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Taxonomic Review of the Siphlonuridae (Ephemeroptera) in Korea

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Abstract. Three siphlonurid mayflies, *Siphlonurus chankae* Tshernova, *S. immanis* Kluge (new Korean record), and *S. palaearcticus* Tshernova are reviewed from Korea. Descriptions of known stages, illustrations of key characters, and larval and adult keys are provided.
Key words. *Siphlonurus*, Siphlonuridae, Ephemeroptera, Taxonomy, Korea

Introduction

The family Siphlonuridae is a relatively small group of mayflies, but members of the family are important due to their primitive position in Ephemeroptera phylogeny (Edmunds *et al.*, 1976). The family includes the Holarctic genera *Siphlonurus* Eaton, which contains more than 20 species, and *Parameletus* Bengtsson, which contains six species, and the Nearctic monotypic genera *Edmundsius* Day and *Siphlonisca* Needham (Kluge *et al.*, 1995).

In East Asia, *Siphlonurus* is the only representative of the family. Six species of the genus are known from Russian Far East (Tshernova *et al.*, 1986) and five species are known from Japan (Ishiwata, 2001). In Korea, Imanishi (1940) reported the larva of *Siphlonurus sanukensis* Takahashi and Yoon and Bae (1988) reported the adult and larva of *S. chankae* Tshernova. Bae and Soldán (1997) and Bae and Andrikovics (1997) added *S. palaearcticus* Tshernova to the Korean siphlonurid fauna. Bae *et al.* (1994) and Bae and Yoon (1997) catalogued the Korean species of Siphlonuridae.

The purposes of this study are to review and describe the species of Siphlonuridae in Korea and to provide larval and adult keys.

Adult and larval materials used in this study are deposited in Seoul Women's University Aquatic Insect Collection (SWU-AIC). Reference materials from Japan and Russian Far East are also used for comparisons. All materials are preserved in 80% ethyl alcohol.

Taxonomic Accounts

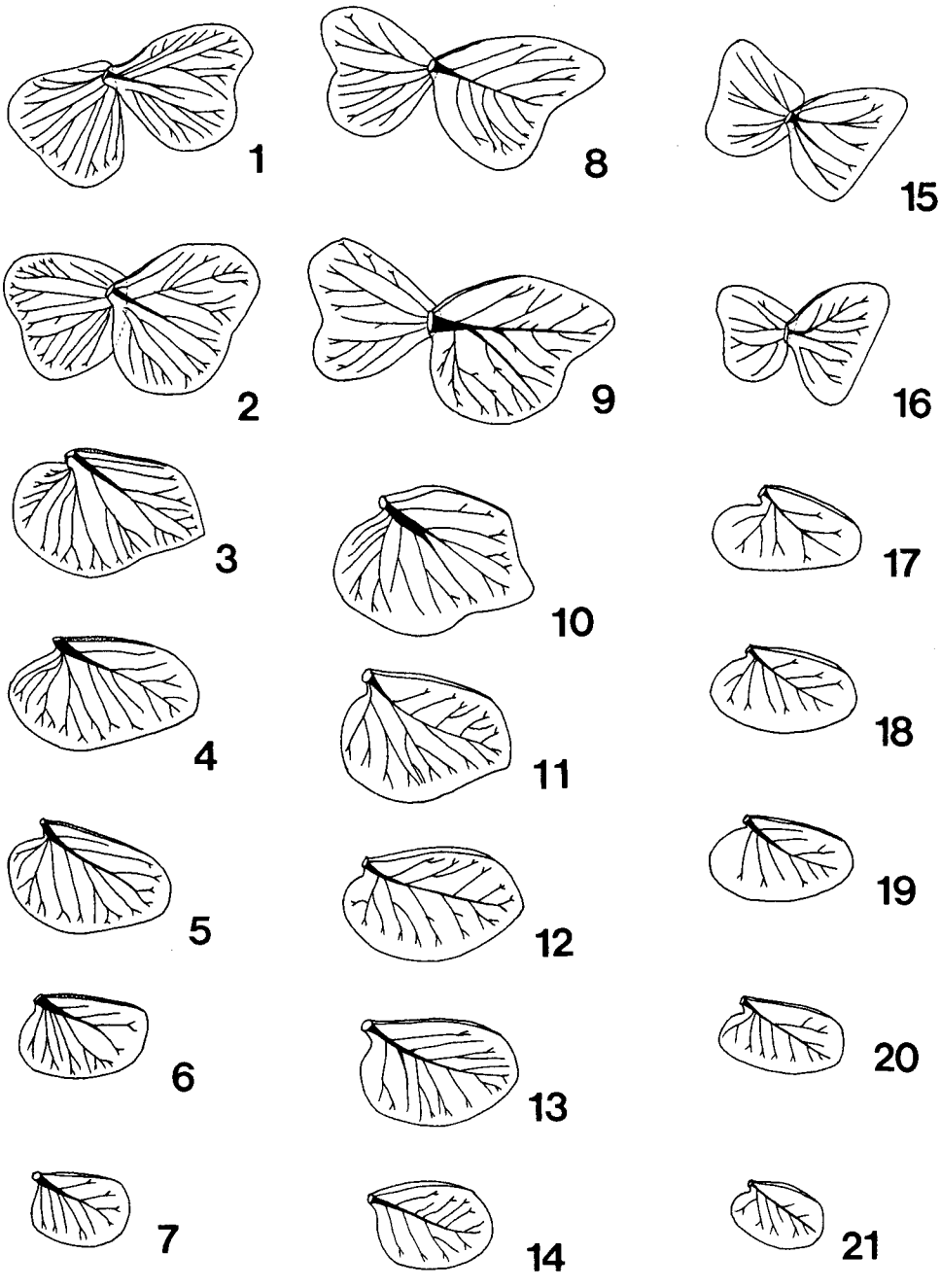
Siphlonurus chankae Tshernova
(Figs 1-7)

