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Discovery of an obligate cave-dwelling caddisfly (Trichoptera, Polycentropodidae) in Japan

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Abstract

I had a chance to examine polycentropodid caddisfly larvae collected in a cave in Fukui, central Honshu, Japan in 2009. These larvae are unusual in that their heads and pronota are entirely yellow without pigmented muscle scars and their eyes are very small. Surveys from late autumn in 2009 to 2011 in the cave have yielded additional larvae and several adult females. The adult has the usual features of large compound eyes and forewings with white spots on the black ground color. The wing venation is similar to that of *Plectrocnemia*. The habitat in the cave is described, with particular reference to the evidence of an obligate, troglobite cave-dwelling caddisfly. The larva and adult female are described and illustrated.

Key words: cave-dwelling caddisfly, troglobite, Japan

Introduction

Cave-dwelling caddisflies are known for some species within the European Stenophylacine genera *Stenophylax*, *Mesophylax* and *Micropterna* (Nimmo 1996). They are considered ‘subtroglophiles’ (creatures which temporarily refuge in caves) because adults migrate to caves for aestivation and larvae live in streams flowing from caves or adjacent temporal water (e.g. Salavert *et al* 2008). *Diplectrona marianae* of the Hydropsychidae was described from northwestern Georgia, USA, and its larvae were collected in a subterranean stream (Reeves & Paysen 1999). But, because the larvae have been also collected from surface streams, this species is probably troglophilic (Jason Robinson pers. comm.). Sato (1964) reported a cavenicolous polycentropodid from Toku-no-shima Island of the Ryukyu Archipelago, southwestern Japan. He collected three larval specimens in a stream about 60 m from the cave entrance.

In 2009 I had a chance to examine polycentropodid caddisfly larvae collected in a cave in Fukui, central Honshu, Japan. The first collection occurred in September 2009 by Junichi Fujiwara, who was a graduate student of Kobe University at that time. I was very interested in these larvae because their heads and pronota are entirely yellow without pigmented muscle scars and their eyes are very small. In late October of that year, with the help of Takao Momosaki who is studying the cave-dwelling creatures in Fukui, I entered and investigated the cave, and succeeded in collecting some larvae and 4 adult females. Subsequent surveys have been conducted in May 30, 2010, September 5, 2010, October 11, 2010, November 3, 2010 and October 29, 2011. Larvae were found in all surveys, and an additional adult female was collected in October 11, 2010.

These peculiar cave-dwelling caddisfly can not be identified to species because no males have been found yet despite an intensive investigation. The wing venation indicates this species belongs to *Plectrocnemia* Stephens (Oláh & Johanson 2010), but its generic distinction from *Polycentropus* Curtis has not accepted by Wiggins (1996). Furthermore, the larvae have characters not found in previously described larvae of *Plectrocnemia* and *Polycentropus*, possibly resulting from an adaptation to dark, cave conditions.

The purpose of this study is to record the presence of the obligate, cave-dwelling caddisfly in Japan. In this paper, I provide the habitat information on this caddisfly and describe its larvae and female adults for valid species identification and generic assignment in the future.

Morphological terminology follows that of Schmid (1998) for female genitalia and Wiggins (1996) for larvae. Material is deposited in the author’s personal collection. All material is preserved in 70% alcohol except 2 adults pinned.

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Collection site and habitat

The cave is in a mixed forest on the side of a small mountain Asuwa-yama, which is in the urban area of Fukui city in central Honshu, Japan, about 117 m in height (Figs1, 2A). Its entrance is very narrow, about 40 cm in height and 80 cm in wide (Fig. 2B). The cave is divided into two portions by a narrow reach of large broken rocks near the entrance; the main interior area is 1.7 to 2.0 m in height, about 2.0 m in width, and about 30 m in length (Fig. 3). Daylight never reaches the main area of the cave, which is in complete darkness. Water seepage occurs from cave walls in the back and about half way in. The groundwater runs very slowly in the main interior area of the cave, 1.4 to 2.0 m in width and 5 to 15 cm in depth, and the substrate is composed of silt with sparse stones. The air and water temperatures both are 12°C, constant throughout the year. The water seeps into the ground at the beginning of the main area. There are no other streams or pools around the cave entrance. It is thought that this cave was artificially mined by hand for gravestones about 1500 years ago. There are a lot of similar caves around this area (Yoshizawa 2008; Momosaki 2009). It is said that they were also used as bomb shelter during World War II. But, most of those caves are not currently utilized at all, and some are buried by cave-ins or filled with groundwater. I investigated other caves, but did not find caddisflies. The caddisfly larvae were found only in the subterranean stream in this cave. Besides caddisflies, in this cave some other arthropods could be found; eye-less cave carabid beetles (*Trechiama sasajii* S. Ueno), Diplurans called two-pronged bristletails, cave crickets, small spiders, springtails (Tomoceridae gen.? sp.) on the water surface, and eye-less amphipods (*Pseudocrangonyx* sp.) in the water.

Description

Polycentropodidae gen.? sp.
(Figs 4–10)

Female Adult (Figs 4–7). Habitus (Fig. 4A) typical of the Polycentropodidae. Head and thorax densely covered with black, stout hairs dorsally. Eyes normal, not atrophied. Antennae thick, as long as forewings. Maxillary palpi (Fig. 5) 5-segmented, first and second segments very short and somewhat globular, forth segment slightly shorter than the third, and terminal segment flagelliform, about 3 times as long as fourth. Forewing length 6.4–7.2 mm (n=5). Forewings black with cream-colored spots as in Fig. 4. Venation (Fig. 6) similar to that of *Plectrocnemia*; forewings each with folks I, II, III, IV, and V; cross-veins *C-Sc*, *Sc-R1*, and *R1-R2* present; closed discoidal and median cells long and subequal, tyridial cell longer than preceding cells; hind wings each with folks I, II, and V; *Sc* usually present but absent in 2 of 5 specimens; discoidal cell closed and very short; *Rs* slightly sinuate before discoidal cell. Tibial spur formula 3, 4, 4. Gland of abdominal sternite V (Fig. 7A) thick, relatively short and about half as long as height of segment V.

