

SYSTEMATICS AND EVOLUTION

Larvae of the Heptageniid Mayfly Genus *Epeorus* (Ephemeroptera: Heptageniidae) from Vietnam

Van Vinh Nguyen and Yeon Jae Bae*

Department of Biology, Seoul Women's University, Seoul 139-774, Korea

Abstract Larvae of six Vietnamese species of heptageniid mayflies in the genus *Epeorus* Eaton are reviewed: *Epeorus aculeatus* Braasch (new record), *E. bifurcatus* Braasch and Soldán, *E. carinatus* Braasch and Soldán, *E. hieroglyphicus* Braasch and Soldán, *E. tiberius* Braasch and Soldán, and *E. soldani* sp. n. Their descriptions, diagnoses, line drawings of key characters, distributions, habitat and biological data, taxonomic remarks, and a larval key are provided.

Key words description, *Epeorus soldani*, Southeast Asia, taxonomy

Introduction

The larvae of the heptageniid mayfly genus *Epeorus* Eaton occur in a wide range of lotic freshwater habitats, but they more abundantly inhabit torrential areas of upper to mid-reaches of streams. The genus is distributed in the Holarctic and Oriental regions (Edmunds *et al.*, 1976; Hubbard, 1990). The larvae of *Epeorus* can be characterized by their extremely flattened body with two caudal filaments; the head capsule possesses rowed dense hairlike setae on its anterior and anterolateral margins; the gills on the 1st to 7th abdominal segments consist of lamellate and fibrilliform portions but the lamellate portion is much larger than the fibrilliform portion (Edmunds *et al.*, 1976).

Although *Epeorus* is one of the most well-known groups of mayflies in the temperate Holarctic region, members of the genus from tropical Southeast Asia have been investigated by only a few mayfly taxonomists (Braasch, 1990; Braasch and Soldán, 1979, 1984, 1986). In Vietnam, Braasch and Soldán (1979) firstly described *Epeorus bifurcatus*, and Braasch and Soldán (1984) additionally described *E. carinatus*, *E. hieroglyphicus*, and *E. tiberius* based on larval materials. In a series of systematic study of Vietnamese

mayflies, we herein review and describe the species of *Epeorus* including a new species.

Materials and Methods

Larval materials (indicated as L in *Material examined*) were collected throughout Vietnam during the field trips in 2000-2002 using Surber nets and kick nets. All materials are preserved in 80% ethyl alcohol and deposited in the Aquatic Insect Collection of Seoul Women's University. In the future, type materials will be appropriately returned to the places (e.g., Hanoi University of Science or authorized museums) where they originated. Since Braasch and Soldán's (1979, 1984) original descriptions are written in German, we provide descriptions of the species in English based on our materials for a wider readership.

Taxonomic Accounts

Epeorus aculeatus Braasch (Figs. 1-6)

Epeorus aculeatus Braasch, 1990: 7.

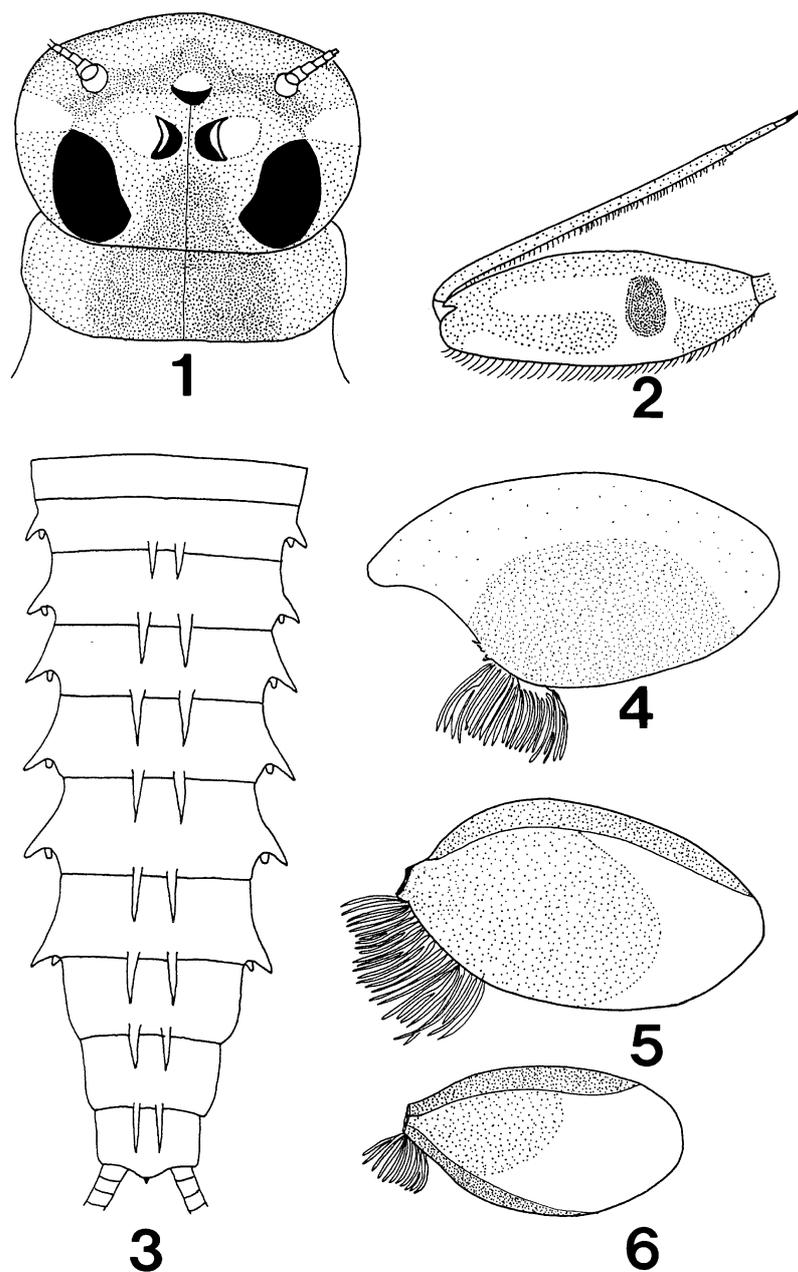
Description. Mature larva. Male body length 9.3 mm; caudal filaments 12.6 mm. Female body length 11.2 mm; caudal filaments 16.5 mm. Body generally brown, with lighter or darker markings. Head: Head (Fig. 1) 2.2 mm in length, 3.1 mm in width, brown, with indistinct lighter markings as in Fig. 1; anterior margin round, with rowed dense hairlike setae. Thorax: Pronotum (Fig. 1) 3.0 mm in width, brown, with various lighter markings, with hairlike setal fields in median area and on posterior margin. Forefemora (Fig. 2) light yellow, with irregular light brown markings and median dark brown spot, with scattered short simple stout setae on dorsal surface, with row of long hairlike setae along posterior margin; foretibiae and foretarsi with rowed hairlike setal field dorsally. Midlegs and hindlegs similar to forelegs in

