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Tsudaea, a new genus of Brachycentridae (Trichoptera) from Japan

TAKAO NOZAKI
Kanagawa Environmental Research Center, 1-3-39, Shinomiya, Hiratsuka, 254-0014 Japan. E-mail: takao.nozaki@nifty.com

Abstract

The species, previously known as "*Eobrachycentrus kitayamanus* (Tsuda 1942)" originally described based on a male specimen, is here associated with the larval stage described by Akagi (1962) as "*Micrasema* sp. MD". Because both the adult and larva of this species have many unique characters within the family Brachycentridae, a new genus, *Tsudaea,* is erected for this species. Descriptions and illustrations of the adult and immature stages of *Tsudaea kitayamana* are provided. The larvae of *T. kitayamana* are unique among the Brachycentridae in having lateral humps present on the first abdominal segment.

Key words: Trichoptera, Brachycentridae, new genus, *Tsudaea*

Introduction

The Brachycentridae are a small family consisting of six previously recognized genera with about 100 species. Wiggins *et al*. (1985) reviewed the Japanese Brachycentridae, and transferred *Brachycentrus kitayamanus* Tsuda 1942 to the genus *Eobrachycentrus.* Tsuda (1942) described this species based on a single male collected from Kibune, a mountain area of Kyoto, central Japan. Subsequently, Morita and Kawase (2004) provided a new distributional record based on male and female material from a mountain area of Ishikawa, central Japan. Although the type specimen of this species was probably lost (Wiggins *et al*. 1985, Tanida *personal communication*), male specimens provided by H. Morita and T. Hattori are in accord with the original species description (Tsuda 1942). The male genitalia have some characters in common with *Eobrachycentrus* species, as previously suggested by Wiggins *et al*. (1985), but the phallus bears strong spines, which are not known from other *Eobrachycentrus* males.

Akagi (1962) described a unique brachycentrid larva as *Micrasema* sp. MD from a pond on the mountaintop of Utsukushigahara, Nagano, central Japan. The larva has a cylindrical case similar to those of *Micrasema*, but bearing many plant fragments somewhat similar to those of *Eobrachycentrus*. A few larvae of this species were provided to me by T. Ito and H. Kato in the 1990's. The larvae have some characteristics in common with those of other brachycentrid genera, but they differ by having first abdominal segment with lateral humps present. Lateral humps are common in all other case-making Trichoptera larvae (Wiggins 1996).

Mr. D. Tsuruta kindly provided me with larval specimens collected from the headwaters of the Tama River, Yamanashi, central Japan. I visited the same location and collected immature specimens. Some of these specimens were reared to adults in the laboratory, thus confirming identification of the larvae.

The purpose of this paper is to establish a new brachycentrid genus for this interesting species, and redescribe and illustrate the adult and immature stages. The pupal stage is described for the first time. Additionally, information on the larval habitat and biology is provided.

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Material and methods

Male and female genitalia and some larval characters were figured after being cleared in a 10% solution of KOH. Larval characters described are based on final instar larvae. Morphological terms mainly follows Schmid (1998) for the adult and Wiggins (2004) for the larva and pupa. Depositories of the specimens are abbreviated as follows: Natural History Museum and Institute, Chiba (CBM); H. Morita, Yokkaichi-shi, (HM); T. Nozaki, Kanagawa Environmental Research Center, Hiratsuka (TN); National Museum of Natural History, Smithsonian Institution, Washington, DC (USNM). All adult specimens used in this study were obtained by a sweep net or rearing.

Genus *Tsudaea* gen. nov.

Type species: *Brachycentrus kitayamanus* Tsuda 1942.

Diagnosis— The genus *Tsudaea* is generally similar to the genus *Eobrachycentrus* Wiggins in both adult and immature stages. The adults of *Tsudaea* have frons with a large central setal wart and a pair of large lateral setal warts (Fig. 1B), but in *Eobrachycentrus* the frons has two pairs of lateral warts (Wiggins 1965, Wiggins *et al*. 1985). Males of *Tsudaea* are distinguished from other known brachycentrid genera by having distinct phallic spines (Fig. 2E, F). The larval submental sclerites are fused into a single plate in *Tsudaea* (Fig. 3C), but separated in *Eobrachycentrus* (Wiggins 1965); and a pair of abdominal gills are present in *Tsudaea* (Fig. 3A) but absent in *Eobrachycentrus* (Wiggins 1965, 1996). The presence of lateral humps on the first abdominal segment is unique to larvae of *Tsudaea*. In the pupal stage, the posterior hook plate on the fifth abdominal segment shows a linear row of spines in *Tsudaea* (Fig. 4A), but a more ovoid group in *Eobrachycentrus* (Wiggins 1965). Pupal anal processes of *Tsudaea* are shorter (Fig. 4A) than those of *Eobrachycentrus* (Wiggins 1965). Cases are cylindrical and constructed of sand grains in *Tsudaea* (Fig. 4C, D), but 4-sided and made from plant materials in *Eobrachycentrus* (Wiggins 1965, 1996).