Siphlonurus chankae Tshernova, 1952: 263; Bajkova, 1980: 53; Kluge, 1985: 13; Yoon and Bae, 1988: 104; Bae *et al.*, 1994: 44; Bae and Yoon, 1997: 50.

Diagnosis. *Siphlonurs chankae* can be distinguished from other species of the genus by the combination of the following characters. ***Larva***: Wingpads lack dark spots, femora possess two transverse stripes, gills I and II (Figs 1 and 2) are heart-shaped and their posterior margin is notched, gills III (Fig. 3) possess proximal plate and their posterior margin is slightly notched, and gills VII (Fig. 7) possess pooly developed proximal plate.

Description. ***Adult.*** See Kluge (1985).

Larva. Body length 6.5-13.1 mm; antennae 0.7-1.3 mm; cerci 2.5-5.3 mm. General body color brown, with irregular light and dark markings. *Head.* Head brown, with paired dark brown



Figs 1-21. Gills I-VII. (1-7) *Siphlonurus chankae*. (8-14) *S. immanis*. (15-21) *S. palaeacrticus*.

strips on vertex. Compound eyes gray. Antennae yellowish brown; each segment apically darker. Frons laterally dark brown. Clypeus light brown with pair of dark brown C-shaped markings. Labrum with three light round markings. Maxillary palpi 3-segmented; segment II < 3/4 x length of segment I; segment III apically dark brown. Labial palpi 3-segmented; segment I inner margin apically constricted; segment III apically dark brown. *Thorax*. Thorax yellowish brown, with unclear light brown markings. Wingpads light yellowish-brown, without dark spot. Legs ground color pale; femora with transverse stripes apically and basally; tibiae basally dark, tibiae < 2/3 x length of tarsi; tarsi apically and basally dark; claws apically dark, acute, without denticle. *Abdomen*. Abdomen yellowish brown, with light brown markings. Tergum I-X with pair of small elongated dark brown submedian markings (markings on tergum I unclear). Gills I and II (Figs 1 and 2) paired, heart-shaped; anterior rim very short; posterior margin notched. Gills III (Fig. 3) single, leaf-shaped, apically pointed; anterior rim relatively long; posterior margin slightly notched; proximal plate developed. Gills IV-VII (Figs 4-7) single, apically round; anterior rim relatively long; posterior margin round. Caudal filaments light yellow, apically darker; each segment with whorls of short stout setae apically and long hairlike setae laterally.