*Corresponding author.

E-mail: yjbae@swu.ac.kr

Tel: +82-2-970-5667; Fax: +82-2-970-5974

(Received October 21, 2003; Accepted December 17, 2003)



Figs. 1-6. *Epeorus aculeatus*: 1, head; 2, foreleg, dorsal; 3, abdomen, dorsal; 4, gill 1; 5, gill 3; 6, gill 7.

color and setation. Abdomen: Terga (Fig. 3) brown, with various darker and lighter markings, with long hairlike setal field along median line, with minute marginal spines on posterior margin; terga 2-9 with long acute submedian spines on posterior margin; terga 2-7 with moderately developed posterolateral projections. Gills (Figs. 4-6) on segments 1-7; lamellae of gills with fine hairlike marginal setae; lamellae of gills 1 (Fig. 4) somewhat extended beneath abdomen; lamellae of gills 2-7 oval, anteriorly thicker and darker, anteromarginally with numerous tiny setae;

lamellae of gills 7 (Fig. 6) not extended beneath abdomen, with 18-20 fibrillae.

Adult. Unknown.

Diagnosis. The larvae of *E. aculeatus* can be easily distinguished from other congeners by the abdominal tergum 2-9 (Fig. 3) each of which bears long acute submedian spines on its posterior margin.

Material examined. 5 L, Ha Giang Prov., Vi Xuyen, Tay Con Linh, 9 December 2000, V.V. Nguyen; 2 L, Lao Cai Prov., Sa Pa, Cat Cat, 18 October 2000, V.V. Nguyen; 9 L, Lao Cai Prov., Sa

Pa, Thac Bac (alt. 2400, 2800 m), 19 October 2000, V.V. Nguyen.

Distribution. Thailand, Vietnam.

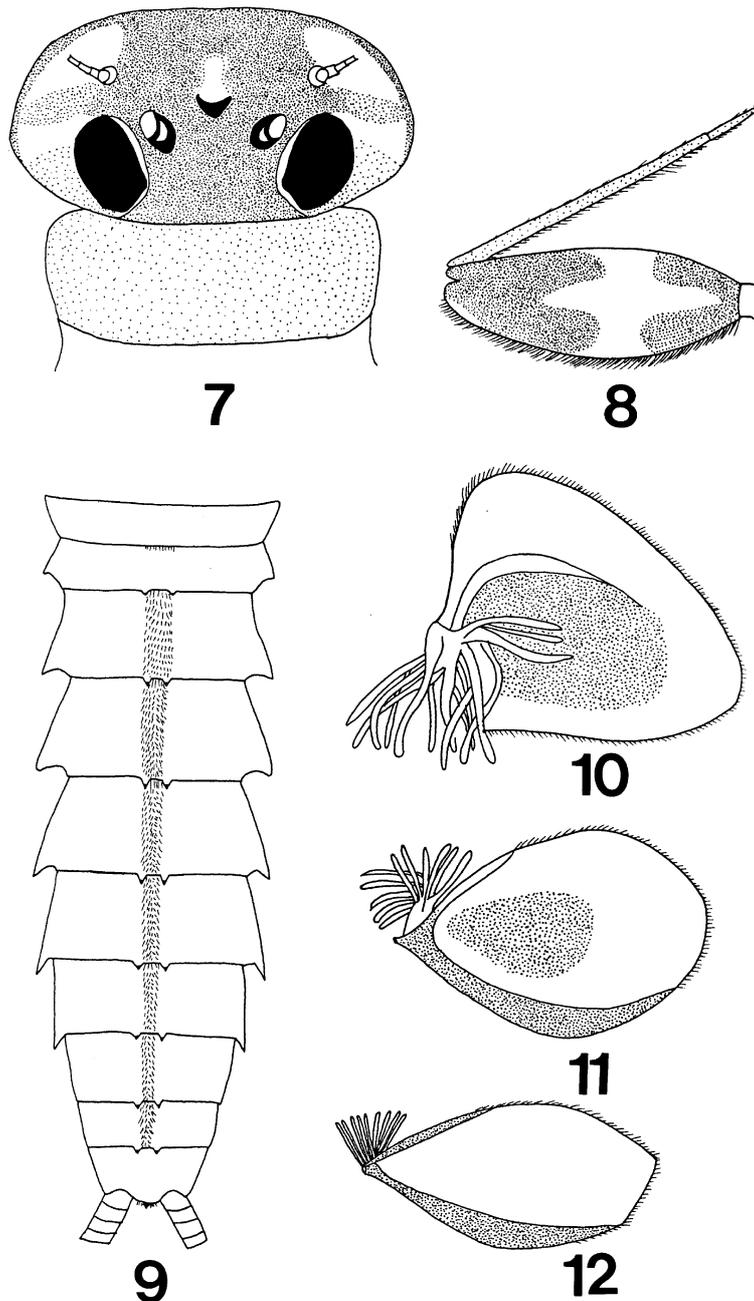
Habitat and biology. The larvae of *E. aculeatus* occur in high mountain streams ranging 1400-2800 m in altitude. The streams are 12-15 m wide and 10-40 cm deep in the dry season (November - April). The water temperature ranges 18-22°C, and pH ranges 7.2-7.8. The larvae are found underneath stones in moderately flowing areas of the streams where the

substrate is mostly stony on a sandy bottom.