Description— *Adult (Figs. 1, 2, 8).* Small, dark brown to black. Head without ocelli; with anterior setal warts oval, posterior and posterolateral setal warts slender; large round setal wart present on center of frons, with pair of large setal warts laterally; maxillary palpi 3-segmented and very short in male, 5-segmented in female. Both mesoscutal and mesoscutellar setal warts small, oval. Legs with tibial spurs formula 2, 3, 3 in both sexes. Venation with discoidal cell closed in fore- and hindwings of both sexes; venation of forewings similar in both sexes, with apical forks I, II, III and V; venation of hindwings with apical forks I, II and V in male, I, II, III and V in female. Abdominal sternite V with one pair of small scent glands near anterolateral margins in both sexes.

Male genitalia (Fig. 2A–F). Segment X long, weakly sclerotized, with large strongly sclerotized intermediate appendages. Inferior appendages 2-segmented. Phallus with long spines at base of endotheca.

Female genitalia (Fig. 2G–I). Sternite VIII large, tergum IX and segment X separated. Spermathecal sclerite simple.

Larva (Figs. 3A–J, 9). Head flattened with distinct carina, ventral apotome longer than wide, submental sclerites fused into single plate. Prosternal horn absent. Pronotal sclerite with many, long, stout setae along anterior margin and transverse depression. Mesonotal sclerites with long, stout setae along anterior and posterior margins, each sclerite subdivided longitudinally. Metanotal *sa*1 with single short seta, *sa*2 and *sa*3 sclerites with long, stout setae. Forelegs short, coxae with many, long setae, femora broad with teeth-like spines ventrally. Mid- and hindlegs slender with many, long setae. Abdominal segment I with pair of lateral humps. Abdominal segment II with pair of single gills. Lateral fringes present. Forked lamellae absent. Abdominal segment VIII with pair of protuberances dorsolaterally. Anal claw with two dorsal accessory hooks.

Pupa (Fig. 4A–B). Labrum with five pairs of long, apically hooked setae, mandibles acute with many fine teeth on mesal margin. Tarsi of midlegs with dense fringe of setae. First abdominal segment with pair of spine-bearing ridges; anterior hook plates present on segments III to VII; segment V with two rows of spines posteriorly. Lateral fringe present. Abdominal gills absent. Anal process short with two apicomesal, long, apically hooked setae and with short thick seta apically.

Case (Figs. 4C–E, 9). Cylindrical, constructed of sand grains and with pieces of moss and other plant materials attached.

Etymology. The genus is named in honor of the late Dr. Matsunae Tsuda, who was instrumental in the development of the study of Japanese aquatic insects. He described the type species of this genus in the first monograph of Japanese Trichoptera (Tsuda 1942).

***Tsudaea kitayamana* (Tsuda 1942)**
Figures 1–5, 8, 9

Brachycentrus kitayamanus Tsuda 1942, 326, male.
Micrasema sp. MD: Akagi 1962, 44–45, larva, case.
Eobrachycentrus kitayamanus: Wiggins *et al*. 1985, 66–67; Morita and Kawase 2004, 18.

Description— Adult (Figs. 1, 2, 8). Body, wings and antennae dark brown, almost black. Forewings 4.6–6.8 mm long in male, 4.4–7.5 mm long in female; slenderer in female than in male. Head shorter than width; ocelli absent; anterior setal warts oval, smaller in female than in male; both posterior and posterolateral setal warts slender; large round setal wart present on center of frons, with pair of large rectangular setal warts laterally. Male maxillary palpi very short, about 0.2 mm long in total length; 3-segmented; third segment usually minute, but males from Ishikawa and Hyogo with third segment approximately same length as second segment. Female maxillary palpi 5-segmented, 0.8–1.2 mm long in total length, ratio of five segments approximately 1: 1: 3: 2.5: 2.6. Labial palpi 3-segmented in both sexes, first segment short, third segment longest; total length 1.0–1.2 mm long in male, 0.4–0.7 mm long in female. Antennae shorter than forewings in both sexes, scape 2.7 times as long as wide. Pronotum with pair of oval setal warts dorsally and pair of ovoid setal warts laterally, approximately same size as dorsal pair. Both mesoscutal and mesoscutellar setal warts small, oval. Legs with tibiae and tarsi brown; tibial spur formula 2, 3, 3 in both sexes; with brown spine-like setae present on tibiae and first to fourth segments of tarsi of all legs. Discoidal cell elongate and closed in fore- and hindwings of both sexes. Forewing venation similar in both sexes; apical forks I, II, III and V present, fork II petiole; crossveins c-sc and sc-r at middle of anterior margin and near distal end of Sc, respectively; crossveins r-m and m-cu present; anal veins A1 and A2 fused into a single vein, A3 absent. In hindwings, apical forks I, II and V present in male; I, II, III and V present in female; fork II petiole in female, but usually branching close to discoidal cell in male. Abdominal sternite V with pair of scent glands near anterolateral margins. Abdominal sternite VII with small triangular process at middle of posterior margin; apex round in male, acute in female.

