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**NEW ASIAN EPHEMERELLA WITH NOTES  
(EPHEMEROPTERA: EPHEMERELLIDAE)<sup>1</sup>**

RICHARD K. ALLEN

California State College at Los Angeles

**Abstract**

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The currently recognized *Ephemerella* species are included in 13 subgenera. New subgenera are Cincticostella and Acerella. *Ephemerella levanidovi* Tshernova is transferred to *Cincticostella* n. subg., thus it contains six species, *E. nigra* Ueno n. comb., *E. castanea* n. sp., *E. delicata* n. sp., *E. imanishii* n. sp., *E. insolta* n. sp., and *E. levanidovae* Tshernova n. comb. The subgenus *Acerella* n. subg. includes four species, *E. longicaudata* Ueno n. comb., *E. commodema* n. sp., *E. perculata* n. sp., and *E. undatella* n. sp., *Ephemerella yoshinoensis* Gose is transferred to the subgenus *Drunella* and four undescribed and unnamed species, *E. kohnoi* n. sp., *E. aculea* n. sp., *E. bifurcata* n. sp., and *E. borakensis* n. sp., are placed in *Drunella*. Three undescribed species, *E. denticula* n. sp., *E. keijoensis* n. sp., and *E. maxima* n. sp., are included in the subgenus *Ephemerella* s. s.

Edmunds (1959) considered the genus *Ephemerella* Walsh, 1862, to be composed of nine subgenera. *Ephemerella* s. s. (= *Chitonophora* Bengtsson, 1908) and *Drunella* Needham, 1905, known from Eurasia and North America; *Serratella* Edmunds, 1959, *Attenuatella* Edmunds, 1959, *Dannella* Edmunds, 1959, and *Timpanoga* Needham, 1927, known from North America; *Torleya* Lestage, 1917, known from Europe; and *Eurylophella* Tiensuu, 1935, known from Europe and North America. Allen and Edmunds (1963) characterized and named

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*Crinitella* from Asia, and Allen (1965) reduced *Teloganopsis* Ulmer, 1939, known only from Java and Sumatra, to a subgenus of *Ephemerella*. In the present paper the new Asian subgenera *Cincticostella* and *Acerella* are established, and the total number of subgenera now included in the genus is 13.

Abbreviation for collections in which specimens are deposited is: INHS, Illinois Natural History Survey.

### ***Cincticostella* n. subgen.**

*nigra*-group Imanishi, 1938: 33.

The subgenus *Cincticostella* is characterized by the following morphological features:

**MALE IMAGO.** The second segment of the genital forceps is sharply angled by a submedian constriction, and the third segment is less than twice as long as broad (Fig. 1). The penes lobes are sharp apically, widest subapically, and without chitinized structures and spines (Fig. 1). The fore tibiae are twice as long as the fore femora, and the fore tarsi rank 2, 3, 4, 5, and 1 in length.

**NYMPH.** The head is with or without tubercles, and without frontal projections (Figs. 13-15). The maxillae are without apical canines, with an apical tuft of setae, and the maxillary palpi are well developed, vestigial, or absent (Figs. 2-4). The fore femora possess a band of spines near the middle as in Fig. 10, and the tarsal claws are with a variable number of denticles. The antero-lateral corners of the prothorax are produced anteriorly, and the mesothorax is expanded laterally in the anterior portion (Figs. 15-18). The abdominal terga are with paired dorsal tubercles, and abdominal terga 3-7 bear lamellate, imbricated gills. The caudal filaments are shorter than the body, with whorls of short spines at the apex of alternate segments, and without long intersegmental setae (Fig. 5).

Type-species: *Ephemerella* (*Cincticostella*) *nigra* Ueno, 1928.

**REMARKS.** The male imago of *E.* (*Cincticostella*) *nigra* is similar to the male imagoes of the subgenus *Drunella* as the second segment of the genital forceps is distinctly incurved. In *Drunella* the third (apical) segment of the genital forceps is more than twice as long as broad. In *Cincticostella* the apical segment is nearly as broad as long. The nymphs of *Cincticostella* seem to be most closely related to *Serratella* as they possess whorls of spines on the caudal filaments, and the maxillary palpus is vestigial or absent in some species. The nymphs of *Cincticostella* are distinguished from *Serratella*, and all other subgenera of *Ephemerella*, as the maxillae are without apical canines, the prothorax is produced anteriorly, and the anterior portion of the mesothorax is produced laterally.

The subgenus includes six species as follows: *Ephemerella castanea* n. sp.; *E. delicata* n. sp.; *E. imanishii* n. sp.; *E. insolta* n. sp.; *E. levanidovae* Tshernova, 1952; and *E. nigra* Ueno, 1928. *Ephemerella nigra* is the only species in the subgenus in which the male imago stage is known.

### ***Ephemerella* (*Cincticostella*) *nigra* Ueno**

*Ephemerella nigra* Ueno, 1928: 44; Imanishi 1937: 325; Ueno 1950: 128 (male genitalia); Edmunds 1959: 546.

*Chitonophora* (?) *nigra* Ueno, 1931: 224.

*Ephemerella nigra* was described by Ueno (1928) from a long series of nymphs collected in a stream in Shimotsuke Province on the island of Honshu, Japan. In 1931, Ueno questionably included this species in the subgenus *Ephemerella* s. s. (as *Chitonophora*). Imanishi (1937) described the male imago from near the type locality, and in 1938, he placed *E. nigra* in the *nigra*-group of the genus *Ephemerella*. Edmunds (1959) did not assign this species to subgenus.

**MALE IMAGO.** Length: body 8.5–11.5 mm; fore wing 10.0–11.5 mm. Head chocolate brown; upper portion of compound eye yellow, lower portion black. Thoracic nota chocolate brown; pleura dark brown, sutures pale; legs yellow; fore tibiae twice as long as fore femora; fore tarsi rank 2, 3, 4, 5, and 1 in length; wings hyaline, stigmatic area opaque; primary longitudinal veins yellow basally, brown apically, intercalary and cross-veins pale. Abdominal terga light brown with dark brown markings; segments 1–7 with paired submedian dark brown stripes; segments 8–10 dark brown; pleura with dark brown maculae; sterna light brown with a round median purple macula. Penes pointed at apex and with a subapical swelling; second segment of genital forceps sharply angled inward and with a subapical constriction; third segment less than twice as long as broad (Fig. 1). Caudal filaments brown.

**NYMPH.** Length: body 9.5–10.5 mm; caudal filaments 7.0–8.0 mm. General color dark brown to black, usually with a pale median stripe on head, thorax and abdomen. Head without tubercles; genae rounded as in Fig. 13; maxillary palpi well developed, more than two-thirds as long as galea-lacina (Fig. 2). Thoracic nota without tubercles or ridges (Fig. 16); fore femora with subapical and subbasal bands of spines (Fig. 10); femora with numerous conspicuous spines on anterior surface; middle and hind femora with spines along dorsal margin, ventral margin without spines (Fig. 9); tarsal claws with 5–8 denticles (Fig. 6). Abdominal terga 2–9 with paired submedian tubercles; tubercles small on segments 2–4, often barely discernible; tubercles well developed on segments 5–9 (Fig. 16); abdominal sterna brown, often with paired sublateral maculae. Caudal filaments dark brown with pale annulations at apex of each segment.