***Epeorus bifurcatus* Braasch and Soldán (Figs. 7-12)**

Epeorus bifurcatus Braasch and Soldán, 1979: 270.

Description. Mature larva. Male body length 9.2 mm; caudal filaments 13.6 mm. Female body length



Figs. 7-12. *Epeorus bifurcatus*: 7, head; 8, foreleg, dorsal; 9, abdomen, dorsal; 10, gill 1; 11, gill 3; 12, gill 7.

10.0 mm; caudal filaments 15.9 mm. Body generally brown, with lighter or darker markings. Head: Head (Fig. 7) 2.0 mm in length, 3.1 mm in width, brown, with indistinct lighter markings as in Fig. 7; anterior margin round, with rowed dense hairlike setae. Thorax: Pronotum (Fig. 7) 3.1 mm in width, brown, with various lighter markings, with hairlike setal fields in median area and on posterior margin. Forefemora (Fig. 8) light yellow, with irregular light brown markings and median dark brown spot, with scattered short simple stout setae on dorsal surface, with row of long hairlike setae along posterior margin; foretibiae and foretarsi with rowed hairlike setal field dorsally. Midlegs and hindlegs similar to forelegs in color and setation. Abdomen: Terga (Fig. 9) brown, with dark brown area along posterior margin, with long hairlike setal field along median line, with minute marginal spines on posterior margin; terga 2-9 with small submedian spines on posterior margin; terga 2-7 with moderately developed posterolateral projections. Gills (Figs. 10-12) on segments 1-7; lamellae of gills with fine hairlike marginal setae; lamellae of gills 1 (Fig. 10) somewhat extended beneath abdomen; lamellae of gills 2-7 oval, anteriorly thicker and darker, anteromarginally with numerous tiny setae; lamellae of gills 7 (Fig. 12) not extended beneath abdomen, with 9-10 fibrillae.

Adult. Unknown.

Diagnosis. The larvae of *E. bifurcatus* can be distinguished from other congeners by the abdominal tergum 2-9 (Fig. 9) each of which bears small submedian spines on its posterior margin.

Material examined. 1 L, Lao Cai Prov., Sa Pa, Cat Cat (alt. 1400 m), 18 October 2000, V.V. Nguyen; 44 L, Lao Cai Prov., Sa Pa, Thac Bac (alt. 2400 m, 2800 m), 19 October 2000, V.V. Nguyen.

Distribution. Vietnam.

Habitat and biology. Habitat of this species is similar to that of *E. aculeatus*.

Remarks. We collected larvae of this species from northern Vietnam including a place near the holotype locality.

***Epeorus carinatus* Braasch and Soldán (Figs. 13-18)**

Epeorus carinatus Braasch and Soldán, 1984: 109.

Description. Mature larva. Male body length 9.5 mm; caudal filaments 11.6 mm. Female body length 11.5 mm; caudal filaments 12.5 mm. Body light brown, with brown markings. Head: Head (Fig. 13) 2.9 mm in length, 3.0 mm in width, light brown, with brown markings as in Fig. 13; anterior margin round, with rowed dense hairlike setae. Labrum anterior margin relatively widely notched. Thorax: Pronotum

(Fig. 13) 2.7 mm in width. Forefemora (Fig. 14) light yellow, with irregular light brown markings, with scattered short simple stout setae on dorsal surface, with row of long hairlike setae along posterior margin; foretibiae and foretarsi with rowed hairlike setal field dorsally. Midlegs and hindlegs similar to forelegs in color and setation. Abdomen: Terga (Fig. 15) light brown, with brown area in posterior margin, with long hairlike setal field along median line; terga 1-9 with acute submedian spines; terga 2-10 additionally with marginal spines; marginal spines on terga 2-10 acute, curved inward, and laterally larger; terga 2-7 with strongly developed posterolateral projections. Gills (Figs. 16-18) on segments 1-7; lamellae of gills with fine hairlike marginal setae; lamellae of gills 1 (Fig. 16) somewhat extended beneath abdomen; lamellae of gills 2-7 oval, anteriorly thicker and darker, anteromarginally with numerous tiny setae; lamellae of gills 7 (Fig. 18) not extended beneath abdomen, with 10-12 fibrillae.

Adult. Unknown.

Diagnosis. The larvae of *E. carinatus* can be easily distinguished from other congeners by the abdominal tergum 1-9 (Fig. 15) each of which bears acute submedian spines on its posterior margin and by the abdominal tergum 2-10 each of which bears curved acute marginal spines additionally. The marginal spines are acute, curved inward, and laterally larger. The abdominal tergum 1 lacks such marginal spines. Posterolateral projections on the abdominal terga 2-7 are strongly developed.

Material examined. 9 L, Da Nang Prov., Bana, Nui Chua, Mo Cr., 31 March 2002, 1 April 2002, V.V. Nguyen & D.H. Hoang; 4 L, Nghe An Prov., Con Cuong, Khe Choang, 6 April 2002, V.V. Nguyen & D.H. Hoang.