Female genitalia (Fig. 7B, C). Ventral lobes of sternite VIII well sclerotized, scoop-shaped, extending posteromesad. Vulvar scale of segment X weakly sclerotized, triangular in ventral view; ceiling of anovaginal opening not extended posterad. Segment XI with pair of well-developed papillae posteriorly, each bearing 3 cerci.

Larva (Figs. 8–10). Length of final instar larva 11.2–13.8 mm and maximum head width 1.74–1.90 mm (n=5). Head (Figs 8, 9) entirely yellow without pigmented muscle scars. Eyes very small. Four pairs of primary setae on anterior margin of head (Fig. 9A) (numbers tentatively assigned in accordance with those of Wiggins (1996)), seta 1 and unnumbered medial seta almost transparent, seta 4 thin and semitransparent, setae 6, 7, and 12 relatively long, seta 9 very long and about twice length of seta 7, setae 13 and 14 arising closely together, setae 15 and 16 relatively short; setae 5, 8, 17, and 18 not detected. Labium (Fig. 9C) with submental sclerites fused into a large plate; maxillae each with 2 sclerites basally, medial sclerite short and not reaching to basal margin of labium; maxillary lobes elongate. Ventral apotome (Fig. 9C) short and broad. Labrum (Fig. 9D) with 6 pairs of primary setae, setae 2, 4, and 5 almost unpigmented. Mandibles (Fig. 9E, F) sharply pointed apically, deeply hollowed medially, each with dorso- and ventromedial edges bearing 2 or 3 teeth. Sclerotized pronotum (Figs 8, 9G) yellowish as in head, with faint muscle scars in posterior half; long and short setae arising on anterior margin and along posterior 2/3 of dorsum. Mesonotum and metanotum (Figs 9F, 10A) entirely membranous, each with *sa1*, *sa2*, and *sa3* bearing 1, 2, and 3 setae, respectively; single seta on *sa1* very short and one of 2 setae very long. Forelegs (Fig. 10B) each with tarsus about 2/3 length of tibia;

tarsus with short setae along ventral margin, tarsal claw elongate and as long as tarsus. Abdomen (Fig. 10A) flexible, often slightly transparent with internal tract visible, bearing long setae dorsolaterally, ventrolaterally, and laterally; anal prolegs (Fig. 10C) each with basal segment much longer than distal segment, slightly constricted at middle; anal claws obtuse-angled, each bearing a dorsal accessory hook but lacking accessory teeth; two dark sclerotized bands of dorsal plate partially fused (Fig. 10D).

Specimens examined. JAPAN. Fukui: 3 larvae, a cave in Asuwa-yama, Oyamadani-cho, Fukui-shi, 19.x.2009, J. Fujiwara; 4 females 6 larvae, same locality, 23.x.2009, H. Nishimoto; 1 pupa 1 larva, same locality, 11.x.2010, H. Nishimoto; 1 female, same locality, 3.xi.2010; 3 larvae, same locality, 29.x.2011, H. Nishimoto.

Distribution. This cave-dwelling caddisfly is only known from a single cave in Asuwa-yama, Fukui, Japan.

