



Descriptions of larvae of four species of *Hydropsyche* (Hydropsychidae: Trichoptera) from Thailand

TAENG ON PROMMI

Faculty of Liberal Arts and Science, Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom, 73140, THAILAND

E-mail mail: faastop@ku.ac.th

Abstract

Morphological characters of the larvae of four species in the genus *Hydropsyche* (*H. dolosa*, *H. brontes*, *H. napaea*, and *H. camillus*) are described and figured for the first time. The most important diagnostic features are illustrated, and some information regarding their distribution, biology, and habitat are included.

Key words: morphology, *Hydropsyche dolosa*, *Hydropsyche brontes*, *Hydropsyche camillus*, *Hydropsyche napaea*

Introduction

Species-level identification of aquatic insects is often required for ecological, evolutionary, or biomonitoring studies. Identification can be difficult because many formal descriptions are based only on adult males, which are often the most morphologically variant sex and life stage (Zhou *et al.* 2010). Caddisfly larvae (Trichoptera) are an important component of the benthic fauna in many streams and are routinely used in environmental assessments because of the relatively high sensitivity of most caddisfly species to environmental change. For many species, accurate identification of larvae requires the collection and study of the terrestrial adults and association of those identifiable adults with the yet-unidentifiable larvae.

The knowledge of taxonomy of Thai caddisflies has been confined mainly to descriptions of the adult stages (Malicky 2010). Presently, there are 998 described species of adult caddisflies in Thailand, including 30 described species of *Hydropsyche* adult males (Malicky 2010). There is no documentation of the larvae of *Hydropsyche* species. Previous data on larval stages of Hydropsychidae have been descriptions of larvae of *Pseudoleptonema quinquefasciatum* and *P. supalak* (Prommi *et al.* 2006a), *Potamyia phaidra* (Prommi *et al.* 2006b), *Amphipsyche gratiosa* and *A. meridiana* (Permvarunyoo and Prommi 2013), *Hydromanicus malayanus*, *H. abuid*, and *H. inferior* (Prommi and Permkam 2015).

Larvae of *Hydropsyche* have the typical characteristics of the family. *Hydropsyche* can be distinguished from other genera of the Hydropsychinae by a pair of large sclerites in the inter-segmental fold posterior to the prosternal plate, the frontoclypeus never has an anteromedian notch, and scale hairs and hair-like setae are present on the abdominal segments (Pescador & Rasmussen 1995). Herein, the final larval instar of four species of *Hydropsyche* (*H. dolosa* Banks 1939, *H. brontes* Malicky & Chantaramongkol 2000, *H. camillus* Malicky & Chantaramongkol 2000, and *H. napaea* Mey 1996) from Thailand are described and figured. Some notes on the biology, distribution and habitat of the species are provided.

Materials and methods

Hydropsyche larvae and pupae were collected by hand and aquatic net from moderately to fast-flowing water zones of the stream from a 100 m reach of each stream in the Phachi and Mae Klong watersheds, western Thailand. The specimens were preserved in 95% ethyl alcohol and brought back to the laboratory where they were sorted to morpho-species level.

The immature forms were associated with adults using the metamorphotype method, which relies on the collection of a pharate male within the pupal case or shelter (Milne 1938; Wiggins 1996). Terminology for morphological structures follows that of Wiggins (1996). Voucher specimens have been deposited in the Faculty of Liberal Arts and Science, Kasetsart University, Kamphaeng Saen Campus, Nakhon Pathom Province, Thailand.

Larval descriptions

Hydropsyche dolosa Banks 1939

(Figs. 1–9)

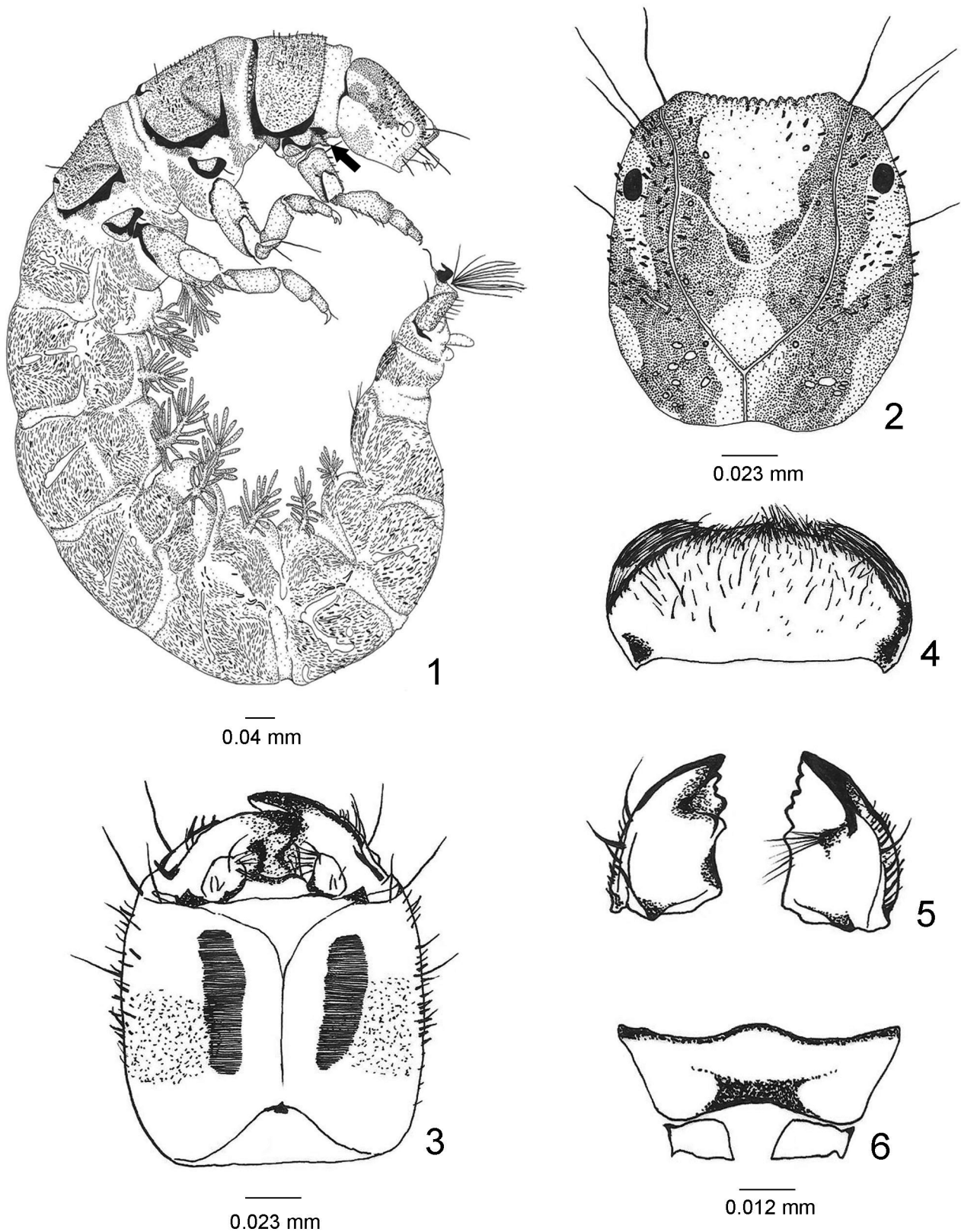
Larva: Total length 13.0–14.0 mm (n = 10). Overall body shape as usual in Hydropsychidae (Fig. 1). Head dark-brown with yellow stripe on midline appearing to be continuation of longitudinal stripe on thoracic plates.