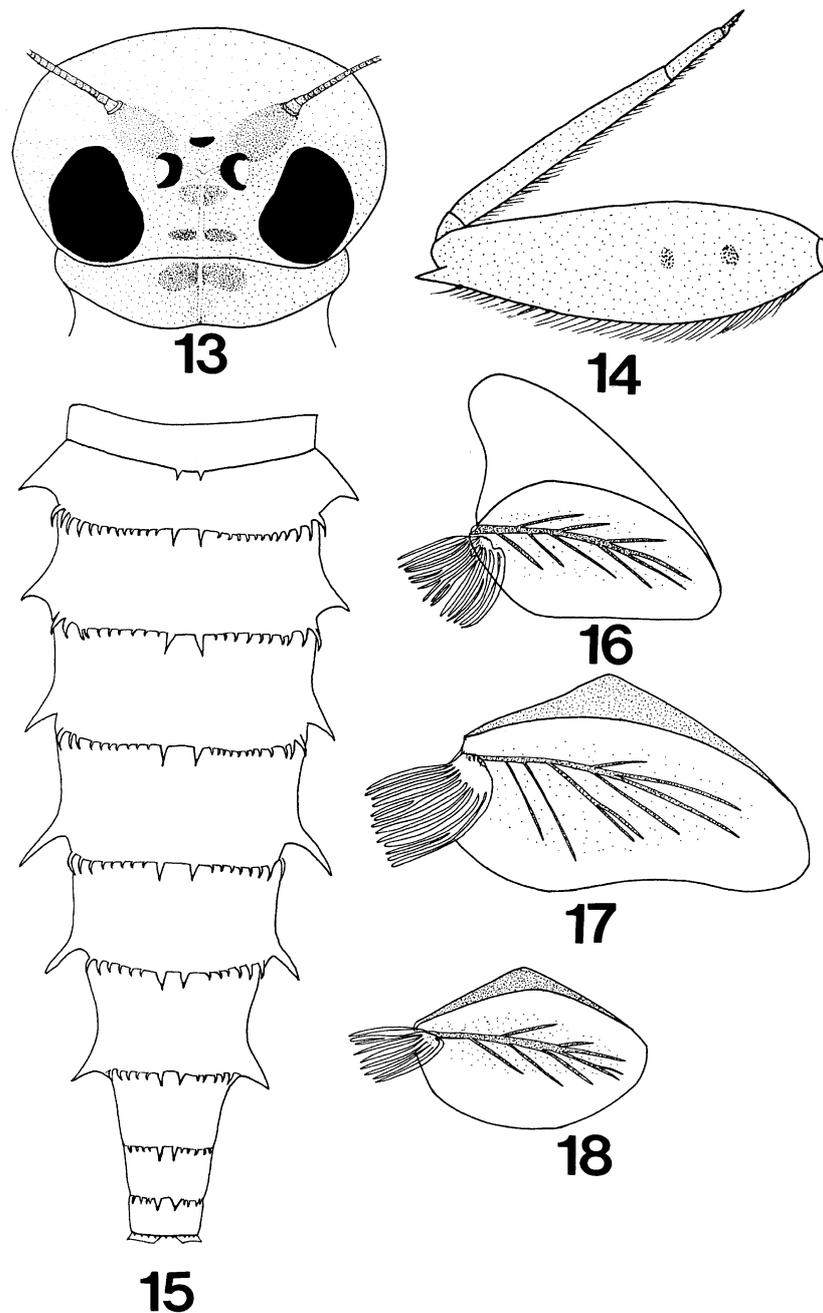
Distribution. Vietnam.

Habitat and biology. The larvae of *E. carinatus* occur in mountain streams ranging 200-600 m in altitude. The streams are 7-12 m wide and 15-40 cm deep in the dry season. The water temperature ranges 22-27°C, and pH ranges 7.2-7.8. The larvae are found underneath stones in moderately flowing areas of the streams where the substrate is mostly stony on a sandy bottom.

Remarks. Braasch and Soldán (1984) firstly described the larval stage of this species based on material from mid-Vietnam. We collected larvae of this species near the holotype locality.

