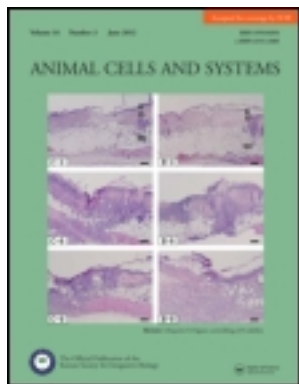


This article was downloaded by: [Korea University]

On: 27 June 2012, At: 18:05

Publisher: Taylor & Francis

Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK



Animal Cells and Systems

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/tacs20>

Riffle beetle genus *Leptelmis* (Coleoptera Elmidae) in Korea with descriptions of two new species

Sang Woo Jung^{a b} & Yeon Jae Bae^a

^a College of Life Sciences and Biotechnology, Korea University, Seoul, 136-701, Korea

^b Environmental Resources Research Department, National Institute of Environmental Research, Incheon, 404-708, Korea

Version of record first published: 09 Nov 2011

To cite this article: Sang Woo Jung & Yeon Jae Bae (2012): Riffle beetle genus *Leptelmis* (Coleoptera Elmidae) in Korea with descriptions of two new species, *Animal Cells and Systems*, 16:3, 254-259

To link to this article: <http://dx.doi.org/10.1080/19768354.2011.630410>

PLEASE SCROLL DOWN FOR ARTICLE

Full terms and conditions of use: <http://www.tandfonline.com/page/terms-and-conditions>

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to date. The accuracy of any instructions, formulae, and drug doses should be independently verified with primary sources. The publisher shall not be liable for any loss, actions, claims, proceedings, demand, or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.

Riffle beetle genus *Leptelmis* (Coleoptera Elmidae) in Korea with descriptions of two new species

Sang Woo Jung^{a,b} and Yeon Jae Bae^{a*}

^aCollege of Life Sciences and Biotechnology, Korea University, Seoul 136-701, Korea; ^bEnvironmental Resources Research Department, National Institute of Environmental Research, Incheon 404-708, Korea

(Received 19 June 2011; received in revised form 25 September 2011; accepted 4 October 2011)

The riffle beetle genus *Leptelmis* is newly recorded in the Korean fauna with descriptions of two new species, *L. coreana*, n. sp. and *L. ochra*, n. sp. Dorsal habitus and line-drawings of diagnostic characters are provided. The adults of *L. coreana* and *L. ochra* are similar to those of *L. gracilis* Sharp or *L. parallela* Nomura in general appearance, but can be distinguished by the absence of apical spurs on the middle and hind tibiae, light brown body color, smaller body size, and the shape of aedeagus apex. *Leptelmis coreana* can be distinguished from *L. ochra* by the absence of hindwings, lack of prominent humeri and wider elytra in posterior portion. Adults of both species occur in lowland streams and large rivers, but *L. ochra* were encountered relatively infrequently.

Keywords: *Leptelmis coreana*; *Leptelmis ochra*; Elmidae; Coleoptera; new species; Korea

Introduction

The genus *Leptelmis* was elected by Sharp in 1888 based on the type species *Leptelmis gracilis* Sharp collected from Japan. Brown and Thobias (1984) revised members of the genus to include 23 species known at that time throughout the world. Jäch (1984) synonymized one of the species, *Leptelmis nietneri* Champion, 1923, with *Podelmis quadriplagiata* (Motschulsky), 1859. Jeng and Yang (1993) treated *Leptelmis vietnamensis* Delève as a subspecies of *L. formosana* Nomura, *L. formosana vietnamensis* Delève. Zhang and Ding (1995), Yang and Zhang (2002), and Zhang et al. (2003) added five new *Leptelmis* species from China. Eleven *Leptelmis* species are currently recorded in the Palearctic region, and another 17 species have been recorded in the Afrotropical and Oriental regions (Brown 1981a; Kodada and Jäch 2005; Jäch et al. 2006). Like many other aquatic insect groups, *Leptelmis* occurs diversely in the eastern Palearctic and Oriental regions with a high degree of species richness in the area of southern mainland China that lies on the subtropical climatic region (Cao and Bae 2010). Hayashi and Sota (2010) associated larvae of *Leptelmis gracilis* based on mitochondrial DNA sequences and briefly described the larvae.

