INTRODUCTION

The Leptophlebiidae is a cosmopolitan family of mayflies that represents an extremely high degree of diversity in the southern hemisphere (Edmunds et al., 1976). The larvae occur in a variety of lotic and lentic freshwater habitats and thus show a highly successful and diverse forms of adaptation. The family includes over 100 described genera in the world (Peters and Edmunds, 1970; Hubbard, 1990).

The Leptophlebiidae is well characterized by larval and adult characters (Peters and Edmunds, 1970; Edmunds et al., 1976). The larvae are more or less elongated and depressed; if the body and head are strongly depressed, upper surface of the head is partially formed from mandibles. The maxillary and labial palpi are three-segmented. Gill filaments are present on the abdominal segments 2–6; they are forked or composed of two plates. Caudal filaments are composed of two plates. Three caudal filaments bear whorled setae at apex of each segment. The family includes over 100 described genera in the world (Peters and Edmunds, 1970; Hubbard, 1990).

Members of the Leptophlebiidae from tropical Southeast Asia have been studied by some mayfly taxonomists such as Eaton (1883–1888), Ulmer (1924, 1939), Ueno (1928, 1969), Gillies (1951), Peters and Edmunds (1970), Peters and Tsui (1972), Grant and Peters (1993), and Kang and Yang (1994), but they are still poorly known from the region. Although there were no taxonomic studies on the Vietnamese Leptophlebiidae, Nguyen et al. (2001) reported larvae of three species of Leptophlebiidae, Choroterpes trifurcata Ueno, Habrophlebiodes

Abstract: A comprehensive examination of larval and adult materials of mayflies collected throughout Vietnam in 2000–2001 resulted in the recognition of eight species of the Leptophlebiidae including two new species and three species new to Vietnam: Choroterpes proba Ulmer (new record), C. trifurcata Ueno, C. vittata sp. nov., Choroterpes major Ulmer (new record), Habrophlebiodes promontor Ueno, Isca fascia sp. nov., l. juncceae Peters and Tsui, and Thraulus bishop Peters and Edmunds (new record). A larval key, diagnoses for known stages of the genera and species, descriptions for new species, line-drawings, and material and distributional data are provided.

Key words: Choroterpes vittata, Choroterpes, Habrophlebiodes, Isca fascia, taxonomy, Thraulus, Southeast Asia

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The purpose of this study is to describe the species of Leptophlebiidae based on larval and adult materials collected throughout Vietnam during the field trips in 2000-2001. Larvae (indicated as L in Material examined) were collected by Surber nets and kick nets. Male and female adults (indicated as M and F, respectively) were collected by light traps and sweeping nets. The materials are preserved in 80% ethyl alcohol and are deposited in the Aquatic Insect Collection of Seoul Women's University. In the future, the type materials will be appropriately returned to the places (e.g., Hanoi University of Science or authorized museums) where they originated.

