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## **NEMOURA JEJUDOENSIS A NEW SPECIES OF STONEFLY AND THE REDESCRIPTION OF AMPHINEMURA BAEI HAM AND LEE (PLECOPTERA, NEMOURIDAE) FROM JEJU ISLAND, KOREA**

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### **ABSTRACT**

*Nemoura jejudoensis* sp. n. is described from specimens collected on Jeju Island, Korea. A detailed redescription is given of *Amphinemura baei* Ham and Lee 1999, including new illustrations and scanning electron micrographs of adult genitalia based on numerous specimens collected from Jeju Island. In addition, a list of miscellaneous stonefly species from Korea is included based on specimens housed in the Monte L. Bean Life Science Museum, Brigham Young University, Provo, Utah USA.

**Keywords:** Plecoptera, Nemouridae, *Amphinemura*, *Nemoura*, new species, stoneflies, Jeju Island [= Cheju-do], Korea

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### **INTRODUCTION**

A paper on the stonefly fauna of Korea based on a large recent malaise trap collection of stoneflies possessed by the Smithsonian Institution, Washington, D.C. (Zwick 2010) engendered new interest in the Korean stonefly fauna. It brought to mind a small collection of stonefly adults that were collected in the 1980s from several waterfalls on Jeju Island [= Cheju-do], that had not been studied sufficiently. The present paper is based on these specimens that were obtained by Michael Whiting while he was an undergraduate student at Brigham Young University. A *Nemoura* species new to science is described in the present paper. Our series of *Amphinemura* specimens represent new populations of *Amphinemura baei* Ham and Lee 1999 originally described from very few specimens. We present a redescription of this species, provide new illustrations and list the additional collecting

localities. Our paper also includes a list of the stoneflies from Korea that are presently kept in the Brigham Young University collection.

### **MATERIALS AND METHODS**

Specimens were studied using Wild M-8 stereo microscopes. The Scanning Electron Micrographs were produced at Brigham Young University using a Philips XL30 ESEM FEG electron microscope. Line drawing illustrations were produced using a Leica DMLS microscope in Schlitz, Germany. Specimens used in this study will be deposited at the Brigham Young University Collection (BYUC) in Provo, Utah and the Peter Zwick Stonefly Collection (PZSC) in Schlitz, Germany. The holotype of *Nemoura jejudoensis* sp.n. will be deposited at the United States National Museum of Natural History, Smithsonian Institution, Washington, D.C. USA.

Lists of material give the locality names as on the

collection labels. Many are in the classical now obsolete transliteration of Korean names. Where necessary, and as far as we were successful, names in the presently valid transliteration are added in square brackets.

Frequently used abbreviations: S, sternite; T, tergite.

## RESULTS AND DISCUSSION

### *Nemoura jejuensis* sp. n.

(Figs. 1-6)

**Material examined.** Holotype ♂, 3♂ paratypes, Republic of Korea, Cheju Island, Chungmoon City, Chonyeon waterfalls, 1 December 1986, M.F. Whiting [Jeju Island, Seogwipo City, Jungmun, Cheonjeyeon falls] Additional material with the same collection data: 13♀ plus 1♂ and 2♀ used for SEM study.

**Size and habitus.** Front wing length 6.4-7.4 (mean 6.8) mm in ♂, 8.4-9.9 (mean 9.2) mm in ♀. Habitus typical of genus, not characteristic. Body and antennae brown, legs and palpi paler, yellowish brown. Wing veins brown, membrane of front wing with faint brownish tinge.

**Male.** Tergite 9 medially short, otherwise unmodified. T10 forms the medially largely membranous base plate of the epiproct. Epiproct closely appressed to base plate, basally firmly connected, difficult to detach for study. The epiproct consists of a short body and a long anterior rostrum-like process.