Head: Head capsule length 1.19–1.33 mm; width, 1.02–1.05 mm (n = 10). Dorsum of head light-brown with yellow stripe on midline wider anteriorly (Fig. 2). Lateral portion of head with yellow band connecting yellow areas around eyes reaching toward back of head; light-brown muscle scars posteriorly near posterior areas of head. Frontoclypeus with anterior margin slightly concave, with pairs of setae #1, #2, and #3 extending beyond anterior margin (Fig. 2). Head ventrally with transverse stridulatory lines on either side of ventral midline, extending about 2/3rds of length of head capsule; light brown region lateral of stridulatory lines surrounded by yellow (Fig. 3). Labrum light brown, slightly convex posteriorly; bearing well-developed, lateral, golden brown, pectinate setae and stout setae on dorsal surface (Fig. 4). Mandibles golden brown, asymmetrical, right mandible with 1 apical and 3 mesal teeth, left mandible with 2 apical and 3 mesal teeth and with mesal tuft of hairs; lateral surfaces of mandibles with scattered, long, setae (Fig. 5). Submentum with shallow median cleft; maxillae with long, black setae and stout setae laterobasally (Fig. 3). Anterior ventral apotome broadly triangular, posterior ventral apotome minute, triangular (Fig. 3).

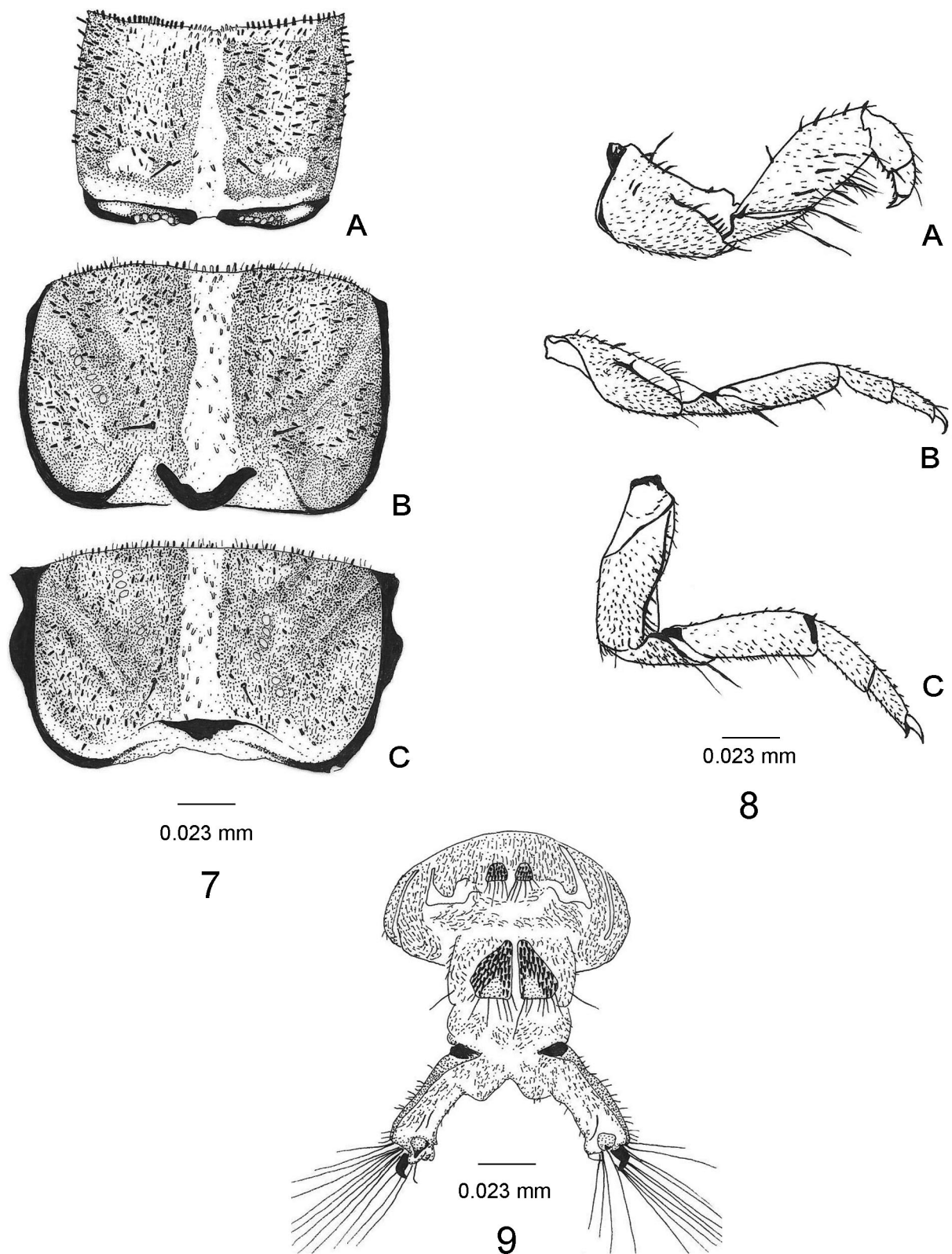
Thorax: Notum brown with very conspicuous yellow stripe on midline appearing to be continuation of longitudinal stripe on head. Notum covered with long, dark and clear, erect, truncate peg setae, intermixed with tapered setae on surface and anterior margin of each notum (Fig. 7). Prosternite light-brown, transverse, narrow, with broad dark band posteromesally; with pair of large, light brown, posterolateral sclerites (Fig. 6). Foretrochantin deeply forked (Fig. 1). Forelegs with feather-like setae on posterior surfaces of coxae; trochanters and femora with long feather-like setae on ventral surfaces and with long setae; tibiae and tarsi with stout setae (Fig. 8A). Mid- and hind legs similar in size, shape, and structure; with stout setae on posterior surfaces of femora; tibiae and tarsi with scattered setae in ventral margins (Figs. 8B, 8C). Mesosternum with one pair of single-stemmed gills and metasternum with 2 pairs of single-stemmed gills; gills bearing approximately 50 lateral filaments.

Abdomen: Abdominal segments densely covered with dark, hair-like setae and club-like hairs (Fig. 1). First sternum with 2 pairs of bifid-stemmed gills. Segments II–V each with one pair of median gills. Segments II–VII each with one pair of lateral gills arising from common base (Fig. 1). Sternum VIII with pair of half-moon sclerites (Fig. 9). Sternum IX with pair of spine-bearing plates, with spines emanating from prominent sockets. Tergum IX with small lateral sclerites (Fig. 9) and pair of large dorsal sclerites. Anal prolegs each with bent claw and cluster of long bristles, without spike-like setae on ventral surface.

Material examined. THAILAND: RATCHABURI Prov.: Huai Nueng stream from Phachi watershed, 140 m. 13°32.135'N, 099°17.842'E, 26-x-2013, Prommi, 80 larvae, 10 pupae, 5 male pupae, 5 male adults; Huai See stream from Phachi watershed, 170 m. 13°34.078'N, 099°15.495'E, 4-xii-2013, Prommi, 27 larvae, 5 male adults; Huai Phark from Phachi watershed, 183 m. 13°30.241'N, 099°15.889'E, 5-xii-2013, Prommi, 10 larvae, 3 pupae; Phachi Nueng stream from Phachi watershed, 160 m. 13°48.379'N, 099°19.152'E, 5-xii-2013, Prommi, 40 larvae, 6 male pupae, 5 male adults; Phachi Song stream from Phachi watershed, 155 m. 13°31.017'N, 099°27.449'E, 5-xii-2013, Prommi, 32 larvae; Phachi Sarm stream from Phachi watershed, 123 m. 13°34.275'N, 099°21.778'E, 5-xii-2013, Prommi, 42 larvae, 3 male pupae, 2 male adults; KANCHANABURI Prov.: Huai Kayeng, 244 m. 14°36.224'N, 098°34.822'E, 6-xii-2014, Prommi, 43 larvae, 8 male pupae, 7 male adults; Huai Lin Thin, 116 m. 14°34.445'N, 098°50.039'E, 8-xii-2014, Prommi, 9 larvae, 1 male pupa.



FIGURES 1–6. Larva of *Hydropsyche dolosa* Banks 1939: 1, larval habitus, right lateral; 2, head, dorsal; 3, head, ventral; 4, labrum, dorsal; 5, mandibles, ventral; 6, prothorax, ventral.



FIGURES 7–9. Larva of *Hydropsyche dolosa* Banks 1939: 7A, pronotum, dorsal; 7B, mesonotum, dorsal; 7C, metanotum, dorsal; 8A, right foreleg, right posterolateral; 8B, right midleg, right posterolateral; 8C, right hind leg, right posterolateral; 9, sterna VIII and IX and anal prolegs, ventral.