Male genitalia (Fig. 2A–F). Segment IX triangular in lateral view, narrow dorsally. Segment X long, deeply divided into two long triangular lobes separated by deep V-shaped notch in dorsal view; weakly sclerotized and lightly pigmented, with small, rounded preanal appendages basolaterally. Intermediate appendages large and oval in lateral view, slightly shorter than segment X, anterodosal corner angled laterally. Inferior appendages 2-segmented: basal segment large, trilobed posteriorly in lateral view, dorsal process long and finger-like in lateral and dorsal view, and protruding slightly posteroventrally in lateral view; distal segment rectangular in lateral views, apex with three, short, strong, spine-like setae. Phallus with sclerotized phallotheca almost straight; endotheca usually with three pairs of long spines at base, two dorsally, one ventrally (sometimes absent); aedeagus broad dorsoapically, distal end of ejaculatory duct and phallotremal sclerite darkly pigmented.

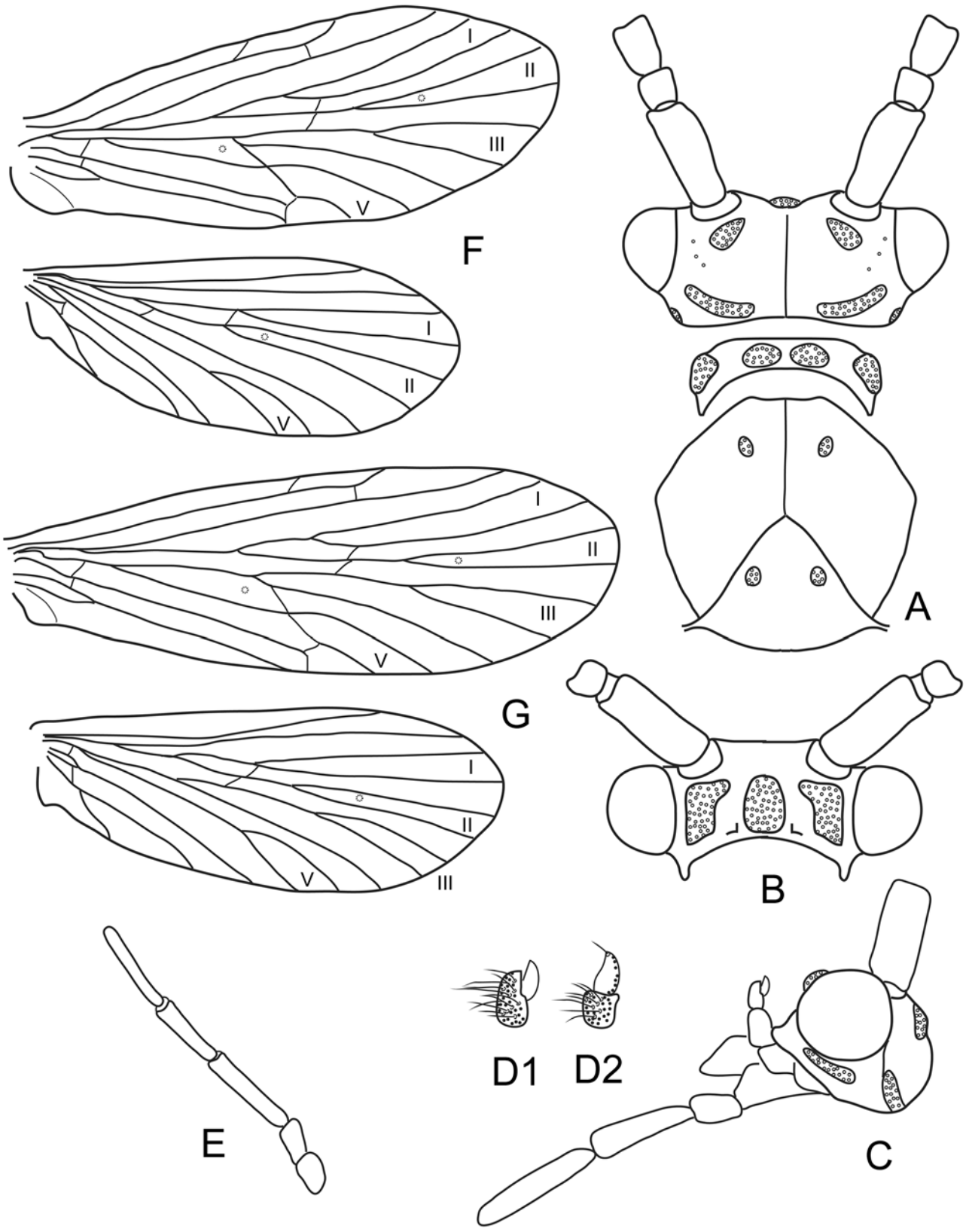

FIGURE 1. *Tsudaea kitayamana*. A: male adult, head and pro- and mesonota, dorsal; B: Male adult, head, frontal; C, male, head, lateral; D, male, maxillary palp, lateral (D1: Yamanashi, D2: Hyogo); E, female, maxillary palp, lateral; F, male, wings; G: female, wings.

