Taxonomic Treatments of Two Japanese Elmid Beetles, *Stenelmis vulgaris* Nomura and *Leptelmis gracilis* Sharp (Coleoptera: Elmidae), with Descriptions of Their Larvae

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Abstract Two synonymic treatments are made: *Stenelmis miyamotoi* Nomura et Nakane, 1958 is wingless form of *Stenelmis vulgaris* Nomura, 1958; *Leptelmis parallela* Nomura, 1962 is winged form of *Leptelmis gracilis* Sharp, 1888. The larvae of two species are easily distinguishable by the body shape and coloration from other Japanese elmid larvae.

Key words. egg, hind wing venation, new synonymy, riffle beetles, wing dimorphism

Introduction

The family Elmidae (elmid beetles, riffle beetles) lives in lotic environments, which is one of the most diverse group of lotic beetles in Japan. Approximately 50 species of elmid beetles, classified into 17 genera are known from Japan (Satô, 1985, 1999; Jeng & Yang, 1998; Yoshitomi & Satô, 2005; Kamite et al., 2006; Yoshitomi & Nakajima, 2007, 2012; Kamite, 2009) but the taxonomic problems exist in several species and genera. Hayashi et al. (2013) determined that the previously separated winged and wingless species, *Stenelmis vulgaris* and *S. miyamotoi*, and *Leptelmis gracilis* and *L. parallela*, are two forms of the same species by molecular phylogenetic analysis based on mitochondrial cytochrome oxidase subunit I and nuclear 28S rRNA gene sequences. In the dimorphic species, wingless forms have sloping shoulders (antero-lateral part of the elytra) due to degeneration of the hind wings, whereas winged forms have square shoulders (Hayashi et al., 2013). However, their formal synonymization of these species has not been made. In this paper, we treated two pare of synonymy, described their larvae, and discussed their ecology.

Materials and methods

Field collecting

From June to August of 2006 and 2014, the first author investigated Elmidae in Hii-kawa Riv., Izumo, Shimane Prefecture, Japan. All adults found in one hour during the day were collected from riparian roots and decaying woods under the running water.

Specimens

All the specimens observed in this paper are collected from Japan: almost adult specimens are dry condition with pinned label; larval specimens are also dry in part, other specimens fixed 70% or 99% ethyl alcohol. Abbreviation of depositaries are as follows:

EUMJ: Ehime University Museum, Matsuyama (H. Yoshitomi)
HOWP: Hoshizaki Institute for Wildlife Protection, Izumo (M. Hayashi)
NSMT: National Science Museum, Tsukuba (S. Nomura)

Morphological observation

Living adults and larvae on small water tank were photographed by Canon digital camera, EOS 70D attached macro photo lens MP-E 65 mm and macro twin light MT-24EX in the laboratory.

The external morphology of adults and larvae were examined under a stereoscopic microscope (Nikon SMZ) and photographed for the external structure under a zoom microscope, Nikon AZ-100 with a CCD camera, Nikon Digital Sight (DS-L2). Egg is photographed under a light microscope, Nikon Eclipse E600 attached phase contrast microscopy with a CCD camera (DS-L2). About 5 to 10 digital photographs were made by focus stacking, using a digital image processing software, Adobe Photoshop CS4 for Macintosh.

Observation and drawing method of the genitalia and hind wing venation are followed by Yoshitomi (2014).


Taxonomic treatments

*Stenelmis vulgaris* Nomura, 1958

(Figs. 1A–B, 2A–C, 3A–F, 4A–C, 5A)

*Stenelmis vulgaris* Nomura, 1958, 44

*Stenelmis vulgaris*: Nomura, 1960, 36; Satô, 1977, 2; Satô, 1985, 437.

*Stenelmis miyamotoi* Nomura et Nakane, 1958, 81

*Stenelmis miyamotoi*: Nomura, 1960, 36; Satô, 1977, 2; Satô, 1985, 437.

*Leptelmis gracilis* Sharp, 1888

(Figs. 6A–B, 7A–D, 8A–D, 9A–C, 10A–B)

*Leptelmis gracilis* Sharp, 1888, 599


*Leptelmis parallela* Nomura, 1962

*Leptelmis parallela*: Nomura, 1962, 36;


Descriptions. Body size: macropterous 2.6–3.0 mm, apterous 2.5–3.1 mm.