***Hydropsyche brontes* Malicky & Chantaramongkol 2000**

(Figs. 10–18)

Larva: Total length 10.0–11.0 mm (n = 10). Overall body shape as usual in Hydropsychidae (Fig. 10). Head yellow to dark-brown, with dark muscle scars in posterior 1/5th. Nota light-brown, each with posterolateral muscle scars.

Head: Head capsule length 1.02–1.05 mm; width, 0.85–0.94 mm. Dorsum of head dark-brown with two distinct yellow marks on frontoclypeus; T-shaped mark anteriorly and circular mark posteriorly (Fig. 11). Area around each eye and posterior 1/5th of head yellow with dark muscle scars (Fig. 11). Frontoclypeus with anterior margin convex, slightly crenulate, with pairs of setae #1, #2, and #3 extending beyond anterior margin (Fig. 11). Head with moderately long, erect, acuminate peg setae; with brush of setae, tapered setae on dorsal and lateral regions in anterior 3/4ths. Frontoclypeus devoid of acuminate peg setae and tapered setae (Fig. 11). Head ventrally dark-brown with transverse stridulatory lines arranged on either side of median suture about 3/4ths length of head capsule (Fig. 12). Labrum brown; elliptical in dorsal view; bearing well-developed, lateral, golden yellow, pectinate setae and stout setae on dorsal surface (Fig. 13). Mandibles dark-brown, asymmetrical, right mandible with 1 apical and 2 mesal teeth, left mandible with 2 apical and 3 mesal teeth and with well-developed mesal brush of setae (Fig. 14); lateral surfaces of both mandibles with scattered setae (not shown). Submentum light-brown, with deep anteromesal cleft, anterior margins on either side of cleft with long setae. Anterior ventral apotome broadly triangular, posterior ventral apotome small, triangular (Fig. 12).

Thorax: Nota brown, with posterolateral muscle scars darker. Pronotum with numerous, erect, acuminate peg setae and long, appressed scale hairs; dark muscle scars midway between midline and lateral margin in posterior half (Fig. 16). Meso- and metanota with numerous, long, appressed scale hairs and scattered, erect, acuminate peg setae; posterolateral margins of meso- and metanota each with dark muscle scars (Fig. 16). Prosternite brown, transverse, narrow, with broad dark band along posterior margin and with pair of large, paler, posterolateral sclerites (Fig. 15). Foretrochantin deeply forked (Fig. 10). Forelegs with numerous feather-like setae on posterior surfaces of coxae; trochanters with long, feather-like setae in ventral margins; femora each with row of long, dark, spike-like setae on ventral margin and few, short, dark, setae on external surface (Fig. 17A). Mid- and hind legs similar in size, shape, and structure; with feather-like setae on posterior surfaces of femora (Fig. 17B, 17C). Mesosternum with one pair of single-stemmed gills and metasternum with 2 pairs of single-stemmed gills; gills bearing approximately 28 lateral filaments.

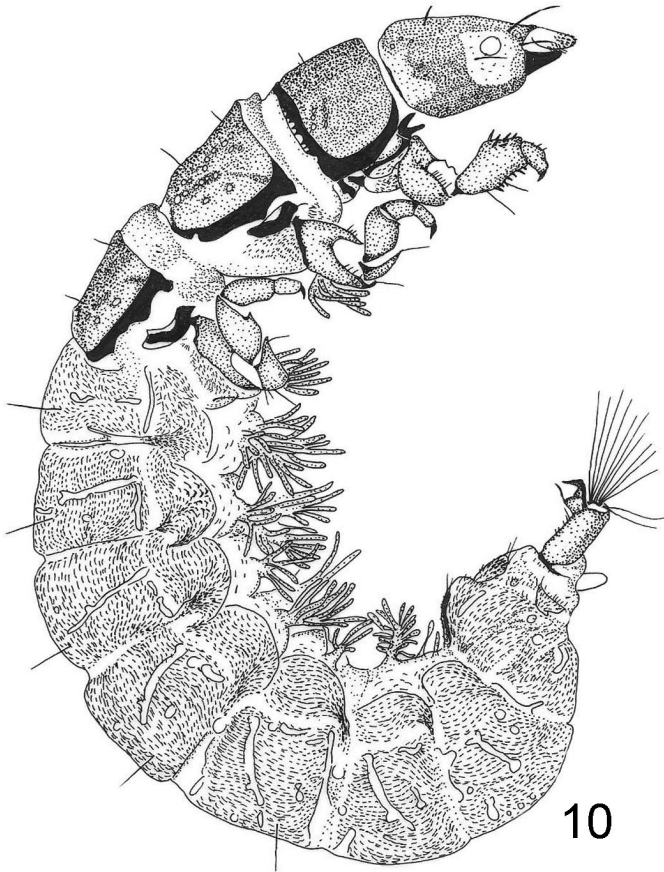
Abdomen: Abdominal segments densely covered dorsally and laterally with dark, recumbent setae (Fig. 10). Sternum I with 2 pairs of bifid-stemmed gills. Segments II–V each with one pair of median gills. Segments II–VII each with one pair of lateral gills, each arising from common base. Sternum VIII with pair of small, subtriangular sclerites bearing spike-like setae. Sternum IX with pair of large, triangular sclerites bearing spike-like setae emanating from prominent sockets. Tergum IX with small lateral sclerites (Fig. 18) and pair of large dorsal sclerites. Anal prolegs each with bent claw and cluster of long bristles. Venter of each anal proleg with spike-like setae on caudal lobes; outer sclerites with same setae (Fig. 18).

Material examined: THAILAND: RATCHABURI Prov.: Huai Nueng stream from Phachi watershed, 140 m. 13°32.135' N, 099°17.842' E, 27-xii-2014, 14 larvae, 3 male pupae; Huai See stream from Phachi watershed, 170 m. 13°34.078' N, 099°15.495' E, 27-xii-2014, 127 larvae, 20 pupae, 5 male adults; Huai Phark from Phachi watershed, 183 m. 13°30.241' N, 099°15.889' E, 19-xii-2014, 26 larvae, 5 male pupae; Phachi Sarm stream from Phachi watershed, 123 m. 13°34.275' N, 099°21.778' E, 12-xii-2014, 12 larvae; Huai Namnak, 219 m. 13°22.563' N, 099°16.585' E, 10-v-2014, 27 larvae, 3 male pupae KANCHANABURI Pro.: Huai Kayeng, 244 m. 14°36.224' N, 098°34.822' E, 11-iv-2015, 98 larvae, 12 male pupae, 3 male adults; Huai Pakkok, 246 m. 14°39.518' N, 098°32.237' E, 12-iv-2015, 119 larvae, 16 male pupae, 2 male adults. All material leg. Prommi.