**TAXONOMIC ACCOUNTS**

**Key to genera and species of Vietnamese Leptophlebiidae**

1. Gills on abdominal segments 2–7.............................................. 2
   - Gills on abdominal segments 1–7 ....................................... 4
2. Gills 2–7 ventrolaterally oriented (Fig. 19); gills 2–6 forked; gills 7 single .......................... Genus *Isca*, Eaton
   - Gills 2–7 laterally oriented (Fig. 12); gills 2–6 with 2 lamellae; each lamella with 2–3 processes at apex (Figs. 13, 16) .................................................. Genus *Choroterpes*
3. Abdominal terga 1–10 brown; sternae 1–10 light brown; posterolateral projections on abdominal segment 9 shorter than 1/2 x length of segment 10 (Fig. 19) ....... *Isca janiceae* Eaton
   - Abdominal terga 1–2 and 7–9 black; terga 3–6 light brown (Fig. 20); sternae 1–6 and 10 light brown; sternae 7–9 black (Fig. 21); posterolateral spines on abdominal segment 9 as long as segment 10 (Fig. 20) ................................................. *Isca fascia* sp. nov.
4. Gills on abdominal segments 2–7 slender and deeply forked (Fig. 18) .................................................. Genus *Habrophlebiodes*
   - Gills on abdominal segments 2–7 oval or plate-like with processes or fringes (Figs. 8, 28) .................................................. Genus *Habrophlebiodes* prominens Eaton
5. Lamellae of gills 2–7 with marginal fringes (Figs. 28) .................................................. Genus *Thraulus*
   - Lamellae of gills 2–7 with 2 or 3 processes at apex (Figs. 2–5, 8) .................................................. Genus *Choroterpes*, Eaton
6. Upper and lower lamellae of gills 2–7, each with 3 processes at apex (Figs. 8, 11) .............. 7
   - Upper lamellae of gills 2–7 with 2 processes at apex; lower lamellae of gills 2–7 with 3 processes at apex (Figs. 2–5) .................................................. *Choroterpes proba* Eaton
7. Femora with 3 transverse dark brown markings dorsally (Fig. 7); posterolateral projections on abdominal segment 9 as long as segment 10 (Fig. 6) .................................................. *Choroterpes trifurcata* Ueno
   - Femora with longitudinal black stripe dorsally (Fig. 10); posterolateral projections on abdominal segment 9 1/3–1/2 x length of segment 10 (Fig. 9) .................................................. *Choroterpes viitata* sp. nov.

**Genus *Choroterpes* Eaton**


**Diagnosis.** The larvae of *Choroterpes* can be distinguished from those of other leptophlebid genera by the combination of the following characters: Gills (Figs. 1–5, 8, 11) present on abdominal segments 1–7; gills 1 slender, lanceolate; gills 2–7 alike, with dorsal and ventral portions, plate-like, and terminated in 2–3 slender processes.

**Choroterpes proba** Ulmer

*Choroterpes proba* Ulmer, 1939: 493, 613.

**Diagnosis.** The larvae of *Choroterpes proba* can be distinguished from those of other congeners by the combination of the following characters: Gills 1 (Fig. 1) slender, single, with fine marginal setae; upper lamella of gills 2–7 (Figs. 2–5) with 2 apical processes (one relatively long, with fine setae laterally; the other relatively short); lower lamella of gills 2–7 with 3 apical processes (median process longer than lateral processes).


**Distribution.** Sumatra, Vietnam.

**Choroterpes trifurcata** Ueno

(Figs. 6–8)


**Diagnosis.** The larvae of *Choroterpes trifurcata* can be distinguished from those of other congeners by the combination of the following characters: Femora with 3 transverse dark brown markings dorsally (Fig. 7). Gills 1 slender, single, with fine marginal setae; gills 2-7 lamellae with distinct arborescent dark tracheae, and terminated with 3 long processes; median process slightly longer than lateral processes (Fig. 8). Abdominal segments 4-9 with posterolateral processes; posterolateral processes 9 as long as segment 10 (Fig. 6).


**Distribution.** Java, Vietnam.

**Choroterpes vittata sp. nov.**

(Figs. 9-11)

**Diagnosis.** The larvae of *Choroterpes vittata* can be distinguished from those of other congeners by the combination of the following characters: Femora and tibiae with distinct longitudinal black stripe dorsally (Fig. 10); abdominal terga 1-9 brown, each with distinct transverse arched black stripe (Fig. 9); gills 1 slender, single, with fine marginal setae; posterolateral projections of abdominal segment 9 relatively short (1/3 to 1/2 × length of segment 10) (Fig. 9).

**Description.** Mature larva. Male body length 4.5 mm; cerci 6.5-7.0 mm; terminal filament 9.0-10.5 mm. Female body length 5.6 mm; cerci 7.0-7.5 mm; terminal filament 10.0-11.5 mm.

