monophyly of the genus.

Biology. In common with most planthopper groups, few biological data are available for species of *Zanna*. Gade (1985) reported that *Z. madagascariensis* in Madagascar feeds Lima bean and related plants and that the adults of *Z. madagascariensis* are known as sakandry, and are consumed by the rural people of Madagascar (van

der Heyden 2014). Chou *et al.* (1985) and Hua (2000) reported that *Z. chinensis* can infest *Glycine max* (Linn.) Merr. (soybean) and *Cocos nucifera* L. (coconut palm) in China. Li (1987) recorded the occurrence of *Z. chinensis* as *Pyrops chinensis* in Guizhou of southwest China and reported that in Guizhou the adults of this species can be attracted under light in early May and the nymphs can be found in late October infesting soybeans.

Distribution. Oriental region (India (northern part), Sri Lanka, Sikkim, Bengal, Nepal, China (southern and southwestern parts), Vietnam, Thailand, Malaysia (Malay Peninsula, Borneo), Singapore, Indonesia (Java, Sumatra), Afrotropical region.

Check-list of Oriental *Zanna* species

Zanna affinis (Westwood, 1839)

Distribution: India (Assam), Nepal, Sikkim, Sri Lanka, China (Hong Kong), Indonesia (Java).

Zanna chennelli (Distant, 1906)

Distribution: India (Assam).

Zanna chinensis (Distant, 1893)

= *Zanna distanti* (Schmidt, 1911)

Distribution: South and southwest China (Yunnan, Sichuan, Guangxi, Guizhou, Guangdong, Hainan, Taiwan), northeast India, north Burma, Vietnam, Thailand.

Zanna dalyi (Distant, 1905)

Distribution: Thailand.

Zanna dohrni (Stål, 1858)

= *Pyrops mustelinus* Distant, 1883

Distribution: Sri Lanka, India, Indo-China.

Zanna nobilis (Westwood, 1839)

Distribution: Malaysia (Malay Peninsula, Borneo, Sarawak), Indonesia (Sumatra, Java).

Zanna pulmuncula Distant, 1905

Distribution: Indonesia (Java).

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Distribution: Southwest China (Yunnan).

Zanna servillei (Spinola, 1839)

= *Zanna javanensis* (Distant, 1883)

Distribution: Indonesia (Java, Sumatra), Malaysia (Malay States).

Zanna tapira (Distant, 1905)

Distribution: Indonesia (Java).

Zanna terminalis (Gerstaecker, 1895)

Distribution: Indonesia (Sumatra), Malaysia (Borneo, Sarawak, Penang Is.), Singapore.

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(Figures 2–8)

Diagnosis. This new species can be distinguished from both *Z. chinensis* and *Z. affinis* by the following characters: body slightly paler, shorter and broader; cephalic process relatively shorter, broader and more robust; vertex with black spots constricted to basal area, without black spots medially and apically; frons without or with only very few black spots on basal area; and the pronotum, mesonotum and forewings with relatively fewer and smaller black spots (Figs 1, 2, 3A–D).

Description. *Male:* BL: 36.0–40.5 mm; HL: 10.0–12.3 mm; HW: 4.0–4.1 mm; FWL: 23.0–25.6 mm.

General color pale brownish ochraceous; with numerous small black spots on: cephalic process with dorsal basal area and lateral areas (mainly on basal two thirds) of vertex, basal part of frons, postclypeus (mainly on lateral areas), pronotum, mesonotum, pleurae of thorax, tegulae, legs and forewings; each black spot with one short, brown seta in center, sometimes small black spots merging together and forming bigger spots (Figs 2, 3A–D); cephalic process sparsely covered with short, pale pubescence laterally and ventrally. Antennae ochraceous, with scape (excluding apex) and flagellum brown. Rostrum ochraceous, with apical segment and apex of penultimate segment fuscous.

Forewings densely covered with numerous, very small, protuberant, black spots which are mainly located on veins, spots on anterior and apical areas slightly larger and more prominent; hind wings milky white, veins pale brownish ochraceous. Legs ochraceous, strongly pilose, femora and tibiae covered with small black spots; fore and middle legs with distal part of femora, tibiae and claws fuscous; hind legs with 3rd tarsomeres (excluding proximal and distal areas) and claws fuscous.

Abdomen ventrally ochraceous, with sterna medially largely marked with black in an irregularly inverted trapezoid shape, sometimes the black marking obliterated subapically; sublateral areas with 2–5 irregular black spots or small markings resulting from merging of spots; abdomen above black, with posterior segmental margins ochraceous. Pygofer and anal tube blackish; parameres in basal two fifths ochraceous and apical three fifths fuscous; hook-shaped process on basal outer edge blackish with basal area ochraceous.