Material examined. 2L: GW, Hajagae, 1986-V-4; 10L: GW, Joyanggang (R.) at 200m upstream from Naeyeoncheolgyo (Br.), 1998-V-30.

Distribution. Russian Far East, Korea.

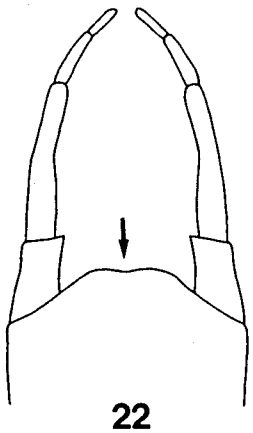
Siphlonurus immanis **Kluge**

(Figs 8-14, 22-24)

Siphlonurus chankae Bajkova, 1980: 53. (misidentification: corrected by Kluge, 1985).
Siphlonurus immanis Kluge, 1985: 18.

Diagnosis. *Siphlonurus immanis* can be distinguished from other species of the genus by the combination of the following characters. ***Male adult***: Wings lack dark markings, subgenital plate (Fig. 22) is slightly notched, dorsal elongation of penis is rounded without apical spine, and penis robe (Fig. 23) is arched with spines on inner margin. ***Female adult***: Posterolateral spines of tergum VIII and IX are well developed and curved downward, subgenital plate (Fig. 24) is slightly concave medially, and subanal plate is broadly rounded. ***Larva***: Wingpads lack dark spots, femora possess transverse stripes apically and basally, gills leaf-shaped, posterior margin of gills I and II (Figs 8 and 9) is notched, and proximal plate of gill VII (Fig. 14) is poorly developed.

Description. ***Male adult***. Body length 16.7-16.9 mm; antennae 1.4-1.5 mm; forewings length 14.8-15.9 mm; forewings width 5.1-5.7 mm; hindwings length 5.9-7.3 mm; hindwings width 3.3-4.9 mm; caudal filaments 23.4-27.3 mm. General body color purplish brown. *Head*. Antennae pale in color. Compound eyes gray in alcohol, moderately large. Ocelli white apically and dark brown basally. *Thorax*. Thorax shiny purplish brown. Forewings hyaline, without dark markings; longitudinal veins brown to dark brown; crossveins yellowish brown to brown; crossveins in stigmatic area anastomosed. Hindwings hyaline; costal projection round; Sc dark brown; other longitudinal veins and crossveins white to yellowish brown. Forelegs brown; midlegs and hindlegs light yellow; claws similar, pointed. *Abdomen*. Abdominal tergum I-X with pair of brown elongated submedian markings; posterolateral spines of tergum VIII and IX well developed, acute, curved downward. Abdominal sternum I dark brown; sternum II-VIII brown, with pair of brown elongated submedian markings; sternum IX brown. Genitalia as in Figs 22 and 23; genital forceps 3-segmented, purplish brown to dark brown; segment I inner margin constricted at 1/3 basally; subgenital plate convex and slightly notched apically; dorsal elongation of penis yellowish brown, arched, without apical spines; penis robes widely separated, dark brown, apically greatly concave, with ca. 8 spines on inner margin. Cerci basally



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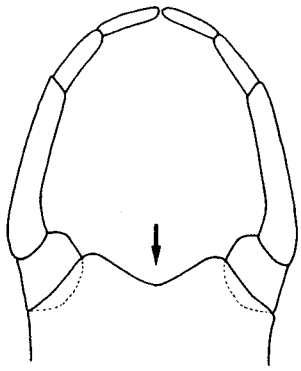

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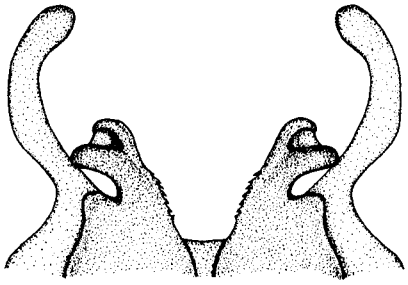