mm. Head: Head 0.97 mm in length and 1.30 mm in width, brown. Male compound eyes divided into 2 portions; upper portion light brown; lower portion black: distance between compound eyes 0.17 mm. Female compound eyes black, 0.37 mm in length, 0.27 mm in width, and 0.72 mm in distance between compound eyes. Antennae 2.9–3.5 mm in length, light yellow. Clypeus light brown, with hairlike setae dorsally; lateral margin dark brown, slightly divergent apically. Labrum 0.65 mm in width, and 0.34 mm in length, with row of long hairlike setae on dorsal surface, divergent laterally; anterior margin with emargination. Mandible incisors forked apically; lateral margin of mandibles convex and with long hairlike setae. Maxillae light yellow, apicomically with a tooth-like process and a large thick comb-shaped setae; maxillary palpi 3–segmented; segment 1, 2, and 3 0.21 mm, 0.17 mm, and 0.15 mm, respectively; segment 3 with numerous long hairlike setae. Hypopharynx well developed; lingua with well developed lateral processes, with short hairlike setae on apex of lateral processes, with anterior margin deeply cleft; superlingua relatively broad, with row of hairlike setae along anterior margin. Labium glossae reniform, ventrally with clavate setae; paraglossae oval, ventrally with a transverse row of hairlike setae near anterior margin.

Thorax: Pronotum brown, with light markings, with shallow emargination anteromedially; lateral margins light yellow; anterolateral margins round and with 6–8 acute setae. Forewingpads light brown. Hindwingpads small. Legs light yellow; femora and tibiae stout setae mixed with 22–24 long hairlike setae on posterior margin, with blunt setae in median area, with long hairlike setae on anterior margin; forefemora, midfemora, and hindfemora with acute pinnate setae. Forefemora, foretibiae, foretarsi, and midtibiae with distinct longitudinal black stripe dorsally (Fig. 10). Forefemora, foretibiae, and foreclaws 1.12 mm, 1.00 mm, 0.47 mm, and 0.12 mm, respectively; forefemora with 15–20 stout setae mixed with 22–24 long hairlike setae on posterior margin, with blunt setae in median area, with long hairlike setae on anterior margin; foretibiae with acute pinnate setae on lateral margins; foreclaws with 12–14 denticles apically. Midfemora, midtibiae, midtarsi, and midclaws 1.10 mm, 0.97 mm, 0.35 mm, and 0.10 mm, respectively; posterior margin of midfemora with acute setae sparsely. Hindfemora, hindtibiae, hindtarsi, and hindclaws 1.05 mm, 0.95 mm, 0.30 mm, and 0.12 mm, respectively; hindfemora with long hairlike setae laterally; hindtibiae and hindtarsi with short hairlike setae laterally. Abdomen: Terga 1–9 (Fig. 9) brown, each with distinct transverse arched black stripe; tergum 10 brown, with dark brown marginal markings; sterna brown, without marginal markings; terga 4–9 with posterior lateral projections; posterolateral projections on tergum 9 relatively short, 1/3 to 1/2 × length of tergum 10. Gills on abdominal segments 1–7; gills 1 slender, with marginal setae; gills 2–7 alike, each included 2 broad plate-like lamellae; lamella with distinct arborescent dark tracheae; each lamella terminated with 3 processes, with median process longer than lateral processes (Fig. 11). Caudal filaments ca. 1.4 × length of body, with whorled setae at apex of each segment.

Adult: Unknown.


Other material examined. 1 L, Vinh Phuc Prov., Tam Dao N.P. (alt. 350 m), 15 II 2001, VV Nguyen.

Distribution. Vietnam. Etymology. The specific name viitata (striped) is Latin, an allusion to the abdominal black stripes.

Genus Choroterpides Ulmer


Diagnosis. The larvae of Choroterpides can be distinguished from those of other leptophlebiid genera by the combination of the following characters: gills (Figs. 12–16) present on abdominal segments 2–7; gills 2–7 alike, with dorsal and ventral portions, plate-like, and terminated in 2–3 processes; median process equal to or longer than lateral processes.

Choroterpides major Ulmer

Choroterpides major Ulmer, 1939: 497, 619.

Diagnosis. The larvae of Choroterpides major can be distinguished from those of other congeners by the combination of the following characters: Maxillary and labial palpi greatly elongated and extended beyond sides of head; anterior margin of labrum with emargination; upper and lower lamellae of gills 2 (Figs. 13, 14) apically with 3 processes; upper lamellae of gills 7 (Fig. 15) apically with 2 processes; lower lamella of gills 7 (Fig. 16) with 3 processes (processes equal in length), with distinct tracheae.


