

First Record of *Teloganopsis chinoi* (Ephemeroptera: Ephemerellidae) Based on Larval Morphology and mtDNA in Korean Peninsula, with a Checklist of Korean Ephemerellidae

Sang Woo Jung¹, Jaeick Jo², Jeong Mi Hwang^{3,*}

¹DASARI Research Institute of BioResources, Daejeon 35203, Korea

²Fukushima Regional Collaborative Research Center, National Institute for Environmental Studies,
Fukushima 963-7700, Japan

³Korean Entomological Institute, Korea University, Seoul 02841, Korea

ABSTRACT

The genus *Teloganopsis* Ulmer belonging to the family Ephemerellidae is only known from the species of *T. punctisetae* (Matsumura, 1931) in the Korean Peninsula. The members of the genus *Teloganopsis* are characterized by the following characteristics: head and abdominal tergites without any tubercles and complex setae; forefemur with a row of long and stout setae perpendicularly; maxilla covered with dense setae. A total of 17 species had been previously recorded in this family. Here, *Teloganopsis chinoi* (Gose, 1980), is newly recorded in Korea which was found under a large stone in Kyeongho river. Larval habitus, habitat, line-drawings of key characters of the species, a checklist with habitus photos of Korean Ephemerellidae, and a key to the larvae of Korean *Teloganopsis* are provided.

Keywords: mayfly, new record, taxonomy, checklist, Korea

INTRODUCTION

The genus *Teloganopsis* was elected by Ulmer in 1939 based on the type species *Teloganopsis media* Ulmer collected from Java and Sumatra (Ulmer, 1939). Members of this genus have been known 17 species worldwide and distributed from the Holarctic to the Oriental regions (Jacobus and McCafferty, 2008; Ubero-Pascal and Sartori, 2009; Gorovaya, 2019). In recent Korean checklist of mayflies (Bae, 2010, 2021), 17 species of Ephemerellidae were recorded and only one species (*T. punctisetae* (Matsumura)) of *Teloganopsis* group was distributed on the Korean Peninsula. They are usually found in riffle areas of wide streams and can be used for the biological monitoring of freshwater ecosystems because of environmental sensitivity related to water pollution and disturbances (Kong et al., 2018).

The larvae of genus *Teloganopsis* is characterized by combination of the following characters: head and abdominal tergites without tubercles and complex setae; forefemur with

a row of long and stout setae perpendicularly; maxilla covered with densely setae (crown-like), truncated apically, canine poorly developed or vestigial (Ubero-Pascal and Sartori, 2009).

Here, we first report the species of *Teloganopsis chinoi* (Gose, 1980) to the mayfly fauna in Korean Peninsula. Larval morphological characters of the species including the line drawing, mtDNA information, checklist of Korean Ephemerellidae with some living photos, and key to the Korean *Teloganopsis* are provided.

MATERIALS AND METHODS

The larvae were collected using a featherweight forceps or hand net (mesh size 1.0 mm) under a large stone in Kyeongho river (Fig. 1) which is located on south part of Korean Peninsula. The whole materials are kept in 80% ethanol for preservation. Two individuals were dissected under the ste-

© This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/3.0/>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

***To whom correspondence should be addressed**

Tel: 82-2-3290-4260, Fax: 82-2-3290-3623
E-mail: msmay74@korea.ac.kr



Fig. 1. Habitat of *Teloganopsis chinoi* in Kyeongho River. The point of red circle is observed the species.

reomicroscope and were mounted on slide in glycerol solution for detailed examination and illustration. Photograph of habitus was taken using Cannon digital camera (EOS 5Ds) with 65 mm Macro Lens (Canon, Inc., Tokyo, Japan). Most of materials are deposited in the aquatic insects collection of DASARI Research Institute of BioResources (DRIBR). The one larval specimen is deposited in the National Institute of Biological Resources, Incheon, Korea (NIBR).

