



## A new species and first stage associations in *Crinitella* (Ephemeroptera: Ephemerellidae: Ephemerellinae)

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### Abstract

The alates of *Crinitella coheri* (Allen and Edmunds) are described for the first time, and morphological variability of the species is discussed. Male adults have penes with dorsal projections at the base of the gonopores and forceps with a relatively straight lateral profile. *Crinitella coheri* female alates and associated eggs have been misidentified as those of a *Hyrtanella* species. *Crinitella coheri* is reported from Vietnam for the first time. We describe *C. lacuna*, new species, based on male and female subimagos and larvae, and the species is included in *Crinitella* on the basis of genitalia morphology. Alates of *C. lacuna* are distinguished from *C. coheri* by the presence of a prominent dorsal longitudinal stripe, and larvae are distinguished by having paired median spines on abdominal terga, mouthparts that are not greatly reduced, and gills 3 that are relatively larger than those of *C. coheri*. *Crinitella lacuna* is reported from India, Thailand and Vietnam. The structures of *Crinitella* and *Hyrtanella* gill cavities are different and do not represent a synapomorphy for the two genera.

**Key words:** Ephemeroptera, Ephemerellidae, *Crinitella coheri*, *Crinitella lacuna*, new species, descriptions, Oriental

### Introduction

*Crinitella* Allen and Edmunds (Ephemeroptera: Ephemerellidae) was described originally as a subgenus of *Ephemerella* Walsh (Allen and Edmunds 1963), but Allen (1980) later elevated it to generic status. McCafferty and Wang (2000) included *Crinitella* in the subfamily Ephemerellinae of Ephemerellidae, and Jacobus and McCafferty (2003b) revised the genus such that it included one species, *C. coheri* (Allen and Edmunds), which was known only from the larval stage.

Subsequent examination of recently collected Oriental specimens led to the discovery of the winged stages of *C. coheri* and additional material that very closely resembles *C. coheri* in the alate stages. After examination of more material, the larva associated with the latter alate stages was discovered and found to be a new species.

Data associated with the new species and the previously unknown stages of *C. coheri* are of immediate practical importance to those seeking to establish biomonitoring protocols for aquatic habitats in the Oriental Region (RWS; J. Morse, personal communication; see also discussion by Jacobus and McCafferty, 2006). Furthermore, these data are important for recognizing Ephemerellinae species groups and their relationships (Jacobus and McCafferty, in progress). Thus, we provide here the first descriptions of *C. coheri* alates and describe a new species based on alates and larvae. The new species is included in *Crinitella* provisionally, based on the striking similarity of its alates to those of *C. coheri*. In light of Kluge's (2004) observations about

putative larval synapomorphies of *Crinitella* and *Hyrtanella* Allen and Edmunds, we discuss the gill cavity structures of these two taxa.

## Materials and methods

Material examined is deposited at Florida A & M University, Tallahassee, Florida, USA [FAMU]; Iowa State University, Ames, Iowa, USA [ISUI]; Purdue University Entomological Research Collection, West Lafayette, Indiana, USA [PERC]; Royal Ontario Museum, Toronto, Ontario, Canada [ROME]; and Enns Entomology Museum, University of Missouri, Columbia, Missouri, USA [UMRM]. Certain material currently housed at ISUI and UMRM will be deposited with: Entomology Collection, Kasetsart University, Bangkok, Thailand; and Royal Forestry Department, Thailand. Some of the material examined as part of this study was collected in conjunction with a survey of Thailand Ephemeroptera (e.g., Sites et al. 2001, Parnrong et al. 2002). Images of collecting localities ("L" numbers) in Thailand are available online, via a locality image database at the Enns Entomology Museum website.

## Species accounts

### *Crinitella coheri* (Allen and Edmunds, 1963)

Figs. 1–4

= *C. permkami* Wang and Sites, 1999 (syn. by Jacobus and McCafferty 2003b)

**Descriptions.** *Male adult* (in alcohol)—Length: body 5.2 mm; forewing 5.5 mm; hindwing 1.3 mm; axillary cord 0.1 mm; cercus and medial caudal filament subequal, 5.2 mm.

Head: General color brown. Antenna brown. Ocelli light brown; base brown, ringed with black. Compound eyes contiguous anteriorly; upper portion pink, lower portion black.