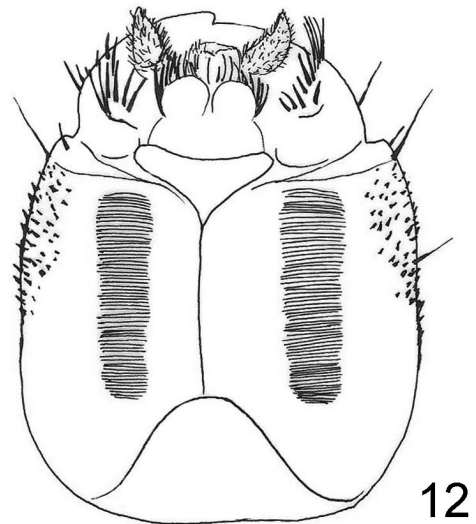
***Hydropsyche camillus* Malicky & Chantaramongkol 2000**

(Figs. 19–27)

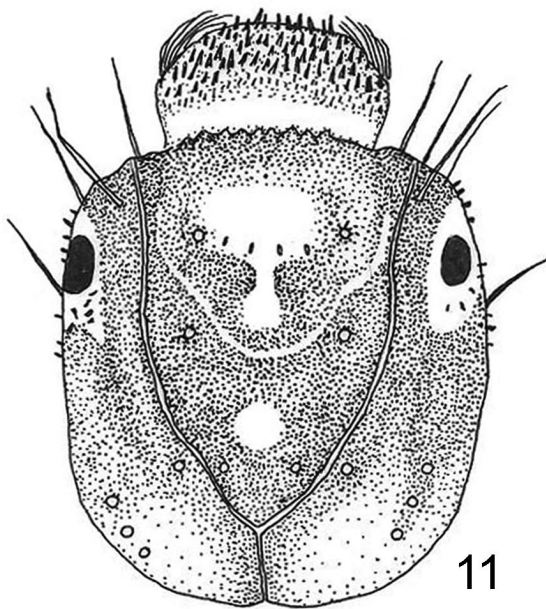
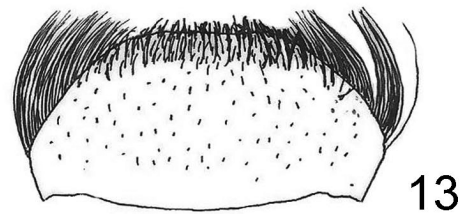
Larva: Total length 10.0–11.0 mm (n = 10). Overall body shape as usual in Hydropsychidae (Fig. 19). Head yellow to dark brown, with dark muscle scars in posterior 1/5th. Nota light brown, each with posterolateral muscle scars.



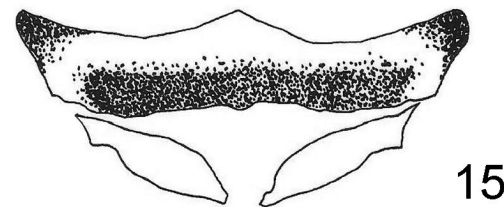
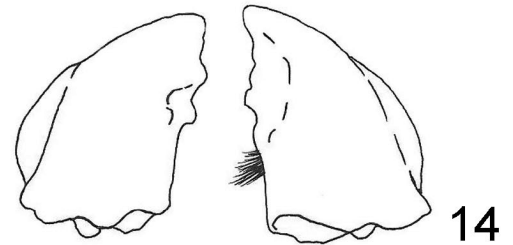
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0.023 mm

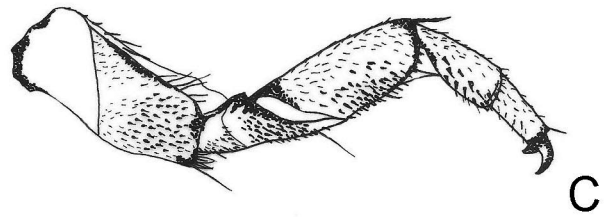
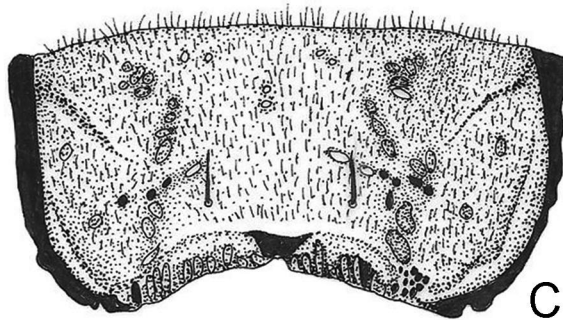
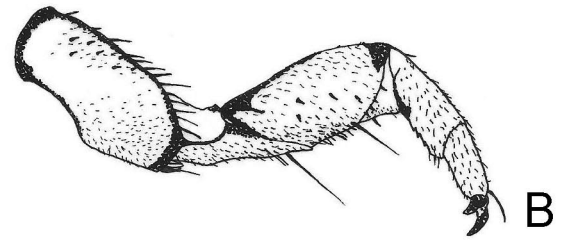
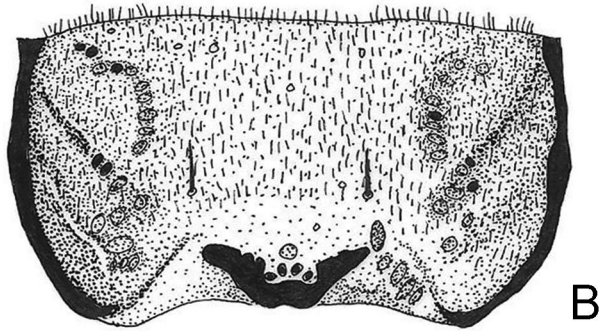
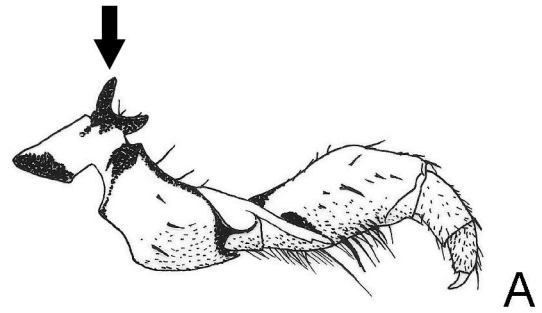
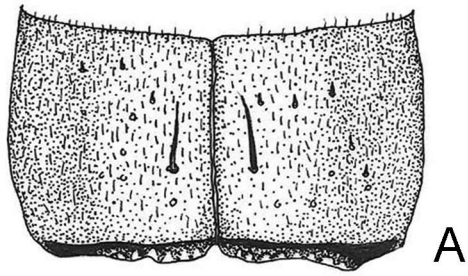


0.023 mm



0.012 mm

FIGURES 10–15. Larva of *Hydropsyche brontes* Malicky & Chantaramongkol 2000: 10, larval habitus, right lateral; 11, head, dorsal; 12, head, ventral; 13, labrum, dorsal; 14, mandibles, ventral; 15, prosternum, ventral.