Head (Figs 2A–D, 3A–D) with cephalic process relatively broad and robust, hexagonal, gently narrowing from base to apex, slightly upturned at apex in lateral view, apex obliquely truncate, about 2.1–2.2 times longer than length of pronotum and mesonotum combined; vertex slightly transversely convex with faint median carina, lateral margins weakly ridged with distal half of carinae being slightly zigzagged. Frons distinctly elongate, with lateral margins weakly ridged, with lateral and submedian carinae, distal half of both carinae being slightly zigzagged, median carina absent (Figs 2C, 3C). Postclypeus short and small (Figs 2C, 3C). Eyes and ocelli relatively small. Antennae with scape relatively short; pedicel short, thick and subbulbose with top broadly depressed, densely covered with sensory plaque organs over entire surface (Figs 4, 5A–D). Rostrum moderately long, reaching between coxae of middle legs, apical segment distinctly shorter than penultimate segment; rostral apex consisting of two lateral lobes separated by dorsal stylet groove, each lateral lobe bearing several bristle-like sensilla and numerous peg sensilla and protuberances on disc (Fig. 5E–H).

Pronotum and mesonotum with disc slightly transversely convex, without median carina, lateral areas strongly sloping downwards; pronotum with posterior margin very slightly and broadly arched anteriorly; mesonotum distinctly longer than pronotum. Forewings relatively narrow, elongate and slender, almost entirely reticulate; stigma absent; inner marginal areas overlapping at tips (Figs 2A, 2E, 2F, 3A). Hindwings semihyaline. Legs relatively robust and short; hind tibiae with 5–7 lateral, tip-blackened spurs (proximal one smallest, gradually largened distally) and 8 (6+2) apical, tip-blackened spurs; 1st and 2nd metatarsomeres covered with a pad of silver, dense setae ventrally, 1st metatarsomere more than 2 times larger than 2nd metatarsomere in ventral aspect (Figs 6E, 6F); pretarsus of hind legs with two long, dorsal setae on proximal, dorsal area medially (Figs 6A, 6B); claws of hind legs with 4–5 long setae on subbasal lower margin (Figs 6A, 6D).

Male genitalia with pygofer (Fig. 3F) symmetrical, distinctly shorter than parameres, with ventral posterior margin broadly excavated caudad, in ventral view and posterior margin angularly produced posteriorly above middle, in lateral view. Anal tube (Fig. 3E) relatively short and broad, nearly rectangular in dorsal view, with apical part expanded outwards; anal style short and broad, greater than half length of anal tube, arched in dorsal view (Fig. 3E). Parameres (Figs 3F, 3G) in lateral view elongate, with basal part relatively narrow and apical part somewhat blunt, upper margin expanded upwards submedially; outer edge near upper margin at basal two fifths strongly expanded and armed with a black, robust, hook-shaped process directing outwards and anteroventrally, in lateral view. Aedeagus (Fig. 3H) relatively short, membranous, compact, with apical three fourths directing posterodorsally, in lateral view; bi-lobed, with each lobe being wrapped by 10 membranous laminates, which are apically slightly curving dorsally and bearing many tiny marginal spines.

Female. Similar to males in general appearance and coloration, but cephalic process and other body parts with a few more black spots. BL: 39.0–44.5 mm; HL: 12.3–13.5 mm; HW: 4.2–4.3 mm; FWL: 25.5–28.0 mm.