Thorax: General color brown; prothorax with anterior and posterior margins dark purple; mesothorax with axillary cords folded under mesoscutellar hind projection. Forewing hyaline with translucent milky tinge along costal margin and faint brown tinge in basal one-eighth; stigmatic area clouded with white; costa and subcosta light yellow; longitudinal veins light yellow to light brown; intercalaries and crossveins hyaline. Hindwing hyaline with purple tinge basally; all veins and intercalaries translucent white; costal projection obtuse-angulate and submedial. Foreleg light brown; length (mm) of segments: trochanter = 0.2, femur = 0.8, tibia = 1.7, tarsal segment I = 0.1, tarsal segment II = 0.6, tarsal segment III = 0.4, tarsal segment IV = 0.25, tarsal segment V = 0.2; inner claw obtuse, outer claw pointed. Mid- and hindlegs pale; midfemur light brown distally; all tarsi light brown.

Abdomen (Figs. 3, 4): General color pale anteriorly and medially, light brown posteriorly, with extensive dark purple shading throughout. Abdominal terga with shading darkest laterally and posteriorly. Abdominal sterna with variable and sparse dark purple shading. Genitalia (Fig. 2) light brown; forceps pale. Penes lobes rounded apically and with acute dorsal projection at base of gonopore (Fig. 4); gonopore directed dorsally. Forceps segment 2 slightly expanded distally, but with margins subparallel in lateral profile (Fig. 4); forceps segment 3 subovoid (Fig. 2). Cercus and median caudal filament pale; segments densely covered with relatively short, hairlike setae.

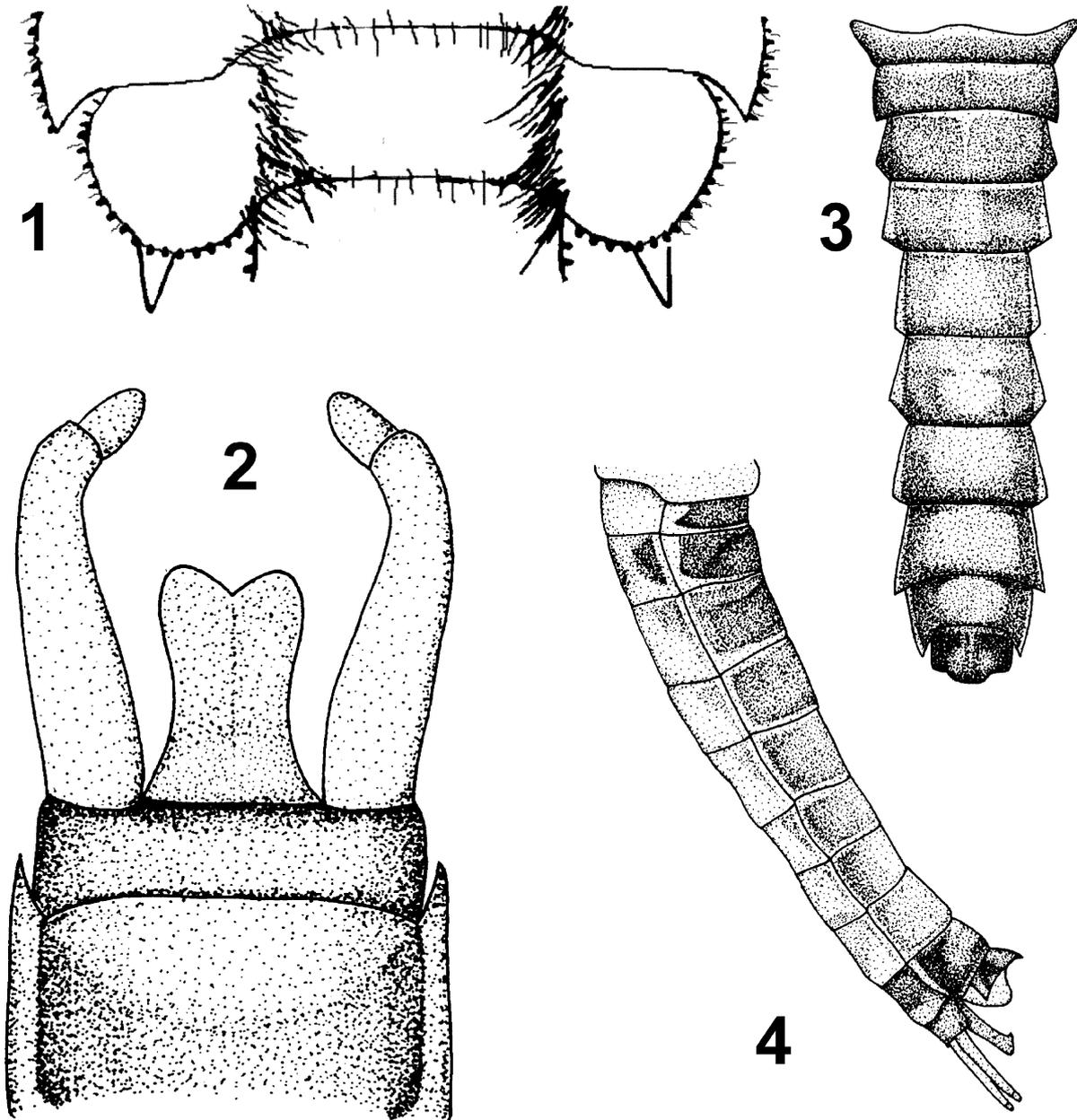
*Male subimago*—Similar to adult, but head with frontal shelf dark purple. Abdominal shading more diffuse than adult.