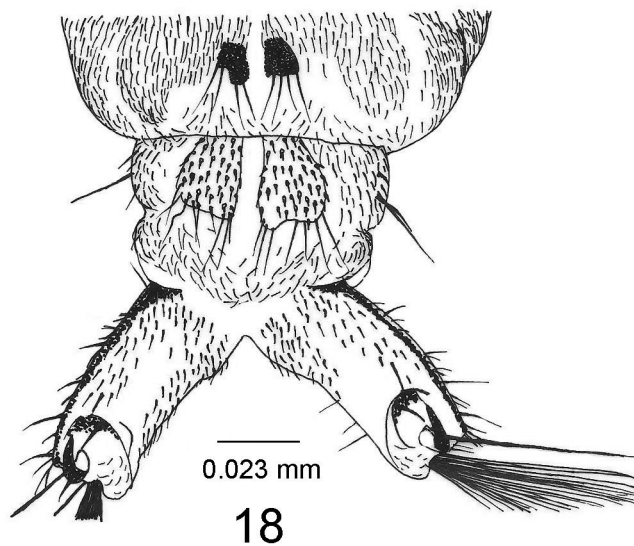


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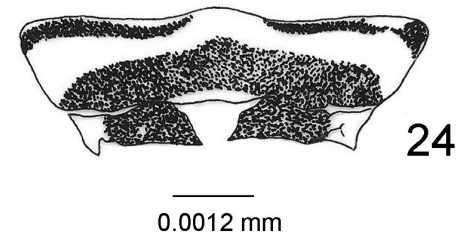
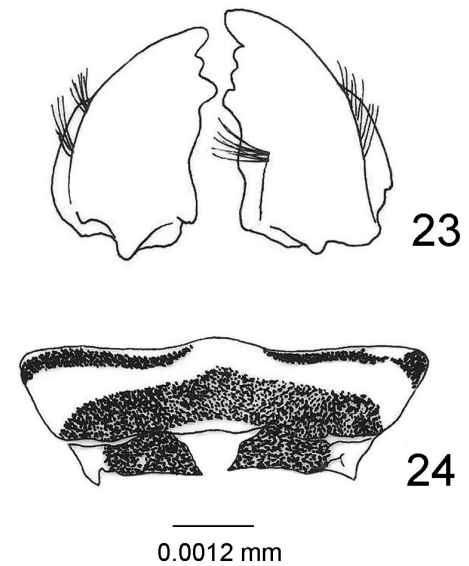
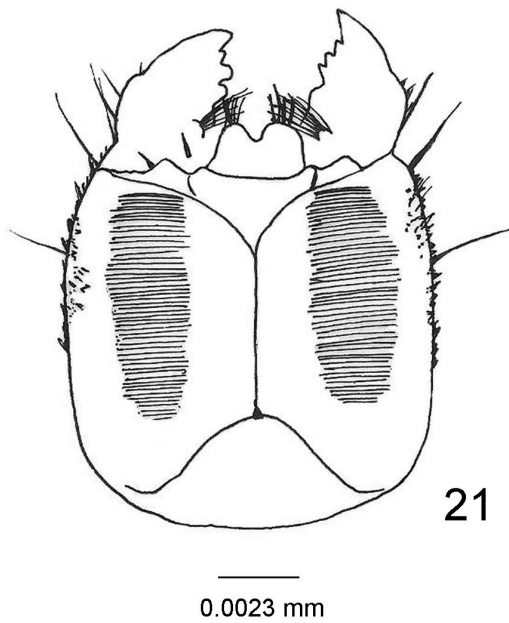
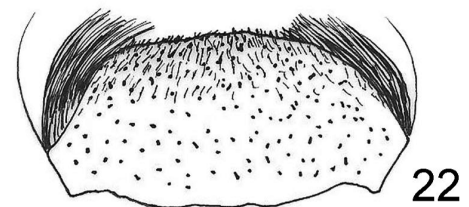
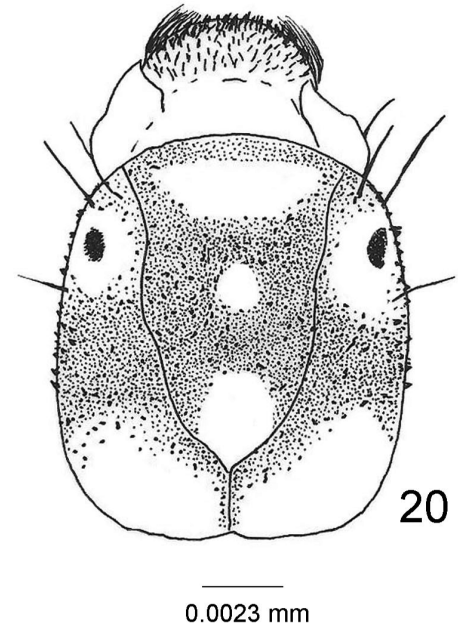
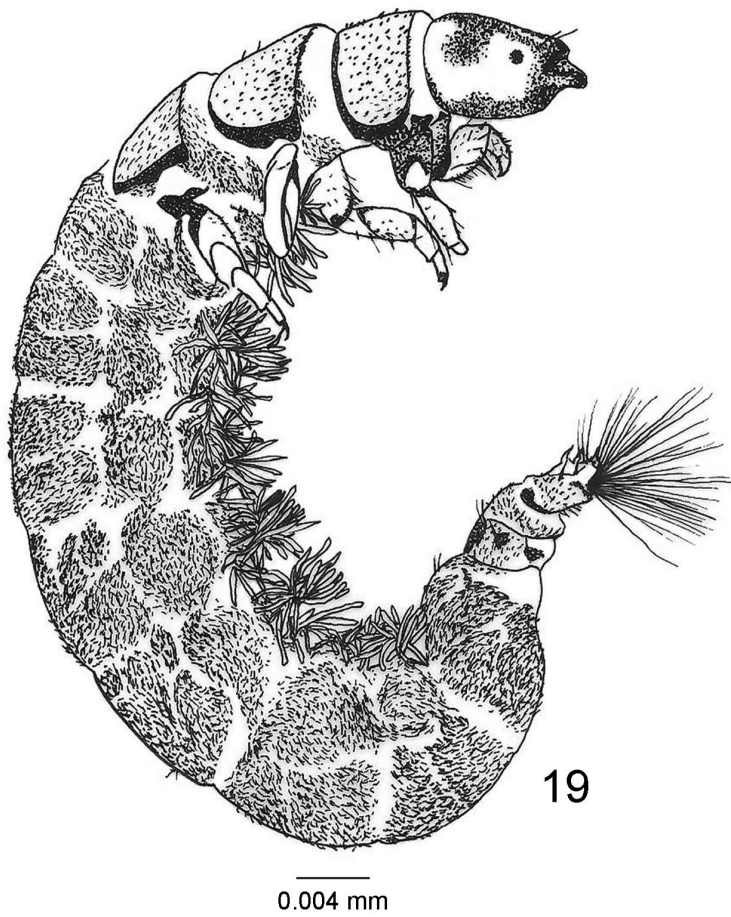
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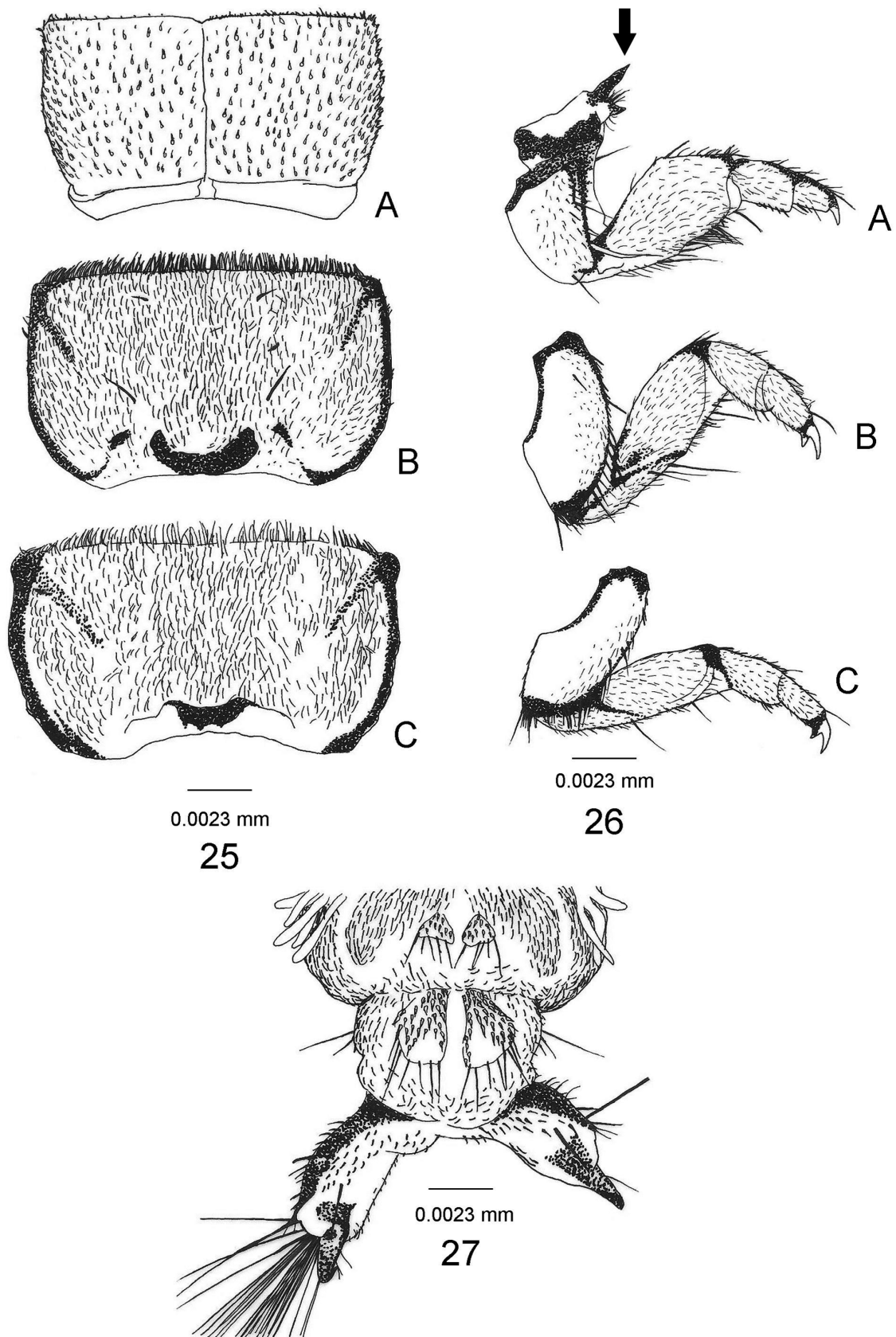
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FIGURES 16–18. Larva of *Hydropsyche brontes* Malicky & Chantaramongkol 2000: 16A, pronotum, dorsal; 16B, mesonotum, dorsal; 16C, metanotum, dorsal; 17A, right pleuron, foretrochantin (arrow), and foreleg, right posterolateral; 7B, right midleg, right posterolateral; 17C, right hind leg, right posterolateral; 18, sterna VIII and IX and anal prolegs, ventral.