Total genomic DNA was extracted from one larva, using the thorax part. The primer pair LCO1490-F (5'-GGTCAA-CAAATCATAAAGATATTGG-3') and COIA-R (5'-CCCG-GTAAAATTTAAATATAAACTTC-3') was used to amplify a 676 base pairs (bp) of the cytochrome c oxidase subunit I (COI) gene (Folmer et al., 1994; Simon et al., 1994). The obtained sequence was deposited in GenBank.

SYSTEMATIC ACCOUNTS

Order Ephemeroptera
Family Ephemerellidae Klapálek, 1909

Genus *Teloganopsis* Ulmer, 1939: 513
Type species: *Teloganopsis media* Ulmer, 1939

***Teloganopsis chinoi* (Gose, 1980) (Figs. 2, 3, 5G)**

(Korean name: JJalb-eun-kko-ri-ha-ru-sa-ri)

Ephemerella (*Serratella*) *chinoi* Gose, 1980: 366; 1985: 28.
Serratella chinoi (Gose): Ishiwata, 1987: 32; Takemon, 1990:



Fig. 2. Larval habitus of *Teloganopsis chinoi*. Scale bar=2 mm.

53.

Uracanthella chinoi (Gose): Ishiwata, 2001: 63.

Teloganopsis chinoi (Gose): Nakamura, 2017: 8; Ishiwata, Takemon, and Fujitani, 2018: 88.

Material examined. Korea: 4L, Gyeongsangnam-do: Sancheong-gun, Sancheong-eup, Chatan-ri (35°26'09.7"N, 127°51'41.4"E), 14 May 2019, leg. S.W. Jung (DRIBR); 1L, ditto but deposited in NIBR (VOZYIN0000007966).

Diagnosis. Size: Mature larva (Fig. 2). Body length 6.2–6.5 mm, caudal filaments length 1.9–2.1 mm.

Color: Body brown to light brown. Head, labrum, and thorax brown. Head sutures and antennae whitish. Legs light brown with dark brown marks in tibia and tarsi; Abdomen and caudal filaments light brown.

Morphology: Head without tubercles or projection. Antennae relatively short, as long as head width. Compound eyes black. Labrum (Fig. 3A) widest at middle part, about two times wider than long, with wide distomedial notch; distal margin covered with long setae. Hypopharynx (Fig. 3B) relatively long, with densely long setae along anterior and inner margins on superlinguae. Mandibles slightly slender, incisors elongated; left mandible (Fig. 3C) with three outer incisors and two inner incisors; right mandible (Fig. 3D) with four outer incisors and one inner incisor; dense feathered setae present on prosthema. Maxillae rectangular (Fig. 3E), without palp, truncated with dense long setae on apex. Labium (Fig. 3F) with submentum, wide and rounded, with dense hair-like setae; glossae wider