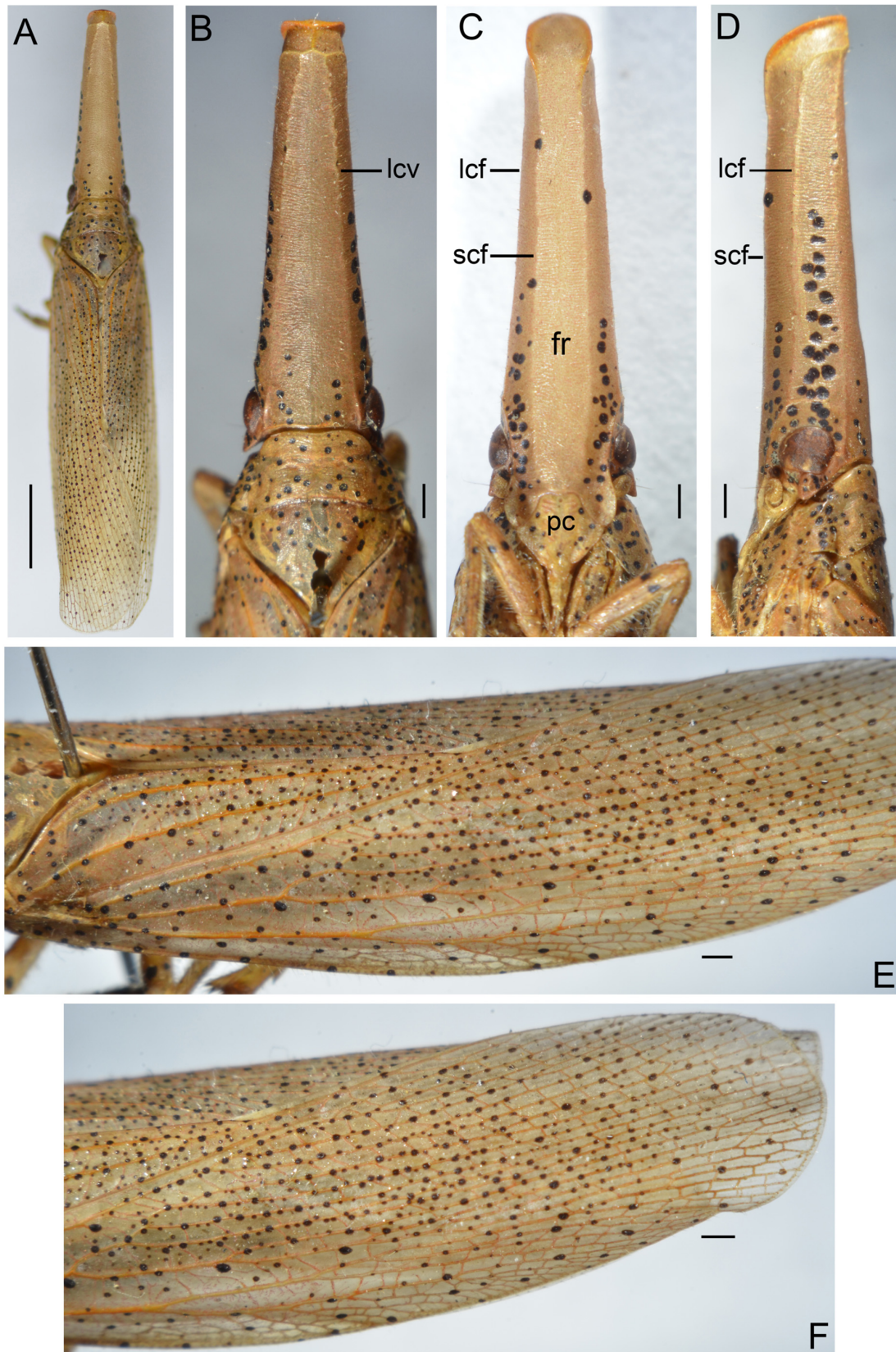


FIGURE 2. *Zanna robusticephalica* sp. nov., male adult, holotype (China: Yunnan: Xishuangbanna). (A) Habitus, dorsal view; (B) head, pronotum and mesonotum, dorsal view; (C) head, ventral view; (D) head, pronotum and mesonotum, lateral view; (E) forewing (excluding apical part), dorsolateral view; (F) same (excluding basal part), dorsolateral view. Abbreviations: fr—frons; g—gena; lcf—lateral carina of frons; lcv—lateral carina of vertex; pc—postclypeus; scf—submedian carina of frons; v—vertex. Scale bar = 1 cm for all but = 5 cm for A.

Genitalia not examined. Gonoplac with posterior margin being strongly and densely pilose, with hairs tapering apicad with raised, scale-like tegmental base (Figs 7, 8A, 8B). These hairs may play a role of mechanic or chemical sensilla for oviposition.

Wax glands. Anal tube in female adults expanded, nearly cardiform in ventral aspect (Figs 8B, 8C), with ventral surface densely covered with long, whitish wax threads (Fig. 8A). When the wax threads are removed, numerous fine wax gland units are visible on the ventral surface of the anal tube (Fig. 8B–D). The wax gland unit is regularly hexagonal with a side length of 20.0–24.7 μm . All hexagonal units possess a single, centrally positioned, long, tapering seta up to 105.5–109.5 μm in length (Fig. 8B–D). Numerous very tiny wax gland pores are present on the surface of each hexagonal unit and they are 0.31–0.38 μm in diameter with a density of 3.8–5.0 pores per mm^2 (Fig. 8E–H).

Etymology. The name of this new species is derived from the Latin words “*robust*” and “*cephalica*”, referring to its relatively broad and stout cephalic process.

Distribution. Southwest China (Yunnan Province).

Type material examined. Holotype ♂, **China, Yunnan Province:** Jinping, Changpotou, 1200 m, 23 May 1956 (K. R. Huang *et al.*) (IZCAS). Paratypes. **China, Yunnan Province:** 1 ♂, definite locality absent, 1956, collector name absent; 1 ♂, 3 ♀♀, same data as holotype; 1 ♀, same data as holotype, but 25 May 1956, collector name absent; 1 ♂, same locality, but 2200 m, 26 Sept 1957 (L. C. Zang); 1 ♀, near Jindong, 1450 m, 23 Mar 1957, collector name absent; 1 ♂, Longling, Sanqu, 1600 m, 12 May 1955 (B. R. Eo); 1 ♀, near Puwen, 1000 m, 27 Mar 1957, collector name absent; 1 ♂, Xishuangbanna, Mt. Kongmingshan, 16 Aug 1957 (S. Y. Wang) (all in IZCAS).