***Epeorus hieroglyphicus* Braasch and Soldán (Figs. 19-24)**

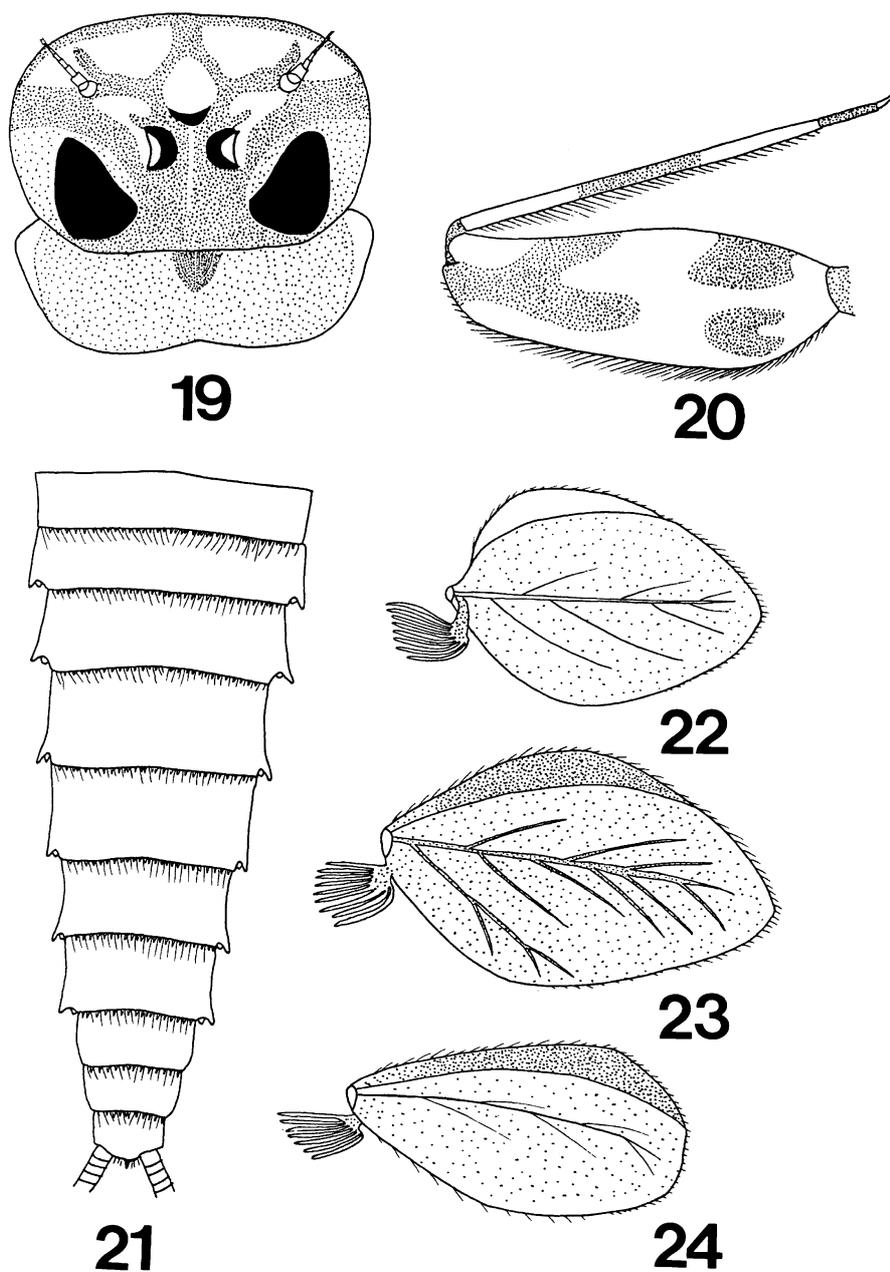
Epeorus hieroglyphicus Braasch and Soldán, 1984: 112; Braasch and Soldán, 1986: 41.



Figs. 13-18. *Epeorus carinatus*: 13, head; 14, foreleg, dorsal; 15, abdomen, dorsal; 16, gill 1; 17, gill 3; 18, gill 7.

Description. Mature larva. Male body length 8.5 mm; caudal filaments 13.9 mm. Female body length 10.0 mm; caudal filaments 15.5 mm. Body light brown, with darker markings. Head: Head (Fig. 19) 2.1 mm in length, 3.0 mm in width, brown, with light brown markings as in Fig. 19; anterior margin round, with rowed dense hairlike setae. Thorax: Notum and forewingpads with numerous short hairlike setae on dorsal surface. Pronotum 3.1 mm in width, brown,

with dark brown anteromedian marking as in Fig. 19. Forefemora (Fig. 20) light yellow, with irregular brown markings, with scattered short hairlike setae on dorsal surface, with row of long hairlike setae along posterior margin; foretibiae and foretarsi with rowed hairlike setal field dorsally. Midlegs and hindlegs similar to forelegs in color and setation. Abdomen: Terga (Fig. 21) light yellow, with various darker markings, and dorsally with numerous hairlike setae



Figs. 19-24. *Epeorus hieroglyphicus*: 19, head; 20, foreleg, dorsal; 21, abdomen, dorsal; 22 gill 1; 23, gill 3; 24, gill 7.

(hairlike setae more densely distributed in median area); terga 1-9 with rowed long hairlike setae mixed with short spines on posterior margin; terga 2-7 with moderately developed posterolateral projections. Sterna light yellow. Gills (Figs. 22-24) on segments 1-7; lamellae of gills with fine hairlike marginal setae; lamellae of gills 1 (Fig. 22) not extended beneath abdomen; lamellae of gills 2-7 oval, anteriorly thicker and darker, anteromarginally with numerous tiny

setae; lamellae of gills 7 (Fig. 24) not extended beneath abdomen, with 20-25 fibrillae.

Adult. Unknown.

Diagnosis. The larvae of *E. hieroglyphicus* can be distinguished from other congeners by the abdominal tergum 1-9 (Fig. 21) each of which bears mixed long hairlike setae and minute spines on its posterior margin. Posterolateral projections on the abdominal terga 2-7 are moderately developed.

Material examined. 3 L, Ha Giang Prov., Vi Xuyen, Thanh Thuy, 8 December 2000, V.V. Nguyen; 2 L, Ha Giang Prov., Vi Xuyen, Tay Con Linh, 9 December 2000, V.V. Nguyen.

Distribution. Vietnam, Malaysia.