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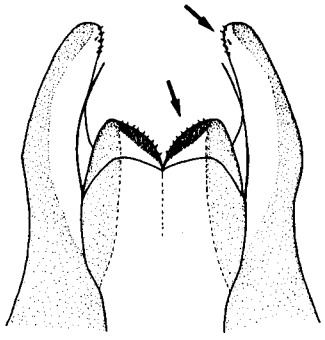

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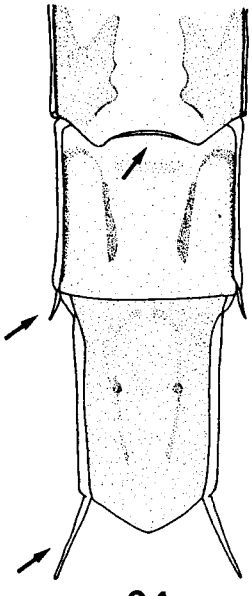

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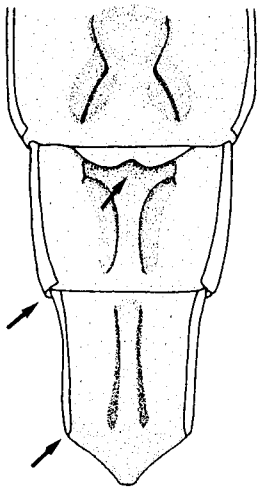

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Figs 22-24. *Siphlonurus immanis*. (22) ventral abdomen, male. (23) penes, ventral. (24) ventral abdomen, female. Figs 25-27. *S. palaeacrticus*. (25) ventral abdomen, male. (26) penes, ventral. (27) ventral abdomen, female.

light brown, apically light yellow; median terminal filament light yellow, vestigial.

Female adult. Body length 16.8-18.9 mm; antennae 1.2-1.5 mm; forewings length 17.1-17.8 mm; forewings width 6.8-8.9 mm; hindwings length 7.6-8.1 mm; hindwings width 4.1-5.1 mm; caudal filaments 20.6-21.8 mm. General body color similar to male. *Head.* Compound eyes gray in alcohol. Antennae light yellow. *Thorax*. Thorax color as in male. Forewings and hindwings color as in male. Legs color as in male; claws similar. *Abdomen.* Abdomen color and markings as in male. Posterolateral spines of tergum VIII and IX well developed (Fig. 24). Subgenital plate (Fig. 24) slightly concave medially; subanal plate convex. Cerci color as in male; median terminal filament as in male.

Larva. Body length 12.8-20.5 mm; antennae 1.2-1.8 mm; cerci 6.3-7.5 mm. General body color yellowish brown. *Head.* Head brown, with paired dark brown strips on vertex. Antennae light yellow, relatively short. Compound eyes dark gray. Frons laterally dark brown. Clypeus brown, without markings. Labrum with two light round markings. Maxillary palpi 3-segmented; segment III apically darker; segment II ca. 2/3 x length of segment I. Labial palpi 3-segmented; segment I inner margin apically constricted; segment III apically dark brown. *Thorax*. Thorax light brown with unclear lighter areas. Wingpads without dark markings. Legs ground color yellowish brown; femora with transverse stripes apically and basally; forefemora ca. 2/3 x length of middle and hind femora; tibiae basally darker, ca. 2/3 x length of tarsi; tarsi basally and apically darker; claws apically darker, acute, without denticles. *Abdomen*. Abdomen yellowish brown with lighter areas; tergum I light brown, without submedin dark markings; tergum II-X with pair of small elongated dark brown submedian markings. Sterna with dark lateral stripes; sternum II-IX with light submedian spots. Abdominal segment I-X with well developed posterolateral spines. Gills I and II (Figs 8 and 9) paired; anterior rim relatively short; posterior margin notched. Gills III and IV (Figs 10 and 11) single, leaf-shaped, moderately pointed apically; anterior rim relatively long; posterior margin slightly notched; proximal plate developed. Gills V-VII (Figs 12-14) single, oval, apically round; anterior rim relatively long; posterior margin round. Caudal filaments light yellow, apically darker; each segment with whorls of short stout setae apically and long hairlike setae laterally.