Male: Tergite VIII (Fig. 3A) semicircular, sparsely bearing short setae, covered with microtrichia in basal portion. Sternite VIII (Fig. 3B) transverse, bearing short setae and short spines, with rather short median strut. Sternite IX (Fig. 3C) asymmetrical, straight in caudal margin, with stout median strut. Aedeagus (Fig. 3D–F) atout, about 0.65 mm; phallobase short, about 0.6 times as long as parameres; parameres long, slightly curved interiorly in apical portion, projecting dorso-interiorly and ventro-apically in proximal 1/2 of dorsal and ventral portions respectively, sparsely punctate, sparsely bearing short setae; median lobe long, about 1.1 times as long as parameres, tapered posteriorly from base to apical 1/3, slightly expanded in apical part, sparsely punctate in ventral portion.

Female: Tergite VIII (Fig. 4A) semicircular, densely bearing short setae in caudal portion, covered with microtrichia in basal portion. Sternite VIII (Fig. 4B) projecting antero-laterally in lateral portions, bearing long/short setae, with long and slender median strut. Ovipositor (Fig. 4C) relatively short and stout; approximate ratio of stylus, distal portion of coxite, basal portion of coxite, and valvifer (n = 1) as 1.0 : 3.4 : 1.9 : 5.7.
Hind wing: The venation as shown in Fig. 5A.

Remarks. *Stenelmis miyamotoi* Nomura et Nakane is wingless form (apterous) of *Stenelmis vulgaris* Nomura (Hayashi et al., 2013).

*Leptelmis gracilis* Sharp, 1888
(Figs. 1C–D, 2D–F, 3G–L, 4D–G, 5B)

*Leptelmis gracilis* Sharp, 1888, 244.
*Leptelmis gracilis*: Satô, 1960, 43; Satô, 1977, 2; Satô, 1985, 437.


Additional specimens examined (in coll. of HOWP). 4 exs. (apterous) & 3 larvae, Ibo-gawa, Ibo, Hikawa-chô,

**Descriptions.** Body size: macropterous 2.6–2.8 mm, apterous 2.4–2.8 mm.

Male: Tergite VIII (Fig. 3G) semicircular, densely bearing short setae in caudal portion, covered with microtrichia in basal portion. Sternite VIII (Fig. 3H) transverse, bearing rather long setae and short spines, with long median strut. Sternite IX (Fig. 3I) asymmetrical, shallowly concave in caudal margin, with long and slender median strut. Aedeagus (Fig. 3J–L) long, about 0.69 mm; phallobase long, as long as parameres; parameres long, straightly projecting, sparsely punctate, bearing short setae; median lobe long, about 1.3 times as long as parameres, subparallel-sided near base to apical 1/3, slightly expanded in apical part, sparsely punctate in ventral portion.

Female: Tergite VIII (Fig. 4D) semicircular, densely bearing short setae in caudal portion, covered with microtrichia in basal portion. Sternite VIII (Fig. 4E) projecting antero-laterally, bearing long setae and minute spines, with long and stout median strut. Ovipositor (Fig. 4F) relatively long; distal portion of coxite slender; approximate ratio of stylus, distal portion of coxite, basal portion of coxite, and valvifer (n = 1) as 1.0 : 3.5 : 3.0 : 7.5; vagina with about 30 small serrae (Fig. 4G).

Hind wing: The venation as shown in Fig. 5B.

**Remarks.** *Leptelmis parallela* Nomura is winged form.
Wing dimorphism and larvae of *Stenelmis vulgaris* and *Leptelmis gracilis*

(macropterous) of *Leptelmis gracilis* Sharp (Hayashi et al., 2013).

In some elmid genera/species, bursa copulatrix of female genitalia have some large sclerites or small spines and serrae (Berthélemy, 1979), and these are vary in form within genera and species (Kodada & Jäch, 2005). In the observation of this species, we found small serrae bearing inner surface of vagina (Fig. 4G), but could not observed the other sclerotized structures in bursa and bursa copulatrix.

**Fig. 4.** Female genitalia of *Stenelmis vulgaris* (A–C) and *Leptelmis gracilis* (D–G). A, D, Tergite VIII; B, E, sternite VIII; C, F, ovipositor; G, sclerites on vagina.