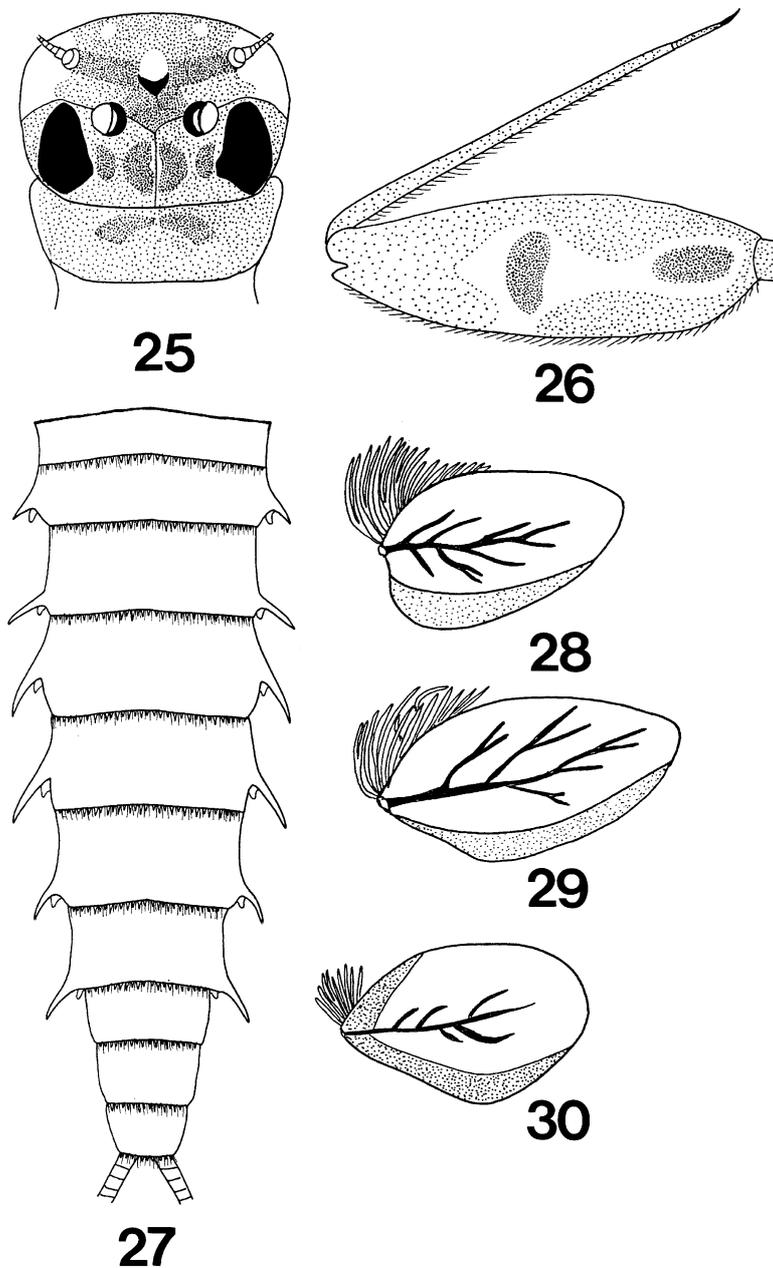
Habitat and biology. The larvae of *E. hieroglyphicus* occur in mountain streams ranging 400-800 m in altitude. The streams are 18-25 m wide and 15-45 cm deep in the dry season. The water temperature ranges 18-22°C, and pH ranges 7.2-7.8. The larvae

are found in the fast flowing areas of the streams where the substrate is mostly stony on a sandy bottom.

***Epeorus tiberius* Braasch and Soldán (Figs. 25-30)**

Epeorus tiberius Braasch and Soldán, 1984: 111.

Description. Mature larva. Male body length 9.4



Figs. 25-30. *Epeorus tiberius*: 25, head; 26, foreleg, dorsal; 27, abdomen, dorsal; 28, gill 1; 29, gill 3; 30, gill 7.

mm; caudal filaments 14.5 mm. Female body length 10.9 mm; caudal filaments 16.5 mm. Body generally brown, with lighter and darker markings. Head: Head (Fig. 25) 2.3 mm in length, 3.3 mm in width, brown, with indistinct markings as in Fig. 25; anterior margin round, with rowed dense hairlike setae. Thorax: Notum brown, with various lighter and darker markings; pronotum 3.2 mm in width. Forefemora (Fig. 26) light yellow, with irregular light brown markings, with median and basal dark brown spots, with scattered short simple stout setae on dorsal surface, with row of long hairlike setae along posterior margin; foretibiae and foretarsi with rowed hairlike setal field dorsally. Midlegs and hindlegs similar to forelegs in color and setation. Abdomen: Terga (Fig. 27) brown, with various darker and lighter markings, with long hairlike setal field along median line; terga 1-10 with long hairlike setae mixed with short acute spines on posterior margin; terga 2-7 with strongly developed posterolateral projections. Sterna light yellow. Gills (Figs. 28-30) on segments 1-7; lamellae of gills with fine hairlike marginal setae; lamellae of gills 1 (Fig. 28) not extended beneath abdomen; lamellae of gills 2-7 oval, anteriorly thicker and darker, anteromarginally with numerous tiny setae; lamellae of gills 7 (Fig. 30) not extended beneath abdomen, with 12-15 fibrillae.

Adult. Unknown.

Diagnosis. The larvae of *E. tiberius* can be distinguished from other congeners by the abdominal tergum 1-10 (Fig. 27) each of which bears mixed long hairlike setae and short acute spines on its posterior margin. Posterolateral projections on the abdominal terga 2-7 are strongly developed.

Material examined. 1 L, Ha Giang Prov., Vi Xuyen, Thanh Thuy, 8 December 2000, V.V. Nguyen; 5 L, Cao Bang Prov., Ha Quang, Soc Ha, 16 December 2000, V.V. Nguyen; 11 L, Vinh Phuc Prov., Tam Dao N.P., Thac Bac Cr. (alt. 200 m, 300 m), 15 February 2001, V.V. Nguyen.

Distribution. Vietnam.