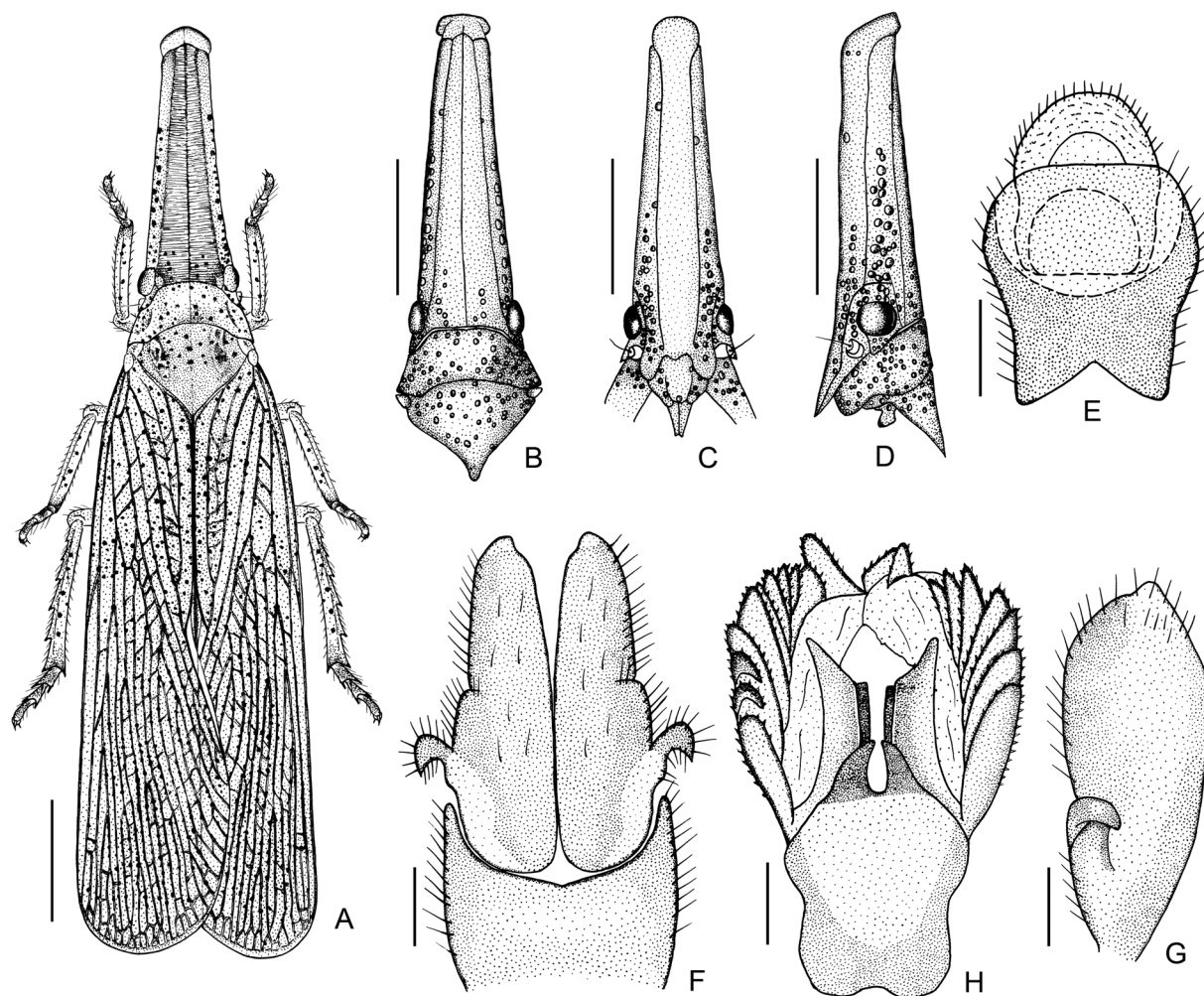


FIGURE 3. *Zanna robusticephalica* sp. nov., male adult, paratype (China: Yunnan: Jinping). (A) Habitus, dorsal view; (B) head, pronotum, and mesonotum, dorsal view; (C) head, ventral view; (D) head, pronotum, and mesonotum, lateral view; (E) apex of anal tube, dorsal view; (F) male pygofer, ventral view; (G) right paramere, dorsal view; (H) aedeagus, ventral view. Scale bar = 5 cm and 0.5 cm for A–D and E–G, respectively.