Body of epiproct short, wider than long (Fig. 1). The transverse anterodorsal sclerite supports two backwardly turned claw-like plates each with four marginal bare teeth. There is an additional anteromedian tooth whose mediodorsal face is beset with cuticular spicules (Fig. 4). A short distance behind the anterodorsal sclerite lies another slender transverse sclerite which is laterally angled backward. Other sclerites are seen only in slide-mounted epiprocts, by transparency (Fig. 1). There are no ventral setae or teeth. The basolateral ear-shaped structures that provide the normally-shaped epiprocts of other *Nemoura*-species with some mobility can be recognized but seem rigid, non-functional.

Rostrum rising from a bulb-like base connected to

the medial ends of the anterolateral sclerites. A central sclerite with median division line appears by transparency. Basal half of rostrum with several oblique folds, in side view seen to be triangularly raised near midlength (Fig. 2).

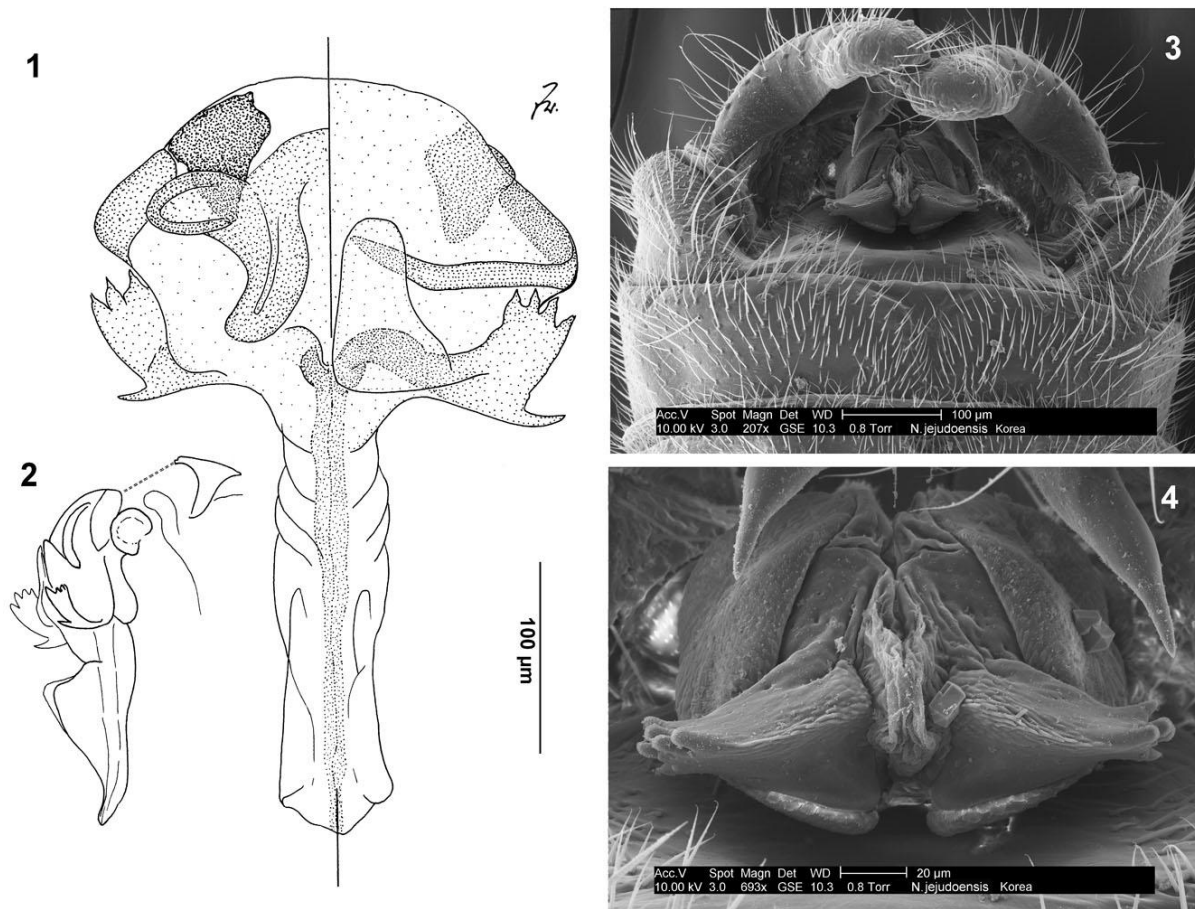
Sternite 9 almost circular, with short pointed caudal tip. The club-shaped vesicle occupies 4/5 of the sternite length. The short blade-like median sclerites of the paraprocts lie alongside the tip of S9. A membranous section separates them from the triangular, apically quite narrow outer lobe.