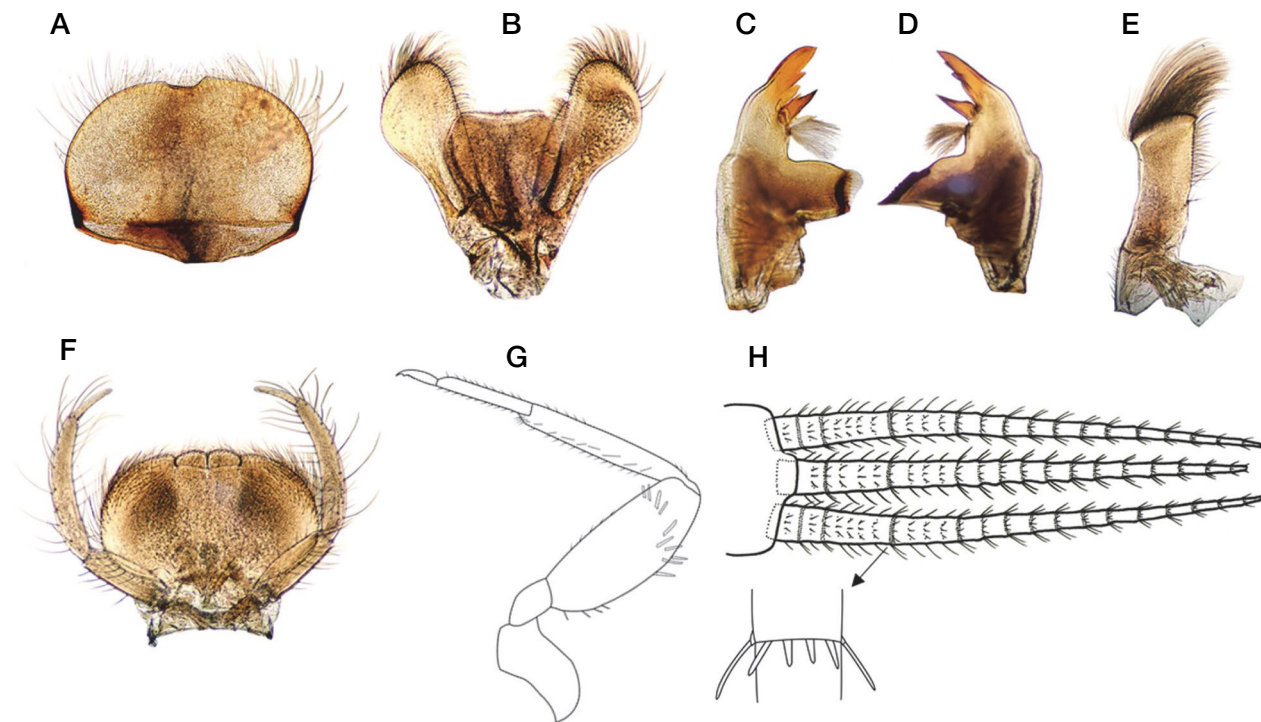


Fig. 3. Larva of *Teloganopsis chinoi*: A, Labrum, dorsal view; B, Hypopharynx, ventral view; C, Left mandible, dorsal view; D, Right mandible, dorsal view; E, Left maxilla, dorsal view; F, Labium, ventral view; G, Right foreleg, dorsal view; H, Caudal filaments, dorsal view.

than long; paraglossae enlarged; labial palp elongated with three segments; first segment more or less stout with long setae; second segment longest with long setae; third segment long and slender without setae.

Pronotum rectangular, antero-lateral angles slightly expanded, without tubercles or protuberances. All legs similar in shape; femora more or less stout with several long and strong setae perpendicularly (Fig. 3G); dorsal surface of forefemora with a transverse row of 4–5 strong and long setae; middle- and hindfemora with strong and long setae on outer femoral margin. Claws with seven denticles from middle to apex, apical one stout, slightly truncated in apical part, and larger than others.

Abdomen without any protuberances and spines; tergites with very fine rounded setae in middle and lateral parts; posterior margin of abdominal segments with row of fine rounded setae. Gills on segments III–VII, with ventral lamella bifurcated, gills III–VI similar in structure and plate-like on dorsal parts; gill VII smaller than others. Caudal filaments shorter than abdomen, with dark brown annuluses at base of each filament; distinct spines at each segment (Fig. 3H).

Distribution. Korea (South), Japan (Honshu).

Remarks. The river where the species of *T. chinoi* were collected is about 30–35 m in width and about 10–20 cm in

depth, with boulders (20%), cobbles (30%), pebbles (40%), and gravel (10%). Larvae of this species usually occur together with *T. punctisetae*, but are observed less frequently than *T. punctisetae*. The species of *Uracanthella punctisetae*, previously known in Korea, was synonymized under genus *Teloganopsis* by Jacobus and McCafferty (2008).