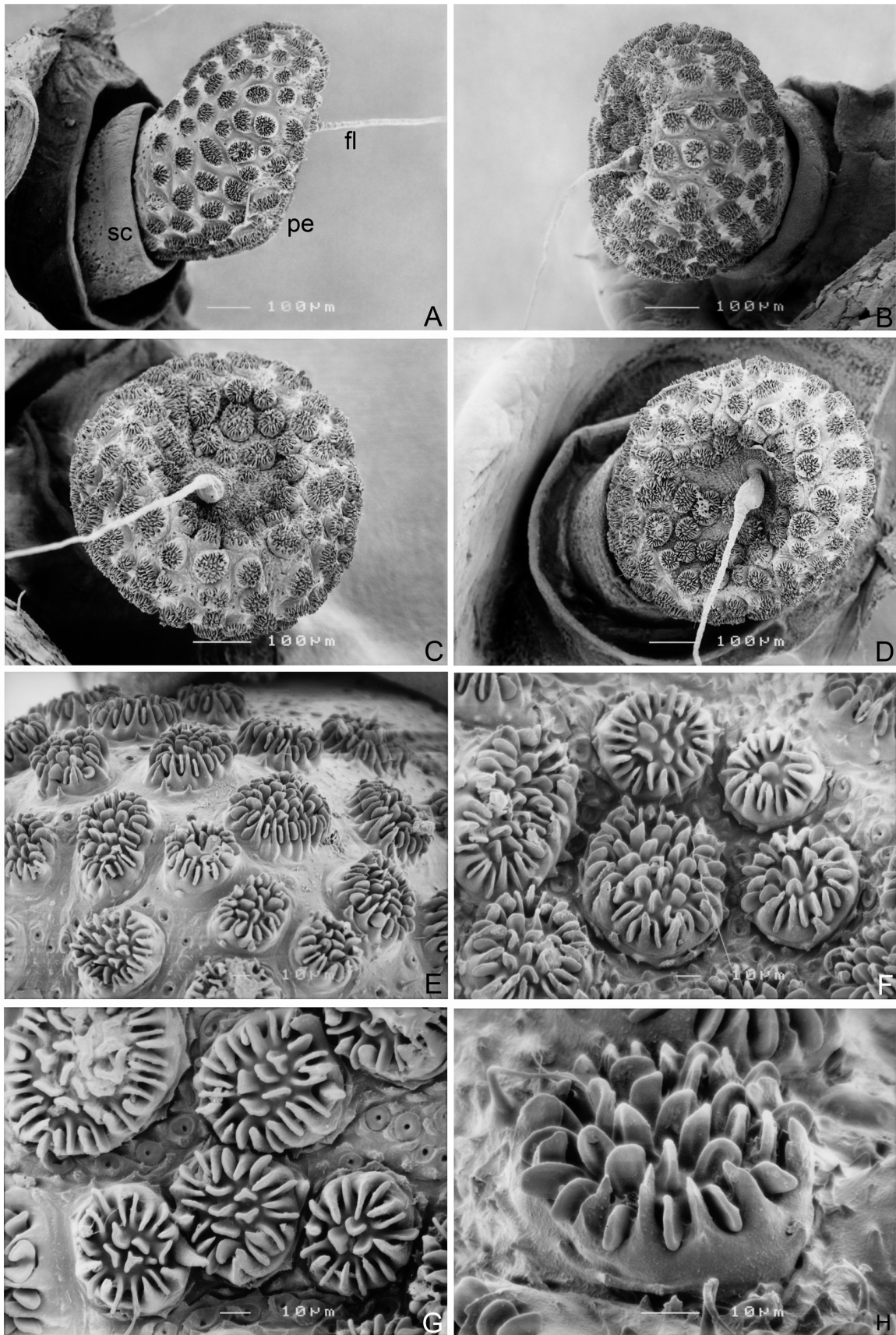


FIGURE 4. Scanning electron micrographs of *Zanna robusticephalica* sp. nov., male. (A) antenna, lateral view; (B) same, frontal view. (C, D) antennal pedicel, frontal view; (E–H) sensory plaque organs on antennal pedicel surface. Abbreviations: fl—flagellum; pe—pedicel; sc—scape.