FIGURES 19–24. Larva of *Hydropsyche camillus* Malicky & Chantaramongkol 2000: 19, larval habitus, right lateral; 20, head, dorsal; 21, head, ventral; 22, labrum, dorsal; 23, mandibles, ventral; 24, prosternum, ventral.



FIGURES 25–27. Larva of *Hydropsyche camillus* Malicky & Chantaramoongkol 2000: 25A, pronotum, dorsal; 25B, mesonotum, dorsal; 25C, metanotum, dorsal; 26A, right pleuron, foretrochantin (arrow), and foreleg, right posterolateral; 26B, right midleg, right posterolateral; 26C, right hind leg, right posterolateral; 27, sterna VIII and IX and anal prolegs, ventral.

Head: Head capsule length 1.02–1.05 mm; width, 0.85–0.94 mm. Dorsum of head dark brown, with two or three distinct yellow marks on frontoclypeus: T-shaped mark anteriorly and circular mark posteriorly or transverse band anteriorly, small spot in middle, and circular mark posteriorly (Fig. 20). Frontoclypeus with anterior margin strongly convex, with setae #1, #2, and #3 extending beyond anterior margin (Fig. 20). Head with moderately long, erect, truncate peg setae; with tapered setae on dorsal and lateral regions of anterior 3/4ths. Frontoclypeus with few setae or no brush of setae; with truncate peg setae anterolaterally (Fig. 20). Head ventrally dark-brown with stridulatory lines in anterior 3/4ths (Fig. 21). Labrum light-brown; elliptical in dorsal view; bearing well-developed, lateral, golden-yellow pectinate setae and stout setae on dorsal surface (Fig. 22). Mandibles dark-brown, right mandible with 2 apical and 2 mesal teeth, left mandible with 2 apical and 3 mesal teeth and well-developed mesal setal brush (Fig. 23). Submentum light-brown, with deep anteromesal cleft, anterior margins on either side of cleft with long setae. Anterior ventral apotome broadly triangular, posterior ventral apotome small, triangular (Fig. 21).

Thorax: Nota brown with darker muscle scars laterally. Pronotum with numerous, erect, truncate peg setae and long, tapered setae (Fig. 25A). Meso- and metanota with numerous scale hairs and with scattered truncate peg setae (Figs. 25B, 25C). Prosternite brown, transverse, narrow, with broad dark transverse band along posterior margin and pair of fine dark transverse bands anterolaterally; with pair of large posterolateral sclerites brown on mesal 2/3rds and pale laterally (Fig. 24). Foretrochantin deeply forked (Fig. 26A). Forelegs each with numerous feather-like setae on posterior surface of coxa; trochanter with long, feather-like setae on ventral margin; femur with row of long, dark, spike-like setae, mingled with feather-like setae on ventral margin and few, short, dark, setae on external surface (Fig. 26A). Mid- and hind legs similar in size, shape, and structure, each with feather-like setae on posterior surface of femur (Fig. 26B, 26C). Mesosternum with one pair of single-stemmed gills and metasternum with 2 pairs of single-stemmed gills; gills each bearing approximately 22 lateral filaments.

Abdomen: Abdominal segments densely covered with dark, club-like hairs (Fig. 19). Sternum I with 2 pairs of bifid-stemmed gills. Segments II–V each with one pair of median gills. Segments II–VII each with one pair of lateral gills each arising from common base (Fig. 19). Sternum VIII with pair of small, triangular sclerites bearing spike-like setae. Sternum IX with pair of large, triangular sclerites bearing spike-like setae emanating from prominent sockets. Tergum IX with small lateral sclerites (Fig. 27) and pair of large dorsal sclerites. Anal prolegs each with bent claw and cluster of long bristles, spike-like setae present on dorsal and ventral surfaces (Fig. 27).

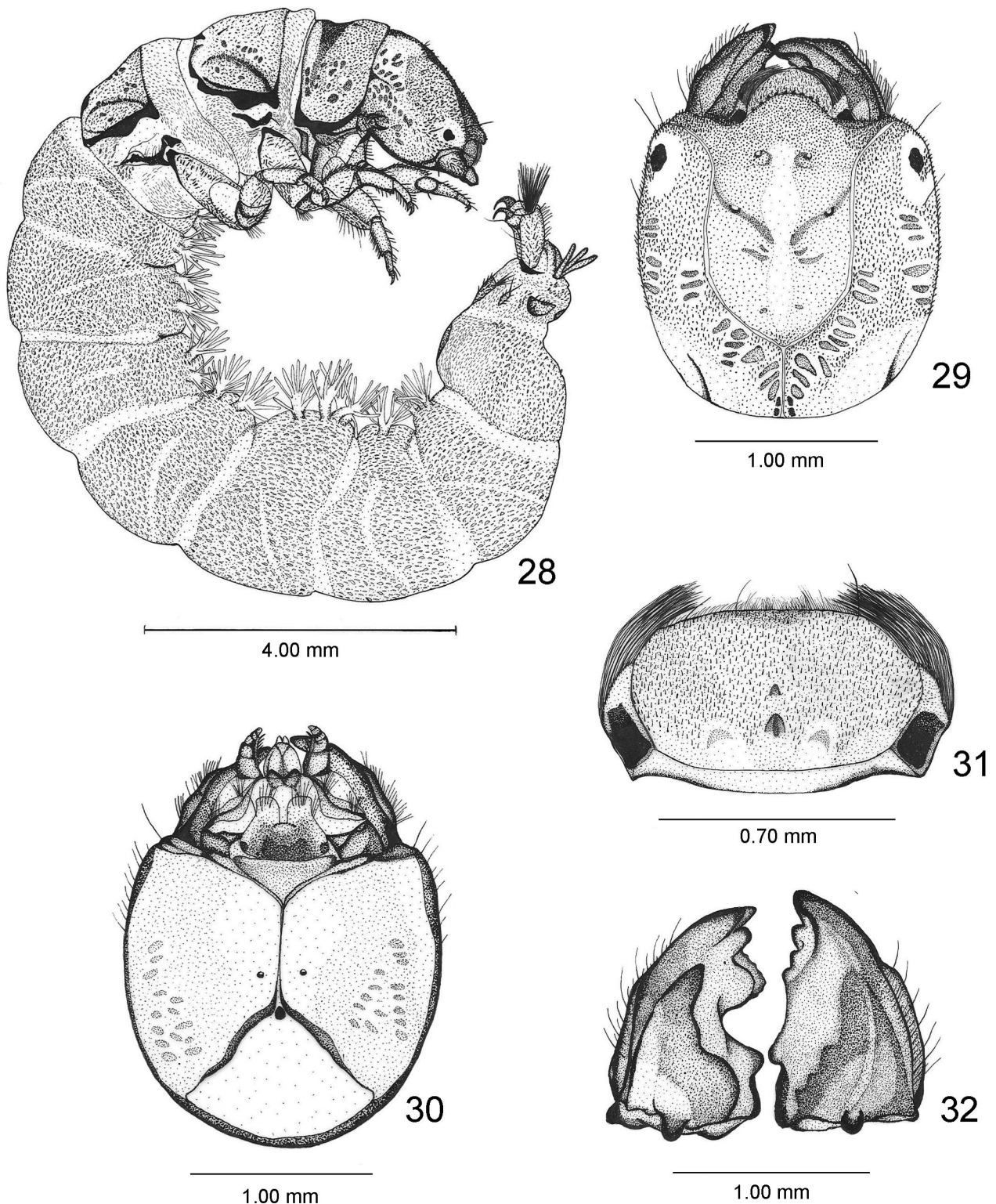
Material examined: THAILAND: KANCHANABURI Prov.: Huai Kayeng, 244 m. 14°36.224' N, 098°34.822' E, 6-xii-2014, 126 larvae, 8 male pupae, 27 male adults; Huai Lin Thin, 116 m. 14°34.445' N, 098°50.039' E, 8-xii-2014, 9 larvae, 4 pupae; Huai Pakkok, 246 m. 14°39.518' N, 098°32.237' E, 12-iv-2015, 195 larvae, 16 male pupae; Huai U-Long, 191 m. 14°47.126' N, 098°40.589' E, 12-iv-2015, 92 larvae, 6 male pupae, 12 male adults. All material leg. Prommi.