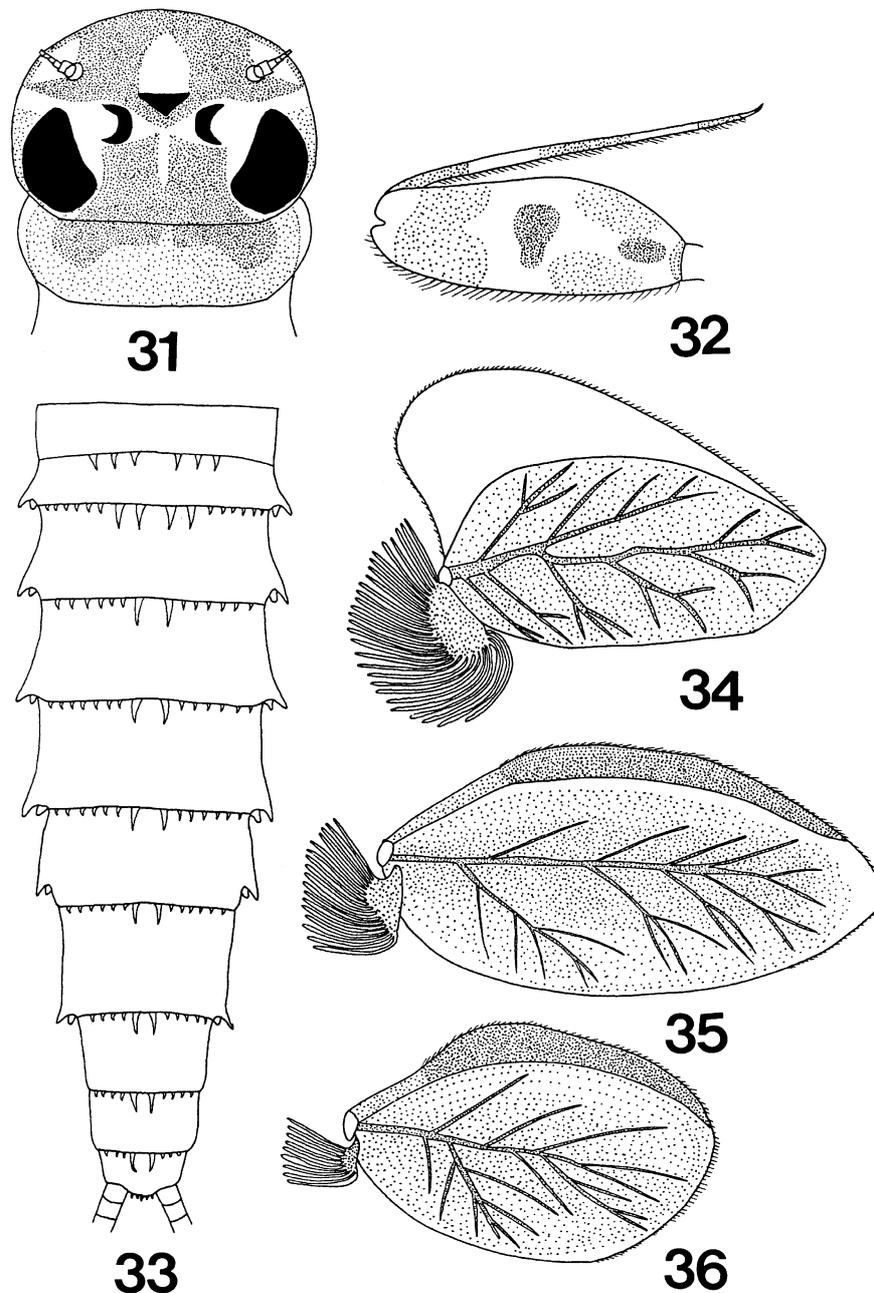
Habitat and biology. The larvae of *E. tiberius* occur in mountain streams ranging 200-600 m in altitude. The streams are 15-20 m wide and 20-45 cm deep in the dry season. The water temperature ranges 18-22°C, and pH ranges 7.2-7.8. The larvae are found underneath stones in fast flowing areas of the streams. The substrate consists of bedrock and cobble-sized stones on a sandy bottom.

Remarks. We collected the larvae of this species from the holotype locality in northern Vietnam.

Epeorus soldani sp. n. (Figs. 31-36)

Description. Mature larva. Male body length 9.6

mm; caudal filaments 16.3 mm. Female body length 11.6 mm; caudal filaments 18.5 mm. Body generally brown, with lighter and darker markings. Head: Head (Fig. 31) 2.0 mm in length, 3.0 mm in width, brown, with indistinct lighter markings as in Fig. 31; anterior and lateral margins round, with rowed dense hairlike setae; posterior margin nearly straight. Compound eyes black. Antennae light brown, 3.1 mm in length. Labrum 0.75 mm in width, with long hairlike setae dorsally and marginally, with median notch on anterior margin. Mandibles lateral margin without setae, incisors weakly to moderately serrate; outer incisor longer than inner incisor. Maxillae without armature on crown of galea-lacinia, apically with three stout teeth and single plumose seta; ventral surface with submedian row of hairlike setae; maxillary palp basal segment 0.67 mm in length, with sparse long hairlike setae; apical segment 0.95 mm in length, with dense long hairlike setae. Hypopharynx lingua with anterolateral lobes; superlinguae slightly expanded laterally with row of dense hairlike setae. Labium with narrow basal separation between glossae; glossae subtriangular; paraglossae slightly expanded laterally; labial palp basal segment 0.85 mm in length; apical segment 0.80 mm in length, with heavy armature. Thorax: Pronotum (Fig. 31) 2.8 mm in width, brown, with various lighter and darker markings; posterior margin round. Forefemora (Fig. 32) light yellow, with irregular light brown markings, with median and basal dark brown spots, with scattered short simple stout setae on dorsal surface, with row of long hairlike setae along posterior margin; foretibiae and foretarsi with rowed hairlike setal field dorsally; foreclaws with 4-5 subapical denticles. Midlegs and hindlegs similar to forelegs in color and setation. Forefemora 3.3 mm, foretibiae 2.9 mm, foretarsi 0.7 mm, and foreclaws 0.2 mm in length. Midfemora 3.5 mm, midtibiae 3.0 mm, midtarsi 0.7 mm, and midclaws 0.2 mm in length. Hindfemora 3.7 mm, hindtibiae 3.1 mm, hindtarsi 0.7 mm, and hindclaws 0.2 mm in length. Abdomen: Terga (Fig. 33) brown, with various lighter markings, with long hairlike setal field along median line; tergum 1 with 3-4 pairs of prominent acute spines on posterior margin; tergum 2 with two pairs of prominent spines and additionally with 7-8 pairs of short spines on posterior margin; terga 3-9 with one pair of prominent submedian spines and additionally with 8-9 pairs of short spines on posterior margin; tergum 10 with short spines and hairlike setae on posterior margin; prominent spines on abdominal terga blackish brown. Sterna light yellow; sternum 10 with rowed long hairlike setae on posterior margin. Gills (Figs. 34-36) on segments 1-7; lamellae of gills with fine hairlike marginal setae; lamellae of gills 1 (Fig. 34) somewhat extended beneath abdomen; lamellae of gills 2-7 oval, anteriorly thicker and