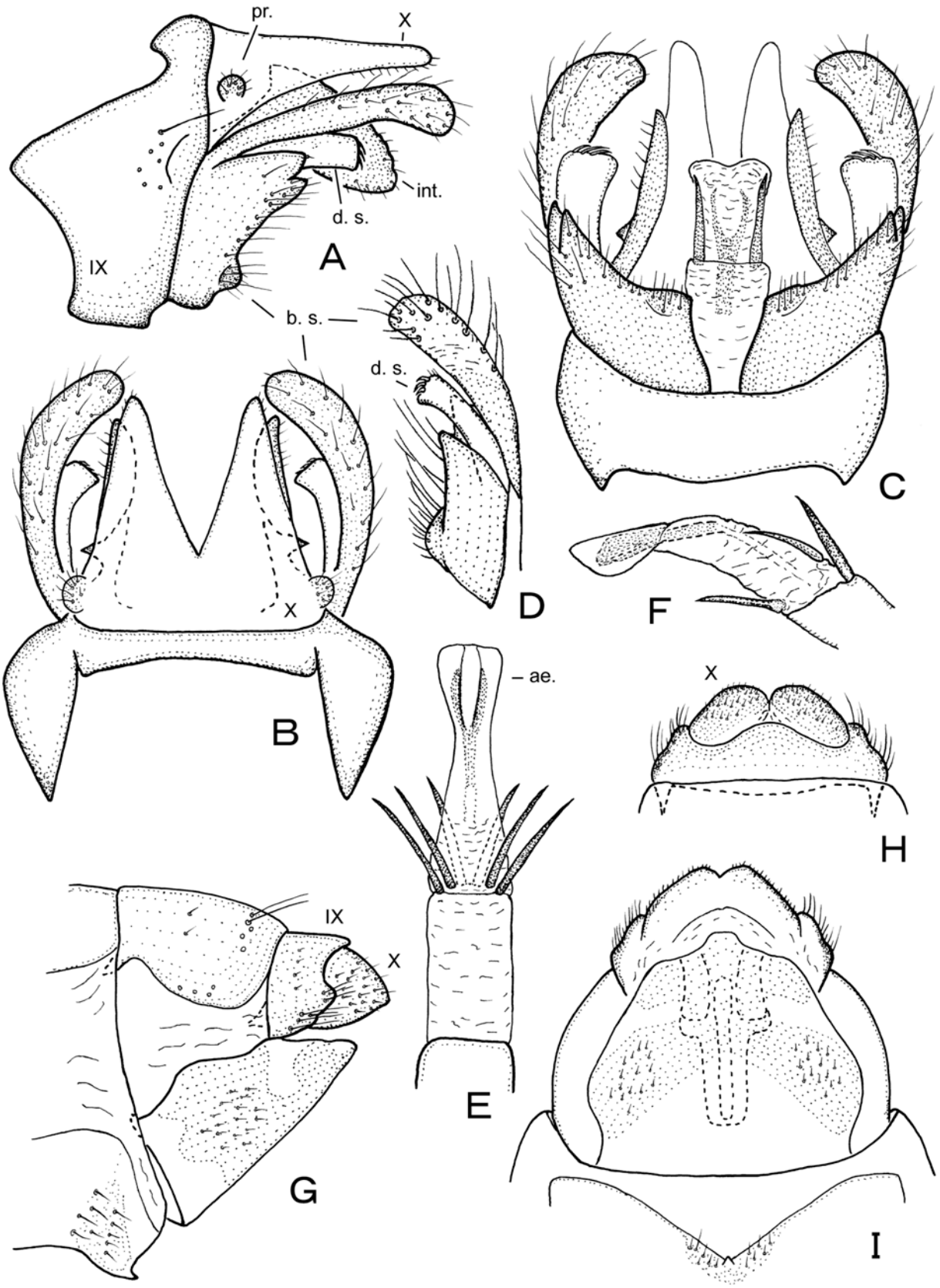

FIGURE 2. *Tsudaea kitayamana*. Male genitalia A–F: A, lateral; B, dorsal; C, ventral; D, inferior appendage, mesal; E, phallus, dorsal; F, phallus, lateral. Female genitalia G–I: G, lateral; H, dorsal; I, ventral. Abbreviations: IX, X, abdominal segments IX and X; ae., aedeagus; b.s., basal segment of inferior appendage; d.s., distal segment of inferior appendage; int., intermediate appendage of segment X; pr. preanal appendage.