**DISTRIBUTION.** This species is known from only Honshu, Japan. Specimens examined by the author are from the following localities: **Japan.** Honshu Island: Tatangouchimura, Kita-aizu-gun, Fukushima Pref., 24-II-50, M. Kohno (INHS); Higashiyama, Fukushima Pref., 6-II-50, M. Kohno (INHS); Yu River, Oku-Nikko, Totigi Pref., 27-V-46, M. Kohno (INHS); Yu River, Wakamatsu City, 13-I-50, M. Kohno (INHS); Shimanakatsugawa, 20-IV-50, S. Kariki (INHS).

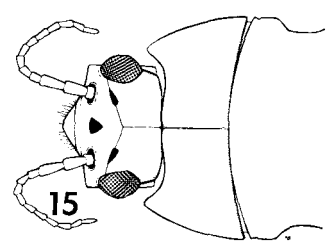
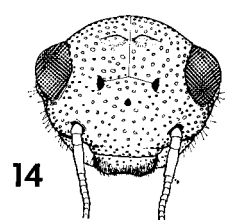
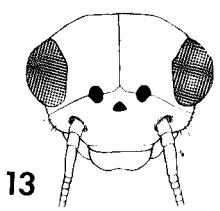
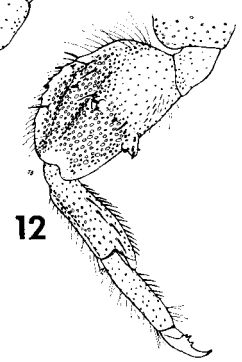
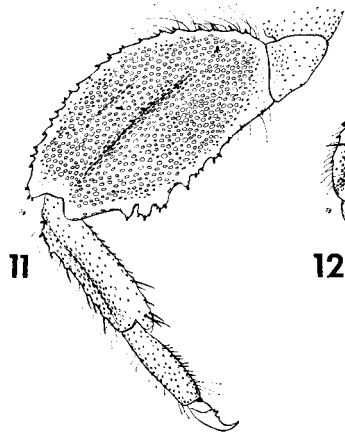
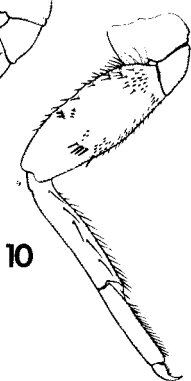
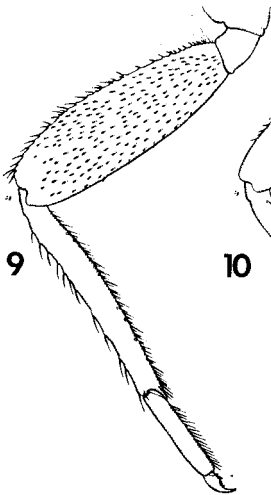
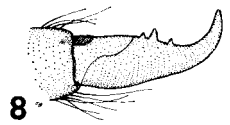
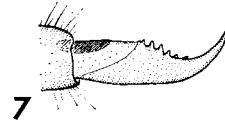
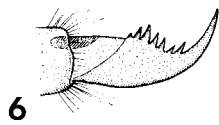
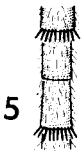
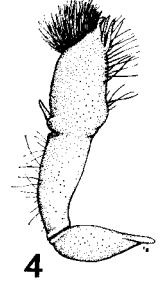
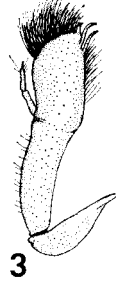
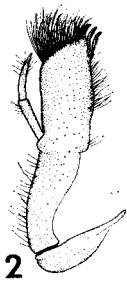
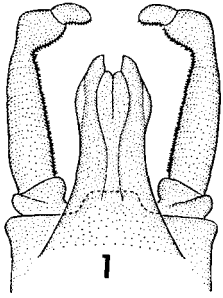
#### *Ephemerella (Cincticostella) castanea* n. sp.

**NYMPH.** Length: body 10.0–11.0 mm; caudal filaments 7.0–8.0 mm. General color reddish brown with dark brown markings. Head without tubercles; genae rounded (Fig. 13); maxillary palpi moderately developed, less than two-thirds as long as galea-lacina (Fig. 3). Thoracic nota without tubercles or ridges (Fig. 17); pronotum reddish brown; mesonotum reddish brown, often with 4 submedian dark brown maculae anterior to base of wing pads; fore femora with a subapical band of spines; femora with inconspicuous spines on anterior surface; middle and hind femora with spines along dorsal margin, ventral margin without spines; tarsal claws with 5–8 denticles (Fig. 7). Abdominal terga 2–9 with paired submedian tubercles; tubercles on segments 2–4 small and sharp, always discernible; tubercles on segments 5–9 moderately well developed (Fig. 17); abdominal terga reddish brown with paired dark brown submedian stripes in line with paired dorsal abdominal tubercles (Fig. 17); abdominal sterna brown, sterna 2–8 with sublateral dark brown maculae, paired submedian spots, and a thin chevron-shaped marking. Caudal filaments brown with dark brown annulations at apex of each segment.

**TYPES.** Holotype: Male nymph, Kwang Nung, Korea, 3-IV-60, G. Field, in collection of the University of Utah, Salt Lake City. Paratopotypes: 8 male and 3 female nymphs, same data as holotype, 2 nymphs each in the collections of California State College at Los Angeles, and the California Academy of Sciences, San Francisco. Paratypes: 1 male and 1 female nymphs, Seoul, Korea, 17-IV-52, Bullock. Remaining paratopotypes and paratypes in the University of Utah collection.

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Figs. 1–15. 1, male genitalia, dorsal view, *Ephemerella nigra*. 2–4, maxillae: 2, *E. nigra*; 3, *E. castanea*; 4, *E. insolta*. 5, segments of caudal filaments, *E. nigra*. 6–8, tarsal claws: 6, *E. nigra*; 7, *E. castanea*; 8, *E. insolta*. Figs. 9–12, legs: 9, hind leg, *E. nigra*; 10, fore leg, *E. nigra*; 11, hind leg, *E. insolta*; 12, fore leg, *E. insolta*. 13–14, heads, front view: 13, *E. castanea*; 14, *E. insolta*. 15, head and thorax, dorsal view, *E. levanidovae* (after Tshernova, 1952).



REMARKS. *Ephemerella castanea* is most closely allied to *E. nigra*, and it is distinguished from it by the degree of development of the paired, dorsal abdominal tubercles; by the length of the maxillary palpi; by color; by the degree of development of the spines on the anterior surface of the femora; and by known distribution.

***Ephemerella (Cincticostella) insolta* n. sp.**

NYMPH. Length: body 5.0–6.0 mm; caudal filaments 4.0–5.0 mm. General color light brown to brown with small pale spots on head, body, and legs. Head with paired suboccipital tubercles (Fig. 14); genae rounded; maxillary palpi absent or reduced to a single segment (Fig. 4). Thoracic nota without distinct tubercles, but with ridges; prothorax with a median ridge; mesothorax with a series of submedian and lateral ridges (Fig. 18); anterior surface of fore femora with a subapical band of spines and protuberances (Fig. 12); anterior surface of middle and hind femora with protuberances and only an occasional spine; ventral margin of fore femora with a single protuberance with spines; dorsal margin of fore femora with 3–4 protuberances; ventral and dorsal margins of middle and hind femora with numerous protuberances and spines (Fig. 11); tarsal claws with 2–3 denticles (Fig. 8). Abdominal terga unicolorous brown; abdominal terga 1–10 with well developed, paired submedian tubercles as in Fig. 18; abdominal sterna unicolorous brown. Caudal filaments brown.