Cerci curved forward and mediad, partly concealing the epiproct in dorsal view (Fig. 3). Medial flat face pale and convex outer face brown, and pilose. The tiny rudiment of segment 2 is at the top of the curved cercus, on the soft medial face. There is an inconspicuous subterminal point on the front side of the cercus.

**Female.** Similar to the female of *N. geei* as illustrated by Shimizu (1997, his fig. 48). The almost circular pregenital plate on S7 covers the middle of S8 almost completely, the curved edges of the unpigmented vaginal lobes may be faintly visible (Fig. 5). Sides of S9 with a poorly defined elongate pigmented strip. Triangular sclerites in the dorsal wall of the genital opening and the end of the oviduct, respectively, may be visible by transparency.

In cleared genitalia (Fig. 6), two anterolateral cap-like brown sclerites are seen at the side of a long carrot-shaped transparent tube connecting to the receptacula. Behind it the dorsal wall of the vagina has two paramedian areas with concentric cuticular rings, probably extensible pouches.

**Diagnosis.** A member of the East Asian *Nemoura ovocercia*-group (sensu Shimizu 1997). *N. geei* Wu 1929 occurs on the Asian mainland (China, Korea, Russian Far East) as well as on Hokkaido and Honshu. *Nemoura pekinensis* Claassen 1929 and *N. brevicercia* Zhiltzova 1982 are junior synonyms (Shimizu 1997). We studied some specimens from mainland Korea. Excellent illustrations of *N. geei* are also available (Zhiltzova 1982, 2003, Shimizu 1997, Teslenko & Zhiltzova 2007). Several additional species occur in Japan, the surrounding islands, Taiwan (Shimizu 1997), and China (Li & Yang 2007). *Nemoura geei*, the present species, *N. quadrituberculata* Shimizu 1997 (Tsushima Island), *N. longilobata*



Figs.1-4. *Nemoura jejudoensis* sp. n., male. 1. Epiproct in dorsal (right half of figure) and ventral view (left half of figure), respectively. 2. Slightly oblique lateral view of male epiproct, diagrammatic, (not to scale). 3. Dorsal view of abdominal tip. 4. Anterior view of the apical epiproct sclerites.

Note that figures 3 and 4 show a strongly contracted specimen with the epiproct pulled down and the paraprocts forward. The normally barely noticed blade-like inner paraproct lobes appear as sharp spines between the cerci and the epiproct while the obtuse pilose apex of the outer lobe is concealed between the epiproct and base of the cercus.

Shimizu 1997 (Hokkaido), and *N. atristrigata* Li & Yang 2007 (Henan) share a very long rostrum of the epiproct in combination with large, dentate, claw- or hand-shaped anterolateral sclerites. *Nemoura jejudoensis* possesses an anteromedial rough process above these toothed sclerites which is absent in *N. geei*. The shape of the transverse dorsal epiproct sclerites also differs between the two species.

