Sand burrowing mayflies of the family Behningiidae (Ephemeroptera) from South Korea

Hyoung Rye Park¹, Sang Wook Lee¹, Geonho Cho²

¹ Korean Insect Mania Society, Seoul, Korea. ² Insect Biosystematics Laboratory, Research Institute of Agriculture and Life Science, Department of Agricultural Biotechnology, Seoul National University, 151-921, Korea.

Corresponding author: Geonho Cho, geonho@snu.ac.kr

Abstract
New distributional record of little-known Behningiidae is presented from South Korea for Behningia tshernovae Edmunds & Traver, 1959. South Korea represents the first report of the species outside of the Russian Far East. We provide the photos of B. tshernovae nymphs as well as the male and female for diagnosis and confirm the previously known relation between the larva and adult.

Keywords
Distribution, new record, Behningia.

Introduction
Behningiidae are small mayfly family consisting of only three genera and six species worldwide (Bauerfeind and Soldán 2012). They are characterized by their unique morphology as sand dwellers (Fig. 1) and little is known regarding their biology and ecology. Among them, the genus Behningia Lestage, 1929 currently comprises three species, occurring in East and West Palaearctic, and Oriental regions, respectively (Bauerfeind and Soldán 2012).

Within Behningia Lestage, 1929, Behningialestagei Matos & Bacesco, 1937 was described from a single female larva and the validity of the species has been discussed by various authors (Bauerfeind and Soldán 2012). Hubbard (1994) and McCafferty & Jacobus (2006) recognized the species as distinct from B. ulmeri Lestage, 1929, but Bauerfeind and Soldán (2012) considered the species as a junior subjective synonym of B. ulmeri Lestage, 1929.

Behningia tshernovae Edmunds & Traver, 1959 is currently known only from the Russian Far East (Edmunds and Traver 1959; Hubbard 1994; Tiunova 1997, 2009, 2012; Bauerfeind and Soldán 2012). According to McCafferty and Jacobus (2006), B. tshernovae nymph sensu Edmunds and Traver (1959) actually referred to B. ulmeri Lestage, 1929 (as B. lestagei Matos & Bacesco, 1937) and the nymph of B. tshernovae is unknown or questionable. We examined several Korean B. tshernovae nymphs and male imagoes and female subimagos grown from the nymphs and confirmed that the diagnostic characters and the key to species given by previous authors (Tshernova 1964; Hubbard 1994; Bauerfeind and Soldán 2012) are correct.
Here we report the first distributional record of Behningiidae in South Korea and confirm larval-adult association.

Methods

The examined specimens are deposited in the College of Agriculture and Life Science, Seoul National University, Seoul, Korea (SNU). We follow the *Behningia* species concept by Bauernfeind and Soldán (2012). Photographs are taken with digital cameras (Nikon D7000 and D810 with Nikon AF Micro Nikkor 60mm f/2.8D Lens, Nikon, Japan and Olympus Tough TG-4, Olympus, Japan. The substrate of sand stream, collection site of *B. tshernovae*, consisting of fine sand having a grain size of 0.06–1.00 mm.

Mayfly nymphs were reared and hatching had been demonstrated in the laboratory at room temperature with no light period control. The rearing method is detailed as follows: A fish tank was utilized and the tank size was

---

**Figures 1–5. Behningia tshernovae** Endmunds & Traver, 1959 from South Korea. 1. Live habitus of nymphs, 180331HR-1. 2. Male imago, dorsal view, 180331SW-1. 3. Female subimago, dark morph, dorsal view, 180331SW-1. 4. Female subimago, pale morph, ventral view, 180331SW-1. 5. Male genitalia, ventral view, 180331SW-1. Scale bars = 1 mm.
Results
Behningiidae Motas & Bacesco, 1937

Behningia Lestage, 1929

Behningia tshernovae Edmunds & Traver, 1959

Figures 1–5


Distribution. Far East Russia (Edmunds and Traver 1959; Hubbard 1994; Tiunova 1997, 2009, 2012; Bauernfeind and Soldán 2012). There are only three extant species in Behningia worldwide, and, among them, Behningia baei McCafferty & Jacobus, 2006 is distinct in morphology (the trochanter of middle legs is considerably longer than the coxa) and distribution (Oriental region). The main characteristic differentiating larvae of the remaining two Palaearctic species are the shape of labial palp and the arrangement of bristles on labial palps (Hubbard 1994; Bauernfeind and Soldán 2012). In B. tshernovae, the apical segment of labial palp is irregularly but evenly covered with bristles of distinctly different length and size, stout bristles are scattered on outer margin (the segment with dense, long and fine bristles on outer marginal surface, bristles arranged in well distinguished longitudinal rows in B. ulmeri). Additionally, adult characters such as the shape of antenal pedicle, compound eyes are also useful (the antenal pedicle longer than \( \frac{1}{2} \) of scape in B. tshernovae, 4–5 times shorter than scape in B. ulmeri; the compound eyes oval in B. tshernovae, spherical in B. ulmeri) (Bauernfeind and Soldán 2012).

Discussion
The examination of relevant material obtained by collecting and rearing revealed unambiguous association between nymph and adult, and thus we can confirm the taxonomy of Behningia tshernovae given by Edmunds and Traver (1959) and Tshernova (1964). We confirmed that females show two colour morphs (dark and pale) (Figs 3, 4). The habitat of B. tshernovae Edmunds & Traver, 1959 is restricted to finer sand stream (Fig. 6) and, as well as, high quality water is needed for their survival. For decades, South Korean streams and rivers have suffered from waterfront developments and dam constructions. Especially the sandy habitats have gradually decreased in South Korea, which threatened the survival of sand dwelling organisms, and several species, such as Macromia daimoji Okumura, 1949, Gobiobotia nakdongensis Mori, 1935, and Microphysogobio koreensis Mori, 1935, are now considered endangered. Behningia tshernovae is also known to live in a very restricted area, and for the sustainability of the species, the conservation of its habitat and preservation of water quality are urgently required.

Acknowledgements
We are grateful to WonGun Kim (Gunchung Nara Sikmul Nara), Rodolfo Mariano (Universidade Estadual de Santa Cruz, Ilhéus, Brazil), Inês Corrêa Gonçalves (Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil), and Marek Polášek (Masaryk University, Brno, Czech Republic) for comments on earlier manuscript drafts. We also thank Hyun Yang (Institute of Biodiversity Research, Jeonju) and Mi Sook Kang (SOKN Institute of Ecology and Conservation, Yangpyeong) for their help and photographs.
Authors’ Contribution

HRP, SWL, and GC wrote the text; HRP and SWL collected material and provided photographs; GC identified the species, and made the illustration.

References