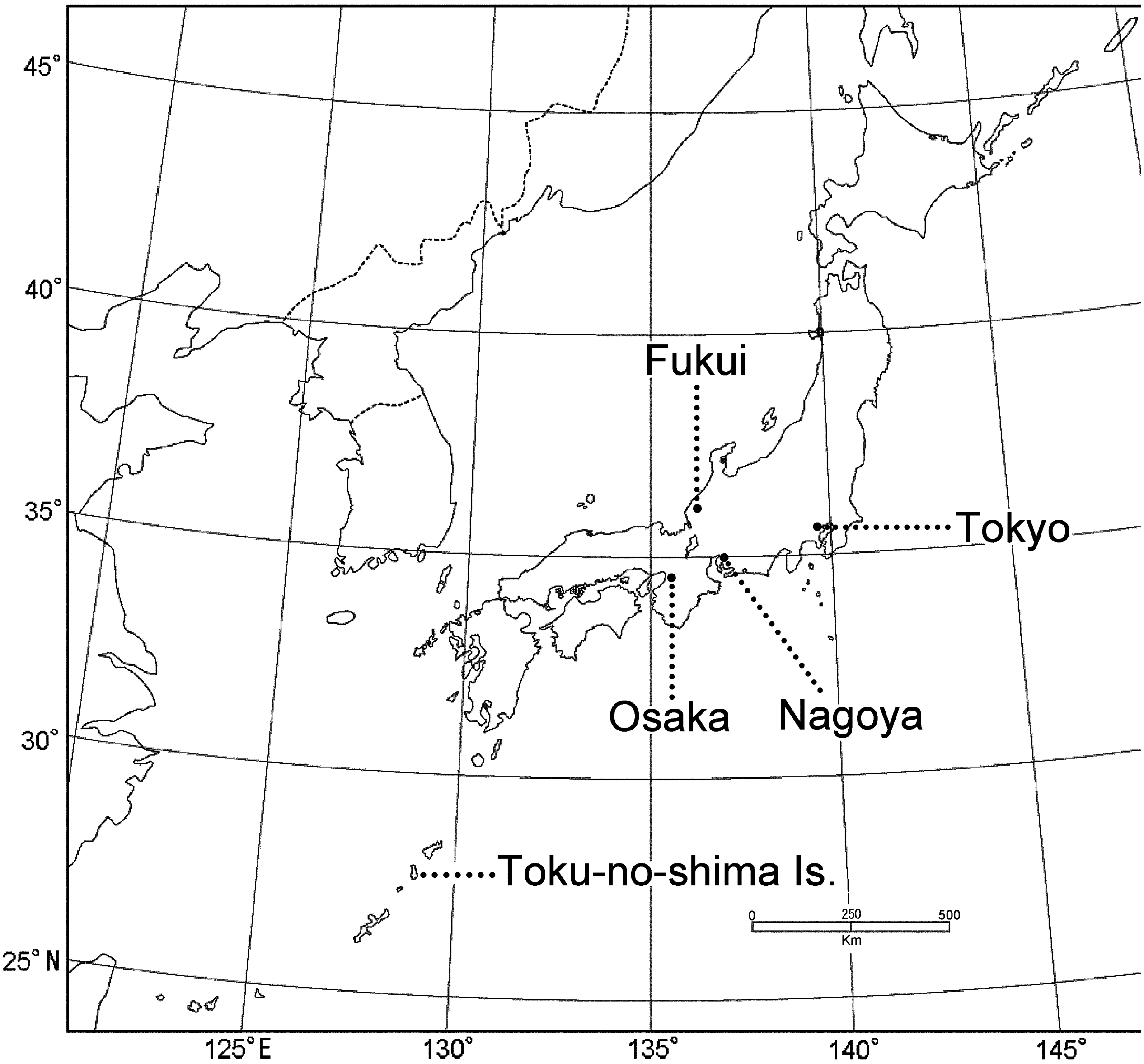

FIGURE 1. Location of collection site (Fukui).

FIGURE 2. Collection site. A, a mixed forest of Mt. Asuwa-yama (Futaba Nishimoto, a collection assistant, is standing near the cave entrance); B, cave entrance.

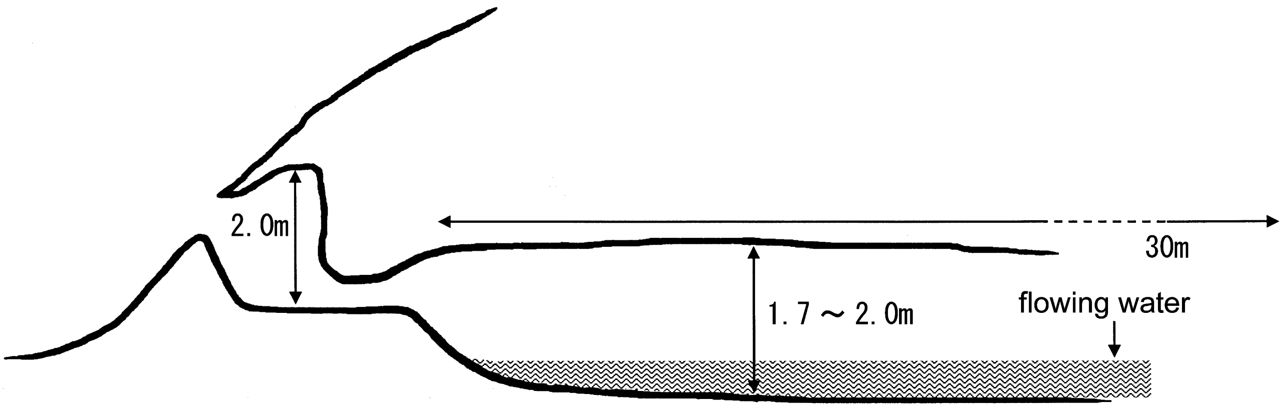

FIGURE 3. Cross-sectional diagram of cave.

Biological note. Pupal cases are primarily constructed of small rock fragments with plant debris including seeds and wood pieces, which are coarsely incorporated. Seeds were thought to be carried on wild animals, probably raccoon dogs, as feces. Pupal cases are attached to the undersides of rocks. Larvae are active in their retreats constructed of coarse nets on the side of stones or actively move around on the net spun on the mud substrate and seem to feed on amphipods (*Pseudocrangonyx* sp.). They require several years to complete their life cycle because early to late instar larvae occurred at the same time in all seasons (except winter). It is probable that the constant low water temperature (12°C) slows growth. All five adults and the only pupa were female, collected from late October to early November in spite of complete darkness and unchanging temperature in a cave. While the number of specimens is very small, it is possible that this species is parthenogenetic because the very low number of emerging females produce offspring in the limited habitat inside the cave.

Remarks. The wing venation of this species is essentially identical to that of *Plectrocnemia*. Forewings have forks I, II, III, IV and V and closed discoidal and median cells. The hind wings have forks I, II and V and closed discoidal cell. The larvae are unique in absence of pigmented muscle scars on the head. Although larvae are not known in all species of *Plectrocnemia* and the related *Polycentropus*, they usually have characteristically arranged muscle scars on their heads (Edington & Hildrew 1995). The presence of lateral abdominal fringes of long setae is also not a common character in polycentropodid genera. In addition, the extraordinarily small eyes of this species are unusual even in Polycentropodidae with relatively small eyes.

Sato (1964) recorded polycentropodid larvae from a Tokuwase-do cave in Toku-no-shima Island which is located far away from Fukui (about 1200 km distance), a small island in a subtropical area of Japan (Fig. 1). According to his description, the head and pronotum of the larvae are light yellow and the mandibles are brown; the abdomen is flexible, white or transparent in color, with developed setae; the anal proleg is long with sparse, long setae; the anal claw is slender, long and simple; the length of larva is about 10 mm. He did not make reference to the eye size and markings of the head and pronotum. But, probably the larvae actually have reduced eyes and no head and pronotal markings judging from his illustrations. Thus, they are similar to Fukui specimens treated in this study and this may indicate that both are closely related.