TYPES. Holotype: Female nymph, Chiangmai Province, small stream and waterfalls, Doi Sutep, W. of Chiangmai, 2-XII-64, W. L. & J. G. Peters, in collection University of Utah, Salt Lake City, Utah. Paratopotypes: 48 female, and 4 male nymphs, same data as holotype, 5 nymphs each in collections of California State College at Los Angeles, California Academy of Sciences, San Francisco, and Florida A. & M., Tallahassee; others in collection of University of Utah.

REMARKS. *Ephemerella insolta* is not closely related to any of the described species included in the subgenus. The nymphs possess head tubercles, the femora are broad and the dorsal and ventral margins are produced into tubercle-like protuberances, the maxillary palpi are absent or vestigial, and the abdominal terga bear tubercles on segments 1–10.

***Ephemerella (Cincticostella) levanidovae* Tshernova**

*Ephemerella levanidovae* Tshernova 1952: 274; Tshernova 1958: 76; Edmunds 1959: 545.

This species was described from a series of nymphs collected from the Hor River in eastern Russia. Specimens of this species have not been examined by the author.

NYMPH (nearly mature). Length: body 12.0 mm; caudal filaments 10.0 mm. General color unicolorous brown. Head without tubercles; genae truncate (Fig. 15); maxillae without canines, and with thick setae; maxillary palpi 3-segmented, segments 1 and 2 large and subequal in length and segment 3 only one-fourth as long as segment 2; glossae of labium one-third as wide as paraglossae. Prothorax only one-third as long as wide, posterior margin longer than anterior margin; lateral margin convex and antero-lateral corners produced anteriorly (Fig. 15); femora of middle and hind legs large and depressed, with an elevated ridge on anterior surface; fore femora smaller; femoral spines on dorsal and ventral margins and on anterior surface; tarsal claws with 6 denticles, second and third from base largest. Abdominal terga with lamellate gills on segments 3–7; well-developed, paired, dorsal abdominal tubercles on segments 5–8, tubercles small on other segments. Caudal filaments with whorls of spines at apex of each segment (rewritten from Tshernova, 1952).

REMARKS. Tshernova (1952) stated that the structure of the prothorax of *E. levanidovae* suggested a close relationship to *Ephemerella* "nay" Imanishi, and *E. "nax"* Imanishi. This species is included in *Cincticostella* on the basis of the characters of the prothorax, the mesothorax, the maxillae, and by the possession of paired, dorsal abdominal tubercles.

***Ephemerella (Cincticostella) imanishii* n. sp.**

*Ephemerella* "nax" Imanishi 1940: 206; Tshernova 1952: 274.

REMARKS. This species was described and figured, but not named, from nymphs collected in Korea. These nymphs are placed in this subgenus on the basis of the characters of the thorax, and by the development of the paired, dorsal abdominal tubercles. *Ephemerella imanishii* is most closely related to *E. nigra*, and Imanishi compared these species at the time of the original description. I take pleasure in naming this species in honor of the describer, K. Imanishi.

TYPE. Holotype: The specimen from which Fig. 17 was illustrated (Rep. Limnobiol. Surv., Kwang and Manchoukuo, Imanishi 1940) is designated as the type of this species.

***Ephemerella (Cincticostella) delicata* n. sp.**

*Ephemerella* "nay" Imanishi 1940: 206; Tshernova 1952: 274.

REMARKS. *Ephemerella delicata* was described and figured, but not named, from nymphs collected in Manchuria. The nymphs of this species are placed in this subgenus on the basis of the characters of the thorax, and by the development of the paired, dorsal abdominal tubercles. Imanishi (1940) included a key and was able to distinguish *E. nigra*, *E. imanishii*, and *E. delicata* as follows:

- |  |                                       |
|--|---------------------------------------|
| 16. With dorsal spines, though indistinct, on abdominal segments 2-4 ..... | <i>Ephemerella</i> (nax)              |
| - Such spines quite absent on abdominal segments 2-4 .....                 | 17                                    |
| 17. Large size, 10.0 mm; cerci fringed with stiff hairs .....              | <i>Ephemerella nigra</i> Ueno (Japan) |
| - Small size, shorter than 7.0 mm; hairs on cerci not so stiff .....       | <i>Ephemerella</i> (nay)              |
|  | (translated from Imanishi, 1940)      |

TYPE. Holotype: The specimen from which Fig. 18 was illustrated (Rep. Limnobiol. Surv., Kwantung and Manchoukuo, Imanishi 1940) is designated as the type of this species.

***Acerella* n. subgen.**

The subgenus *Acerella* is characterized by the following morphological features:

MALE IMAGO. Second segment of genital forceps bowed inwardly by a shallow constriction, and the third segment is scarcely longer than wide. Fore tibiae and fore femora are subequal in length, and the fore tarsi rank 3, 2, 4, 5, and 1 in length.

NYMPH. The head is with or without tubercles, and without frontal projections. Maxillae with a single apical canine and with a tuft of setae (Fig. 20). The maxillary palpi are well developed or vestigial. The fore femora are with or without spines, and the number of denticles on the tergal claws are variable. The prothorax bears tubercles, and the antero-lateral corners are not produced anteriorly. The mesothorax is with or without tubercles, and the lateral margin is expanded into a distinct projection near the anterior margin (Figs. 23, 26-28). Abdominal terga are with paired dorsal tubercles (Figs. 23, 26-28). Lamellate, imbricated gills are present on abdominal terga 3-7. Caudal filaments are longer than the body, with whorls of long spines at apex of each segment, and without long intersegmental setae (Fig. 21).

Type-species: *Ephemerella (Acerella) longicaudata* Ueno, 1928.

REMARKS. The male imagoes of *Acerella* are similar to those of the subgenus *Drunella* as the second segment of the genital forceps is bowed. In *Drunella* the third segment of the genital forceps is more than twice as long as broad, whereas in *Acerella* the apical segment is subequal in length and width. The nymph of *Acerella* is distinguished from the nymphs of all known subgenera by the following combination of characters: (1) the caudal filaments are longer than the body, and

the apex of each segment bears a whorl of long spines (Fig. 21); (2) the mesothorax bears paired lateral projections (Figs. 23, 26–28); the prothorax is not produced anteriorly; the mandibles are symmetrical (Fig. 19); and the maxillae possess a single apical canine and a tuft of setae (Fig. 20).

The subgenus includes four species as follows: *Ephemerella longicaudata* Ueno, 1928, and *Ephemerella commodema* n. sp., *E. perculata* n. sp., and *E. undatella* n. sp. The adults of *E. commodema*, *E. perculata*, and *E. undatella* are not known.

### *Ephemerella (Acerella) longicaudata* Ueno

*Ephemerella longicaudata* Ueno 1928; Imanishi 1937: 323 (adult); Edmunds 1959: 545.