*Female subimago*—Similar to male, but general body color pale. Head with dark maculae between lateral ocellus and compound eye. Forewing subcosta dark brown. Posterior margin of each abdominal tergum darkened.

*Egg*—See Jacobus and Sartori (2004: Fig. 20) and Remarks below.

**Diagnoses.** *Male adults* are identifiable by a combination of genitalia structural characters (Figs. 2, 4) and abdominal coloration (Figs. 3, 4). The penes lobes are apically rounded and each has an acute dorsal projection; the genital forceps have segment 2 with a relatively straight lateral profile; and segment 3 is subovoid. The abdomen has a generally light basal coloration with purple shading and has no prominent middorsal longitudinal stripe.

*Larvae* are distinguished from other Ephemerellinae by their highly reduced labium (Allen and Edmunds 1963: Fig. 17) and by the structure and setation of abdominal segment 8 (Fig. 1).



**FIGURE 1–4.** *Crinitella coheri*. 1. Larva, abdominal tergum 8 gill cavity, dorsal view; 2. Male adult, genitalia, ventral view; 3. Male adult, abdomen, dorsal view; 4. Male adult, abdomen, lateral view.

**Variability.** The alates that we examined have some basal shading on the wings, especially in the sub-imago stage, but it covers only a relatively small area. It is possible that the extent of shading on the wings is variable, given the variation we have observed in the coloration of forewingpads of final instars. All speci-

mens examined had dark color basally in the developing wing, including the faded *C. coheri* holotype. *Crinitella coheri* larvae from Vietnam show variation in the extent of this basal coloration. In these specimens, the coloration ranges from covering only the extreme base of the developing forewing (as in the *C. coheri* types) to covering up to half of the forewing.

**Distribution.** *Crinitella coheri* has a wide Oriental distribution. It has been reported from Nepal (Allen and Edmunds 1963), northern India, western Malaysia (Allen 1980), and Thailand (Wang and Sites 1999; Sites et al. 2001). We provide the first records of *C. coheri* from Vietnam. Bishop (1973) detailed the biology of a Malay peninsula stream inhabited by *C. coheri*, and Jacobus et al. (2004) reviewed some of the literature associated with the insect fauna of that stream.

**Remarks.** Subimagos and adults recently were collected by Dietrich Braasch (Potsdam, Germany) in Thailand from near a stream that contained *C. coheri* larvae in the final instar. Braasch's collections tentatively associated alates with *C. coheri*, but no reliable association could be made based on this material alone. However, two *C. coheri* final instars were collected from two other Thailand locations and fixed in alcohol just prior to the emergence of the subimago. We dissected the pharate subimago from each larva. These subimagos have genitalic structure and body color that match the tentatively associated alates and, therefore, confirm the association.