The habitat and biology of *Leptelmis* is not well known. Like other riffle beetle genera, *Leptelmis* adults are true aquatic beetles and are generally found in flowing streams as described in Lee and Bae (2011). Macropterous adults are caught at lights in the forest. Larvae occur in similar stream habitats as adults such as pool areas in streams and rivers with sandy substrates mixed with gravel, cobble or larger stones

and submerged tree branches. Because of their tiny body size (normally 2–3 mm in adult and larval body length), the adults and larvae are rarely collected in the field. To date, six species of elmids belonging to four genera (*Stenelmis*, *Optioservus*, *Zaitzevia*, and *Heterlimnius*) are known in Korea (Satô 1978; Yoon 1988; Lee and Lee 1992; Jung et al. 2011). In this paper, we describe two new species of Korean *Leptelmis*.

Materials and methods

Adult specimens of the Korean *Leptelmis* species were collected using hand nets and Surber samplers. The specimens were then preserved in 80% EtOH. Voucher specimens of Japanese species (*L. gracilis* and *L. parallela*) were borrowed from the Nagoya City Public Health Research Institute, Japan. Adult specimens were measured, dissected, and illustrated using a dissecting microscope with an image analyzer (Carl Zeiss Stemi 2000-C with AxioCam MRc5, Germany). Male and female genitalia were placed in 10% KOH for 2–3 days before they were examined and illustrated.

Morphological terminology follows Kodada and Jäch (2005). The types and other specimens of the two species described here are deposited in the Entomological Museum of Korea University (KU) in Seoul and the National Institute of Biological Resources (NIBR) in Incheon, Korea. The abbreviations used in this study are as follows: S, Seoul; CN, Chungcheongnam-do; JB, Jeollabuk-do; JN, Jeollanam-do; GN, Gyeongsangnam-do.

*Corresponding author. Email: yjbae@korea.ac.kr

Taxonomic accounts

Genus *Leptelmis* Sharp

(Korean name: Hok-yeo-ul-beol-re-sok)

Leptelmis Sharp, 1888: 243; Kôno, 1934: 126; Delève, 1945: 11; Satô, 1960: 43; Brown and Thobias, 1984: 28; Satô, 1985: 258; Zhang and Ding, 1995: 17; Satô and Yoshitomi, 2005: 639.

Lepthelmis Zaitzev, 1910: 21; Bollow, 1941: 84.

Type species: *Leptelmis gracilis* Sharp, 1888.

Diagnosis (modified from Brown and Thobias 1984). The adult of *Leptelmis* can be distinguished from other genera of Elmidae by the following characters: head retracted into prothorax; eyes relatively small; maxillary palpomere four slender; pronotum with broad transverse impression; legs relatively long; anterior tibiae inner surface without tomentum; tarsal claws large with basal teeth. The larva of *Leptelmis* can be distinguished by the following characters (Hayashi and Sota 2010): body entirely cream-colored, flat and broad, slightly convex dorsally, with dense granules on dorsal surface; area between procoxae posteromedially sclerotized.

Leptelmis coreana n. sp.

(Figure 1A, Figure 2A–K; Korean name: Dung-geunhok-yeo-ul-beol-re)

Material examined. Holotype: ♂, Korea, JN, Gokseong-gun, Ogok-myeon, 16.vi.2007, HG Lee and IK Shin (KU). Paratypes: 2♂, Korea, CN, Cheongyang-gun, Jangpyeong-myeon, Guryong-ri, 17.ix.1997, US Hwang, MS Kim and SJ Park (KU); 1♀, Korea, CN, Gongju-si, Okryong-dong, 15.ix.2005, DH Lee (KU); 1♀, Korea, S, Gangdong-gu, Goduk-dong, Han River, 25.vii.2006, IK Shin and SW Jung (NIBR); 1♂, Korea, JN, Gokseong-gun, Gokseong-eub, Sewolgyo (Br.), 29.vi.2007, HG Lee and IK Shin (KU); 1♀, Korea, GN, Gimhae-si, Saengrim-myeon, Anyang-ri, 11.vii.2009, SW Jung and HG Lee (KU).