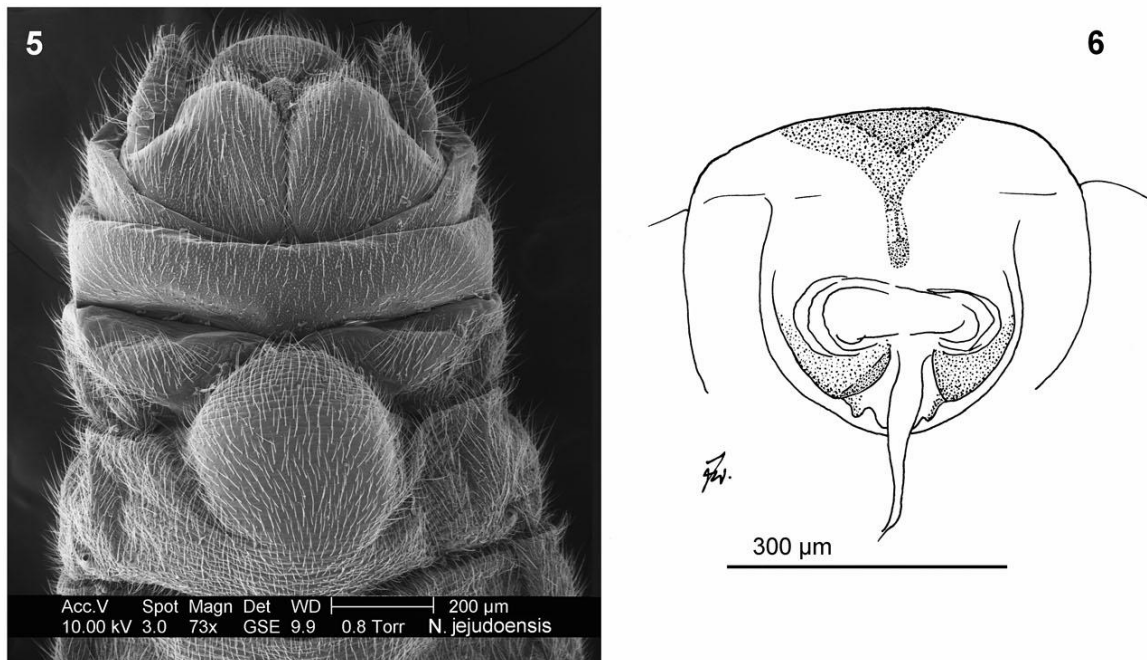
Details of epiproct structure distinguish also the other two similar species but they differ in additional characters from *N. geei*: *N. quadrituberata* by four

hairy swellings on tergites 9 and 10, toothless cerci, and broad paraprocts; *N. longilobata* and *N. atristrigata* by a large hook on the cercus and broad, tongue-shaped paraprocts.

*Nemoura jejudoensis* differs from *N. geei* only in the epiproct. We imagine that *N. jejudoensis* developed fairly recently from a small founder population of *N. geei* that ventured to the off-shore island of Jeju-do.

**Etymology.** The specific name is a noun in apposition after Jeju Island where the specimens were collected that represent this new species.





Figs. 5-6. *Nemoura jejuensis*, female. 5. Ventral view of abdominal tip. 6. Dorsal view of cleared vagina.

### *Amphinemura baei* Ham and Lee (Figs. 7-18)

*Amphinemura baei* Ham and Lee 1999:120. Holotype male; Donneko, Sugyipo-si [Seogwipo City], Jeju-do, Korea.