A *C. coheri* male adult had been collected with female alates (see material examined below from a large tributary of the Sungai Selangor, Selangor, Malaysia) that Jacobus and Sartori (2004) discussed as possibly being *Crinitella* but which had been reported as *Hyrtanella* by Edmunds and Polhemus (1990). Jacobus and Sartori (2004: Fig. 20) provided a scanning electron micrograph of an egg dissected from one of these female alates, showing geometric ridges on the chorion. This morphology differs considerably from the smooth chorion of the *Hyrtanella* egg (Jacobus and Sartori 2004: Fig. 19). We dissected a *C. coheri* female subimago from Thailand that is identical to the Malaysia series of female alates, except for having less distinct coloration on the femora. Eggs extracted from the abdomen of the Thailand female subimago correspond to eggs dissected from the Malaysia specimens (Jacobus and Sartori 2004: Fig. 20). Based on all of this evidence, we consider the Malaysia female alates and associated eggs to be those of *C. coheri*.

The male adults of *C. coheri* are difficult to distinguish definitively from those of several species now belonging to the Ephemerellinae genera *Serratella* Edmunds and *Torleya* Lestage. Unfortunately, the current generic assignments of many Ephemerellinae species are questionable and comparisons of genera should be made with great caution. In the absence of a comprehensive global treatment of Ephemerellinae species, we note here ways to differentiate *C. coheri* from the type species (and therefore type concepts) of *Serratella* and *Torleya* (Jacobus and McCafferty 2003a, Jacobus et al. 2004). Genital forceps segment two of *Serratella serrata* (Morgan) is somewhat twisted in lateral profile, unlike the relatively straight forceps segment two of *C. coheri*. The length of genital forceps segments three of *Torleya major* (Klapálek) is more than twice its width; genital forceps segment three of *C. coheri* is subovoid.

Kluge (2004) suggested a close relationship between *Crinitella* and *Hyrtanella*. Based on the subimago of *Hyrtanella pascalae* Jacobus and Sartori, a greater length of the terminal segment of the genital forceps will distinguish the male adults of *Hyrtanella* from *Crinitella* (Jacobus and Sartori 2004).

**Material examined.** Holotype: NEPAL, **Palung**, ca. 5850 ft. altitude, 17/IV/1957, E. I. Coher, larva [PERC].

Paratypes: *same data as holotype*, two larvae (one set mouthparts on slide, one set mandibles in vial) [PERC].

Other Material:

INDIA, **Kashmir**, 22 mi. west of Srinagar on road to Tangmarg, ca. 6500 ft. altitude, 5/IX/1968, C. Weins, one larva [PERC]. MALAYSIA, Malay Peninsula, **Selangor**, Gombak R., 9 mi. north of Kuala Lumpur on Bentong Rd., 9/I-4/IX/1969, J. E. Bishop, 19 larvae, one male subimago and associated larval exuviae [FAMU, PERC]; large trib. Sungai Selangor (24°C), 6 mi. northeast of Kota Kuba Baharu (mile 44), 1/IX/

1978, GF&CH Edmunds, one male adult, ten female alates [PERC]; **Perak**, Sungai Jor, Cameron, Highlands Rd., mile 19, 22/IX/1978, G. F. & C. H. Edmunds, one larva [PERC]. THAILAND, **Chiang Mai**, Nam Chai River above hydro station intake at Fang Horticultural Station, 15/XI/1985, J. T. & D. A. Polhemus, one larva [PERC]; **Khampaeng Phet**, Khlong Lan National Park, Namtok Khlong Lan, 16°07'N, 99°16'E, 20/IV/2002, five larvae [ISUI]; same locale, but 19–20/VI/2002, BLT, one male adult [ISUI]; **Mae Hong Son**, Namtok Mae Surin National Park, Nam Mae Surin, above falls, 18°56'N, 98°04'E, 12220 m altitude, 15/X/2002, GW Courtney, two larvae [ISUI]; River Nam Lang, Soppong, 3–27/IV/2003, Braasch, four larvae, three male adults, one female subimago (dissected for eggs) [PERC]; **Phang Nga**, Taimuang-Khao Lam Pi National Park, Tone Prai Waterfall, 8°26'N, 98°18'E, 63 m altitude, 12/VI/2004, Sites, Vitheepredit, Prommi, L-761, one male subimago and associated larval exuviae [UMRM]; **Phrae**, Wieng Ko Sai National Park, Namtok Mae Kueng, tier 1, 17°58'N, 99°35'E, 400 m altitude, 19/XII/2002, CMU team, one male subimago and associated larval exuviae [UMRM]; **Songkhla**, stream at Buddhist temple, Ton Nga Chang Wildlife Sanctuary, 6/VII/1997, RW Sites, five larvae (*C. permkami* paratypes) [PERC]; same locale, 7/I/1995, Sites & Nichols, two larvae (*C. permkami* paratypes) [PERC]. VIETNAM, **Nghê An**, Khe Moi R, ca. 25km southwest of Con Cuông, Khe Moi River Forestry Camp, tropical forest edge, 18°56'N, 104°49'E, 308 m altitude, 3/VI/1995, B Hubley, ROM956164, three larvae [ROME]; same locale, but 7/VI/1995, one larva [ROME]; tributary of Khe Moi R, ca. 25km southwest of Cuông, Khe Moi River Forestry Camp, near “Ophiophagus” field, tropical forest edge, 18°56'N, 104°49'E, 308 m altitude, 9/VI/1995, B Hubley, ROM956188, one larva [ROME].