Male adult (holotype). Body length 2.56 mm; width 0.93 mm. Body elongate, convex. General body color light brown; pronotum, femur, tibia, and antennomeres 8–11 reddish brown; antennae, elytra, mouthparts (except labrum), tarsi, and claws shiny brown; head darker than pronotum and ventral body surface brown.

Head retracted into prothorax, with fine granules. Frons convex; clypeus front angles round; frontoclypeal suture indistinct, slightly arcuate. Labrum dark in color, wider than long, with round frontal angles. Antennae (Figure 2A) 11-segmented; antennomeres 1 and 2 short and stout; antennomeres 3, 6, and 7 slender; antennomeres 4 and 5 slender and shorter than antennomere 3; antennomeres 8–10 gradually

increasing in length and width; antennomere 11 oval, with acute apex. Mandibles (Figure 2B) with three apical teeth; prostheca apically spinose. Maxillary palp (Figure 2C) four-segmented; palpomere 1 very short; palpomere 4 relatively long and slender; galea two-segmented. Labial palp (Figure 2D) three-segmented; palpomere 1 very short; palpomere 3 large and stout. Eyes small, oval in lateral view and convex in dorsal view.

Pronotum (Figure 2E) 0.76 mm in length, 0.66 mm in width, longer than wide, and widest at posterior 1/3 part; anterior margin broadly round, sparsely pubescent anteromedially, without punctures; anterior angles round and more or less protrude; posterior angles subacute; transverse impression at anterior 2/5 part, with deep and large punctures and distinct longitudinal impression at middle part; subtriangular elevation located behind transverse impression, densely pubescent; two anterior elevations very prominent, with somewhat smaller elevation posteriorly; two conspicuous deep impressions in front of scutellum. Prosteronum (Figure 2G) coarsely punctured posteriorly; prosternal process subparallel or slightly oblique laterally. Mesoventrite with large and deep punctures, 0.15 mm in length, 0.35 mm in width; longitudinal sulcus located at middle part. Metaventrite with large punctures, longitudinal sulcus 0.42 mm in length, with transverse suture posteriorly. Legs relatively long and slender, pubescent; femurs and tibiae coriaceous red in color; tarsi five-segmented; tarsomeres 1 and 2 short, shiny brown; tarsomeres 3, 4, and 5 gradually increasing in length; tarsomere 5 as long as tarsomeres 1–4 combined; two claws shiny and strong, with one tooth basally.

Elytra (Figure 2F) oval, posteriorly convex, 1.76 mm in length, 0.93 mm in width, 2.3 times as long as pronotum, and widest at posterior 2/3 part, with densely pubescent posteriorly; humeri not prominent, without hindwings; each elytron with eight punctate striae, punctate striae moderately large and deep anteriorly, becoming gradually smaller and obsolete toward apex; 1st/2nd and 3rd/4th punctate striae starting from same puncture near base; 3rd and 4th striae merging at anterior 2/3 part and merging again with 2nd stria at posterior 1/5 part; accessory stria (11 punctures) from anterior 1/3 to posterior 1/3 part between 5th and 6th striae; strial intervals 3 and 7 convex, paler near base; intervals 3 and 4 paler at posterior 1/3 part; lateral margins finely serrate; epipleura narrowed gradually toward apex. Scutellum flat and small, as long as wide, and laterally round.

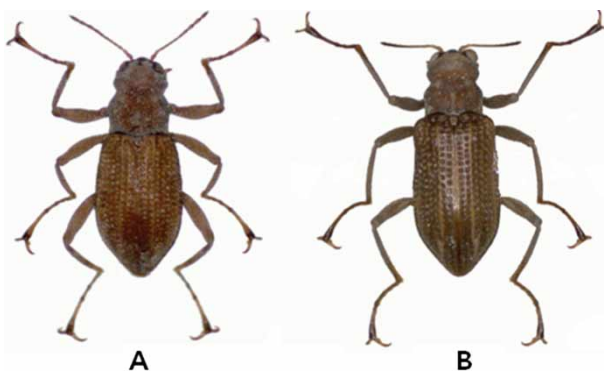


Figure 1. A, *Leptelmis coreana*, n. sp., body length 2.5 mm; B, *L. ochra*, n. sp., body length 2.6 mm.