Figs. 12–16. Choroterpides major: 12, larval abdomen, dorsal; 13, gill 2, upper lamella; 14, gill 2, lower lamella; 15, gill 7, upper lamella; 16, gill 7, lower lamella.

**Genus Habrophlebiodes Ulmer**


**Diagnosis.** The larvae of *Habrophlebiodes* can be distinguished from those of other leptophlebiid genera by the combination of the following characters: Gills (Fig. 18) present on abdominal segments 1-7; gills 1-7 alike, long, slender, and deeply forked; posterolateral projections present on abdominal segments 8 and 9, and those on segment 9 longer.

**Habrophlebiodes prominens Ulmer**

(Figs. 17-18)


**Diagnosis.** The larvae of *Habrophlebiodes prominens* can be distinguished from those of other congeners by the combination of the following characters: Head and thorax with distinct markings as in Fig. 17; gills on segments 1-7 alike, long, slender, and deeply forked, with distinct tracheae; gills 4 (Fig. 18) forked at 1/6 basally.


**Isca Gillies**


**Diagnosis.** The larvae of *Isca* can be distinguished from those of other leptophlebiid genera by the combination of the following characters: Gills (Fig. 19) present ventrolaterally on abdominal segments 2-7; gills 2-6 (Fig. 22) alike, forked, slender; gills 7 (Fig. 23) unforked, slender.

**Isca janiceae Peters and Edmunds**

(Fig. 19)


**Diagnosis.** The larvae of *Isca janiceae* can be distinguished from those of other congeners by the combination of the following characters: Abdominal terga brown; abdominal sterna light brown; posterolateral projections of abdominal segment 9 (Fig. 19) relatively small; abdominal gills as in Fig. 19.


Isca fascia sp. nov.
(Figs. 20–24)

Diagnosis. The larvae of Isca fascia can be distinguished from those of other congeners by the combination of the following characters: Abdominal terga (Fig. 20) 1–2 and 7–9 black; abdominal terga 3–6 light brown; abdominal sterna (Fig. 21) 1–6 and 10 light brown; abdominal sterna 7–9 black; posterolateral projections on segment 9 as long as abdominal segment 10. The adults of I. fascia can be distinguished by their abdominal markings: Terga 1–2 and 7–9 dark brown; terga 3–6 brown. In male adults, the subgenital plate is slightly convex and the penes are light yellow, relatively broad and flattened, fused, and weakly notched apically (Fig. 24).

Description. Mature larva. Male body length 4.6 mm; cerci 5.5–6.0 mm; terminal filament 7.5–8.2 mm. Female body length 4.9 mm; cerci 6.1–6.5 mm; terminal filament 8.5–9.2 mm.