Hydropsyche napaea Mey 1996

(Figs. 28–34)

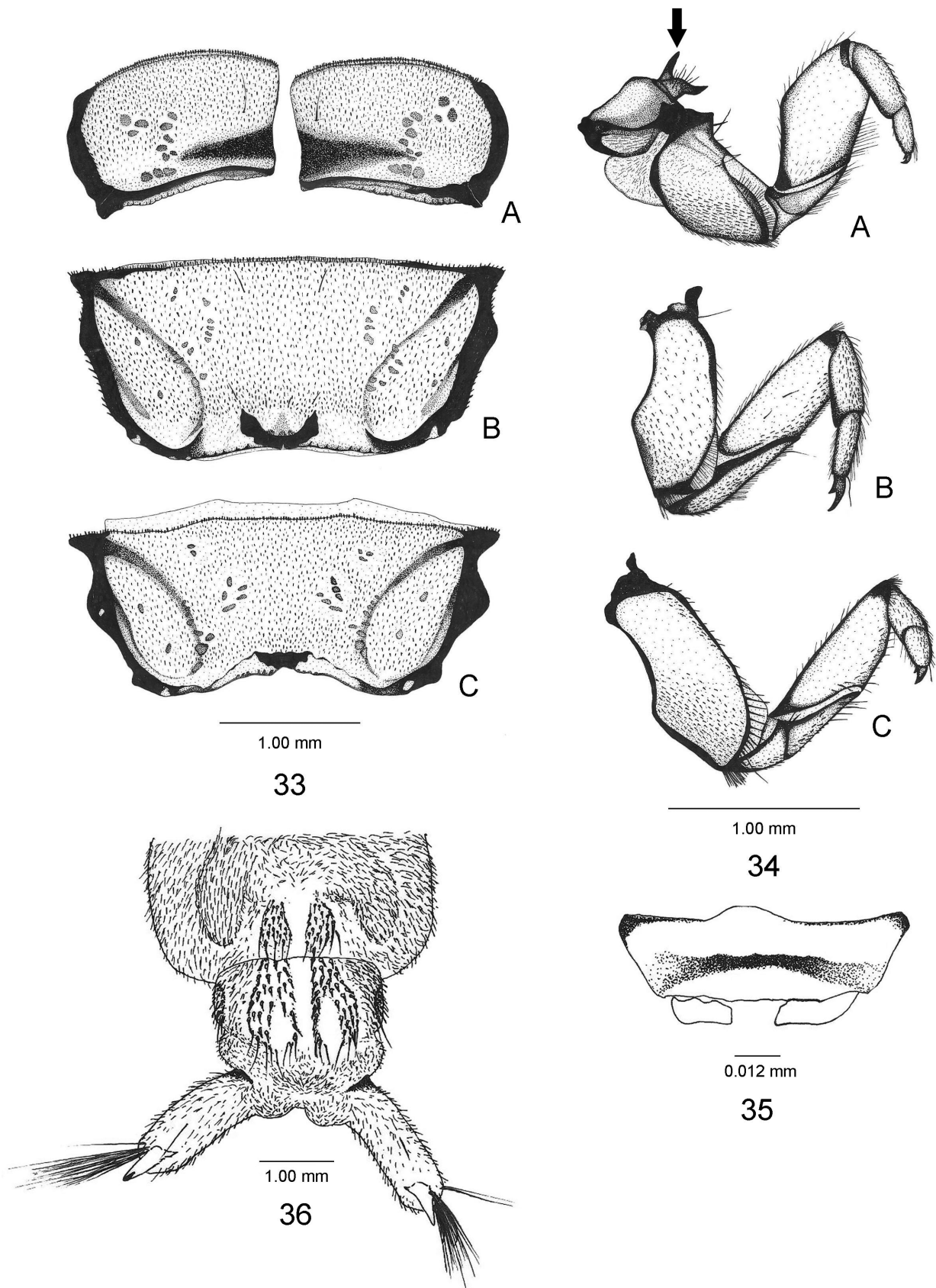
Larva: Total length 16.0–16.5 mm (n = 10). Overall, body shape as usual in Hydropsychidae (Fig. 28). Head and notal sclerites brown to dark brown.

Head: Head capsule length, 1.22–1.26 mm; width, 1.20–1.22 mm. Dorsum of head dark brown with yellow stripe on midline (Fig. 29). Areas around eyes light brown, muscle scars below eyes (Fig. 29). Dorsal and lateral portions of head covered with long, black, truncate peg setae and with tapered setae in anterior 3/4ths (Fig. 29). Frontoclypeus with anterior margin strongly convex medially, with yellow stripe on midline (Fig. 29). Frontoclypeus covered uniformly with truncate peg setae and tapered setae. Ventral surface of head brownish, posterolaterally with group of muscle scars (Fig. 30). Labrum brown; apically rounded in dorsal view; bearing well-developed, golden brown, pectinate, lateral setae and long, stout, dark, dorsal setae (Fig. 31). Mandibles dark brown, asymmetrical: left mandible with 2 apical teeth and 3 mesal teeth, right mandible with 2 apical teeth and 3 mesal teeth and with deep excision between middle and basal mesal teeth, outer surfaces of both mandibles with scattered setae (Fig. 32). Submentum brown, with deep anteromesal cleft, anterior margins on either side of cleft with long setae (Fig. 30). Anterior ventral apotome broadly triangular; posterior ventral apotome small, oval (Fig. 30).



FIGURES 28–32. Larva of *Hydropsyche napaea* Mey 1996: 28, larval habitus, right lateral; 29, head, dorsal; 30, head, ventral; 31, labrum, dorsal; 32, mandibles, ventral.

Thorax: Nota dark brown (Fig. 33) covered with setae similar to those on dorsum of head. Prosternite brown, transverse, narrow, with dark band centrally; with pair of large, posterolateral sclerites (Fig. 35). Foretrochantin deeply forked (Figs. 28, 34A). Forelegs stouter than other legs, each with femur widened dorsally in middle and with long setae on ventral margin (Fig. 34A). Mid- and hind legs similar in size, shape, and structure; with dense setae on mesal surfaces of coxae through tarsi (Figs. 34A, 34B). Mesosternum with one pair of single-stemmed gills and metasternum with 2 pairs of single-stemmed gills; gills each bearing approximately 58 lateral filaments.



FIGURES 33–36. Larva of *Hydropsyche napaea* Malicky & Chantaramonngkol 2000: 33A, pronotum, dorsal; 33B, mesonotum, dorsal; 33C, metanotum, dorsal; 34A, right pleuron, foretrochantin (arrow), and foreleg, right posterolateral; 34B, right midleg, right posterolateral; 34C, right hind leg, right posterolateral; 35, prosternum, ventral; 36, Sterna VIII and IX and anal prolegs, ventral.