### ***Crinitella lacuna*, new species**

Figs. 5–7

**Descriptions.** *Mature larva* (final instar) (Fig. 5)—Length: body 4.5–4.9 mm; cercus and median caudal filament subequal, each 2.2–2.6 mm. General color light brown with variable brown shading and markings; body and legs covered with long, hairlike setae.

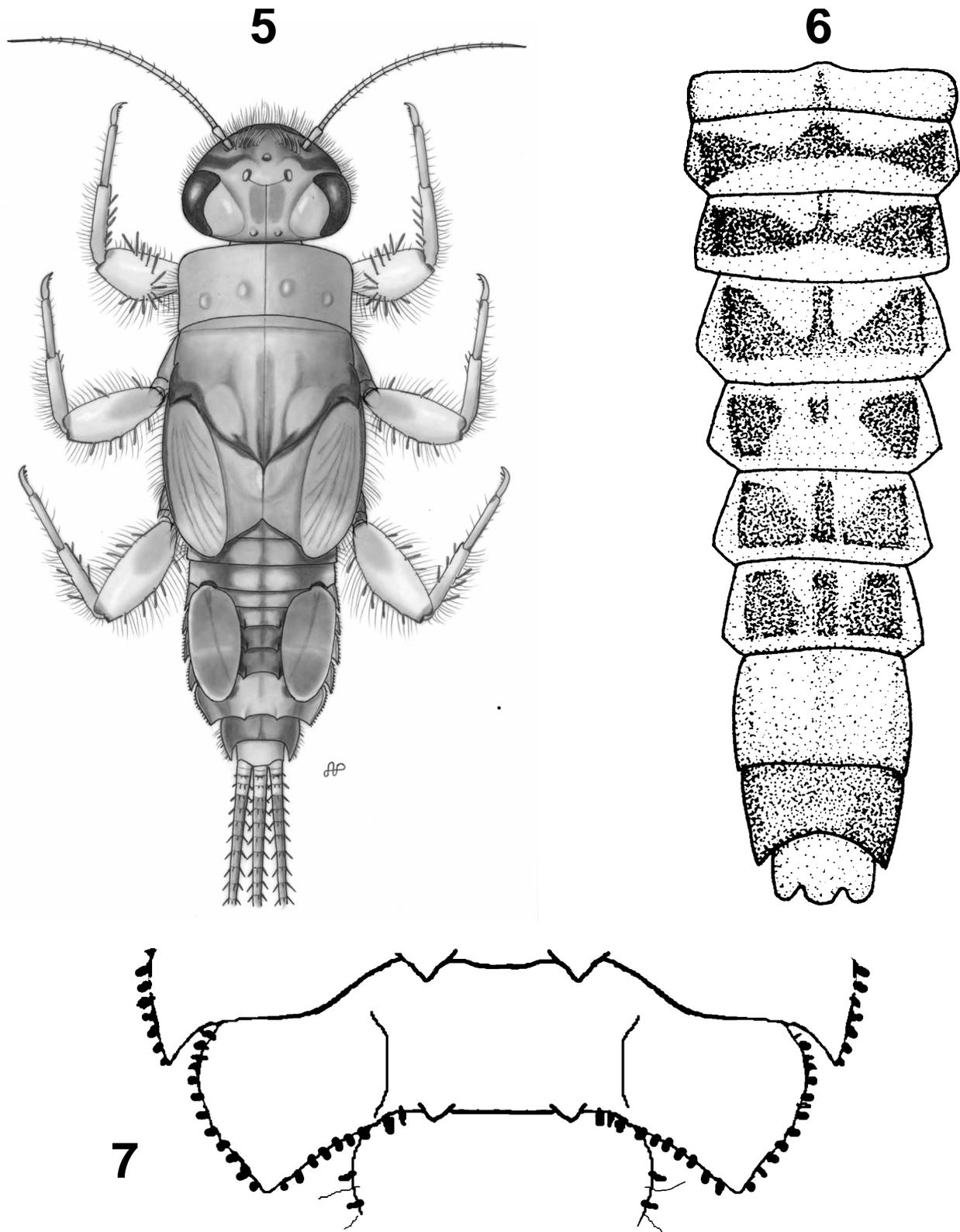
Head: Color light brown with variable brown markings; frons pale; antennal pit, area surrounding compound eye, and area between ocelli dark brown. Antennal scape and pedicel light brown; flagellar segments golden brown, with fine, hairlike setae at apex of each segment; hairlike setae nearly one-third length of respective segment. Suboccipital spines blunt. Frons with long hairlike setae. Clypeus with scattered fine setae. Labrum brown; dorsal surface with dense transverse row of cilia-like setae. Mandible external margin with scattered hairlike setae basally and pair of long cilia-like setae medially. Maxilla with few distal hairlike setae; palp absent; spinous processes long and narrow, extending well beyond tip of maxilla. Labium with cilia-like setae on ventral surface; palp segment 3 approximately one-half length segment 2.