Abdomen with five ventrites, 1.16 mm in length, 0.9 mm in width, slightly longer than wide, sparsely pubescent; ventrite 1 with large punctures; posterior margin of ventrite 5 truncate, with tufts of hairs. Aedeagus as in Figure 2H,I; penis elongate, slightly convex apically, slightly curved from lateral view; parameres parallel-innersided; phallobase shorter than penis; speculum gastrale as in Figure 2J.

Female adult. External morphology similar to male; ovipositor long and slender as in Figure 2K.

Distribution. Korea.

Etymology. The specific epithet, *coreana*, refers to Korea, the distributed region of this species.

Remarks. Adults of *Leptelmis coreana* were collected from stones covered with algae or submersed branches in lowland streams and large rivers. The adult of this species is similar to that of *Leptelmis gracilis* Sharp or *Leptelmis gracilis impubis* Zhang and Ding, but can be distinguished by the combination of the following characters: light brown body color, small body size (2.50–2.56 mm in body length), pronotum that is widest at posterior 1/3 part, posteriorly expanded elytra, absence of hind wings, presence of eight punctate striae and an accessory stria between 5th and 6th striae, absence of prominent apical spurs at middle and hind tibiae, and apically not expanded aedeagus. In this study, we provide additional illustrations of the aedeagus of *L. gracilis* (Figure 3A,B) using Japanese fresh material because the original description of *L. gracilis* does not contain such clear illustrations. We cannot observe any differences in aedeagus between *L. gracilis* and *L. gracilis impubis* (see Figure 3 in Zhang and Ding 1995) although we were unable to examine the material of *L. gracilis impubis*.

***Leptelmis ochra*, n. sp.**

(Figure 1B, Figure 4A–D; Korean name: Hwangto-hok-yeo-ul-beol-re)

Material examined. Holotype: ♂, Korea, CN, Buyeogun, Gyuam-myeon, Gyuam-ri, 12.viii.2005, DH Lee (KU). Paratypes: 1♀, same locality and data as holotype (NIBR); 1♀, Korea, S, Goduk-dong, Han River, 25.vii.2006, IK Shin and SW Jung (KU); 1♀, Korea, JB, Namwon-si, Songdong-myeon, 15.vi.2007, SW Jung (KU).

Male adult (holotype). Body length 2.60 mm; width 0.93 mm. Body elongate, convex. General body color brown; pronotum reddish brown; humeri and strial interval 3 paler; femur, tibia, and antennomeres 8–11 reddish brown; antennae, elytra, mouthparts (except labrum), tarsi, and claw shiny brown; head darker than pronotum and ventral body surface brown.

Head retracted into prothorax, with fine granules. Frons convex; clypeus front angles round; fronto-clypeal suture indistinct, slightly arcuate. Labrum dark in color, wider than long, with round frontal angles. Antennae 11-segmented; antennomeres 1 and 2 short and stout; antennomeres 3, 6, and 7 slender; antennomeres 4 and 5 slender and shorter than antennomere 3; antennomeres 8–10 gradually increasing in length and width; antennomere 11 oval, with acute apex. Eyes moderately large, round in lateral view and distinctly convex in dorsal view.