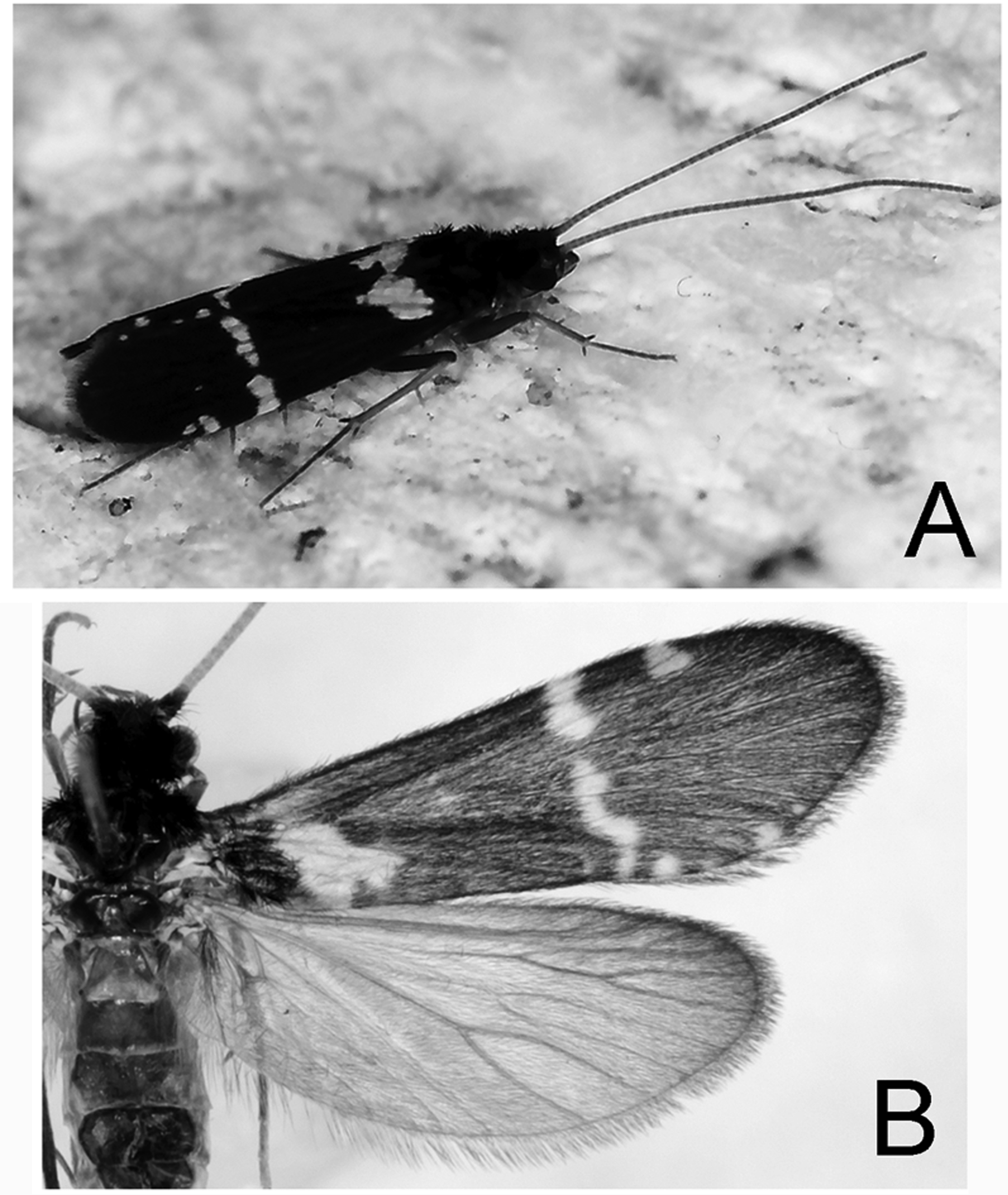

FIGURE 4. Female adult. A, habitus; B, wings enlarged.