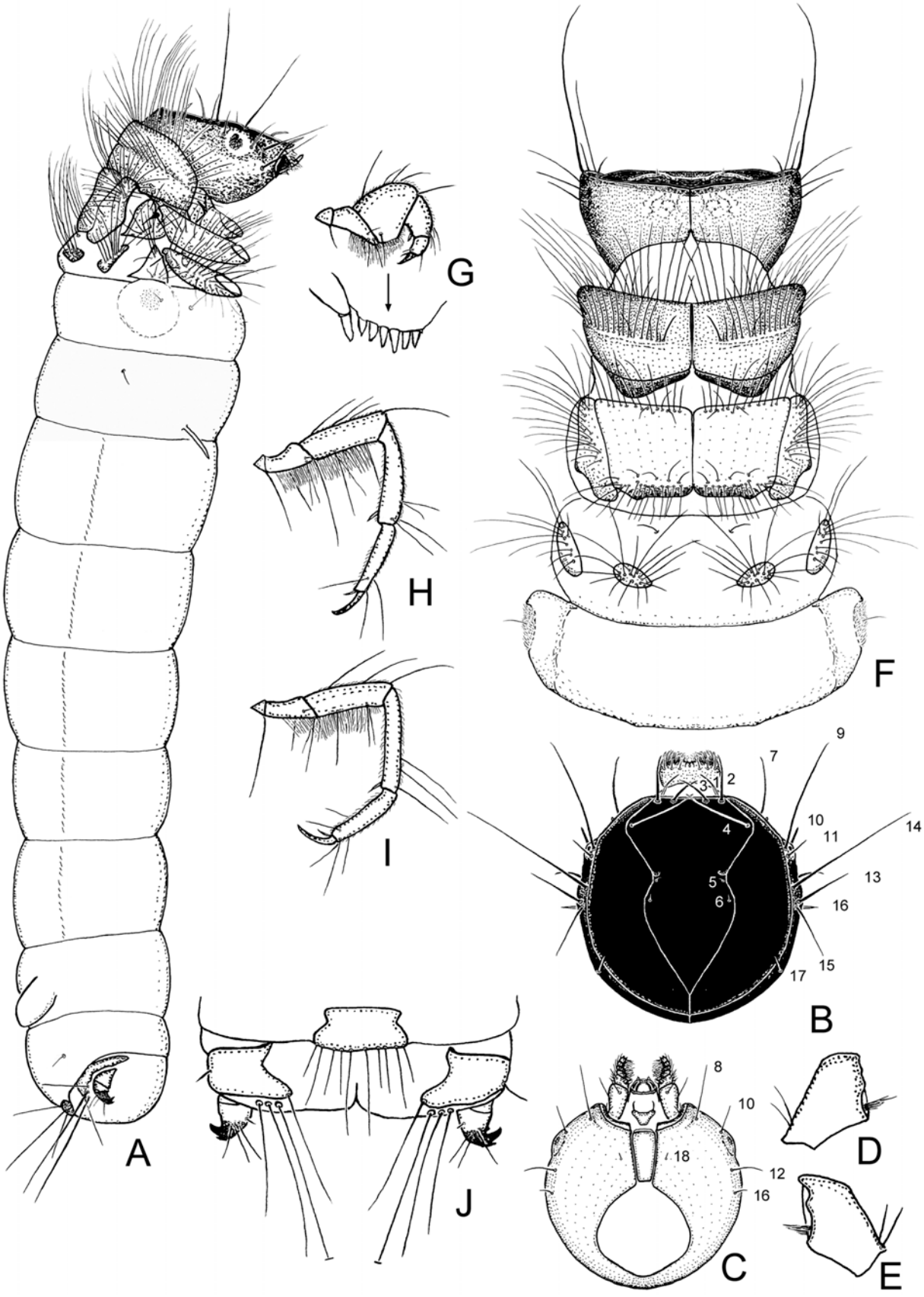

FIGURE 3. *Tsudaea kitayamana*. Larva A–J: A, lateral; B, head, dorsal, primary setae numbered; C, head, ventral, primary setae numbered; D, left mandible, dorsal; E, right mandible, dorsal; F, head, thorax and abdominal segment I, dorsal; G, foreleg, lateral, ventral margin of femur enlarged; H, midleg, lateral; I, hindleg, lateral; J, abdominal segment IX, dorsal.