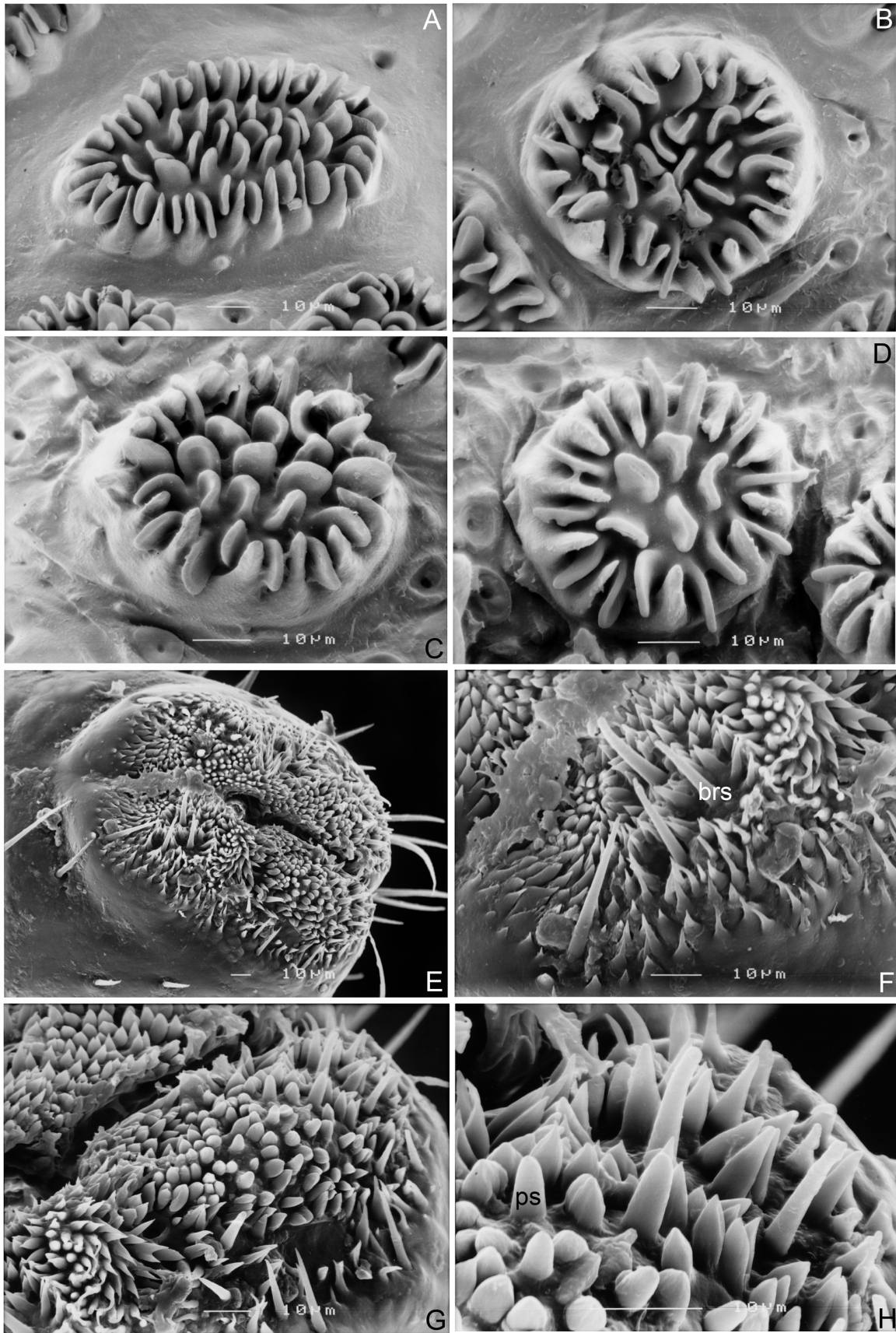


FIGURE 5. Scanning electron micrographs of *Zanna robusticephalica* sp. nov. (A–D) Four separate sensory plaque organs on pedicel surface (male); (E) rostral tip (female); (F–H) sensilla on apex of rostrum (female). Abbreviations: brs—bristle-like sensilla; ps—peg sensilla.