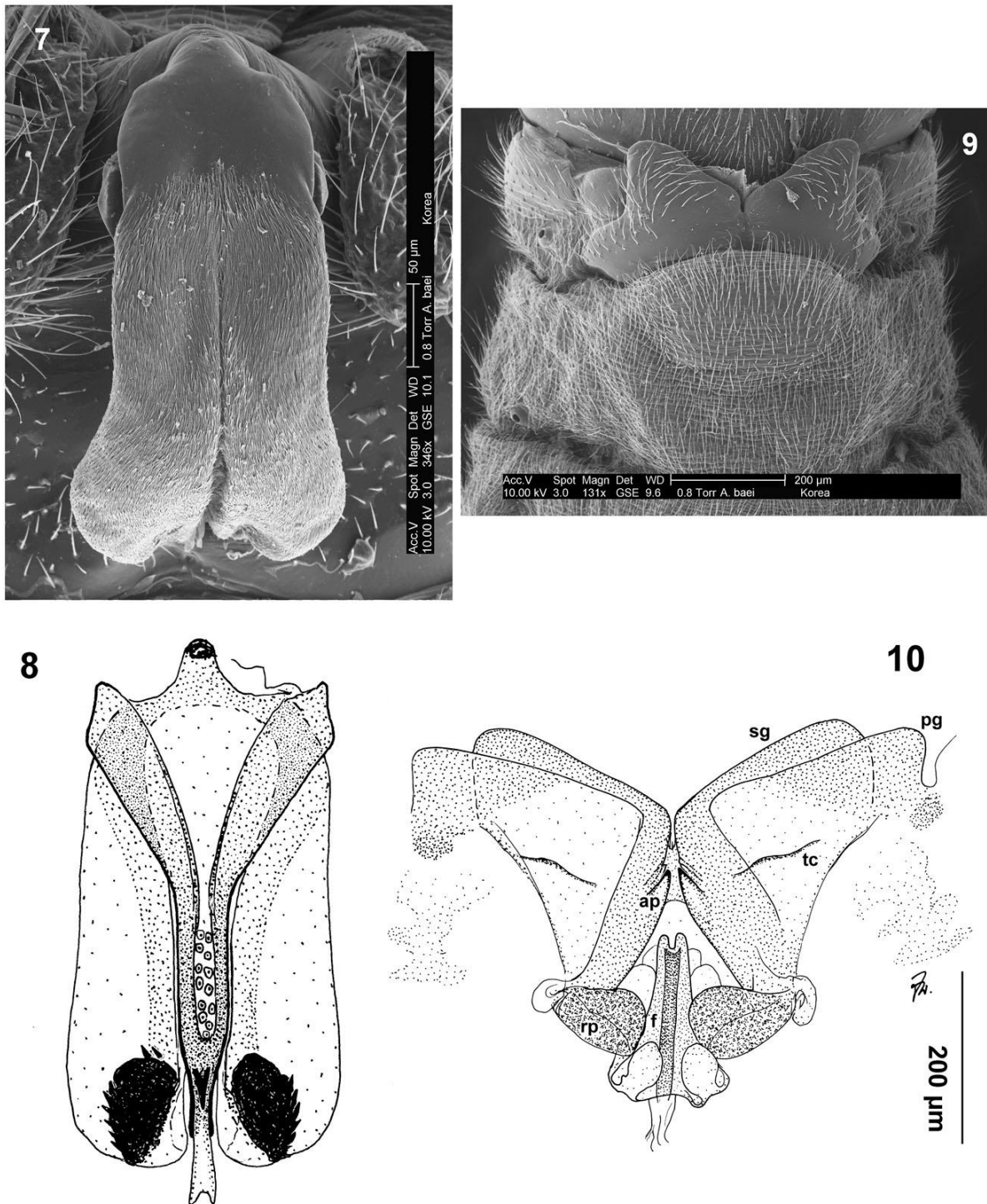
**Material studied.** Republic of Korea, Cheju Island, Sogwipo City [Seogwipo City], spring above KAL Hotel fish hatchery, 10 November 1986, M.F. Whiting, 18 ♂, 9 ♀, plus 4♂, 4 ♀ for SEM study; Sogwipo City, Tonneko spring [Seogwipo City, Donneko], 18-XII 1986, M.F. Whiting, 1♂; Chungmoon City, Chonyeon waterfalls [Seogwipo City, Jungmun, Cheonjeyeon falls], 28 September 1986, M.F. Whiting, 2♂, 1♀; 5 Dec. 1986, M.F. Whiting, 2♂, 2♀.