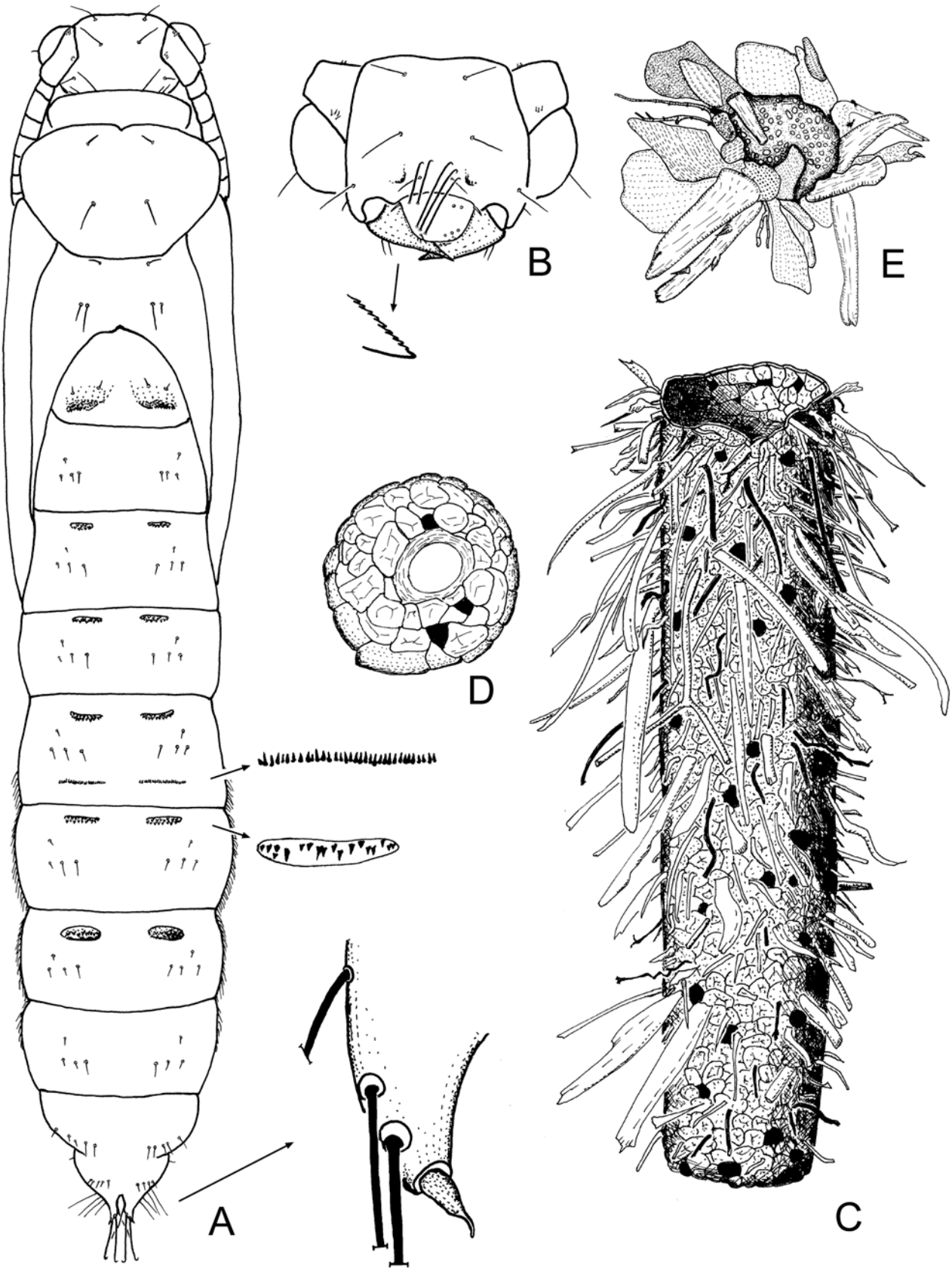

FIGURE 4. *Tsudaea kitayamana*. Pupa A–B: A, dorsal, row of spines of abdominal segment V, anterior hook plate of abdominal segment VI and right anal process enlarged; B, head, frontal, apex of right mandible enlarged. Case C–E: C, lateral; D, caudal; E, anterior closure of pupal case, frontal.