Thorax: Pronotum with four dorsal protuberances. Mesonotum with transverse brown shading medially; tip of forewingpad pale to white. Legs pale; foreleg with submedial row of long spatulate setae; mid- and femora smoky brown proximally, with long spatulate setae on dorsal (posterior) margins. Claws with one or two basal denticles, two or three medial denticles, two to four long subdistal denticles on the inner margin, and subdistal setae.

Abdomen: Dorsal lamella of gill 3 extending to middle of segment 8, apically rounded, with fine distal setae, pale marginally but mostly brown; trilobed pattern indistinct. Terga 1–5 and 10 mostly pale; terga 6–9 usually brown; terga 8 and 9 sometimes pale; terga with dark longitudinal medial line and lateral shading. Terga 1–4 with hairlike setae on outer margins; tergum 5 with hairlike and spatulate setae; terga 6–9 with spatulate setae on outer margins (setae progressively shorter on segments 6–8); terga 3 and 9, and sometimes 2, with paired posterior protuberances; terga 4–8 with paired blunt spines; spines usually have zero to two spatulate setae; tergum 8 with no dorsally projecting setae. Segments 4–9 with posterolateral projections; projections 4–8 produced dorsolaterally; posterolateral projection 9 with dorsally projecting spatulate setae on inner

margin. Sterna with brown sublateral maculae, with few short hairlike setae. Caudal filaments pale to white, with broad dark brown band medially; tips dark brown; whorls of spatulate setae and recurved fine hairlike setae at apex of each segment.

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**FIGURE 5–7.** *Crinitella lacuna*, n. sp. **5.** Larval habitus, dorsal view; specimen from Vinh Phu, Vietnam; **6.** Male sub-imago, abdomen, dorsal view; **7.** Larva, abdominal tergum 8 gill cavity, dorsal view.

*Male subimago* (in alcohol)—Length 4.2–4.5 mm; forewing 4.3 mm; hindwing 1.0 mm; cercus and median caudal filament subequal, 3.2 mm.

Head: General color brown. Antenna with scape and pedicel pale; flagellar segments brown. Ocelli white; base black. Compound eyes contiguous medially; upper portion of eye pink; lower portion black.

Thorax: Prothorax brown with medial longitudinal black stripe and variable dark brown shading and black markings; mesothorax light brown with very prominent longitudinal black stripe on mesoscutellar hind projection; metathorax with very prominent medial longitudinal black stripe. Wings with slight brown shading at base; forewing with subcosta light brown. Legs pale; forefemur light brown.