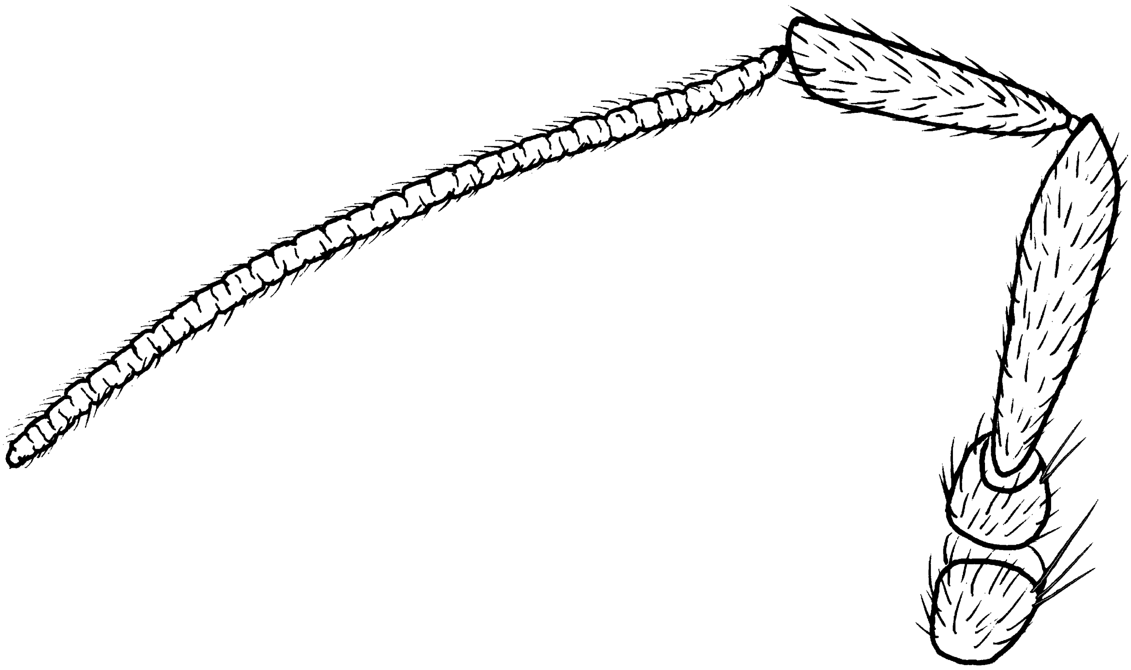

FIGURE 5. Left maxillary palpus, lateral.

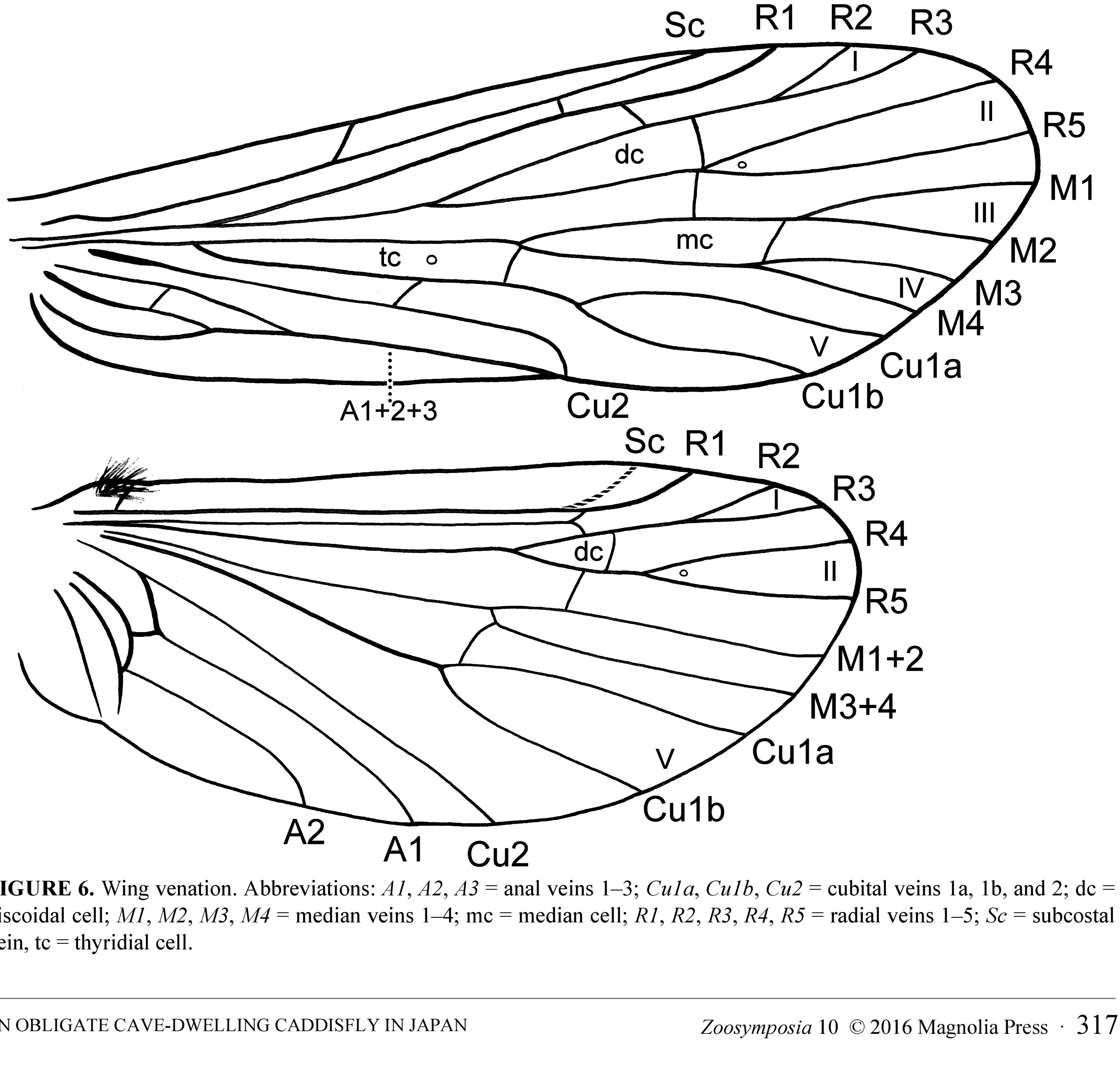

FIGURE 6. Wing venation. Abbreviations: *A1*, *A2*, *A3* = anal veins 1–3; *Cu1a*, *Cu1b*, *Cu2* = cubital veins 1a, 1b, and 2; dc = discoidal cell; *M1*, *M2*, *M3*, *M4* = median veins 1–4; mc = median cell; *R1*, *R2*, *R3*, *R4*, *R5* = radial veins 1–5; *Sc* = subcostal vein, tc = thyridial cell.