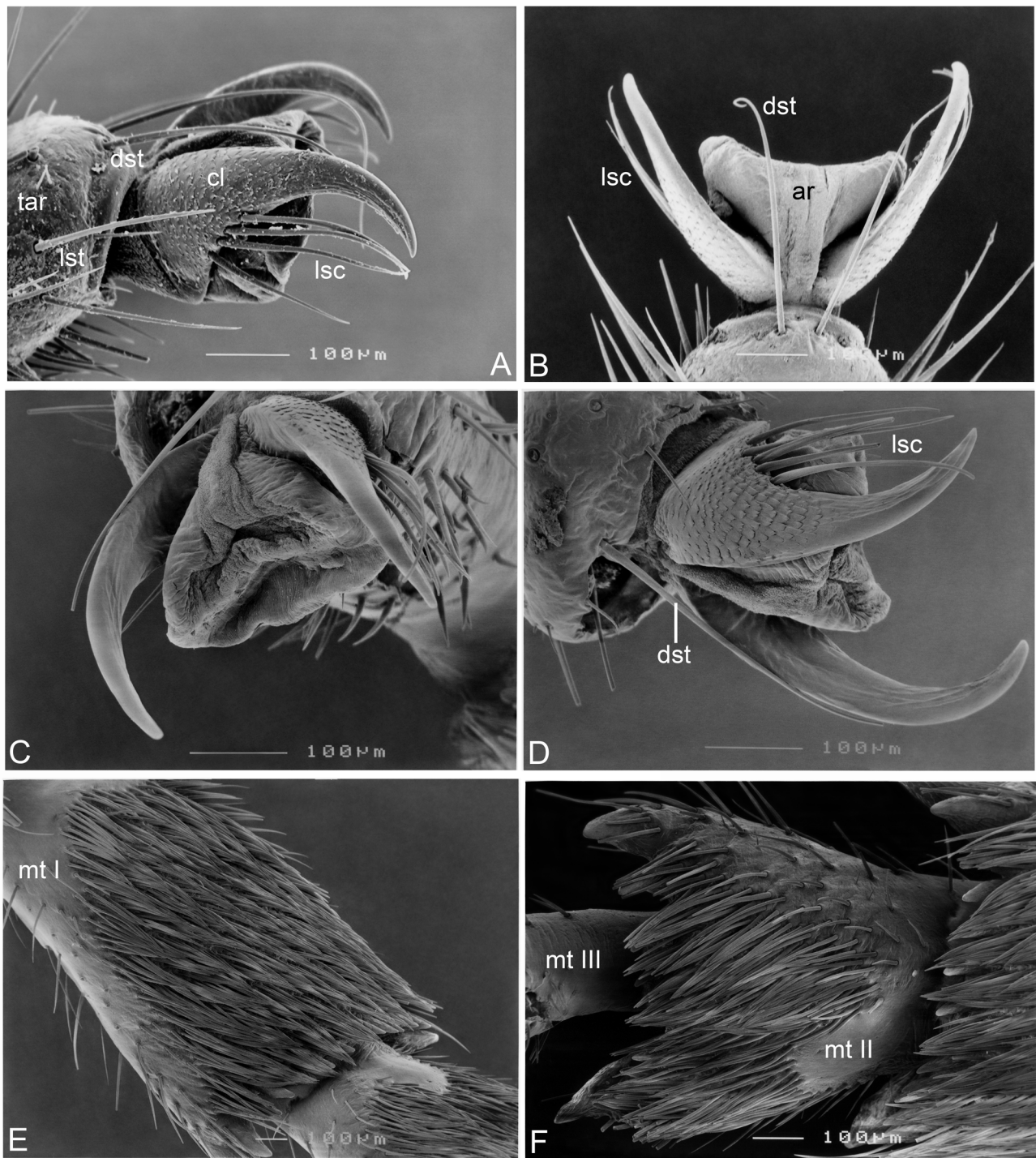


FIGURE 6. Scanning electron micrographs of *Zanna robusticephalica* sp. nov., female. (A) Pretarsus of hind leg, right side, lateral view; (B) same, dorsal view; (C) same, fronto-ventral view; (D) same, left side, dorsolateral view; (E) metatarsomere I with ventral pad of setae, ventral view; (F) metatarsomere II with ventral pad of setae, ventral view. Abbreviations: ar—arolium; cl—claw; dst—dorsal seta on tarsus; lsc—lateral seta on claw; lst—lateral seta on tarsus; tar—tarsus; mt I, II and III—metatarsomeres I, II, and III, respectively.

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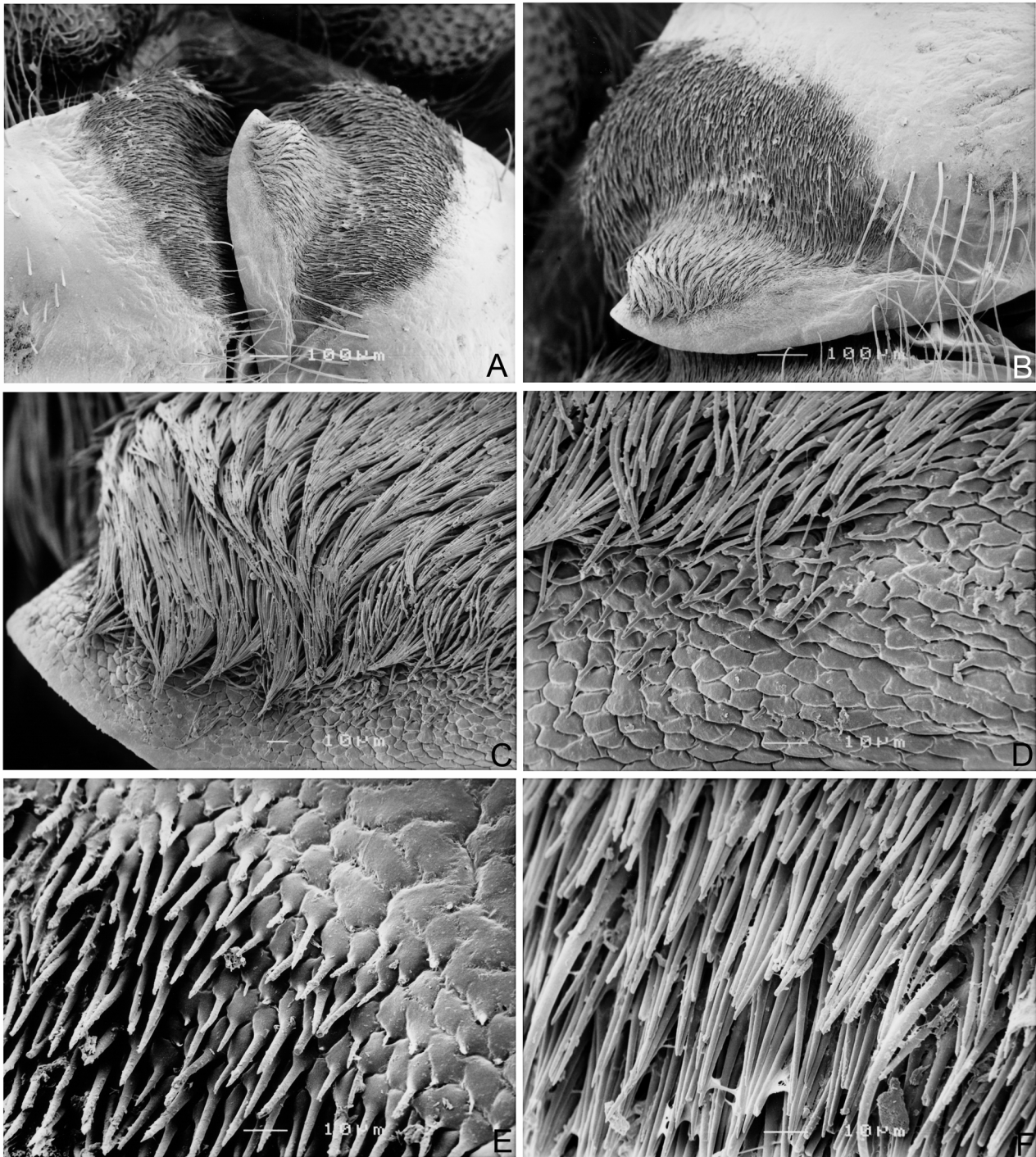


FIGURE 7. Scanning electron micrographs of *Zanna robusticephalica* sp. nov., female. A, B. Basal inner part of gonoplac, with strongly pilose area. C–F. Hairs on the basal inner part of gonoplac.