FIGURES 5–9. *Tsudaea kitayamana*. 5: Map of Honshu, showing collection sites with arrow pointing to the type locality. 6: Habitat at headwater of the Tama River, Enzan, Yamanashi. 7: Larval microhabitat, mossy boulders in marginal area. 8: Adult female, scale: 1 mm. 9: Larva, scale: 1 mm.

Female genitalia (Fig. 2G–I). Sternite VIII large, trapezoidal and as long as wide ventrally. Tergum IX short, approximately same length as segment X, with short, rounded, posteroventral process in lateral view. Segment X bilobed, each oval in dorsal view. Spermathecal sclerite simple, anterior half rectangular and slender in ventral view.

Larva (Figs. 3A–J, 9). Length up to 8 mm. Head mostly dark brown, almost black, round in dorsal view; dorsum flat, surrounded by distinct carina; antennae located approximately midway between eye and labrum; setae 1, 4, 11,16 and 17 transparent; setae 5, 6 and 18 very short, seta 14 longest. Ventral apotome rectangular, about 2 times as long as wide. Labrum hairy along its anterior margin; mandibles each with pair of long setae laterally and mesal brush of fine hairs, with two or three apical teeth (sometimes indistinct); maxillary lobe setose; submental sclerites fused into single triangular plate, bearing pair of setae anterolaterally. Prosternal horn absent. Pronotal sclerites dark brown, anterior half and posterior margin darker brown, anterior margin and transverse depression bearing many long, stout setae. Mesonotal sclerites mostly pale brown with posterior margin dark brown; each sclerite subdivided longitudinally, with anterior and posterior margins of mesal sclerite bearing long, stout setae, setae also arising from anterolateral corner to middle part of lateral sclerite. Metanotal sa1 with one short seta, *sa*2 and *sa*3 sclerites each oval with long, stout setae. Forelegs short, approximately half length as mid- and hind legs, coxae with many long setae, femora broad with six tooth-like spines ventrally. Mid- and hindlegs slender; coxae with many long setae; long setae arising on ventral and dorsal edges of trochanters, femora, tibiae and tarsi. Abdominal segment I with pair of lateral humps, humps with many tiny setae apically. Abdominal segment II with pair of single gills posteroventrally. Lateral fringes present on abdominal segment III to VII, very short, unpigmented. Forked lamellae absent. Abdominal segment VIII with pair of dorsolateral lobes. Dorsal sclerite of segment IX rectangular, concave laterally; posterior margin with ten long setae. Lateral sclerite of anal prolegs with one long seta on posteromesal corner; basal tuft with three long setae, mesal seta longest; anal claw with two dorsal accessory hooks.

Pupa (Fig. 4). Length 7–8 mm. Antennae shorter than body, scape with several short setae dorsally and ventrally. Head with three pairs of setae on vertex and frons, two pairs of setae between each eye and mandible, each eye with one seta. Labrum with five pairs of long, apically-hooked setae, one pair of short transparent, basolateral setae; and three pairs of minute apical setae. Mandibles acute with many fine teeth on mesal margin. Tarsi of midlegs with dense fringe of setae. Abdominal segment I with pair of spined ridges near posterior margin; anterior hook plates present on segments III to VII, with 7 to 16 spines, plates on III to VI slender, plates on VII long oval; segment V with two rows of spines posteriorly. Abdominal gills absent. Lateral fringe present from posterior part of segment V to posteroventral part of segment VIII. Anal processes shorter than segment IX; each process with two, long, apically-hooked setae apicomesally and one short, thick, apical claw-like seta having its apex slightly curved.

Case (Figs. 4, 9). Case of final instar larva up to 8 mm long, constructed of sand grains, straight, tapered, with many loosely attached moss pieces and other plant materials; posterior end closed by silk and sand with central hole. Prior to pupation, posterior end of case is attached to moss and both anterior and posterior openings closed by silken membrane with many perforations.