Thorax. Pronotum (Figure 4C) 0.72 mm in length, 0.65 mm in width, longer than wide, and widest at posterolateral corners; subparallel posteriorly from posterior 2/5 part to base; anterior margin broadly round; somewhat fine pubescent anteriorly, without punctures; anterior angles round and more or less protrude; posterior angles subacute; transverse impression at anterior 2/5 part, with deep and large punctures and distinct longitudinal impression at middle part; subtriangular elevation located behind transverse impression; two anterior elevations very prominent, densely pubescent; somewhat smaller elevation posteriorly; two conspicuous deep impressions in front of scutellum. Prosternum coarsely

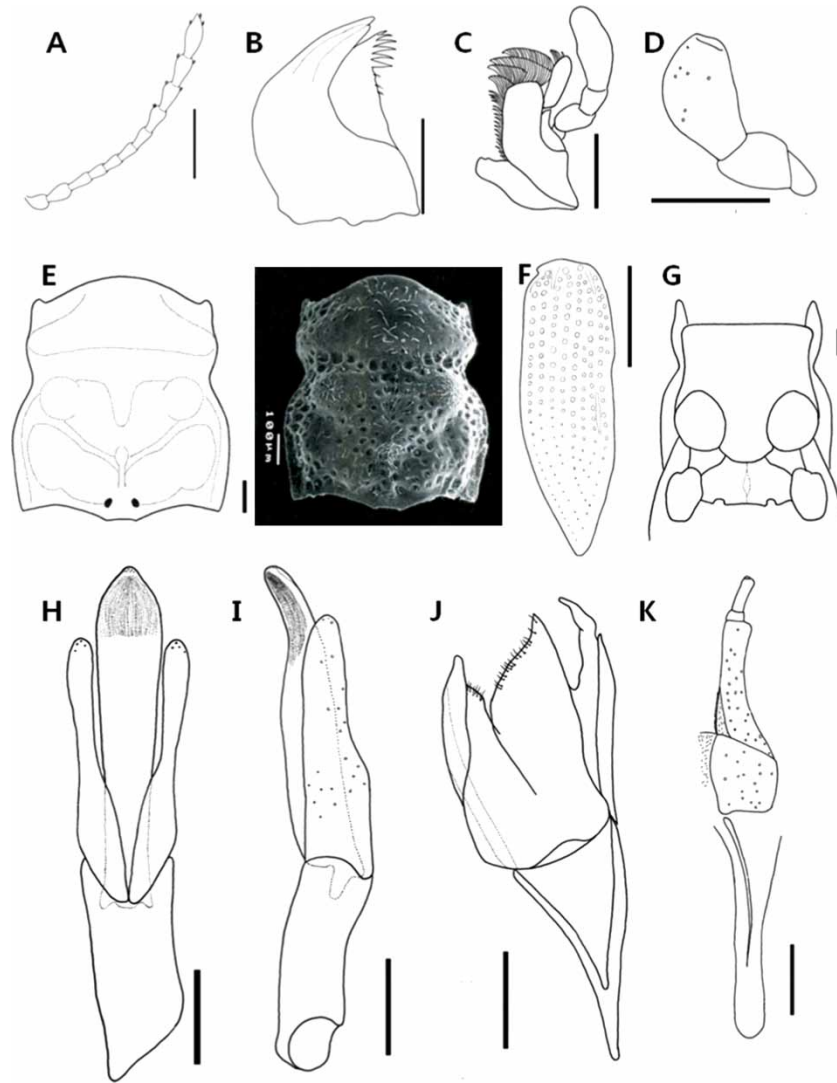


Figure 2. *Leptelmis coreana*, n. sp.: A, left antennae; B, right mandible, ventral; C, right maxillary, ventral; D, right labial palpus, ventral; E, line-drawing (left) and SEM (right) of dorsal pronotum; F, right elytron, dorsal; G, ventral prosternum; H, aedeagus, dorsal view; I, aedeagus, lateral view; J, speculum gastrale; K, ventral ovipositor. Scale bars = 0.1 mm (A–E, G–K), 0.5 mm (F).

punctured posteriorly; prosternal process with sides subparallel or slightly oblique. Mesoventrite with large deep punctures, 0.23 mm in length, 0.35 mm in width; longitudinal sulcus at middle part. Metaventricle with large punctures; longitudinal sulcus 0.44 mm in length, with transverse suture posteriorly. Legs relatively long and slender, fine pubescent and granules; femurs and tibiae coriaceous red in color; tarsi five-segmented, shiny and brown in color; tarsomeres 1 and 2 short; tarsomeres 3 and 4 longer than tarsomere 2; tarsomere 5 as long as tarsomeres 1–4 combined; claws shiny and strong, with one tooth basally.