Materials examined. 1F (reared) & 2L: GG, Namyangju, Gwangreung, 1984-IV-15 (1984-IV-16 emerged), Y.J. Bae; 4M & 5F: GW, Hongcheon, Gyebangsan (Mt.), Undugol, 1983-VI-5, Y.J. Bae; 4L: CB, Danyang, 1986-V-7, Y.J. Bae; 8L: JN, Gwangjucheon, 1968-III-17.

Distribution. Russian Far East, Korea.

Remarks. There are evidently close affinities between the species of *Siphlonurus* of Northeast Asian countries as discussed in Bae (1997). Imanishi (1940) reported larvae of *Siphlonurus sanukensis* Takahashi from Ttukseom in Seoul and Gwangneung in Gyeonggi-do. The Ttukseom area has been seriously affected by the urbanization of Seoul since 1960s, so any siphlonurid mayflies have not been found from the area since then. In this study, however, the siphlonurid materials from Gwangnung area are identified as *S. immanis*.

***Siphlonurus palaearcticus* (Tshernova)**

(Figs 15-21, 25-27, 28)

Oniscigaster palaearctica Tshernova, 1930: 217.

Siphlonurus binotatus Eaton: Bajkova, 1980: 56. (misidentifiation: corrected by Kluge, 1985)

Siphlonurus brodskyi Bajkova, 1980: 57. (synonymized by Kluge, 1985)

Siphlonurus palaearcticus (Tshernova): Kluge, 1982: 114; Bae and Soldán 1997: 151; Bae and Andrikovics, 1997: 159; Bae and Yoon, 1997: 50.

Diagnosis. *Siphlonurus palaearcticus* can be distinguished from other species of the genus by the combination of the following characters: ***Male adult***: Forewings poess dark brown vertical spots, hindwings possess large dark spots in radial sector, tergum VIII-IX is poorly developed,

subgenital plate (Fig. 25) is notched, dorsal elongation of penis possess several spines apically, and penis robe (Fig. 26) is dark and poess spines apically. ***Female adult***: Subgenital plate (Fig. 27) is convex and apically notched and subanal plate is triangular in shape. ***Larva***: Wingpads poess several dark spots, femora lack transverse stripe, gills I and II dorsal lamellae posterior margin (Figs 15 and 16) and proximal plate of gills VII (Fig. 21) are strongly developed.

Description. ***Male adult***. Body length 14.9 mm; antennae 0.7 mm; forewings length 10.8 mm; forewings width 3.8 mm; hindwings length 4.8 mm; hindwings width 2.4 mm; caudal filaments 17.5 mm. General body color yellowish brown. *Head.* Compound eyes milky gray in alcohol, moderately large. Ocelli white apically and dark brown basally. Antennae light yellow. *Thorax.* Thorax color yellowish brown. Forewings hyaline, with dark brown transverse stripe at mid-length; crossveins dark brown; longitudinal veins white to brown; crossveins in stigmatic area anastomosed. Hindwings hyaline, with dark brown transverse stripe at mid-length; crossveins white to yellowish brown. Forefemora brown; foretibiae light brown; foretarsi light yellow. Midlegs and hindlegs light yellow. Claws similar, pointed. *Abdomen.* Abdomianl tergum II-X with pair of brown elongated submedian markings; tergum II-IX with lateral dark brown triangular spots; posterolateral spines of tergum VIII and IX poorly developed. Adominal sternum I anterior half dark brown and posterior half light yellow; sternum II-VIII light yellow, with inverted U-shaped dark brown markings and with paired small dark brown submedian spots; sternum IX anterior half dark brown and posterior half light yellow. Genitalia as in Figs 25 and 26; genital forceps 3-segmented, yellowish brown to brown; subgenital plate concave; dorsal elongation of penis light yellow, laterally brown and arched with ca. 6 spines apicomedially; penis robes fused, dark brown, with spines apicomedially. Cerci light brown to reddish brown; median terminal filament light yellow, vestigial.

Female adult. Body length 14.1-18.7 mm; antennae 0.9-1.3 mm; forewings length 14.4-15.7 mm; forewings width 5.4-5.9 mm; hindwings length 6.3-7.3 mm; hindwings width 3.8-4.4 mm; caudal filaments (broken). General body color brown. *Head.* Compound eyes gray in alcohol. Antennae light yellow. *Thorax.* Thorax color light yellowish brown. Forewings and hindwings color as in male. Legs color as in male; claws similar. *Abdomen.* Abdomen color and markings as in male. Subgenital plate (Fig. 27) convex and apically notched; subanal plate triangular and apically blunt. Cerci color as in male; median terminal filament as in male.