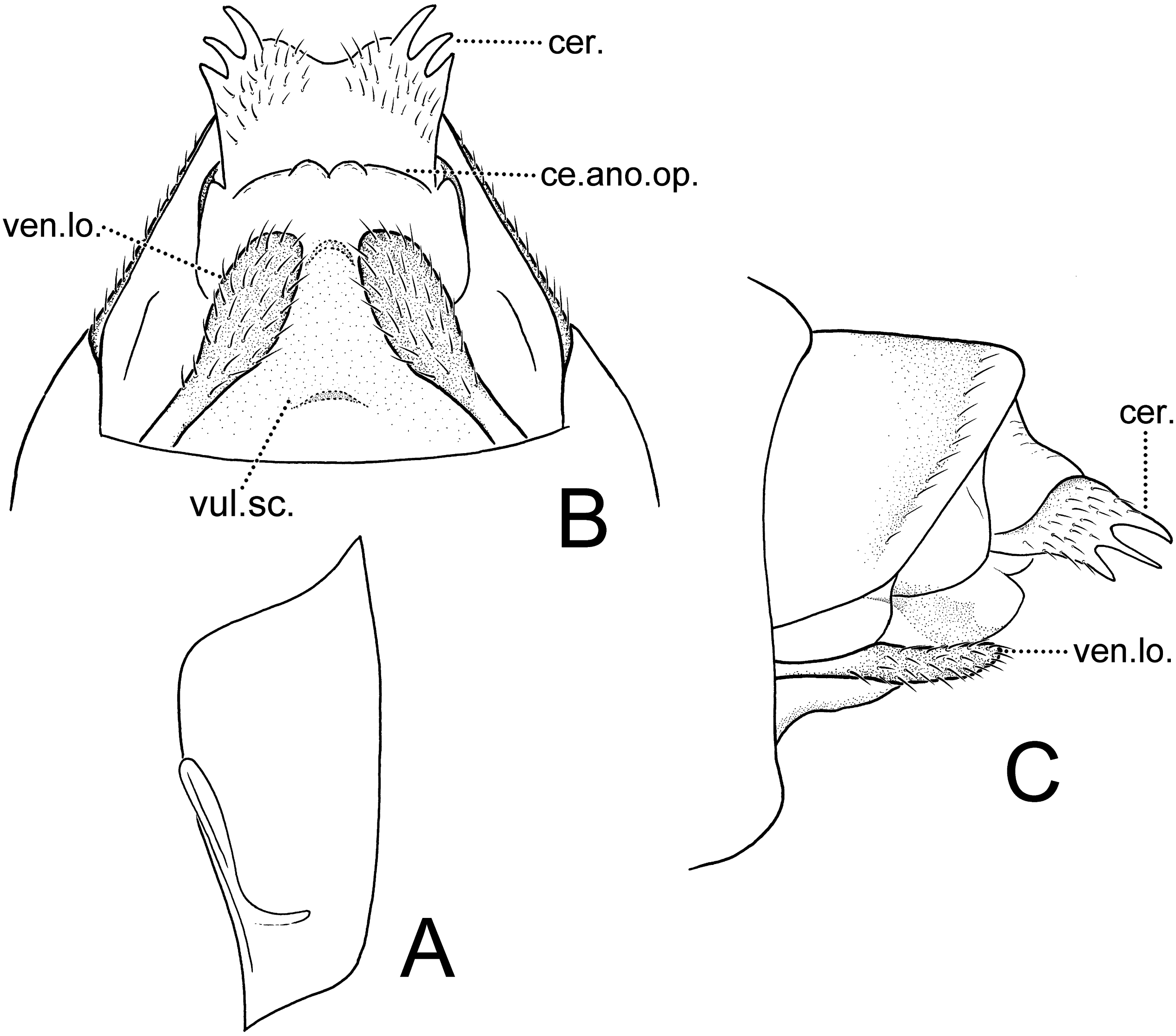

FIGURE 7. Gland of abdominal sternite V and female genitalia. A, sternite V gland, lateral; B, genitalia, ventral; C, lateral. Abbreviations: ce.ano.op. = ceiling of anovaginal opening; cer. = cerci; ven.lo. = ventral lobe of sternite VIII; vul.sc. = vulvar scale of segment X.

Consideration of a possible troglobite caddisfly

It appears to be difficult for the adults to leave the cave because the cave entrance and entry portion are very narrow and the interior area where the caddis exist is in complete darkness. The larvae are restricted the subterranean stream inside the cave. The water seeps into the ground about 5 m before reaching the cave entrance. Therefore, larvae can not leave the cave. The larval characteristics clearly indicate adaption to the darkness. Their eyes are reduced, pigmented muscle scars of the head and pronotum are absent, and the abdominal hairs are long dorsally, ventrally and especially laterally. The lateral abdominal fringes of long setae are unusual except the genus *Ecnomus* (Ecnomidae) and may function as sensory hairs. The larval characters indicate that they are obligate, troglobites. However, the adult characters (compound eyes of usual size and mottled forewings) do not seem to indicate adaption to caves. This may suggest that they are recently evolved species.