This species was described from a series of nymphs collected on Honshu Island, Japan. Imanishi (1937) described the adult stages, but did not figure the male genitalia. Edmunds (1959) tentatively placed *E. longicaudata* in the subgenus *Serratella* on the basis of the reduced maxillary palpi, and the whorls of apical segmental spines on the caudal filaments of the nymphal stage.

**MALE IMAGO.** Length: body 13.5–15.0 mm; fore wing 13.0–16.0 mm. Head dark brown to dull brown; compound eyes gray. Thorax dark brown to dull brown; fore femora and fore tibiae subequal in length; fore tarsi rank 3, 2, 4, 5, and 1 in length; legs yellowish brown and without distinct markings; wings hyaline, costal margin pale yellowish brown; venation pale yellow to brown. Abdominal terga brown, darker laterally; terga 1–9 with a pale median stripe; stripe narrower on anterior segments; terga 1–5 with faint, paired submedian stripes; terga 8–10 purplish; sterna dull brown, often with a pale median stripe. Second segment of genital forceps bowed inwards by a shallow constriction; third segment scarcely longer than wide. Caudal filaments brown, paler distally (rewritten from Imanishi, 1937).

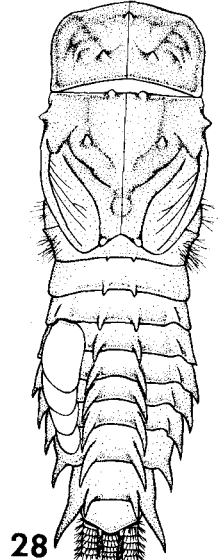
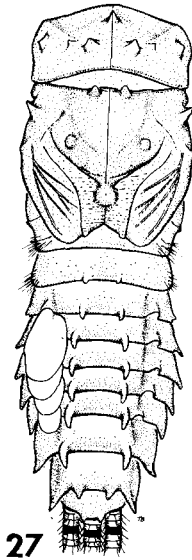
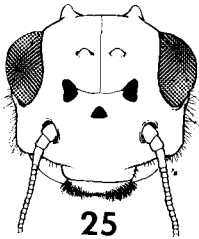
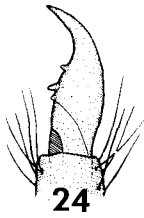
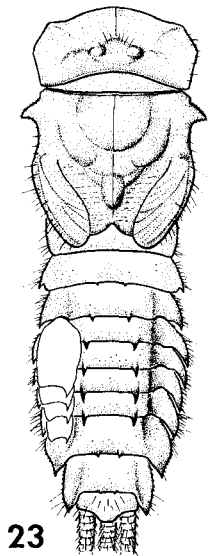
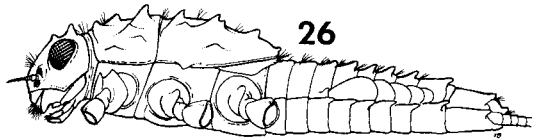
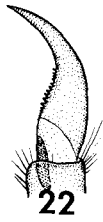
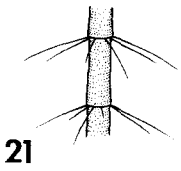
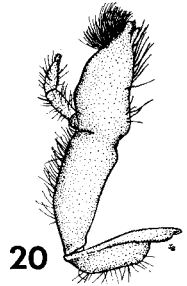
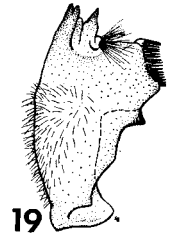
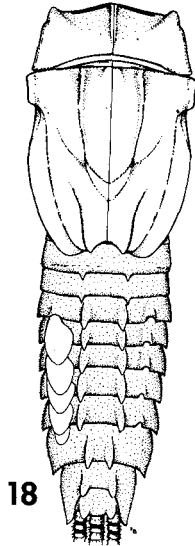
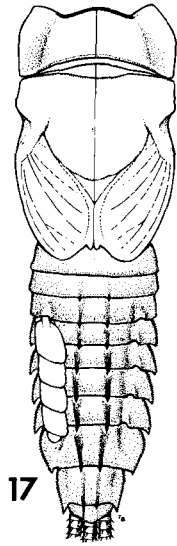
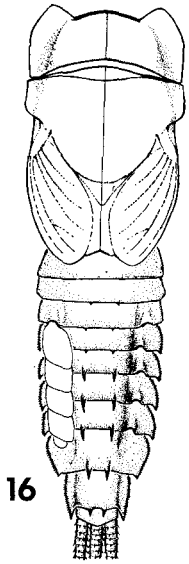
**NYMPH.** Length: body 12.0–13.0 mm; caudal filaments 14.5–17.5 mm. General color light brown. Head brown; head without occipital or suboccipital tubercles; vertex of head with short setae; maxillary palpi 1-segmented. Pronotum with small submedian tubercles (Fig. 23); mesonotum without dorsal tubercles; mesonotum with large lateral projections (Fig. 23); legs brown with dark brown markings; femora brown; tibiae and tarsi brown, dark brown at apices; femora with long setae-like spines; tarsal claws with 12–15 denticles (Fig. 22). Abdominal terga brown, apices of postero-lateral projections and paired submedian tubercles dark brown; paired submedian tubercles on segments 2–9; tubercles short and narrowly separated at bases on segment 2, longer and more widely separated on segment 3, longest and most widely separated on segments 4–7, and short and narrowly separated on segments 8–9 (Fig. 23); upper gill lamellae acuminate apically (Fig. 23); postero-lateral projections on segments 8–9 poorly developed (Fig. 24); abdominal sterna brown. Caudal filaments brown with whorls of long spines at apex of each segment (Fig. 21).

**DISTRIBUTION.** This species is known from only Honshu Island, Japan. The author has examined specimens from the following locality: **Japan:** Honshu Island, Yu River, Wakamatsu City, 13-I-50, M. Kohno (INHS).

**REMARKS.** *Ephemerella longicaudata* nymphs are distinguished from those of *E. commodema* n. sp. and *E. perculata* n. sp. by the number and degree of development of the head and body tubercles, and by the shape and degree of development of the postero-lateral abdominal projections. The mesonotum of *E. longicaudata*

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FIGS. 16–28. 16–18, nymphal bodies, dorsal view: 16, *E. nigra*; 17, *E. castanea*; 18, *E. insolta*. 19–23, nymphal structures, *E. longicaudata*: 19, left mandible; 20, maxilla; 21, segments of caudal filaments; 22, tarsal claw; 23, body, dorsal view. 24–27, nymphal structures, *E. commodema*: 24, tarsal claw; 25, head, front view; 26, head and body, lateral view; 27, body, dorsal view. 28, body, dorsal view, *E. perculata*.





bears an exceptionally long lateral projection, and the head and mesonotum are lacking dorsal tubercles. The abdominal segments possess paired dorsal tubercles on segments 2-9, and the postero-lateral abdominal projections are poorly developed and differ in shape from those of the other described *Acerella*.