Larva. Body length 5.2-13.5 mm; antennae 0.6-1.2 mm; cerci 2.2-5.5 mm. General body color yellowish brown. *Head.* Head brown, with paired dark brown stripes on vertex. Antennae light yellow, relatively short; each segment apically dark brown. Compound eyes dark gray. Clypeus light brown, without markings. Labrum with two light round markings. Maxillary palpi 3-segmented; segment III apically darker; Segment I > 2/3 x length of segment II. Labial palpi 3-segmented; segment I inner margin apically constricted; segment III apically dark brown. Frons light brown with paired elongated dark spots. *Thorax.* Thorax yellowish brown with dark brown markings. Wingpads light yellowish brown, with several dark brown spots (Fig. 28). Legs ground color light yellow; femora without transverse stripes; forefemora ca. 2/3 x length of midfemora; hindfemora as long as midfemora; tibiae basally darker, ca. 2/3 x length of tarsi; tarsi apically and basally darker; claws brown, acute, without denticles. *Abdomen.* Abdomen light brown with various markings; tergum I light brown, without markings; tergum II-X with pair of elongated submedian darker markings; tergum II, VI, and IX with two round lighter markings. Sterna laterally with dark stripes. Gills I and II (Figs 15 and 16) paired; anterior rim relatively short; posterior margin straight to slightly notched. Gills III-VII (Figs 17-21) single, oval, apically round; anterior rim relatively long; posterior margin round; proximal plate well developed. Caudal filaments light yellow, apically darker; each segment with whorls of short stout setae apically and long hairlike setae laterally.

Materials examined. 1M (reared), 10F (2F reared), 1Fs & 11L: GW, Wonju, Chiaksan (Mt.), 1992-VI-5, 1996-VII-16, Y.J. Bae; 2L: GG, Gapyeong, Gapyeongcheon (Cr.) 1994-VII-18, Y.J.