Specimens examined. **Ishikawa**: 2 males (in alcohol), Shaka-rindo, Shiramine, Hakusan-shi, 26.V.2001, H. Kawase (HM). **Yamanashi**: 1 larva, Yato, 1,060 m a.s.l., Oizumi-cho, Hokuto-shi, 28.XII.1979, T. Ito (TN). 4 larvae, Sakubadaira, 1,310 m a.s.l., Ichinose, Enzan-shi, 35˚50’16”N, 138˚49’20”E, 3.IV.2004, D. Tsuruta (TN). 4 larvae, *ibid*., 21.XI.2004, D. Tsuruta (TN). 11 males, 7 females (3 males and 2 females pinned, others in alcohol), 13 pupal skins, *ibid*., larvae collected on 8.IV.2005, emerged 11–13.V.2005, T, Nozaki (2 males & 1 female (pinned): CBM, 7 males, 4 females (in alcohol): TN, 2 males, 2 females (1 male & 1 female pinned, others in alcohol): USNM). 5 larvae, *ibid*., 13.X.2005, T. Nozaki (TN). 2 pupae, *ibid*., larvae collected on 13.X.2005, fixed 18.III.2006, T. Nozaki (TN). 9 larvae, 1 prepupa, *ibid*., 16.IV.2006, T. Nozaki (3 larvae: CBM, 4 larvae, 1 prepupa: TN, 2 larvae: USNM). **Nagano**: 2 males (pinned), Piratasu-no-oka, 1,630 m a.s.l., Chino-shi, 14.VI.1992, T. Hattori (CBM). 11 males (in alcohol), Mitsumata, 1,400–1,600 m a.s.l., Karasu-gawa, Horigane, Azumino-shi, 31.V.1997, T. Hattori (TN). 1 larva, Wada-gawa, Nagawa-

machi, 5.IV.1991, H. Kato & Sugiyama (TN). **Gifu**: 2 larvae, Hodaka-no-mori, Okuhida-onsengo, Kamisaka, Takayama-shi, 31.X.2005, K. Hatano (TN). **Mie**: 1 male (in alcohol), Myojin-daira, Iitaka-cho, Matsusaka-shi, 8.V.1999, H. Morita (HM). **Hyogo**: 2 males, 1 female (in alcohol), Hachibuse-yama, 900 m a.s.l., Yabu-shi, 3.V.2005, K. Inazu (TN).

Distribution (Fig. 5). Japan (central Honshu).

Biology. Larvae of this species were found in moss in cool streams and ponds in high mountain areas. Most specimens used in this study were collected at or above 900 m in elevation. At a headwater of the Tama River, Ichinose, Enzan, Yamanashi, larvae were collected mostly from moss attached to boulders in the margins of the stream (Figs. 6–7). However, sometimes larvae of *T. kitayamana* were found on mossy boulders in rapids, where larvae of *Eobrachycentrus vernalis* (Banks 1906) were found commonly. The most abundant moss at both the margins and rapids of streams inhabited by these two species is *Rhynchostegium riparioides* (Hedw.). This suggests that current velocity, interspecific competition, or other factors may be responsible for the physical separation in their respective microhabitats. Larvae collected on 13.X.2005 and provided only Java Moss, *Taxiphyllum barbieri* (Card. and Copp.), for food in an aquarium developed to the adult stage. Larvae of this species probably feed on moss such as *R. riparioides* in mountain streams. Collections for this study suggest that *T. kitayamana* has a univoltine life cycle with a late spring flight period.

Phylogenetic Considerations

Larvae of Brachycentridae previously have been characterized as having no dorsal or lateral humps on the first abdominal segment. Füller *et al*. (1991) considered that the lack of humps is a primitive feature, and Brachycentridae therefore cannot belong to the superfamily Limnephiloidea and infraorder Plenitentoria. On the other hand, Gall (1994) interpreted that the Brachycentridae are members of the plenitentorian lineage of the Limnephiloidea, and the absence of the humps represents a secondary loss. Gall (1994) also inferred that the presence of two lateral humps and one dorsal hump is plesiomorphic for the ground plan of the Brevitentoria and Plenitentoria. However, the findings herein, that the larvae of *T. kitayamana* have the first abdominal segment with lateral humps present and dorsal hump absent suggests a different phylogenetic interpretation. The larvae of Lepidostomatidae are similar to those of *T. kitayamana*, having abdominal segment I with dorsal hump absent and lateral humps present and based on this fact, I contend the loss of the dorsal hump is a synapomorphy for the families Brachycentridae and Lepidostomatidae. And furthermore I contend that the absence of lateral humps in all other brachycentrids, therefore represents a secondary loss.

Larvae of *T. kitayamana* also bear a pair of dorsolateral protuberances on the abdominal segment VIII similar to that observed for *Micrasema*. Larvae of a Japanese *Eobrachycentrus* species, *E. vernalis*, also bear similar protuberances (Nozaki unpublished), but a North American species, *E. gelidae* Wiggins 1965, does not have them (Wiggins 1965, 1996). Since lepidostomatid larvae bear similar protuberances, this character also may represent a synapomorphy for both Brachycentridae and Lepidostomatidae.

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