***Ephemerella (Acerella) commodema* n. sp.**

**NYMPH.** Length: body 10.0-12.0 mm; caudal filaments 17.0-18.0 mm. General color brown with dark brown markings. Head brown; head with 1 pair of suboccipital tubercles, and 1 pair of larger occipital tubercles (Fig. 25); maxillary palpi 3-segmented. Thorax brown; thoracic nota with tubercles; pronotum with 7 tubercles, 1 median, 2 submedian, 2 lateral, and 2 sublateral; mesothorax with 5 tubercles, 2 submedian anteriorly, 2 submedian medially, and 1 median posteriorly (Figs. 26-27); mesonotum with small lateral projections (Fig. 27); femora brown with median and apical dark brown bands; femora glabrous, without spines; tibiae and tarsi brown; tarsal claws with 2-4 denticles (Fig. 24). Abdominal terga brown; abdomen with paired dorsal tubercles on segments 2-10, tubercles short and narrowly separated at bases on segment 2, longer and progressively more widely separated on segments 3-8, and shorter and more narrowly separated on segments 9-10 (Fig. 27); upper gill lamellae convex (Fig. 28); postero-lateral projections on segments 8-9 moderately developed (Fig. 27); abdominal sterna brown. Caudal filaments brown with whorls of moderately long spines at apex of each segment.

**TYPES.** Holotype: Female nymph, Chiangmai Prov., small stream and waterfall, west of Chiengnai, Thailand, 18-XI-64, W. L. & J. G. Peters, in collection of University of Utah. Paratopotypes: 40 nymphs, 8-XI/2-XII-64, other data same as holotype, 5 nymphs each in the collections of California State College at Los Angeles; California Academy of Sciences, San Francisco; Florida A. & M. University, Tallahassee; remaining paratopotypes in collection University of Utah. Paratypes: 5 nymphs, Chiangmae Prov., Mae Sa, Mae Sa National Reserve, 7 km west of Mae Rim (elev. 1250 ft), 9-XI-64, W. L. & J. G. Peters; 3 nymphs, Chiangmai Prov., small stream at junction of East Fork Mae Ping, 59 km north of Chiangmai (elev. 1350 ft), 30-XI-64, W. L. & J. G. Peters, all paratypes in collection University of Utah.

**REMARKS.** *Ephemerella commodema* is most closely related to *E. undatella* n. sp. as the nymphs of both species bear head and thoracic tubercles, and the postero-lateral projections on segment 9 do not extend beyond the posterior margin of segment 10. These species are distinguished as the nymphs of *E. commodema* possess only 2 pairs of head tubercles, 7 pronotal tubercles, 5 mesonotal tubercles, and paired, dorsal abdominal tubercles on segments 2-10. The head, thoracic, and abdominal tubercles vary in size as a result of the age of the individual. In early instar nymphs the occipital, thoracic, and abdominal tubercles are well developed, and as the nymph matures the tubercles become proportionately reduced in size.

***Ephemerella (Acerella) perculata* n. sp.**

**NYMPH.** Length: body 10.0-12.0 mm; caudal filaments 11.0-13.0 mm. General color brown. Head brown; head with paired occipital tubercles; maxillary palpi 3-segmented. Thorax brown; thoracic nota with tubercles; pronotum with 3 tubercles, 1 median and 2 submedian; mesothorax with 7 tubercles, 2 submedian anteriorly, 2 submedian medially, 1 median near the posterior margin, and 2 submedian posteriorly (Fig. 28); mesonotum with small lateral projections (Fig. 28); femora brown with median and apical dark brown bands; femora glabrous, with dorsal spines; tibiae and tarsi brown; tarsal claws with 5-7 denticles. Abdominal terga brown; abdomen with paired dorsal tubercles on segments 1-9; tubercles short and narrowly separated at bases on segment 1, better developed and more widely separated on segments 2-3, longest and/or more widely separated on segments 2-9; upper gill lamellae convex (Fig. 28); postero-lateral projections on segments 8-9 well developed, projection on segment 9 extends well beyond posterior margin of segment 10 (Fig. 28); abdominal sterna

brown. Caudal filaments brown with whorls of moderately long spines at apex of each segment and with long intersegmental spines.

**TYPES.** Holotype: Female nymph, Stream 6 km S. Dalat, Viet Nam, 20-VI-61, N. R. Spencer, in collection of University of Utah, Salt Lake City. Paratopotypes: 5 female nymphs, same data as holotype, 1 nymph in collection California State College at Los Angeles, others in collection of University of Utah.

**REMARKS.** *Ephemerella perculata* is distinguished from *E. longicaudata* by possessing tubercles on the head and thoracic nota. It is distinguished from *E. commodema* and *E. undatella* by the number of tubercles on the thoracic nota, by the arrangement of tubercles on the thoracic nota, by the arrangement of tubercles on the abdominal terga, and by the development of the postero-lateral projections on segment 9. The head, thoracic, and abdominal tubercles vary in size as a result of age of the individual. In early instar nymphs the occipital, thoracic, and abdominal tubercles are well developed, and as the nymph matures these tubercles become proportionately reduced in size.

### *Ephemerella (Acerella) undatella* n. sp.

*Ephemerella* sp. Ueno, 1953: 302, pl. I.

**NYMPH.** Length: body 8.5 mm; caudal filaments 9.0 mm. General color olivaceous brown. Head with 3 pairs of blunt tubercles, and a single antero-median tubercle; maxillary palpi 3-segmented. Thoracic nota with tubercles; pronotum with 5 knob-like tubercles, unpaired tubercle near anterior margin; mesonotum with small lateral projections; mesonotum with 5 blunt tubercles, 2 sublateral anteriorly, 2 submedian medially, and 1 median posteriorly; femora light brown; femora with a row of setae along dorsal margin, and without tubercles or spines; tarsal claws with 3-4 denticles. Abdominal terga olivaceous brown; abdomen with paired dorsal tubercles on segments 3-9; tubercles increase in length posteriorly, and longest on segment 8; upper gill lamellae convex; postero-lateral projections on segments 8-9 moderately developed, projections on segment 9 not extending beyond posterior margin of segment 10. Caudal filaments paler than body (rewritten from Ueno, 1953).

**TYPE.** Holotype: Nymph, the specimen from which Fig. 1 was illustrated (Fauna and Flora Res. Soc. Kyoto Univ.), stream near Nawakot between Batar Bazar and Tadi Khola, Nepal, 13-XII-52, K. Imanishi.

**REMARKS.** *Ephemerella undatella* is most closely related to *E. commodema* as the nymphs of both species bear head and thoracic tubercles, and the postero-lateral projections on segment 9 do not extend beyond the posterior margin of segment 10. These species are distinguished as the nymphs of *E. undatella* possess 3 pairs of head tubercles, 5 pronotal tubercles, 5 mesonotal tubercles, and paired, dorsal abdominal tubercles on segments 3-9.

### Subgenus *Drunella* Needham

*Drunella* Needham, 1905: 42; Needham 1927: 108 (as subgenus); McDunnough 1931: 210 (= *Eatonella*); Edmunds & Traver 1954: 238; Demoulin 1958: 10; Edmunds 1959: 546; Allen & Edmunds 1962: 147.

*Eatonella* Needham, 1927: 108.

(*Ephemerella*) *cornuta*-group McDunnough, 1931a: 31.

(*Ephemerella*), Section IV McDunnough, 1931b: 210.