COI sequence of *Teloganopsis chinoi*. Total 676 bp (accession number OQ649799) COI showing 98.33% similarity to the reference sequence of the *Uracanthella chinoi* (accession number KP970705.1) from Japan. Mitochondrial DNA sequences are shown below: AACACTATATT TATTTTTGGAGCATGATCTGGGATAGTAGGTACCTC CCTAAGACTTTTGATTTCGTGCTGA ACTAGGA CAACCTGGGTCTTTGATTGGGGATGACCAAATC TATAACGTAATTGTTACTGCTCATGCTTTTATTATA ATTTTCTTCATGGTTATGCCTATTATAATTGGGGG GTTTGGTAATTGACTTGTACCACTCATATTAGGG GCTCCAGATATGGCATTCCCACGAATAAATAATATA AGTTTTTGGTTACTTCCTCCTGCTTTAACCTGT TACTAGCTAGAAGAATGGTAGAAAGCGGGGCCGG GACAGGGTGAACGGTTTATCCTCCTCTTGCCTCT GGTATAGCCCATGCTGGGGCTTCTGTGGATCTCGC TATTTTTCTTTACACTTAGCGGGTGTATCCTCAAT TCTAGGGGCGGTTAACTTTATCACTACTACTATTA

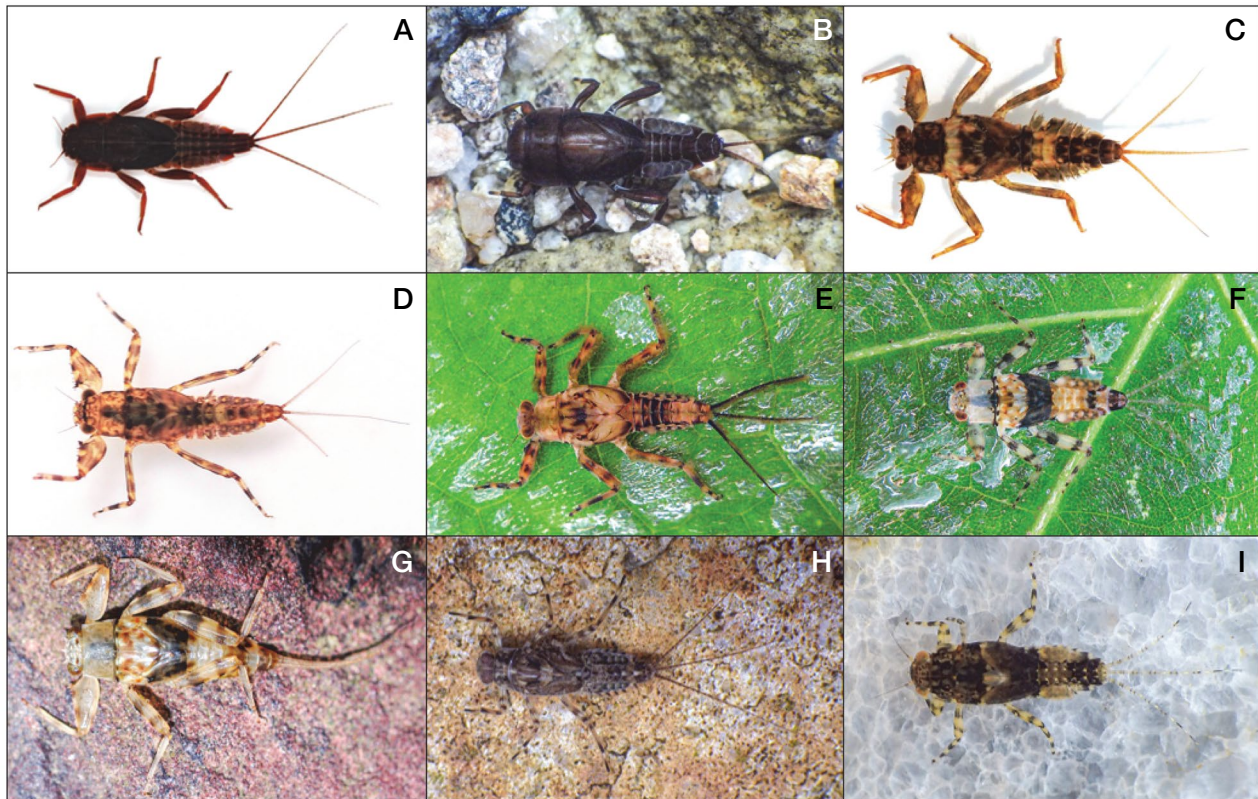


Fig. 4. Habitus photos of Korean Ephemerellidae (Part I): A, *Cincticostella levanidovae*; B, *C. orientalis*; C, *Drunella aculea*; D, *D. ishiyamana*; E, *D. lepnevae*; F, *D. solida*; G, *D. triacantha*; H, *Ephacrerella longicaudata*; I, *Ephemerella atagosana*.