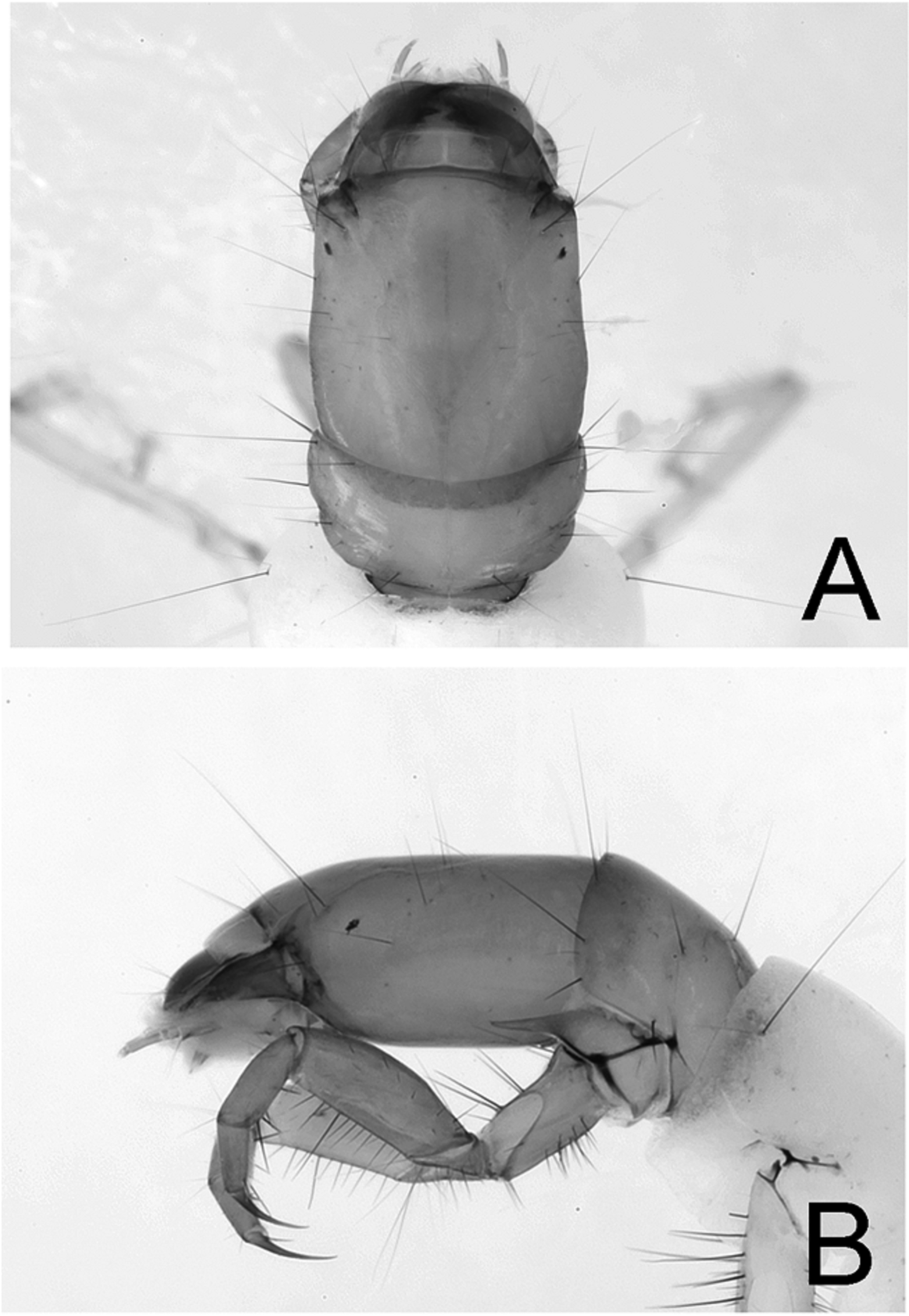

FIGURE 8. Larval head and prothorax. A, dorsal; B, lateral.