Abdomen: Basal coloration pale to light brown. Anterior abdominal terga with dark lateral patches and median longitudinal streak (Fig. 6); posterior terga basal coloration pale; tergum 9 with dark purple shading. Abdominal sterna pale with purple-brown lateral maculae. Genitalia (as in Fig. 2) pale to light brown. Penes lobes apically rounded. Forceps segment 2 with slight distal expansion; forceps segment 3 subovoid. Cercus and median caudal filament white with long hairlike setae abundant.

*Female subimago*—Similar to male, but with thoracic and abdominal coloration less extensive. Abdominal median longitudinal streaks apparent.

**Diagnoses.** *Male subimagoes* have genitalia like those of *C. coheri*. Subimagoes are distinguishable from this species, however, based on the presence of a prominent, mid-dorsal, longitudinal, dark stripe on the thorax and abdomen (Fig. 6).

*Larvae* of *C. lacuna* are distinguished from *C. coheri* by paired, median spines on the abdominal terga, a dorsal longitudinal dark stripe, semioperculate gills 3, no maxillary palps, and by the structure and setation of abdominal segment 8 (Fig. 7), which forms the posterior margin of the abdominal gill chamber. The labium is not greatly reduced.

**Remarks.** The male adult of *C. lacuna* is expected to have penes and forceps similar to those of *C. coheri* (Fig. 2), based on our examination of the subimago of the new species.

The provisional placement of *C. lacuna* in *Crinitella* is based on the structure of male genitalia and the general similarity of alates to those of *C. coheri*. We acknowledge that the larvae of this new species are very similar to several species currently included in the genus *Torleya* (Jacobus et al. 2004) and that this similarity raises questions about the validity and species composition of the genera. Taxonomic revision of *Crinitella*, *Torleya* and *Serratella* (discussed under *C. coheri*) will be treated after completion of global comparisons of ephemere-line species groups and associated phylogenetic analyses (Jacobus and McCafferty, in progress; Ogden et al., in progress). Until that time, we prefer to maintain taxonomic stability by allowing *C. coheri* and assorted *Serratella* and *Torleya* species to remain in their respective generic placements.

**Etymology.** The specific epithet is a Latin word that refers to a place where water collects. It is a reference to the pronounced lateral hollows on abdominal tergum 8.

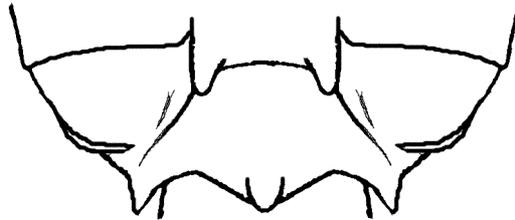
**Distribution.** We have examined specimens from India, Thailand, and Vietnam.

**Material examined.** Holotype: THAILAND, **Kanchanaburi**, stream, Amphur Thong Pha Phum, Heuy Ka Yaeng at Ban Padsadoo Klang, 14°33'N, 98°34'E, 296 m altitude, 9/IV/2003, L-457, Sites, AV, Prommi, Setaphan, larva [UMRM].