Head: Head 0.55 mm in length, and 1.12 mm in width, light yellow with large dark brown to black area in vertex. Compound eyes black. Male compound eyes 0.42 mm in width; distance between compound eyes 0.25 mm. Female compound eyes 0.18 mm in width; distance between compound eyes 0.75 mm. Antennae 3.2–3.5 mm in length, light yellow. Clypeus rectangular, straight in anterior margin, with weakly developed hairlike setae dorsally. Labrum slightly emarginated anteromedially, dorsally with row of hairlike setae, ventrally with hairlike setae in submedian and anterolateral areas. Mandibles with field of hairlike setae on dorsolateral margin; incisors with 3 teeth; molar with 8–9 small teeth. Maxillae with raker-like spines on crown of galea-lacinia; maxillary palpi 3–segmented; segment 1, 2, and 3 0.17 mm, 0.11 mm, and 0.12 mm, respectively; segment 1 and 2 with scattered hairlike setae laterally; segment 3 triangular, with scattered hairlike setae apically. Hypopharynx well developed; lingua with well developed lateral processes, with anterior margin cleft; superlinguae relatively broad, with row of hairlike setae along anterior margin. Labium glossae and paraglossae with dense hairlike setae; labial palpi 3–segmented and laterally oriented; segment 1, 2, and 3 0.25 mm, 0.15 mm, and 0.18 mm, respectively; segment 3 triangular, with hairlike setae laterally. Thorax: Pronotum weakly expanded laterally with round anterolateral corners, light yellow with dark brown anterior margin. Mesonotum light yellow, with dark brown marking medially. Forewing pads black; hindwing pads absent. Forefemora, foretibiae, foretarsi, and foreclaws 0.97 mm, 0.82 mm, 0.45 mm, and 0.09 mm, respectively; forefemora light yellow, with scattered simple stout setae dorsally and on anterior and posterior margins; foretibiae light brown, with rowed sparse hairlike setae along outer margin and with field of stout setae along inner margin; foretarsi with sparse hairlike setae dorsally; foreclaws dark brown, apically hooked, with rowed denticles (denticles apically larger). Midfemora, midtibiae, midtarsi, and midclaws 0.87 mm, 0.85 mm, 0.37 mm, and 0.09 mm, respectively; midfemora with stout setae and hairlike setae dorsally; midtibiae and midtarsi with hairlike setae dorsally and laterally; midclaws dark brown with denticles apically. Hindfemora, hindtibiae, hindtarsi, and hindclaws 1.17 mm, 1.15 mm, 0.67 mm, and 0.10 mm, respectively; hindfemora light yellow, with hairlike setae laterally; hindtibiae and hindtarsi with short hairlike setae laterally. Abdomen: Terga (Fig. 20) 1–2 and 7–9 black; terga 3–6 light brown; sternae (Fig. 21) 1–6 and 10 light brown; sternae 7–9 black. Posterolateral projections on segment 9 as long as segment 10. Gills on segments 2–7; gills 2–6 (Fig. 22) ventrolaterally oriented, forked; gills 7 (Fig. 23) single, slender. Caudal filaments with whorls of weakly developed hairlike setae; cerci ca. 1.3 x length of body; terminal filament ca. 1.8 x length of body.

Male adult. Body length 4.9 mm; cerci 6.5–7.5 mm; terminal filament 7.5–8.5 mm. Head: Head dorsally dark brown; compound eyes divided into large upper portion with larger light brown facets and smaller lower portion with smaller black facets; upper portion of compound eyes 0.52 mm in width and 1.20 mm in distance between compound eyes; ocelli dark brown basally, white apically. Antennae 0.7–0.9 mm, white. Thorax: Pronotum purplish brown. Mesonotum purplish brown, with white median and sublateral lines; posterior hump dark brown and V-shaped. Metanotum brown. Forelegs light brown to light yellow; foretibiae and foretarsi greatly elongated; foretibia, foretarsi, and foretarsus 0.97 mm, 3.20 mm, and 2.92 mm, respectively; foretarsal segments 1, 2, 3, 4, and 5 0.1 mm, 0.92 mm, 0.91 mm, 0.80 mm, and 0.19 mm, respectively. Midlegs light brown to light yellow; midfemora, midtibiae, midtarsi 0.87 mm, 0.72 mm, and 0.32 mm, respectively. Hindlegs light brown to light yellow; hindfemora, hindtibiae, hindtarsi 1.10 mm, 0.82 mm, and 0.35 mm, respectively. Claws dissimilar. Forewings 5.9 mm in length, 2.2 mm in width, stained purplish brown; longitudinal
veins generally white; C, Sc, and R1 slightly darker; posterior margin with numerous trichia; crossveins reduced, white; stigmatic area without crossveins; crossveins between C and Sc 4; crossveins between Sc and R1 6; crossveins between R1 and R2 11; bullae on Sc, R1 and R4+5; MA2 attached to MA1 at base, with 1 intercalary; MP1 attached to MP2 at base, with 1 intercalary; area between MP2 and CuA without intercalaries; area between CuA and CuP with 2 intercalaries; Rs forked 1/8 basally; MA forked 1/3 basally; MPs ca. 0.3 × length of MP1; CuP strongly arched; anal veins 3. Hindwings absent. **Abdomen**: Abdominal segments brown to dark brown; terga 1–2 and 7–9 dark brown; terga 3–6 brown; segments 2–7 with white area 1/3 anteriorly; sternae 3–9 with pair of dark brown longitudinal stripes; posterolateral projections on segment 9 as long as segment 10. Genitalia as in Fig. 24; genital forceps 3-segmented, white; segment 1, 2, and 3 0.35 mm, 0.10 mm, and 0.10 mm, respectively; segment 1 arched; segments 2 and 3 nearly round; subgenital plate slightly convex; penes light yellow, relatively broad and flattened, fused, and notched apically. Cerci white, ca. 1.6 × length of body.