ATATACGGACTAGAGGCATAACTATAGACCGAATC
 CCCCTATTTGTTTTGGTCTGTACTTATTACAGC
 TATCCTTCTGTTACTTTCTTYACCAGTTTTAGCCGGG
 GCTATTACGATGCTTTTAAACAGATCGGAATTTAAATA
 CATCATTCTTTGACCCAGCTGGTGGGGGAGATC
 CCATTCTTTACCAACATCTTTTTTGATTTTTTGGG
 CACCCT

Checklist of the species of Korean Ephemerellidae

1. *Cincticostella levanidovae* Tshernova, 1952 (Korea, Japan, Northeast China, Russian Far East) (Fig. 4A)
2. *Cincticostella orientalis* (Tshernova, 1952) (Korea, Japan, Northeast China, Russian Far East) (Fig. 4B)
3. *Drunella aculea* (Allen, 1971) (Korea, Northeast China, Russian Far East) (Fig. 4C)
4. *Drunella ishiyamana* Matsumura, 1931 (Korea, Northeast China, Russian Far East) (Fig. 4D)
5. *Drunella lepnevae* (Tshernova, 1949) (Korea, Northeast China, Russian Far East) (Fig. 4E)
6. *Drunella solida* Bajkova, 1980 (Korea, Russian Far East) (Fig. 4F)
7. *Drunella triacantha* (Tshernova, 1949) (Korea, Japan, Russia) (Fig. 4G)
8. *Ephacrerella longicaudata* Uéno, 1928 (Korea, Japan) (Fig. 4H)
9. *Ephemerella atagosana* Imanishi, 1937 (Korea, Russian Far East) (Fig. 4I)
10. *Ephemerella aurivillii* (Bengtsson, 1909) (North Korea, Japan, Northeast China) (Fig. 5A)
11. *Ephemerella imanishii* Gose, 1980 (Korea, Japan) (Fig. 5B)
12. *Ephemerella kozhovi* Bajkova, 1967 (Korea, Russian Far East) (Fig. 5C)
13. *Serratella ignita* (Poda, 1761) (Korea, China, Russia) (Fig. 5D)
14. *Serratella setigera* (Bajkova, 1965) (Korea, Japan, China, Russia) (Fig. 5E)
15. *Serratella zapekinae* (Bajkova, 1967) (Korea, China, Russian Far East) (Fig. 5F)
16. *Teloganopsis chinoi* (Gose, 1980) (Korea, Japan) (Fig. 5G)
17. *Teloganopsis punctisetae* (Matsumura, 1931) (Korea, Japan, China, Russia) (Fig. 5H)
18. *Torleya japonica* (Gose, 1980) (Korea, Japan) (Fig. 5I)