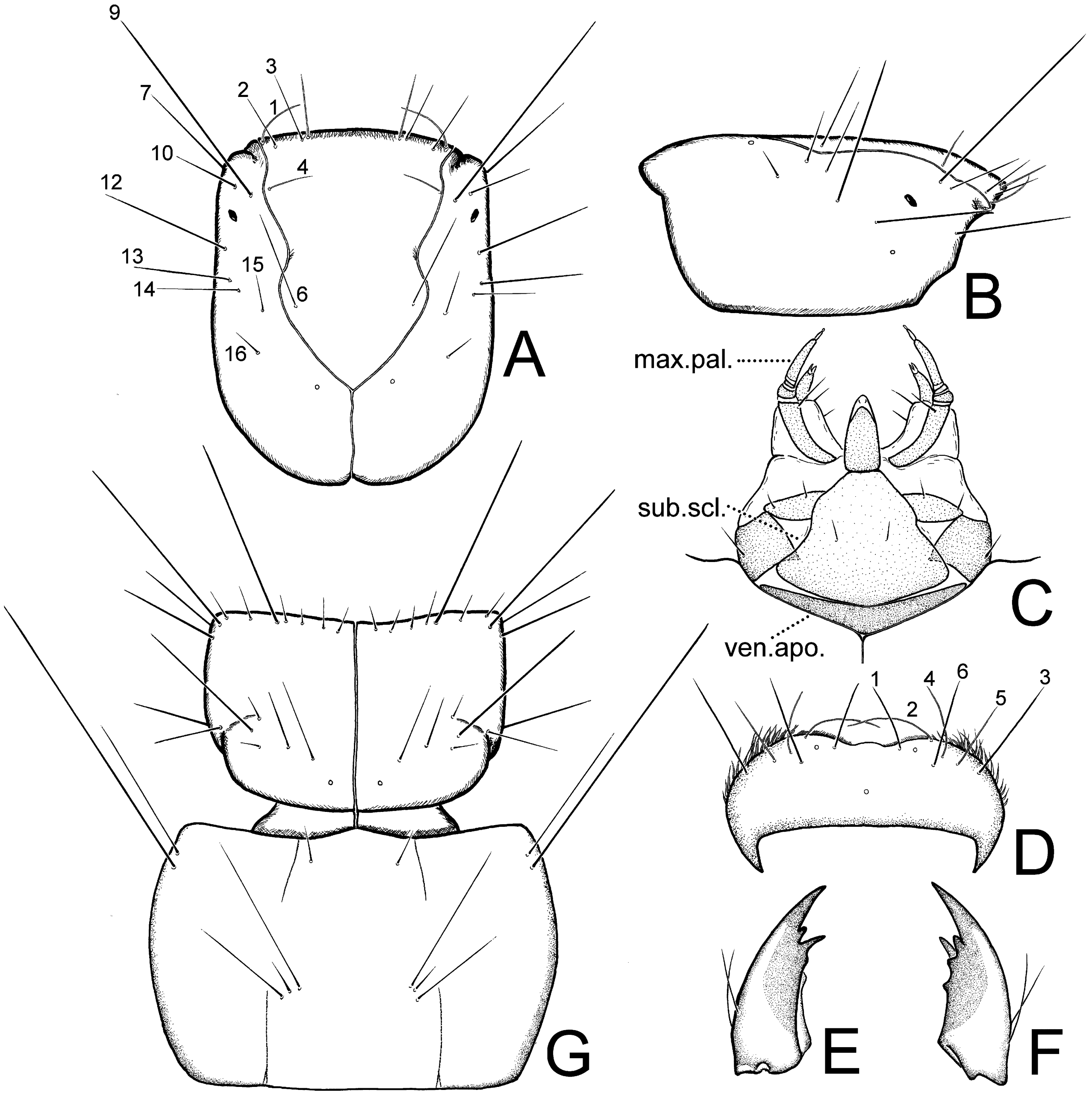

FIGURE 9. Morphology of larva. A, head, dorsal; B, head, lateral; C, maxillae and labium, ventral; d, labrum, dorsal; E, left mandible, dorsal; F, left mandible, ventral; G, pro- and mesonotum, dorsal. Abbreviations: max.pal. = maxillary palpus; sub.scl. = submental sclerite; ven.apo. = ventral apotome.

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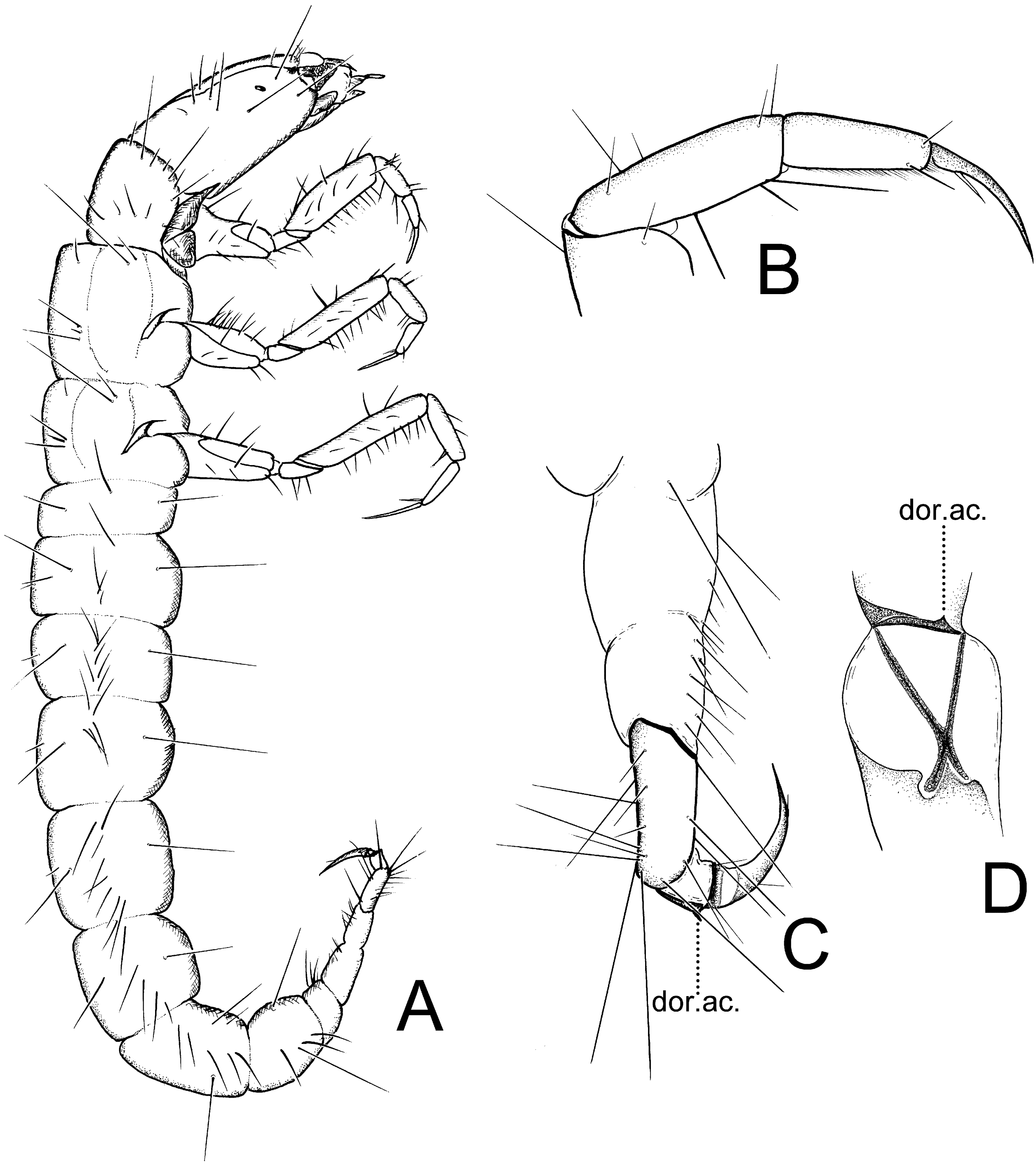

FIGURE 10. Morphology of larva. A, larva, lateral; B, fore tibia and tarsus, lateral; C, anal proleg, lateral; D, dorsal plate of anal proleg, dorsal. Abbreviations: dor.ac. = dorsal accessory hook.

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