Abdomen: Abdominal segments with dense brown, scale hair setae in various sizes (Fig. 28). Sternum I with 2 pairs of bifid-stemmed gills. Segments II–V each with one pair of median gills. Segments II–VII each with one pair of lateral gills arising from common base (Fig. 28). Sternum VIII with pair of small, triangular sclerites bearing spike-like setae. Sternum IX with pair of large, triangular sclerites. Tergum IX with small lateral sclerites (Fig. 36) and pair of large dorsal sclerites. Anal prolegs each with bent claw, spike-like setae present on dorsal and ventral surfaces (Fig. 36).

Material examined: THAILAND: KANCHANABURI Prov.: Huai U-Long, 191 m. 14°47.126' N, 098°40.589' E, 12-iv-2015, 10 larvae, 2 male pupae, 2 male adults, leg. Prommi; CHIANG MAI Prov.: Huai Sai Lueng waterfall, 1060 m. 18°31' N, 098°27' E, 2-xii-2002, 5 larvae, 1 male adult, leg. Thamsenanupap; same locality, 2-ii-2003, 6 larvae, 1 male pupae, 8 male adults, leg. Thamsenanupap; same locality, 2-iv-2003, 10 larvae, 1 male adult, leg. Thamsenanupap; Mae Pan stream, 750 m. 18°31' N, 098°25' E, 31-i-2002, 3 larvae, 1 male adult, leg. Thamsenanupap; same locality, 12-viii-2002, 16 larvae, 2 male pupae, 13 male adults, leg. Thamsenanupap; same locality, 15-xi-2002, 12 larvae, 2 male pupae, 17 male adults, leg. Thamsenanupap; same locality, 22-ii-2003, 8 larvae, 13 male adults, leg. Thamsenanupap; same locality, 1-iv-2003, 18 larvae, 3 male pupae, 9 male adults, leg. Thamsenanupap.

Discussion

Larval morphology of Thai *Hydropsyche*. The four larvae described in the present paper bear morphological characters common to species of *Hydropsyche*, such as a pair of large sclerites in the intersegmental fold posterior to the prosternal plate, absence of an anteromedial notch on the frontoclypeus, and scale hairs and hair-like setae present on abdominal segments (Pescador & Rasmussen 1995).

The final larval instar of *H. dolosa* is easily and quickly recognized by the very conspicuous longitudinal yellow stripe in the midline extending the length of the head through the thoracic nota. However, this larva may be distinguished also from the other 3 Thai *Hydropsyche* species by the following characteristics: First, many long, dark, truncate peg setae are present on the genae but the frontoclypeus is lacking these setae except that they are scattered along the anterolateral margins. Second, heavy dark and clear, long, truncate peg setae cover the nota. Finally, the median cleft of the submentum is shallow on the anterior margin.

The final larval instar of *H. brontes* may be recognized by the following combination of characteristics: Yellowish dark brown coloration and two distinct yellow marks occur on the frontoclypeus, as in *H. camillus* and some other species. *Hydropsyche brontes* may be distinguished from them in that (1) the frontoclypeus is large and its lateral margins are strongly broadened at mid-length, with a brush of many setae and few or no acuminate peg setae and tapered setae scattered on the surface; (2) many truncate peg setae and tapered setae are present on the pronotum; and (3) heavy scale hairs and sparse acuminate peg setae are present on the meso- and metanota.

The final larval instar of *H. camillus* may be separated on the basis of the following characteristics: (1) the frontoclypeus is triangular and its lateral margins are slightly broadened at mid-length, with a few setae or no brush of setae present on the surface and with a few truncate peg setae present on the anterior and lateral surfaces of the frontoclypeus; (2) the pronotum is covered with many truncate peg setae and tapered setae; and (3) many scale hairs and sparse truncate peg setae are present on the meso- and metanota.

The final larval instar of *H. napaea* may be distinguished by the following characteristics: (1) the frontoclypeal apotome is strongly indented laterally and the middle of the anterior margin is strongly convex with a yellow stripe on the midline; (2) a group of muscle scars is present on dorsal and ventral surfaces of each side of the head posterolaterally; and (3) the submentum is deeply cleft anteromesally.

All of these the *Hydromanicus* species characteristics are summarized in Table 1.

Distribution, biology and habitat of *Hydropsyche dolosa*, *H. brontes*, *H. camillus*, and *H. napaea*. The specimens were collected in small and medium sized streams from a second to third order section river in the Mae Klong watershed, in western Thailand at altitudes between 116 m and 246 m a.s.l. The stream water quality was clean. The stream depth was 0.24–0.87 m, stream width ranged 5.7–25.32 m. The water flow in this stream ranged 2.11–3.94 m/sec. The water temperature ranged 23.89–30.84°C, pH ranged 8.05–8.77, dissolved oxygen ranged 6.40–8.46 mg/L, total dissolved solids ranged 35.87–179.00 mg/L, electrical conductivity ranged 68.98–360.55 µS/cm, nitrate-nitrogen ranged 0.92–2.96 mg/L, ammonia-nitrogen ranged 0.11–0.48 mg/L, orthophosphate ranged

TABLE 1. Summary of characteristics of full-grown larvae of Thai *Hydropsyche* species.

Species	Head			Thoracic nota		Abdominal terga
	Color	Frontoclypeus anterior margin	Setation	Color	Setation	Setation
<i>H. brontes</i>	Dorsum dark-brown with two distinct yellow marks on frontoclypeus: T-shaped mark anteriorly and circular mark posteriorly.	Convex, slightly crenulate.	Dorsum with moderately long, erect, acuminate peg setae; with brush of tapered setae on dorsal and lateral regions in anterior 3/4ths. Frontoclypeus devoid of acuminate peg setae and tapered setae.	Brown, with posterolateral muscle scars darker	Pronotum with numerous, erect, acuminate peg setae and long, appressed scale hairs. Meso- and metanota with numerous, long, appressed scale hairs and scattered, erect, acuminate peg setae.	Dark, recumbent setae.
<i>H. camillus</i>	Dorsum dark brown, with two or three distinct yellow marks on frontoclypeus: T-shaped mark anteriorly and circular mark posteriorly OR transverse band anteriorly, small spot in middle, and circular mark posteriorly.	Strongly convex.	Head with long, erect, truncate peg setae; with tapered setae on dorsal and lateral regions of anterior 3/4ths. Frontoclypeus with few setae or no brush of setae; with truncate peg setae anterolaterally.	Brown with darker muscle scars laterally	Pronotum with erect, truncate peg setae and long, tapered setae. Meso- and metanota with scale hairs and with scattered truncate peg setae.	Dark, club-like hairs.
<i>H. dolosa</i>	Dorsum light-brown with yellow stripe on midline wider anteriorly. Lateral portions each with yellow area around eye extended toward back of head.	Slightly concave.	Head anterior 3/4ths dorsolaterally and frontoclypeus anterolaterally covered with scattered moderately long, black, erect, truncate peg setae, with appressed hair-like setae.	Brown with yellow stripe on midline, continuation of longitudinal stripe on head.	All nota covered with long, dark and clear, erect, truncate peg setae, intermixed with tapered setae on surface and anterior margin of each notum.	Hair-like setae and club-like hairs.
<i>H. napaea</i>	Dorsum (including frontoclypeus) dark brown with yellow stripe on midline.	Strongly convex medially.	Dorsolateral portions of head covered with long, black, truncate peg setae and with tapered setae. Frontoclypeus covered with truncate peg setae and tapered setae.	Dark brown	All nota covered with truncate peg setae and with tapered setae.	Dense, scale hair setae in various sizes.

0.32–1.31 mg/L, and water turbidity ranged 4.11–31.7 NTU (Maneechan & Prommi 2015). The stream substrate consisted of boulders, cobbles, pebbles, and gravel. The larvae were found under rocks in rapid current zones. They each constructed a typical hydropsychid fixed tubular retreat with a silken filter net at the entrance, in which larvae capture small food items. Gut content analysis indicated that the larvae are omnivorous filterers (Deemool & Prommi 2015). Pupae were found abundantly in more slowly flowing waters, with shelters firmly attached to rocks. Based on collecting data of the studied material, all four *Hydropsyche* species are found in various larval and adult stages all year round. The four *Hydropsyche* species are well distributed in western and southern Thailand (Prommi 2007; Prommi 2015).

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