**Fig. 5.** Hind wing venation of *Stenelmis vulgaris* (A) and *Leptelmis gracilis* (B).

**Description of larvae**

*Stenelmis vulgaris* Nomura (Figs. 1E, 6A–C, 7A–B)

*Description.* Body elongate, gradually narrowing middle to apex; convex dorsally and flattened ventrally; slightly prominent spiracles on mesothrax and abdominal segment I to VIII; middle suture present on thorax and abdominal segment I to VIII; body color entirely cream-colored but dark band on base and apical margin in all segments, and appendages yellowish brown. Body surface entirely smooth with long setae.

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Head visible from above, well exposed from prothorax; width as long as length; clypeus transverse, with branched setae on front; a pair of spine on both sides of clypeus; vertex with granules and spiky setae; posterior edge emarginate; epicranial stem present but short; frontoclypeal suture distinct. Antenna 3-segmented; 1st shorter than 2nd; 2nd with sensorial appendage; 3rd slender. Labrum transverse and short, with long, simple setae along frontal margin; epipharynx with dense setae. Mandible tridentate at apex, articulated pubescent process in inner margin, long, dense setae in outer margin. Maxilla and labium forming a unit (maxillolabial unit). Maxilla with 4-segmented palpus; cardo small; stipes large; galea and lacinia separate, setose apically. Labium narrow with 2segmented palpus; ligula short and transverse; mentum long; submentum short and transverse.

Thorax not serrated on lateral sides; dorsum entirely smooth with simple setae. Prothorax longer than width, 2.5 times as long as mesothorax; with 1 ventral sclerite, procoxae closed posteriorly; scale-like setae on hind margins. Meso- and metathoraces transverse; metathorax longer than mesothorax. Mesothorax with five ventral sclerites. Legs 5-segmented, short and stout; 2nd segment with robust short setae, 3rd segments with robust short setae and long setae on outer side.

Abdomen 9-segmented; segments I–VIII transverse, dorsum entirely smooth with simple setae; pleural sclerites on segments I–VII; last segment (segment IX) longer than width, gradually narrowing to apex, dorsum smooth without longitudinal ridge, apex with a pair of spines; ventral operculum, opercular claws, and anal gills present.

Body length. Mature larvae is ca. 6.0 mm in expanded specimen preserved in 70 % ethanol; ca. 5.0 mm in dry condition.

Identification of larvae. The larva is indentified by mitochondrial DNA sequences (Hayashi and Sota, 2010).

**Leptelmis gracilis** Sharp (Figs. 1F, 6D–E, 7C–D)

Description. Body elongate and flat, gradually narrowing middle to apex; slightly convex dorsally and flattened ventrally; meso- and metathorax and abdominal segment I to VIII with blade-like lateral projections on both sides; remarkably prominent spiracles on mesothorax and abdominal segment I to VIII; middle suture present on thorax and abdominal segment I to VII; body color entirely cream-colored but head and apical half of abdominal segment IX

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Figure 6. Mature larvae of *Stenelmis vulgaris* (A–C) and *Leptelmis gracilis* (D–E). A, D, Dorsal view; B, lateral view; C, E, ventral view.
dark brown. Two types of granules on body surface and large granule with a pectinate seta.

Head visible from above, well exposed from prothorax; width as long as length; clypeus transverse, with setae on front; frons and vertex with granules and setae; posterior edge emarginate; epicranial stem present but short; frontoclypeal suture distinct. Antenna 3-segmented; 1st shorter than 2nd; 2nd with sensorial appendage; 3rd slender and short. Labrum transverse and short, with setae along frontal margin; epipharynx with dense setae. Mandible tridentate at apex, articulated pubescent process in inner margin, long, dense setae in outer margin. Maxilla and labium forming a unit (maxillolabial unit). Maxilla with 4-segmented palp; cardo small; stipes large; galea and lacinia separate, setose apically. Labium narrow with 2-segmented palp; ligula short and transverse; mentum long; submentum short and transverse.

Thorax dentate on lateral sides and hind margin; dorsum on two types of granules. Prothorax longer than width, 1.9 times as long as mesothorax; with 2 ventral sclerites, procoxae closed posteriorly by a postero-medial sclerite; pectinate setae on front and hind margins. Meso- and metathoracies transverse. Mesothorax with five ventral sclerites. Legs

Fig. 7. Larvae of *Stenelmis vulgaris* (A, B) and *Leptelmis gracilis* (C, D): op, ventral operculum; ps, pleural sclerites on abdominal segment VIII; pms, postero-medial sclerite on prothorax; i to ix showing abdominal segment I to IX; arrows indicate position of spiracles. A, C, Dorsal view; B, D, ventral view. Scale bar = 1.0 mm.