**Female adult.** Body length 5.3 mm; cerci 7.5–8.0 mm; terminal filament 8.5–9.0 mm. **Head**: Head dark brown; compound eyes dark grey in alcohol, 0.20 mm in width, and 0.74 mm in distance between compound eyes; ocelli dark brown basally, white apically. Antennae white, 0.8–0.9 mm in length. **Thorax**: Color and shape as in male. Forelegs light brown to light yellow, foremora, foretibiae, and foretarsi 0.75 mm, 0.70 mm, and 0.25 mm, respectively. Midlegs light brown to light yellow; midmora, midtibiae, and midtarsi 0.78 mm, 0.80 mm, and 0.25 mm, respectively. Hindlegs light brown to light yellow; hindmora, hindtibiae, and hindtarsi 1.15 mm, 0.90 mm, and 0.23 mm, respectively. Claws dissimilar. Forewings 6.3 mm in length, 2.60 mm in width, shape, color, and venation similar to male. Hindwings absent. **Abdomen**: Color and markings similar to male. Cerci white, ca. 1.5 × length of body.

**Type.** Holotype: Female larva (SWU-EPH-3648), VIETNAM, Lao Cai Prov., Sapa, Thac Bac Cr. (alt. 2400 m), 19 X 2000, VV Nguyen, deposited in the Aquatic Insect Collection of Seoul Women’s University. Paratypes: 44 male adults (SWU-EPH-3651, 3652) and 48 larvae (SWU-EPH-3649, 3650), same data as holotype.

**Other material examined.** 8 M, 2F & 47 L; Lao Cai Prov., Sapa, Thac Bac Cr. (2000 m, 2400 m), 19 X 2000, VV Nguyen.

**Distribution.** Northern Vietnam.

**Etymology.** The specific name *fascia* (band) is Latin, an allusion to the abdomen black bands.

**Genus Thraulus Eaton.**


**Diagnosis.** The larvae of *Thraulus* can be distinguished from those of other leptophlebiid genera by the combination of the following characters: Gills present on abdominal segments 1–7, with dorsal and ventral portions; gills 1 (Fig. 27) slender, lanceolate; gills 2–7 (Fig. 28) oval, with marginal fringes; lateral tips of hypopharynx superlinguae emarginated.

**Thraulus bishopi** Peter and Tsui (Figs. 25–28)

*Thraulus bishopi* Peter and Tsui, 1972: 8.

**Diagnosis.** The larvae of *Thraulus bishopi* can be distinguished from those of other congeners by the combination of the following characters: Labrum (Fig. 26) emarginated anteromedially, without denticles on anteromedian emargination; abdominal segments 8–9 (Fig. 25) with relatively short posterolateral projections.


**Distributions.** Malaysia, Vietnam.

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**REFERENCES**


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SUPPLEMENTAL NOTE

Correction and Addition to A Pictorial Key to the Mosquito Genera of the World, Including Subgenera of Aedes and Ochlerotatus (Diptera: Culicidae)

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Since A Pictorial Key to the Mosquito Genera of the World, including Subgenera of Aedes and Ochlerotatus (Huang, 2002) was published, an error has been discovered by Dr. Maria Anice Mureb Sallum. This supplement was prepared to correct the error and also to add the subgenus Pseudoskusea of genus Ochlerotatus which was not included in the key.

The format used in this supplement conforms to that used in the World key (Huang, 2002). Addition and correction to the key can conveniently be made by: (1) replacing Page 48b with new Page 48b, and (2) replacing Page 95 with new Page 95 and Page 95a.

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