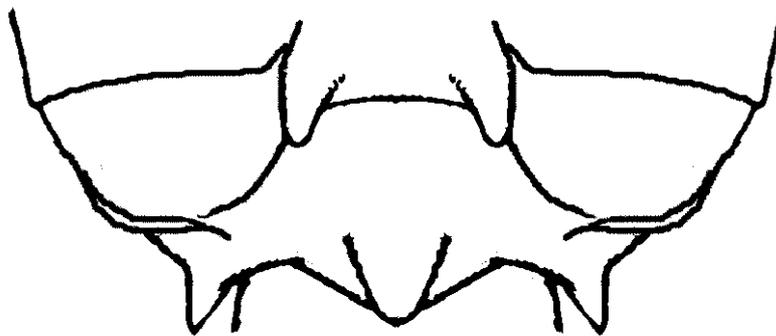
Paratypes: THAILAND, **Chiang Mai**, stream, Doi Suthep-Pui National Park, Pa Ngerb, 18°48'N, 98°56'E, 530 m altitude, 29/III/2003, UMC and CMU Teams, L-426, three larvae [PERC, UMRM]; Doi Inthanon National Park, Mae Pan Waterfall, 18°31'N, 98°27'E, 1100 m altitude, 3/IV/2003, Sites, AV, Seetaphan, L-442, one larva [UMRM]; **Mae Hong Son**, River Nam Lang, Soppong, 4/II–5/III/2004, Braasch, two larvae, two male subimagoes, two female subimagoes [PERC]; **Phrae**, Wieng Ko Sai National Park, lower Nam Panjaen, gravel, 17°56'N, 99°34'E, 270 m altitude, 22/III/2003, CMU Team, three larvae [PERC, UMRM]. VIETNAM, **Thua Thien-Hue**, Bach Ma National Park, ca. 13.5 km from Park entrance, stream flowing into Silvery Falls, subtropical evergreen forest, 1300 m altitude, 16°11'37"N, 107°51'19"E, 13/VI/2000, B Hubley, ROM2000525, one larva [ROME]; **Vinh Phu**, Tam Dao Hill Station, lower waterfall of stream flowing through town, 11/V/1996, B Hubley, DC Darling, ROM961029, one larva (parts on slide) [ROME].

Other material (not paratypes):

INDIA, **Madras**, Kunjankhuzi, 400 ft. altitude, 2/I/1962, Fernand Schmid, one male subimago [PERC]; Komadi, 950 ft. altitude, 18/I/1962, one female subimago [PERC]. THAILAND, **Lampang**, Chae Son National Park, Namtok Chae Son, rock surfaces, 650 m altitude, 18°50'N, 99°28'E, 22/X/2002, CMU Team, two larvae [ISUI]; **Mae Hong Son**, Namtok Maw Pang, gravel, 19°22'N, 98°22'E, 850 m altitude, 14/X/2002, GW Courtney, one larva [ISUI]; **Phrae**, Wieng Ko Sai National Park, Namtok Maekueang, tier 1, 17°58'N, 99°35'E, 400 m altitude, 23/III/2003, CMU Team, one larva [UMRM]. VIETNAM, **Lam Dong**, Da Nhim R., Duc Trong, 27/X/1984, one larva [PERC].



**FIGURE 8.** *Hyrtanella pascalae*. Larva, abdominal tergum 8 gill cavity, dorsal view.



**FIGURE 9.** *Hyrtanella christineae*. Larva, abdominal tergum 8 gill cavity, dorsal view.

### Additional remarks

Kluge (2004) considered the larvae of *Crinitella* and *Hyrtanella* to have certain shared characters, specifically, abdominal “terga IV–VIII form a pair of cavities...deeper posteriorly and distinctly outlined from behind by a pair of semicircular transverse crests on tergum VIII.” On the other hand, Kluge (2004) also noted that in *Crinitella* “each such crest bears a row of stout setae,” but in *Hyrtanella*, “these crests are very prominent and lack setae.” We have confirmed that each gill cavity associated with *Crinitella* (Figs. 1, 7) indeed is bordered by setae on tergum 8. The outer marginal and posterior marginal setae are short and spatulate, and the inner marginal setae are long and bristlelike. The posterior margin of tergum 8 is the posterior margin of the gill cavity. In contrast, we have found that each abdominal tergum 8 cavity associated with *Hyrtanella* (Figs. 8, 9) is bordered posteriorly and interolaterally by prominent glabrous ridges that are not present in *Crinitella*. The posterior glabrous ridge is situated anterior to the posterior margin of the tergum, and in contrast to *Crinitella*, this ridge forms the posterior margin of the gill cavity. The structures of these gill cavities are distinct from one another. Therefore, the gill cavity should not be considered as an apomorphy shared by *Crinitella* and *Hyrtanella*.

**Additional material examined.** *Hyrtanella christineae* (Allen and Edmunds): MALAYSIA, island of Borneo, **Sabah**, Liwagu R, Liwagu Cave, southeast of Headquarters, 14–15/VIII/1972, GF&CH Edmunds, four larvae [PERC]. *Hyrtanella pascalae* Jacobus and Sartori: MALAYSIA, island of Borneo, **Sabah**, Sungai Moyog, 3 mi east of Penampung, 27-IX-1978, GF&CH Edmunds, six larvae [PERC].

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