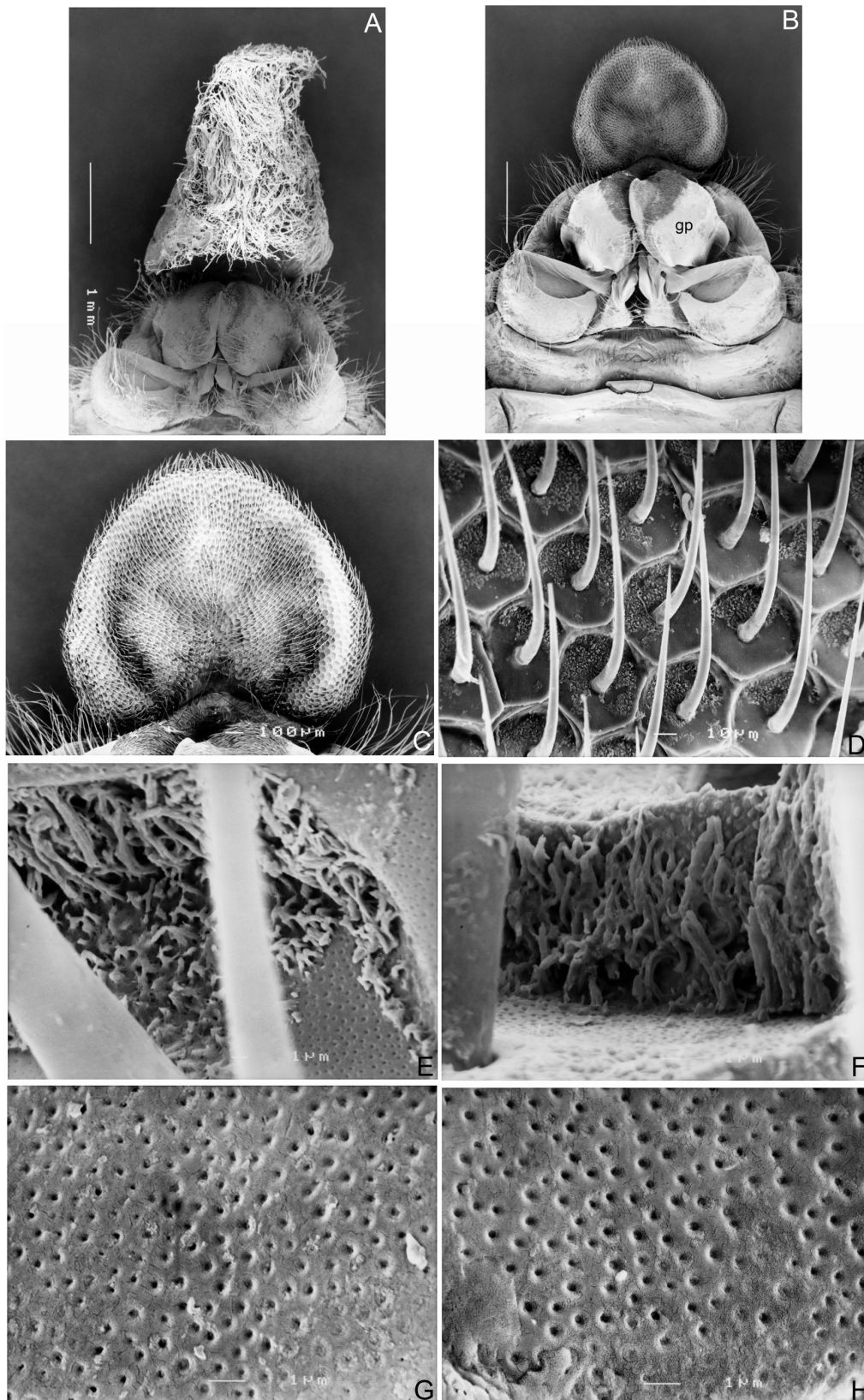


FIGURE 8. *Zanna robusticephalica* sp. nov., female. (A) Terminal abdominal segments with apically waxed anal tube, ventral view; (B) terminal abdominal segments with dewaxed anal tube, ventral view; (C) dewaxed anal tube, ventral view, showing numerous fine wax-secreting units with a central seta on ventral surface of anal tube; (D) ventral surface of dewaxed anal tube, showing hexagonal wax-secreting units with one central, tapering seta; (E, F) ventral surface of partially dewaxed anal tube, showing tiny wax gland pores and wax threads emerging from the wax gland pores; (G, H) wax gland pores on hexagonal, wax-secreting unit on ventral surface of dewaxed anal tube. Abbreviation: gp—gonoplac.

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