Fig. 8. Egg of *Stenelmis vulgaris*. A, Egg on decaying wood; B, same egg of A (photo by phase contrast microscopy, phase condenser “Ph3”).
5-segmented, short and stout; 2nd segment with robust short setae, 3rd segments with robust short setae and long setae.

Abdomen 9-segmented. Segments I to VIII transverse, granules with branched setae on dorsum and lateral parts; pleural sclerites on segments I to VII. Last segment (segment IX) with longitudinal ridge on dorsum, longer than width, gradually narrowing to apex; apex with a pair of spines; ventral operculum, opercular claws, and anal gills present.

Body length. Mature larvae is ca. 5.0 mm in expanded specimen preserved in 70 % ethanol; ca. 4.0 mm in dry condition.

Identification of larvae. The larva is indentified by mitochondrial DNA sequences (Hayashi and Sota, 2010).

Discussion

Ecological notes

The ecological observations of *S. vulgaris* and *L. gracilis* are reported by Hayashi (2007) based on field survey in Hii-kawa River System, Shimane Prefecture, Honshu, Japan. In 2014, the first author reexamined their ecology based on field observations in Hii-kawa and the laboratory rearing. The knowledge of their ecology is noted blow.

*Stenelmis vulgaris* is common species and usually live in middle to lower stream. Adults and larvae are collected from riparian roots of reeds, willows and decaying woods (drift woods) under the running water (Hayashi, 2007). Macropterous adults attack to light at night. Adults appear every summer. The apterous adults appear mid June to October but macropterous adults appear late June or early July to October. The field observations suggest that all adults dead until late autumn and the larvae pass the winter. The total ratio of apterous appeared three months, June to August in 2006 is 33.3 % (n = 418) but that of 2014 is 11.6 % (n = 656) (Tables 1, 2). The difference of ratio between 2006 and 2014 is probably caused by precipitation and/or river flow during the late stage of mature larva. The precipitation of the three months, April to June observed by Izumo weather station is 451 mm in 2006, 237 mm in 2014, and 30 yrs mean is 448.7 mm (Table 3). Increase of precipitation in a particular period might increase the incidence of the apterous adults. In the laboratory rearing, a few scattered eggs are laid on surface of submerged wood. The eggs are nearly round, white colored, about 0.25 mm in diameter, the surface smooth, attached a short stem-like projection. In the water tank, the adults eat organic matter, probably algae on surface of decaying woods and leafs collected with the habitat.

*Leptelmis gracilis* is relatively rare species and usually live in middle to lower stream but apterous adults also live in still water (e.g. Yamaji, 2008) but its records are rare. Apterous adults appear May to October, but macropterous adults appear June to October. The apterous adults probably pass the winter because the adults collected in spring are old which body covered by mud-like matter densely.

Distribution

*Stenelmis vulgaris* (incl. *S. miyamotoi*) is distributed in Japan (Honshu, Shikoku, Kyushu) and Korea (Satô, 1985). It has not been recorded from Hokkaido, Tsushima Island, Ryukyu Islands and the other islands around the main islands (Hondo) of Japan. The northern limits are known from Iwate and Akita Prefectures, near N 40° latitude.

*Leptelmis gracilis* (incl. *L. parallela*) is distributed in...
Honshu, Shikoku and Kyushu (Satô, 1985). It has not been recorded from small islands around the Japanese main islands, Hokkaido, Tsushima Island, Ryukyu Islands and Korea. The northern limit is known from Iwate Prefecture, near N 40° latitude. Two allied species, *L. coreana* and *L. ochra* were described from Korea, the former is wingless form and the latter is winged form (Jung & Bae, 2012). The pair of Korean species is similar to the wing dimorphism of *L. gracilis*. From Taiwan, *Leptelmis formosana* was described (Nomura, 1962), and this species is also allied to *L. gracilis*.

Yoshitomi et al. (1999) reported records of *L. gracilis* from Yahagi River System, Aichi Prefecture, Honshu and figured all known localities on a map until 1999. We made a new map based on the additional records from each prefecture in Japan (Fig. 9).

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References


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