**Size and habitus.** Front wing length 5.8-6.8 (mean 6.4) mm in ♂, 6.6-8.2 (mean 7.8) mm in ♀. Habitus as typical of genus. Pronotum with very dense coarse punctation, rough, matt. Body brown, legs and antennae brown with indistinctly paler bases, palpi yellowish. Wing veins brown, membrane with

brownish tint.

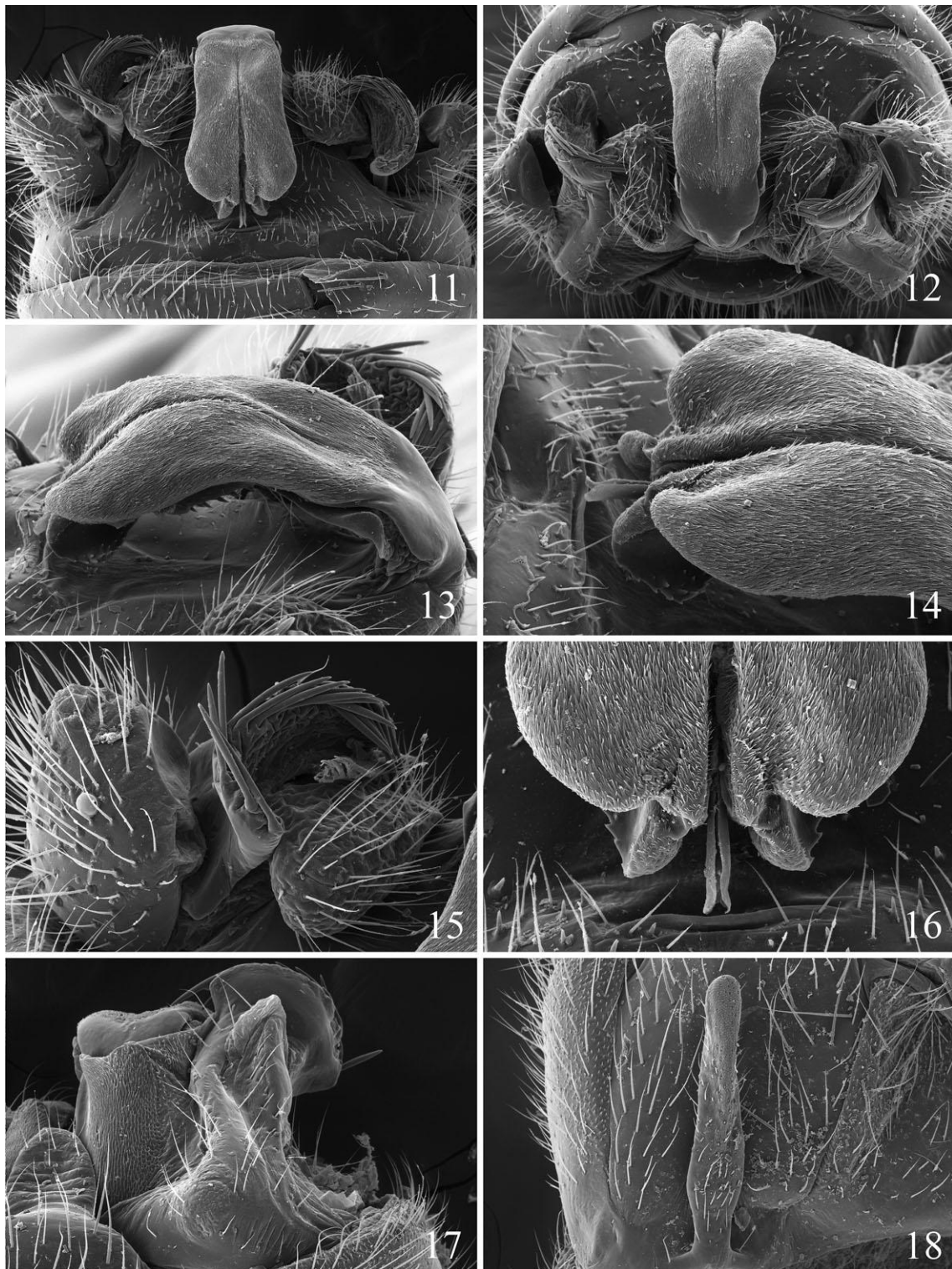
**Male.** T9 medially constricted, caudal margin on either side of constriction curved, with a few rough setae (Fig. 11). A rhomboid membranous pale area remains between T9 and the also constricted T10 which is medially only a narrow strip in front of the epiproct base plate (Fig. 12). Base plate under the epiproct largely membranous.