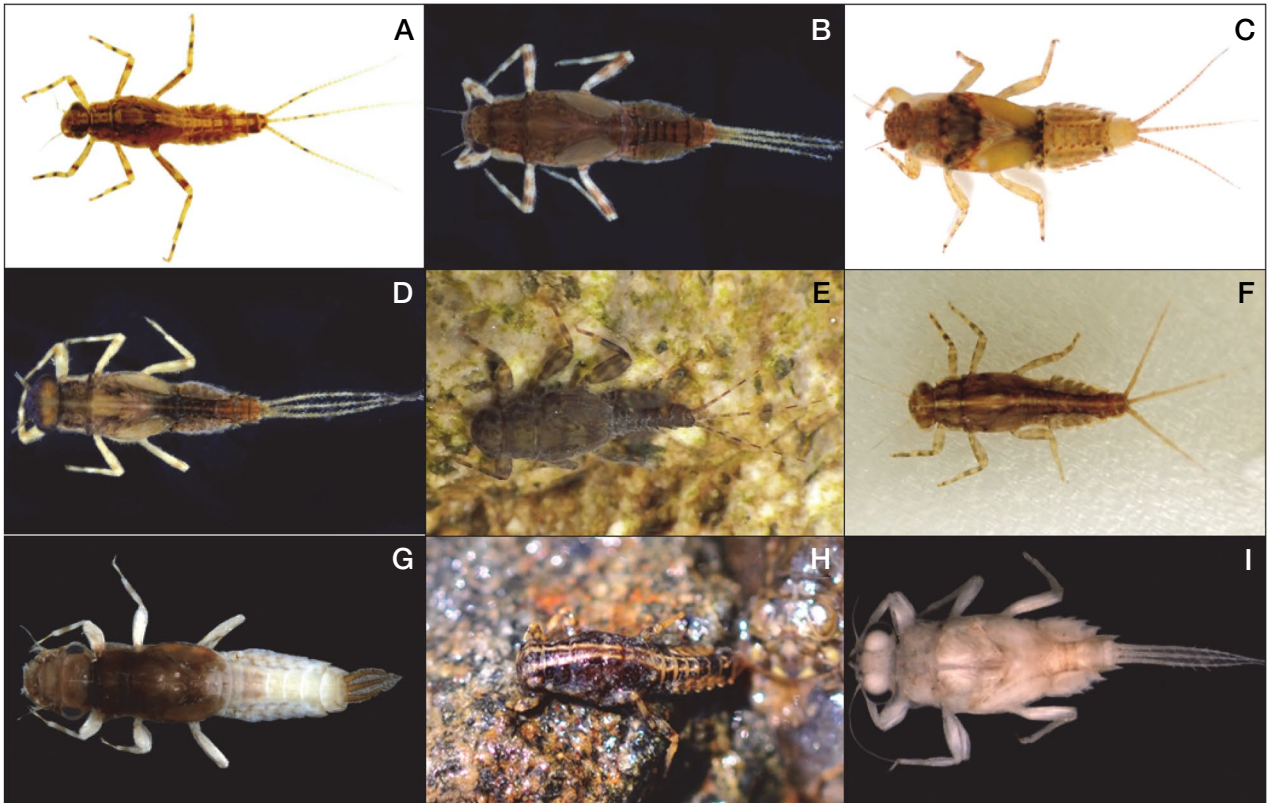


Fig. 5. Habitus photos of Korean Ephemerellidae (Part II): A, *Ephemerella aurivillii*; B, *E. imanishii*; C, *E. kozhovi*; D, *Serratella ignita*; E, *S. setigera*; F, *S. zapekinae*; G, *Teloganopsis chinoi*; H, *T. punctisetae*; I, *Torleya japonica*.

Key to the mature larvae of the *Teloganopsis* species in Korea

- 1. Thorax without pale marking and stripes (Figs. 2, 5G); caudal filaments short (about 2.0 mm) *Teloganopsis chinoi*
- Thorax with two longitudinal pale stripes (Fig. 5H); caudal filaments long (about 3.0 mm) *Teloganopsis punctisetae*

ORCID

Sang Woo Jung: <https://orcid.org/0000-0001-9545-1207>
 Jaeick Jo: <https://orcid.org/0000-0002-6739-4214>
 Jeong Mi Hwang: <https://orcid.org/0000-0003-4743-4474>

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

ACKNOWLEDGMENTS

This work was supported by a grant from the National Institute of Biological Resources (NIBR), funded by the Ministry of Environment (MOE) of the Republic of Korea (NIBR 202102204, NIBR202203201).

REFERENCES

Bae YJ, 2010. Insect Fauna of Korea. Mayflies (Larvae): Arthropoda: Insecta: Ephemeroptera. Flora and Fauna of Korea Series. Vol. 4, No. 1. National Institute of Biological Resources, Incheon, pp. 1-141.

Bae YJ, 2021. Order Ephemeroptera. In: Check List of Insects from Korea. Korean Society of Applied Entomology & The Entomological Society of Korea. Paper and Pencil, Daegu, pp. 54-57 (in Korean).