Edmunds (1959) tentatively placed 8 species from Eastern Asia in this subgenus, Allen and Edmunds (1962) reported 15 from North America, and they added 4 additional Asian species in 1963. In this treatment *E. yoshinoensis* Gose, 1963, is transferred to *Drunella*, and 4 undescribed, or unnamed species, *E. kohnoi* n. sp., *E. aculea* n. sp., *E. bifurcata* n. sp., and *E. borakensis* n. sp., are included in this subgenus.

***Ephemerella (Drunella) aculea* n. sp.**

*Ephemerella basalis* Na, Imanishi 1940: 196, fig. 7.

*Ephemerella basalis* Imanishi, Tshernova 1952: 271, fig. 72.

This previously unnamed species appears to be the one figured by Imanishi (1940) as *E. basalis* Na. The nymph figured by Imanishi has a sharp median ocellar tubercle, and the abdominal terga have only small, paired submedian tubercles. *Ephemerella basalis* Imanishi has only a blunt, median ocellar projection, and the paired submedian tubercles are well developed. Tshernova (1952) determined a series of nymphs, collected in Russia, as being *E. basalis*, and these specimens are thought to be *E. aculea* n. sp. as she states, "Very characteristic are two long and sharp spines — the length of each spine is longer than the length of the eye — on the front edge of the head directed straight forward, and one single shorter, middle, sharp tooth, placed just in front of the simple eyes".

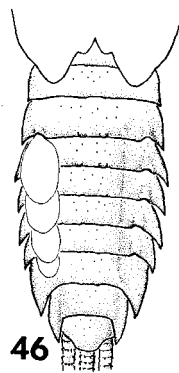
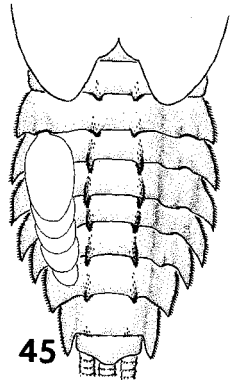
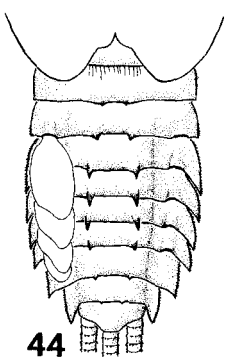
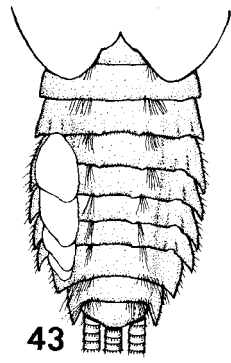
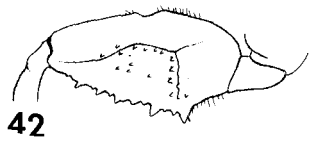
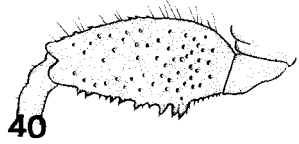
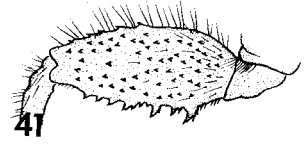
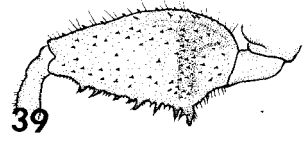
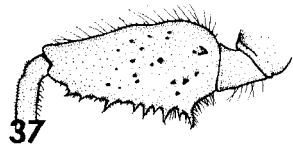
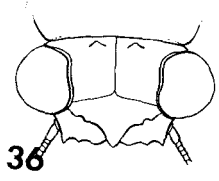
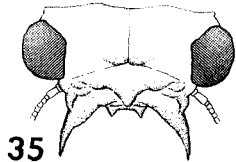
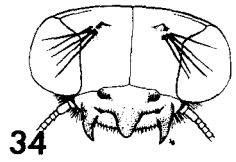
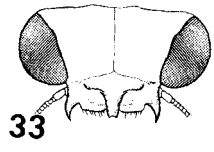
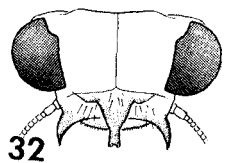
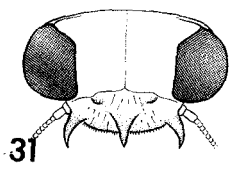
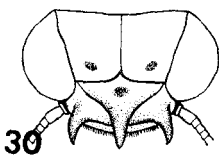
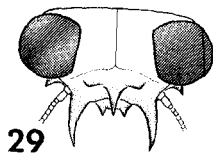
**NYPH.** Length: body 15.5–16.5 mm; caudal filaments 8.0–9.0 mm. General color brown. Head with long, gently curved, lateral fronto-clypeal tubercles, and a smaller, sharp median ocellar tubercle (Fig. 29); head without occipital or suboccipital tubercles. Thorax brown; thoracic nota without tubercles; legs unicolorous brown; ventral (leading) margin of fore femora with large tubercles (Fig. 37); anterior surface of fore femora with long tubercle-like projections; anterior surface of middle and hind femora without projections, apical tibial projection curved and sharp; tarsal claws without denticles. Abdominal terga with small paired submedian tubercles on segments 3–7 (Fig. 43); abdominal terga 1–9 with paired submedian tufts of setae (Fig. 43); abdominal sterna 2–8 often with dark brown sublateral maculae; sterna 2–8 with sparse setae on lateral margins. Caudal filaments light brown.

**TYPES.** Holotype: Male nymph, Kwang Nung, Korea, 3-IV-60, G. Field, in collection University of Utah, Salt Lake City. Paratopotypes: 3 male and 4 female nymphs, 1 male and 1 female nymphs in collection California State College at Los Angeles, others in collection University of Utah.

**REMARKS.** *Ephemerella aculea* n. sp. resembles *E. basalis* Imanishi as the nymphs of both species have a notched frontal shelf. These species are distinguished as the median ocellar tubercles of *E. aculea* are sharp and project beyond the frontal shelf (Fig. 29), whereas this tubercle is small and blunt in *E. basalis* (Fig. 35). These two species are further distinguished by the shape and development of the fronto-clypeal tubercles, and by the number and the degree of development of the paired, dorsal abdominal tubercles. The nymph of *E. basalis* has well-developed, paired, dorsal abdominal tubercles on segments 2–7. The nymph of *E. aculea* also resembles the nymphs of *E. trispina* Ueno, and *E. triacantha* Tshernova as all three species possess a well-developed, sharp median ocellar tubercle (Figs. 29–31), and they have well-developed tubercles on the ventral margin of the fore femora (Figs. 37–39). *Ephemerella aculea* is distinguished from the latter two species by possessing a notched frontal shelf, by the character of the fore femora, and by having only small, paired, dorsal abdominal tubercles on segments 3–7. The nymph of *E. triacantha* is without abdominal tubercles, and those of *E. trispina* have well-developed tubercles on segments 2–7.

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Figs. 29–46. 29–36, nymphal heads, front view: 29, *E. aculea*; 30, *E. triacantha* (after Tshernova, 1949); 31, *E. trispina*; 32, *E. bifurcata*; 33, *E. latipes*; 34, *E. kohnoi*; 35, *E. basalis*; 36, *E. borakensis* (after Ueno, 1966). 37–42, fore femora, dorsal view: 37, *E. aculea*; 38, *E. triacantha* (after Tshernova, 1949); 39, *E. trispina*; 40, *E. bifurcata*; 41, *E. kohnoi*; 42, *E. borakensis* (after Ueno, 1966). 43–46, nymphal abdomens, dorsal view: 43, *E. aculea*; 44, *E. denticula*; 45, *E. keijoensis*; 46, *E. maxima*.