Figs. 31-36. *Epeorus soldani* sp. n.: 31, head; 32, foreleg, dorsal; 33, abdomen, dorsal; 34, gill 1; 35, gill 3; 36, gill 7.

darker, anteromarginally with numerous tiny setae; lamellae of gills 7 (Fig. 36) not extended beneath abdomen, with 18-20 fibrillae. Cerci ca. 1.6 x length of body, with rowed hairlike setae dorsally, with whorls of minute setae on joints.

Adult. Unknown.

Diagnosis. The larvae of *E. soldani* can be distinguished from other congeners by the combination of the following characters: the posterior margin of

abdominal tergum 1 possesses 3-4 pairs of prominent spines; the tegum 2 possesses two pairs of prominent spines and 7-8 pairs of short spines additionally; the terga 3-9 possess one pair of prominent spines and 8-9 pairs of short spines additionally (Fig. 33).

Type material. Holotype: Mature female larva (SWU-EPH-3204), VIETNAM, Ha Giang Prov., Vi Xuyen, Tay Con Linh, 9 December 2000, V.V. Nguyen, deposited in the Aquatic Insect Collection

of Seoul Women's University. Paratypes: 6 larvae (SWU-EPH-3205, 3206), same data as holotype.

Other material examined. 1 L, Ha Giang, Vi Xuyen, Thanh Thuy, 8 December 2000, V.V. Nguyen; 3 L, Cao Bang, Ha Quang, Doc Lap, 18 December 2000, T.K.T. Cao.

Etymology. The specific name, *soldani*, is in honor of Dr. T. Soldán who contributed to the study of Vietnamese mayflies.

Distribution. Vietnam.

Habitat and biology. The larvae of *E. soldani* occur in mountain streams ranging 200-600 m in altitude. The streams are 10-15 m wide and 10-45 cm deep in the dry season. The water temperature ranges 22-25 °C, and pH ranges 7.2-7.6. The larvae are found underneath stones in fast flowing areas of the streams. The substrate consists of bedrock and cobble-size stones on a sandy bottom.

A Larval Key to Species of Vietnamese *Epeorus*

1. Abdominal terga 2-9 with prominent submedian spines on posterior margin. 2
 Abdominal terga 2-9 without prominent submedian spines on posterior margin. 5
2. Abdominal terga 2-9 additionally with curved acute spines on posterior margin (Figs. 15, 33). 3
 Abdominal terga 2-9 additionally without curved acute spines on posterior margin (Figs. 3, 9). 4
3. Curved spines on posterior margin of abdominal terga 2-9 laterally larger (Fig. 15).
 *E. carinatus*
 Curved spines on posterior margin of abdominal terga 2-9 laterally smaller (Fig. 33).
 *E. soldani* sp. n.
4. Submedian spines on abdominal terga 2-9 relatively long, extending over 1/2 x length of following tergum (Fig. 3). *E. aculeatus*
 Submedian spines on abdominal terga 2-9 relatively

- short, not extending over 1/2 x length of following tergum (Fig. 9). *E. bifurcatus*
5. Abdominal terga 2-9 with mixed long hairlike setae and short acute spines on posterior margin; posterolateral projections relatively long and acute (Fig. 27). *E. tiberius*
 Abdominal terga 2-9 with mixed long hairlike setae and minute spines on posterior margin; posterolateral projections relatively short (Fig. 21).
 *E. hieroglyphicus*

Acknowledgment We thank D.H. Hoang (SWU) and T.K.T. Cao (IEBR, Hanoi) for their field trip assistance. This work was supported by the grant No. R01-2001-000-00086-0 from the Basic Research Program of the Korea Science & Engineering Foundation.

Literature Cited

- Braasch, D. 1990. Neue Eintagsfliegen aus Thailand, nebst einigen Bemerkungen zu deren generischem status (Insecta, Ephemeroptera: Heptageniidae). Reichenbachia Mus. Tierkunde Dresden 28: 7-14.
- Braasch, D. and T. Soldán. 1979. Neue Heptageniidae aus Asien (Ephemeroptera). Reichenbachia Mus. Tierkunde Dresden 17: 261-272.
- Braasch, D. and T. Soldán. 1984. Eintagsfliegen (Gattungen *Epeorus* und *Ison*) aus Vietnam (Ephemeroptera, Heptageniidae). pp. 109-114, in Proceedings of the 4th International Conference on Ephemeroptera, Eds. V. Landa, T. Soldán and M. Tonner. Czechoslovak Acad. Sci., CsÉkc Budejovice, Czechoslovakia.
- Braasch, D. and T. Soldán. 1986. Die Heptageniidae des Gombak River in Malaysia (Ephemeroptera). Reichenbachia Mus. Tierkunde Dresden 24: 41-52.
- Edmunds, G.F., Jr., S.L. Jensen and L. Berner. 1976. The Mayflies of North and Central America. Univ. Minnesota Press, Minneapolis.
- Hubbard, M.D. 1990. Mayflies of the World. A Catalog of the Family and Genus Group Taxa (Insecta: Ephemeroptera). Sandhill Crane Press, Gainesville, Florida.