Epiproct in dorsal view parallel-sided, anterior third enlarged in gentle curve which turns abruptly mediad (Fig. 7). Basolaterally, the bases of the ventral sclerites project a little beyond the general contour. Dorsum densely covered with fine spicules, surface divided by fine suture which anteriorly forms a deep cleft separating two short membranous lobes. Between these projects, a dorsally split, anteriorly bifid tube. Laterally from it the spinose dark apices of the lateral sclerites project (Fig. 13). From beneath, the apices appear as black spinose humps (Figs. 14, 16). In ventral view (Fig. 8), the sclerites converge and narrow anteriorly until they lie close together, leaving only a narrow space between them. In it occur some spines of which mainly the insertion



Figs. 7-10. *Amphinemura baei*. 7. Male epiproct in dorsal view. 8. Same, ventral view; 9. Female genitalia, ventral view. 10. Vaginal complex, cleared specimen in dorsal view; ap, acute process; f, funnel; pg, paragenital plate; rp, rough pocket; sg, subgenital plate; tc, transverse crest.





Figs. 11-18. *Amphinemura baei*. 11. Male terminalia, dorsal, anterior. 12. Male terminalia, dorsal, posterior. 13. Epiproct, lateral. 14. Epiproct, apex, lateral. 15. Right paraproct, dorsal. 16. Epiproct, apex, terminal. 17. Subgenital plate, apex and right paraproct, ventral (cercus removed). 18. Subgenital plate, base, showing vesicle.

rings are seen from beneath. The spines themselves are best seen in lateral view. In side view the epiproct is strongly curved, dorsal surface without projections.

S9 with a long and slender vesicle, slightly enlarged above base, center of caudal half membranous (Fig. 18). Caudal margin of S9 forming a triangular subgenital plate, that carries the apical gonopore.

Paraprocts complex. Sclerite of outer lobe straight, then bent forward at right angle, the anterior part joined to apical part of middle sclerite but junction concealed behind the simple cercus. The middle sclerite is a slender sinuous band ending in a forward directed sclerite, with an apical row of long spines forming a concave line. It surrounds the pilose apex of the large membranous lobe situated above the short triangular inner sclerite (Figs. 15, 17).

**Female** (Fig. 9). S8 with distinct pregenital plate. S9 largely covered by sclerotized anteriorly bare subgenital plates (sg) separated by a short narrow median slot. Caudal parts drawn out into triangular lobes appearing a bit swallow-tailed, mediocaudal edge gently sinuous. A caudolateral notch exposes a rounded pilose paragenital plate (pg).

In cleared slide-mounted female genitalia in dorsal view (Fig. 10), the paragenital plates form the dorsal most layer in the form of a transparent triangle on each side. Below it are located the much larger dark triangular extensions of the subgenital plates which carry an acute, apparently hollow process (ap) along the medial edge, near midlength. There is a transverse crest (tc) on each sclerite. Anteriorly each sclerite supports an oval sclerotized internally rough pocket (rp). Between the latter is a funnel (f) formed by a sclerotized cone with a well defined straight median tube leading into the base of the membranous receptacles.

**Diagnosis.** A member of the *Amphinemura luteipes*-group (Aubert 1967) which is, among other things, distinguished by the tube projecting from the epiproct apex. Most species have a roughly punctate matt pronotum, females of most have a distinct pregenital plate and neatly separate truncate lobes of the subgenital plate. The group is widespread in Asia and includes several Korean species (Zwick 2010).