***Ephemerella (Drunella) bifurcata* n. sp.**

**NYPH.** Length: body 12.0–13.0 mm; caudal filaments 7.0–8.0 mm. General color unicolorous brown to light brown with dark brown markings. Head with moderately long, curved, lateral fronto-clypeal tubercles, and with a bifurcate median ocellar tubercle (Fig. 32); head with small, paired, submedian occipital tubercles. Thoracic nota unicolorous brown to light brown with dark brown transverse markings; thoracic nota without tubercles; femora unicolorous brown to light brown with two dark brown bands; tibiae and tarsi unicolorous brown to light brown with median dark brown bands; ventral (leading) margin of fore femora with tubercles and anterior surface of fore femora rounded basally; femora with brown warts (Fig. 40); apical tibial projection straight and moderately sharp; tarsal claws with 2–4 denticles. Abdominal terga unicolorous brown to light brown with variable dark brown markings; terga 1–7 with paired submedian tubercles, tubercles on segment 1 small to barely discernible, tubercles on segments 2–7 well developed; abdominal sterna brown; sterna 2–8 with thick setae on lateral margins. Caudal filaments brown.

**HOLOTYPE.** Male nymph, Kita-aizu-gun, Tatemouchimura, Kita-aizu-gun, Fukushima Pref., Honshu, Japan, 14-V-50, M. Kohno, in collection of Illinois State Natural History Survey, Urbana. **Paratopotypes:** 3 female nymphs, same data as holotype, 2 nymphs in collection of Illinois Natural History Survey, and 1 nymph in collection of University of Utah. **Paratype:** Female nymph, Oku-Nikko, Totigi Pref., Japan, 27-V-46, M. Kohno, in collection of California State College at Los Angeles.

**REMARKS.** *Ephemerella bifurcata* n. sp. is most closely related to *E. latipes* Tshernova from Russia. The nymphs of both species have a notched median ocellar tubercle (Figs. 32–33). This previously undescribed species is distinguished from *E. latipes* as it is much larger in size, the frontal head tubercles are better developed, and the paired, dorsal abdominal tubercles are present on segments 1–7. The mature nymph of *E. latipes* is less than 8 mm in length, and paired, dorsal abdominal tubercles are present on segments 2–8.

***Ephemerella (Drunella) kohnoi* n. sp.**

**NYPH.** Length: body 11.0–11.5 mm; caudal filaments 7.0–7.5 mm. General color dark brown. Head with moderately long, curved, lateral fronto-clypeal tubercles, a moderately developed, blunt median ocellar tubercle, blunt lateral fronto-clypeal projections, and a broad round frontal shelf; vertex with paired submedian tubercles and tufts of long setae mesad to the compound eyes (Fig. 34). Thoracic notum without tubercles but with long setae; femora and tibiae dark brown; tarsi dark brown with darker brown basal bands and apices; ventral (leading) edge of fore femora with tubercles; anterior surface of femora with dark brown warts and long setae (Fig. 41); tibiae with long setae and apical foretibial projection moderately sharp; tarsal claws with 3–4 denticles. Abdominal terga brown; terga 1–9 with long setae; and terga 1–7 with a shallow median emargination and poorly developed, paired submedian tubercles; abdominal sterna dark brown, sterna 2–8 with darker brown sublateral maculae; sterna 4–8 with thick setae on lateral margins. Caudal filaments brown.

**HOLOTYPE.** Male nymph, Oku-Nikko, Totigi Pref., Honshu, Japan, 27-V-46, M. Kohno, in collection of Illinois State Natural History Survey, Urbana. **Paratopotype:** Female nymph, in collection of University of Utah, Salt Lake City.

**REMARKS.** *Ephemerella kohnoi* n. sp. does not appear to be closely related to any other described species of Asian *Drunella*. The nymphs of this species may be distinguished from those of all other described species by the following combination of characters: (1) possession of paired tubercles and tufts of heavy setae on the vertex of the head; (2) shallow median emarginations on abdominal terga 1–7; and (3) shape and degree of development of the fronto-clypeal tubercles and the median ocellar tubercle. I take pleasure in naming this species in honor of the collector of the holotype M. Kohno.

***Ephemerella (Drunella) yoshinoensis* Gose**

*Ephemerella yoshinoensis* Gose, 1963: 142.

Gose (1963) described this species from a male imago and several female imagos collected in Japan. Gose (1963) reared the male imago from nymphs, but he neglected to describe the nymphal stage. He also stated that the male imago is similar to *E. (Drunella) cryptomeria* Imanishi, but that it differed from the latter species by its larger size and by the ratio of the fore femora to the fore tibiae.

This species is herein included in the subgenus *Drunella* as the second segment of the genital forceps is bowed, and the third segment is more than twice as long as wide.

***Ephemerella (Drunella) borakensis* n. sp.**

*Ephemerella* sp. Ueno, 1966: 322, fig. 15.

Ueno (1966) described this species from a series of nymphs collected by the Kyoto University Pamir-Hindukush Expedition.

**NYPH.** Length: body 5.0–11.0 mm; caudal filaments 4.0–5.0 mm. General color reddish brown. Head with 7 blunt tubercles, paired tubercles at the base of each antenna, paired tubercles above lateral ocelli, paired occipital tubercles, and a larger median tubercle below the median ocellus (Fig. 36). Thorax reddish brown; thoracic nota without tubercles; ventral (leading) margin of fore femora with about 15 large and small tubercles (Fig. 42); anterior surface of fore femora with small tubercles, and with a flattened area demarcated by ridges (Fig. 42); tibial spine produced acutely at apex; tarsal claws with 2 marginal denticles. Abdominal terga with paired submedian tubercles on segments 3–9; abdominal segments 3–9 with postero-lateral projections; abdominal sterna pale. Caudal filaments pale (rewritten from Ueno, 1966).

**TYPES.** Holotype: Female nymph, the specimen from which Fig. 15-1 was illustrated (Kyoto Univ. Sci. Exp. Karakoram and Hindukush Ueno 1966), Borak, 9-VII-60, R. Yoshii. Paratopotypes: 11 nymphs, same data as holotype.

**REMARKS.** *Ephemerella borakensis* is distinguished from the nymphs of all described species of *Drunella* from Asia by the number and arrangement of the head tubercles and by the nature of the anterior surface of the fore femora.

**Subgenus *Ephemerella* s. s. Walsh**

*Ephemerella* Walsh, 1862: 377; Walley 1930: 17 (= *Chitonophora*); Edmunds & Traver, 1954: 238; Demoulin 1958: 10; Edmunds 1959: 544; Allen & Edmunds 1965: 245. *Chitonophora* Bengtsson, 1908: 243.

(*Ephemerella*) *excrucians*-group McDunnough, 1925: 169.

(*Ephemerella*) Section 1 McDunnough, 1931: 192.

(*Ephemerella*) *invaria*-group Traver, 1935: 565.

(*Ephemerella*) *needhami*-group Traver, 1935: 565.