Elytra (Figure 4D) 1.74 mm in length, 0.92 mm in width, 2.41 times as long as pronotum; wider than

pronotum; subparallel-sided, and widest anteriorly, densely pubescent posteriorly; humeri prominent and paler; each elytron with nine punctate striae; 1st/2nd and 3rd/4th starting from same punctures near base; 2nd stria vanish at posterior 1/5 part; 3rd stria line merging with 4th at anterior 2/3 part; accessory stria (four punctures) between 5th and 6th striae near base; seven stria intervals; intervals 3 and 7 convex and paler near base; lateral margins finely serrate; hind wings present. Scutellum flat and small, about as long as wide and lateral margin round.

Abdomen with five ventrites, 1.12 mm in length, 0.92 mm in width; slightly longer than width, sparsely pubescent; ventrite 1 with large punctures; posterior margin of ventrite 5 truncate.

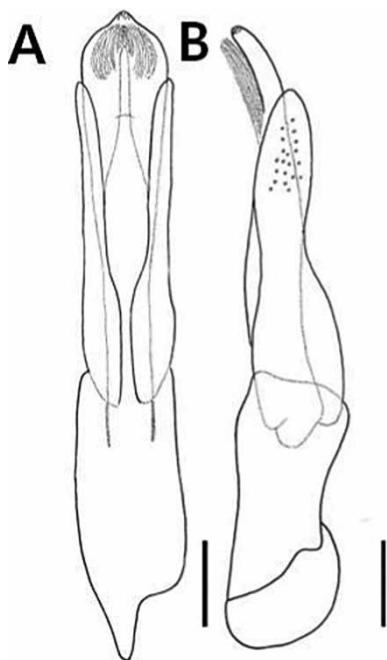


Figure 3. *Leptelmis gracilis*: A, aedeagus, dorsal view; B, aedeagus, lateral view. Scale bars = 0.1 mm (A, B).

Aedeagus as in Figure 4A,B; penis elongate and slightly convex apically; parameres shorter than penis, parallel-innersided; phallobase shorter than penis.

Female adult. External morphology similar to male. Body slightly larger than male.

Distribution. Korea.

Etymology. The species epithet, *ochra*, refers to the general body color (brown) of this species.

Remarks. Adults of *L. ochra* occur in pool areas of lowland streams and rivers together with *L. coreana*, but are collected less frequently than *L. coreana* probably because their hindwings (macropterous) enable dispersal after emergence. *L. ochra* can be distinguished from other species of *Leptelmis* by the combination of the following characters: brown body color and relatively small body size (2.58–2.62 mm in body length), pronotum that is widest at posterolateral corners, subparallel-sided elytra, presence of nine punctate striae and an accessory stria (with four punctures) between 5th and 6th striae, prominent humeri, presence of hindwings, intervals 3 and 7 that are convex and paler at base, and absence of prominent apical spurs at middle and hind tibiae.

Based on an analysis of mitochondrial DNA sequences, Hayashi and Sota (2010) documented that polymorphism is observed in hindwings in some species of Elmidae (e.g. *Stenelmis vulgaris* and *S. miyamotoi*), and presumed that this is a result of hybridization. M.A. Jäch (personal communication) reported the possibility of such a polymorphic condition in the wingless (*L. coreana*, n. sp.) and winged (*L. ochra*, n. sp.) specimens in this study. In most other cases, however, winged and wingless conditions or wing venations are used as good morphological characters in elmid beetles (Brown 1970, 1981b; Manzo 2005). We separated the above two new species based on distinct external morphology such as pronotum and elytra shape, eye size and shape, and conditions of striae, as well as hindwing characters. Additional ultrastructure and molecular studies are useful to additionally verify these two species.