The present male is readily distinguished by the

strong curvature of the row of spines on the paraproct tip, and by its epiproct. Presence of a strong apical sclerite on the lateral epiproct sclerites suggests close relations with *A. steinmanni* Zwick, *A. denstigris* Zwick, and *A. rai* Ham and Lee. However, in these species the apical sclerite is long and tooth-shaped.

Females of the same species are similar, not all can be reliably identified by external characters. The distinctive inner vaginal structures are known only in a few. Among these, *A. denstigris* and *A. rai* also possess apical funnels that during copula may perhaps receive the apical epiproct tube. Females of this species are mainly distinguished by the exceptional length of the funnel, the acute hollow process, and the transverse crest.

We know of no closely similar species from China or Japan.

## Distribution

*Nemoura jejudoensis* and *Amphinemura baei* appear to be Jeju Island endemics although this requires confirmation by future collecting in Korea. Jeju Island is a rather large island located off the southern coast of Korea. Since stoneflies are distributed by freshwater connections or as wind-blown adults, the deep sea water of Jeju Strait probably represents a barrier that is not easily crossed.

## LIST OF KOREAN STONEFLIES AT THE MONTE L. BEAN LIFE SCIENCE MUSEUM, BRIGHAM YOUNG UNIVERSITY, PROVO, UTAH USA

### Nemouridae

*Amphinemura coreana* Zwick 1973

Republic of Korea, Shichon City, Nam-do, Chong [not located], 6 April 1997, 3♂, 1♀.

*Nemoura tau* Zwick 1973

Republic of Korea, Pusan City, Heundae [Busan City, Haeundae], at spring behind Garden Mansion Apts, 18 May 1987, M.F. Whiting, 2♂, 4♀.

### Leuctridae

*Megaleuctra saebat* Ham et Bae 2002

Republic of Korea, Gangwan-do [Gangwon Province], Pyeongchang-gun, Odaesan National Park, trail to Songwon [Songwonsa] Temple, 13



May 2006, M. Kippenhan, 1♀.

*Perlomyia mahunkai* (Zwick 1973)

Republic of Korea, Pusan City, Heundae [Busan City, Haeundae], at spring behind Garden Mansion Apts, 18 May 1987, M.F. Whiting, 3♂, 25♀.

Republic of Korea, Chollanam Province, small village North of Sun-Cheon City [Jeonnam Province, Suncheon City], 12 May 1986, M.F. Whiting, 3♂, 12♀.

### Perlodidae

*Filchneria stigmata* (Ra, Kim, Kang and Ham 1994)

Republic of Korea, Chollanam Province, Sun-Cheon City [Jeonnam Province, Suncheon City], 10-15 April 1986, M. F. Whiting, 1♀, eggs on slide.

Republic of Korea, Seoul, 5 VII 1953, E. L. Shepard, 1♀, without mature eggs.

### Perlidae

Perlinae gen. sp. (*Tyloperla* sp. ?)

Peoples Republic of Korea, 1 mile south Chirummal [not located], 1000 ft higher, XI-53, E. Bullock, 8 larvae.

*Kiotina decorata* (Zwick 1973)

Republic of Korea, Pusan City, Heundae [Busan City, Haeundae], at spring behind Garden Mansion Apts, 18 May 1987, M.F. Whiting, 29 June 1987, M.F. Whiting, 1♂.

Republic of Korea, Chollanam Province, small village North of Sun-Cheon City [Jeonnam Province, Suncheon City], 12 May 1986, M.F. Whiting, 2♂, 1♀.

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that *A. baei* was the same as our specimens from Jeju Island and provided additional constructive criticism. He and Sun Jae Park, National Institute of Biological Resources, Incheon, Republic of Korea helped us to correctly transliterate Korean names. The scanning electron micrographs and plate containing figures 11-18 were prepared with the help of Michael Standing at the Brigham Young University Electron Microscope Laboratory.

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