Edmunds (1959) tentatively placed 8 Eurasian species in this subgenus, but he inadvertently excluded *E. mucronata* (Bengtsson 1908). Allen and Edmunds (1965) reported 25 species from North America, and Allen (1968) reported an additional 3 from western North America. Three undescribed species, *E. denticula* n. sp., *E. maxima* n. sp., and *E. keijoensis* n. sp., are included in this treatment, and the total number of species included in this subgenus is 40.

***Ephemerella (Ephemerella) denticula* n. sp.**

*Ephemerella* nbx Imanishi, 1940: fig. 13.

Imanishi (1940) described and figured the nymph of this previously unnamed species as *Ephemerella* nbx.

**NYPH.** Length: body 8.0–9.0 mm; caudal filaments missing. General color brown with dark brown markings. Head without frontal horns or dorsal tubercles; maxillary palpi

3-segmented. Thoracic nota brown with irregular reddish-brown markings; thoracic nota without tubercles; legs brown, apex of tarsi dark brown; fore femora with a subapical band of spines; tarsal claws with 8-10 denticles. Abdominal terga brown; terga 2-3 with reddish-brown submedian stripes and dark brown sublateral maculae; lateral margins of terga 5-8 with brown markings; terga 2-9 with spiculated, paired submedian tubercles (Fig. 44); tubercles small on segments 2-3 and 8-9, well developed on segments 4-7; width of tubercles at bases narrowest on segments 2 and 9, widest on segment 5; abdominal sterna 2-8 with paired sublateral maculae, and sterna 2-5 with paired submedian dots. Caudal filaments broken at base.

**TYPES.** Holotype: Mature nymph, Oku-Nikko, Totigi Pref., Japan, 27-V-46, M. Kohno, in collection Illinois State Natural History Survey, Urbana.

**REMARKS.** *Ephemerella denticula* possesses paired, dorsal abdominal tubercles as *E. mucronata* (Bengtsson), *E. aurivillii* (Bengtsson), *E. siberica* Tshernova, and *E. keijoensis* n. sp. This new species is distinguished from *E. siberica* as the latter bears thoracic tubercles, and possesses paired, dorsal abdominal tubercles on segments 3-9. It is distinguished from *E. aurivillii* as the body of the latter is nearly twice the length of that of *E. denticula*, and *E. aurivillii* possesses abdominal tubercles on segments 1-9. *Ephemerella denticula* is similar in size to *E. mucronata*, but is distinguished by the number of dorsal abdominal tubercles. The former has tubercles on segments 2-9, whereas in *E. mucronata* they are present on only segments 3-7.

#### ***Ephemerella (Ephemerella) keijoensis* n. sp.**

**NYPH.** Length: body 6.0-7.0 mm; caudal filaments 6.0-7.0 mm. General color light brown. Head brown; head without frontal horns or dorsal tubercles; maxillary palpi 3-segmented. Thoracic nota without tubercles; fore femora with a subapical band of spines; tarsal claws with 5-7 denticles. Abdominal terga with paired sublateral tubercles on segments 2-8 (Fig. 45); paired abdominal tubercles with numerous spicules; distinct postero-lateral projections on segments 3-9 (Fig. 45); abdominal sterna light brown. Caudal filaments with whorls of spines at apex of each segment, and with intersegmental setae.

**TYPES.** Holotype: Mature nymph, Seoul, Korea, 14-V-15, no other data, in collection Illinois Natural History Survey, Urbana. Paratopotype: Mature nymph, same data and deposition as holotype.

**REMARKS.** This species does not appear to be closely related to any other described species of *Ephemerella* s. s. The shape of the abdomen, the number and degree of development of the paired, dorsal abdominal tubercles, and the body size of *E. keijoensis* n. sp. will serve to distinguish this species from all described Asian species included in this subgenus.

#### ***Ephemerella (Ephemerella) maxima* n. sp.**

**NYPH.** Length: body 14.0-15.0 mm; caudal filaments missing. General color brown with reddish-brown markings. Head without frontal horns or dorsal tubercles; maxillary palpi 3-segmented. Thoracic nota brown with submedian reddish-brown stripes and reddish-brown maculae; thoracic nota without tubercles; legs brown; fore femora with a subapical band of spines; tarsal claws with 8-9 denticles. Abdominal terga brown; terga 2-5 with sublateral reddish-brown stripes; terga 4-7 with pale spots mesad to gills; abdominal terga with small, paired submedian tubercles on segments 3-8 (Fig. 46); postero-lateral projections on segments 3-9 (Fig. 46); abdominal sterna reddish brown; sterna 2-8 with paired sublateral maculae, and paired submedian dots and oblique dashes. Caudal filaments broken at base.

**TYPES.** Holotype: Mature nymph, Oku-Nikko, Totigi Pref., Japan, 27-V-46, M. Kohno, in collection Illinois Natural History Survey, Urbana.

**REMARKS.** *Ephemerella maxima* n. sp. does not appear to be closely related to the nymph of any described species. It is distinguished from all known Asian *Ephemerella* s. s. by the combination of its large size and the poorly developed wart-like, paired, dorsal abdominal tubercles on segments 3-8.

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## INTRODUCTION AND EVALUATION OF PREDATORS FROM INDIA AND PAKISTAN FOR CONTROL OF THE BALSAM WOOLLY APHID (HOMOPTERA: ADELGIDAE) IN NORTH CAROLINA

GENE D. AMMAN and CHARLES F. SPEERS

Intermountain Forest and Range Experiment Station, Ogden, Utah  
and

Southeastern Forest Experiment Station, Athens, Georgia

### Abstract

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Between 1961 and 1965, 15 species of predators from India and Pakistan were introduced into North Carolina for use in biological control experiments on the balsam woolly aphid. Recovery studies of these species have been made, but to date there is no evidence that any has become established. Lack of establishment is attributed largely to important differences in climate between the old and new environment and also to poor prey acceptance on the part of predator larvae and ovipositing adults.

### Introduction

The balsam woolly aphid, *Adelges piceae* (Ratzeburg) (Homoptera: Adelgidae), is a very destructive pest of all species of true fir in North America but especially of Fraser fir, *Abies fraseri* (Pursh) Poir. The aphid is of European origin and was accidentally introduced into the Northeastern United States about 1900 (Balch 1952). In 1957 it was discovered on Fraser fir in North Carolina (Speers 1958). This fir is distributed on about 24,000 ha in the high mountains of western North Carolina, eastern Tennessee, and southern Virginia.<sup>1</sup> Mortality of fir in the Mt. Mitchell area alone is now estimated to exceed 2.5 million trees, or one-third of those originally present.

Introductions of foreign insect predators to aid in control of the balsam woolly aphid were started in Canada as early as 1933 (Brown and Clark 1957). Since then, predators have also been introduced into the northeast (Dowden and Crosby 1958), Pacific Northwest (Mitchell and Wright 1967), and southeastern United States (Amman 1961). Preliminary results of introductions into North Carolina from Continental Europe were presented earlier (Amman and Speers 1964). The object of this paper is to report the introductions and probable fates of predators from India and Pakistan.

<sup>1</sup>Rauschenberger, J. L. and H. L. Lambert. Status of the balsam woolly aphid in the Southern Appalachians 1969. U.S. Forest Serv., Division of Forest Pest Control, Asheville, N.C. 28803. Rpt. 70-1-44, 20 pp. 1970.