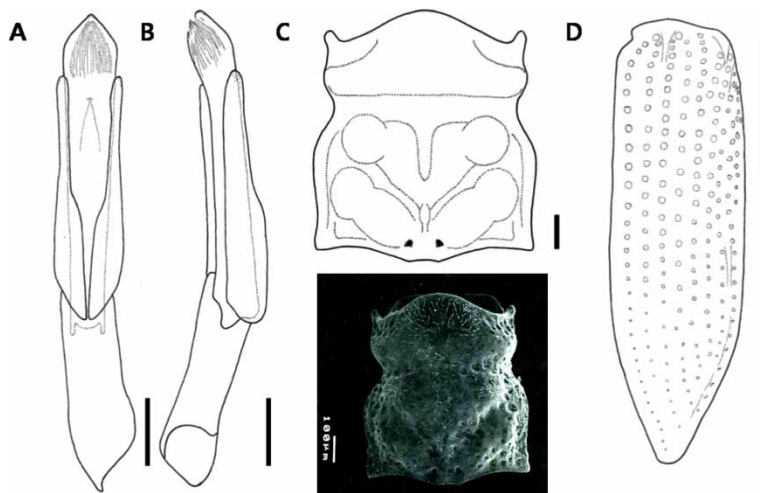


Figure 4. *Leptelmis ochra*, n. sp.: A, aedeagus, dorsal view; B, aedeagus, lateral view; C, line-drawing (above) and SEM (below) of dorsal pronotum; D, right elytron, dorsal. Scale bars = 0.1 mm (A–C), 0.5 mm (D).

Key to the species of Korean *Leptelmis* adults

1. Eyes small (Figure 1A); pronotum widest at posterior 1/3 part (Figure 2E); elytra expanded posteriorly, without hind wings and prominent humeri; accessory stria (11 punctures) present between 5th and 6th striae (Figure 2F)
Leptelmis coreana
 - Eyes large (Figure 1B); pronotum widest at posterolateral corners (Figure 4C); elytra not expanded posteriorly, with hind wings and prominent humeri; accessory stria (four punctures) between 5th and 6th striae (Figure 4D)
Leptelmis ochra

Acknowledgements

We thank Mr. Yuuki Kamite (Nagoya City Public Health Research Institute, Japan) for providing Japanese specimens, Mr. D. H. Lee (National Institute of Environmental Research, Incheon) for providing references and specimens, and Dr. Manfred A. Jäch (Naturhistorisches Museum Wien, Austria) for useful comments. This research was supported by the project on the survey and excavation of Korean indigenous species of the National Institute of Biological Resources (NIBR) under the Ministry of Environment, Korea.