Folmer O, Black M, Hoeh W, Lutz R, Vrijenhoek R, 1994. DNA primers for amplification of mitochondrial cytochrome c oxidase subunit I from diverse metazoan invertebrates. *Molecular Marine Biology and Biotechnology*, 3:294-299.

- Gose K, 1980. The mayflies of Japanese. (9) Key to families, genera and species. *Aquabiology*, 10:366-368 (in Japanese).
- Gose K, 1985. Ephemeroptera. In: An illustrated book of aquatic insects of Japan (Ed., Kawai T). Tokai University Press, Tokyo, pp. 7-32 (in Japanese).
- Gorovaya EA, 2019. A new species of the mayfly genus *Teloganopsis* Ulmer, 1939 (Ephemeroptera, Ephemerellidae) from the South of the Russian Far East, *Entomological Review*, 99:184-192. <https://doi.org/10.1134/S0013873819020064>
- Ishiwata S, 1987. Structure and keys of the family Ephemerellidae (I). Structure and keys to genera from the family Ephemerellidae. *Aquatic Organisms in Kanagawa Prefecture*, 9:27-34 (in Japanese with English abstract).
- Ishiwata S, 2001. A checklist of Japanese ephemeroptera. In: The 21st century and aquatic entomology in East Asia (Ed., Bae YJ). The Korean Society of Aquatic Entomology, Seoul, pp. 55-84.
- Ishiwata S, Takemon Y, Fujitani T, 2018. Ephemeroptera. In: Aquatic insects of Japan: manual with keys and illustrations (Eds., Kawai S, Tanida K). Tokai University Press, Tokyo, pp. 47-149 (in Japanese).
- Jacobus LM, McCafferty WP, 2008. Revision of Ephemerellidae genera (Ephemeroptera). *Transactions of the American Entomological Society*, 134:185-274. [https://doi.org/10.3157/0002-8320\(2008\)134%5B185:ROEGE%5D2.0.CO;2](https://doi.org/10.3157/0002-8320(2008)134%5B185:ROEGE%5D2.0.CO;2)
- Kong D, Park Y, Jeon YR, 2018. Revision of ecological score of benthic macroinvertebrates community in Korea. *Journal of Korean Society on Water Environment*, 34:251-269 (in Korean with English abstract). <https://doi.org/10.15681/KSWE.2018.34.3.251>
- Matsumura S, 1931. Ephemera. In: 600 Illustrated insects of the Japanese Empire, Tokyo, pp. 1456-1480 (in Japanese).
- Nakamura T, 2017. Ephemeroptera. In: Catalogue of the insects of Japan. Vol. 2. Palaeoptera. (Ed., The Editorial Committee of Catalogue of the Insects of Japan). Touka Shobo, Fukuoka, pp. 1-24.
- Simon C, Frati F, Beckenbach A, Crespi B, Liu H, Flook P, 1994. Evolution, weighting and phylogenetic utility of mitochondrial gene sequences and a compilation of conserved polymerase chain reaction primers. *Annals of the Entomological Society of America*, 87:651-701. <https://doi.org/10.1093/aesa/87.6.651>
- Takemon Y, 1990. Mayfly fauna of Kyoto Prefecture: its characteristics and taxonomical problems. *The Science and Engineering Review of Doshisha University*, 31:49-63 (in Japanese).
- Ubero-Pascal N, Sartori M, 2009. Phylogeny of the genus *Teloganopsis* Ulmer, 1939 with a redescription of *Teloganopsis media* Ulmer, 1939 and the description of a new Oriental species (Ephemeroptera: Ephemerellidae). *Aquatic Insects*, 31:101-124. <https://doi.org/10.1080/01650420902819276>
- Ulmer G, 1939. Eintagsfliegen (Ephemeropteren) von den Sunda-Inseln. *Archiv für Hydrobiologie, Supplement*, 16:443-692.

Received December 27, 2022
 Revised March 17, 2023
 Accepted April 30, 2023