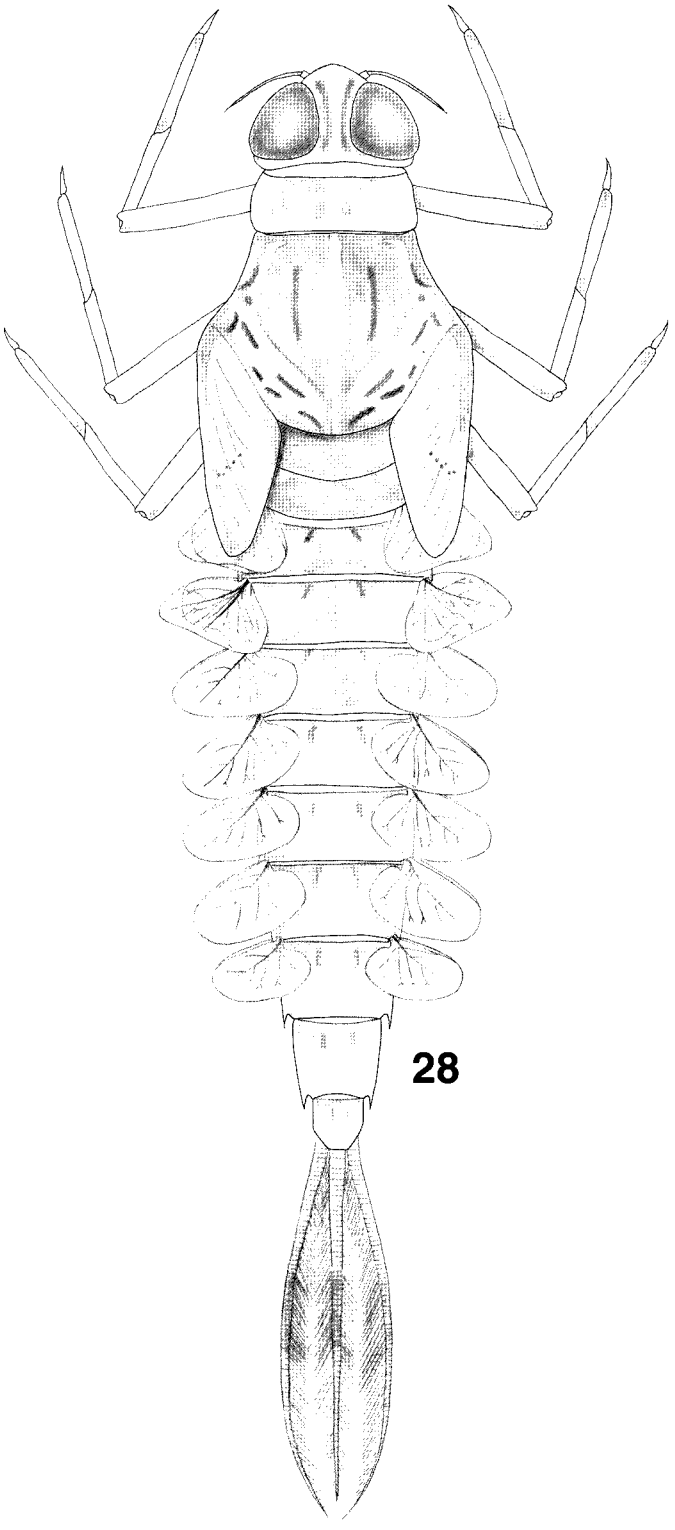

Fig. 28. *Siphlonurus palaeacrticus*, larval habitus.

Bae; 18L: GG, Namyangju, Sudongcheon (Cr.) at Sudonggyo (Br.), 1993-V-27; 9F & 2Fs (reared): GG, Cheongpyeong, Jojongcheon (Cr.), 1993-VI-13, VII-5, VII-9, Y.J. Bae; 1L: CB, Jechon, Wolaksan (Mt.), 1994-VI-24, Y.J. Bae; 1L: CN, Gongju, Gyeryongsan (Mt.), 1995-V-28, Y.J. Bae; 22L: GN, Hamyang, Soju-ri at Sojugyo (Br.), 1997-V-12, Y.J. Bae & S.J. Park; 5L: JB, Jangsu, Nodan-ri at Nodangyo (Br.), 1997-V-11, Y.J. Bae & S.J. Park; 19L: JB, Jinan, Daebul-ri, 1998-V-23, Y.J. Bae.

Distribution. Russian Far East, Korea.

Remarks. Imanishi (1940) reported *Siphlonurus binotatus* Eaton from Northeastern China. Since *S. binotatus* is widespread in Northeast Asia and is morphologically similar to *S. palearcticus*, a close comparison between the two species is needed.

Key to the Korean Species of *Siphlonurus* (Siphlonuridae)

Male adult

1. Forewings and hindwings with dark brown transverse stripe at mid-length. *S. palaearcticus*
   Forewings and hindwings without dark brown transverse stripe at mid-length. 2
2. Penis robes (Fig. 23) with spines on inner margin only. Posterolateral spines of tergum VIII and IX well developed. *S. immanis*
   Penis robes (see Kluge, 1985: Fig. 2-2) with spines on inner and outer margins. Posterolateral spines of tergum VIII and IX poorly developed. *S. chankae*

Female adult

1. Forewings and hindwings with dark brown transverse stripe at mid-length. *S. palaearcticus*
   Forewings and hindwings without dark brown transverse stripe at mid-length. 2
2. Posterolateral spines of tergum VIII and IX well developed (Fig. 24). *S. immanis*
   Posterolateral spines of tergum VIII and IX poorly developed. *S. chankae*

Larva

1. Wingpads with dark spots (Fig. 28). Femora without transverse stripe. *S. palaearcticus*
   Wingpads without dark spots. Femora with transverse stripe. 2
2. Body relatively large (>16 mm). Posterolateral spines of abdomen well developed. Gills I posterior margin of dorsal and ventral lamellae deeply notched (Fig. 8). *S. immanis*
   Body relatively small (<13 mm). Posterolateral spines of abdomen poorly developed. Gills I posterior margin of dorsal and ventral lamellae slightly notched (Fig. 1). *S. chankae*

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