References

- Bollow H. 1941. Monographie der palaearktischen Dryopidae, mit Berücksichtigung der eventuell transgredierenden Arten. (Coleoptera). Mitt Münchner Entomol G. 31(1):1–88.
- Brown HP. 1970. Neotropical dryopids I. *Xenelmis laura*, a new species from Brazil (Coleoptera, Elmidae). Coleopt Bull. 24(3):61–65.
- Brown HP (1981a). A distributional survey of the world genera of aquatic dryopoid beetles (Coleoptera: Dryopidae, Elmidae, and Psephenidae Sens. Lat.). Pan-Pac Entomol. 57(1):133–148.
- Brown HP (1981b). Key to the world genera of Larinae (Coleoptera, Dryopoidea, Elmidae), with descriptions of new genera from Hispaniola, Colombia, Australia, and New Guinea. Pan-Pac Entomol. 57(1):76–104.
- Brown HP, Thobias MP. 1984. World synopsis of the riffle beetle genus *Leptelmis* Sharp, 1888, with a key to Asian species and description of a new species from India (Coleoptera, Dryopoidea, Elmidae). Pan-Pac Entomol. 60(1):23–29.
- Cao TKT, Bae YJ. 2010. *Togoperla thinhi*, a new stonefly from central Vietnam (Plecoptera: Perlidae). Anim Cells Syst. 14(3):221–224.
- Delève J. 1945. Contribution à l'étude des Dryopidae. III. Le genre *Pseudomacronychus* Grouvelle et le dimorphisme alaire de ses espèces. Bull Mus Roy Hist nat Belg. 21(9):1–12.
- Hayashi M, Sota T. 2010. Identification of elmidae larvae (Coleoptera: Elmidae) from Sanin District of Honshu, Japan, based on mitochondrial DNA sequences. Entomol Sci. 13:417–424.
- Jäch MA. 1984. Die Koleopterenfauna der Bergbäche von Südwest-Ceylon (Col.). Arch Hydrobiol Suppl. 69(2):228–332.
- Jäch MA, Kodada J, Ciampor F. 2006. Family Elmidae. In: Löbl I, Smetana A, editors, Catalogue of Palaearctic Coleoptera. Vol. 3. *Scarabaeoidea, Scirtoidea, Dascilloidea, Buprestoidea, Byrrhoidea*. Stenstrup (Denmark): Apollo Books. p. 432–440.
- Jeng ML, Yang PS. 1993. Elmidae of Taiwan Part II: Redescription of *Leptelmis formosna* (Coleoptera: Dryopoidea). Entomol News. 104(1):53–59.
- Jung SW, Kamite Y, Bae YJ. 2011. Description of *Optioservus gapyeongensis* new species and *Heterlimnius hasegawai* (Nomura) (Coleoptera: Elmidae) new to Korea. Entomol Res. 41(5):178–184.
- Kodada J, Jäch A. 2005. Chapter 18.2. Elmidae Curtis, 1830. In: Beutel RG, Leschen RAB, editors, Handbook of Zoology, Volume IV, Arthropoda: Insecta, Part 38, Coleoptera, Beetles, Volume 1: Morphology and Systematics (Achostemata, Adephaga, Myxophaga, Polyphaga partim). Berlin: Walter de Gruyter. p. 471–492.
- Kôno H. 1934. Die Dryopiden aus Japan. Insecta Matsu-murana. 8:124–128.
- Lee HG, Bae YJ. 2011. Recovery of aquatic insect communities after a catastrophic flood in a Korean stream. Anim Cells Syst. 15(2):169–177.
- Lee SH, Lee CE. 1992. Notes on *Optioservus kubotai* Nomura from Korea (Coleoptera, Elmidae). Nat Life. 22(2):63–64.
- Manzo V. 2005. Key to the South America genera of Elmidae (Insecta: Coleoptera) with distributional data. Stud Neotrop Fauna E. 40(3):201–208.
- Satô M. 1960. On the genus *Leptelmis* Sharp from Japan with checklist of the world (Coleoptera: Elmidae). Akitu. 9:43–46.
- Satô M. 1978. *Stenelmis* Dufour species of Korea (Coleoptera, Elminthidae). Ann Hist-Nat Mus Nat Hung. 70:147–149.
- Satô M. 1985. Chapter 9 Coleoptera. Elmidae. In: Kawai T, editor. An illustrated book of aquatic insects of Japan. Tokai: Tokai University Press. p. 255–259.
- Satô M, Yoshitomi H. 2005. Chapter Coleoptera. Elmidae. In: Kawai T, Tanida K, editors. Aquatic insects of Japan: manual with keys and illustrations. Tokai: Tokai University Press. p. 636–641.
- Sharp D. 1888. XXXI. Description of some new Coleoptera from Japan. Ann Mag Nat Hist. 6(2):242–245.
- Yang C, Zhang Z. 2002. Chapter 66. Elmidae. In: Huang P, editor. Fauna of insects in Fujian Province of China. Fujian Science and Technology press. 6:811–824.
- Yoon IB. 1988. Illustrated encyclopedia of fauna and flora of Korea. Vol. 30. Aquatic Insects. Ministry of Education of Korea. p. 646–669.
- Zaitzev P. 1910. Dryopidae, Cyathoceridae, Georyssidae, Heteroceridae. *Coleopterorum Catalogus*, pars 17. 14: 1–68.
- Zhang Z, Ding W. 1995. Two new species and a new subspecies of Elmidae (Coleoptera: Dryopoidea) from China. Entomotaxonomia. 17:15–19.
- Zhang ZH, Su HT, Yang CK. 2003. Three new species and one new record of *Leptelmis* (Coleoptera: Dryopoidea: Elmidae). Entomotaxonomia. 25:189–194.