

**DESCRIPTIONS OF LARVAL *HEPTAGENIA* FROM THE ROCKY
MOUNTAIN REGION (EPHEMEROPTERA: HEPTAGENIIDAE)**

ANDREW F. BEDNARIK AND GEORGE F. EDMUNDS, JR.

Dept. Biol., Univ. Utah, Salt Lake City 84112

To date, only 14 larvae of the 38 nominal species of *Heptagenia* Walsh from North America have been described. Larvae from western North America are especially poorly known. Larvae of five western *Heptagenia* are described and keyed herein. Of these, three [*Heptagenia criddlei* McDunnough, *Heptagenia elegantula* (Eaton), and *Heptagenia solitaria* McDunnough] are based on reared associations and two (*Heptagenia petersi* Allen and *Heptagenia simplicioides* McDunnough) are based on field associations with adults. Descriptions are drawn from mature individuals stored in 70% ethanol in the University of Utah collection.

Traver (1935) placed larvae of *Heptagenia* in two groups. The *maculipennis-lucidipennis* group has the pronotum widest near the middle, denticulate claws, posterolateral projections present on abdominal segments 6-8, and the filamentous portion of gill 7 absent. In the *flavescens-pulla-elegantula* group, the pronotum is widest near the anterior margin, claws are adenticulate, posterolateral projections are absent on segment 8 and usually 6-8, and the filamentous portion of gill 7 is present. In the larvae studied, those of the former group (*H. criddlei*, *H. petersi*, and *H. simplicioides*) also have setae scattered on the apical ventral surface of the maxillary galealacinia and only hair setae on the posterior margin of the fore femur while those in the latter group (*H. elegantula* and *H. solitaria*) have setae on the maxillary surface in a submedial row and spinelike setae in addition to hair setae on the posterior margin of the fore femur. Descriptions are ordered according to the above grouping.

There are a total of 11 species of *Heptagenia* listed for western North America, of which seven are known from the Rocky Mountain region. The larvae of *Heptagenia rosea* Traver were keyed but not described by Day (1956). Edmunds and Allen (1957) listed *H. rubroventris* as a synonym of *H. rosea*. This synonymy was based on the fact that specimens from a single locality in California ranged through the color differences of the two species. This California-Oregon species is closely related to *Heptagenia salvini* Kimmins from Mexico and the two may prove to be synonymous; if so, the name *salvini* is prior. *Heptagenia jewetti* Allen is known only from Oregon; the larvae are unknown. *Heptagenia kennedyi* McD. is confined to the coastal ranges of California and Oregon; the larvae also are

unknown. *Heptagenia otiosa* McD. is known only from the type locality of Maupin, Oregon; the late Jay R. Traver told the junior author on several occasions that she believed this species to be a synonym of *H. criddlei* McD. A study of the types or new collections from Maupin may solve the problem of the identity of *H. otiosa*. *Heptagenia rodocki* Traver was described from specimens taken from store windows in Lewiston, Idaho. The species differs from *H. simplicioides* primarily in having brownish lateral marks on the abdominal sterna and terga. It may be synonymous with *H. simplicioides* which is common at lights in summer in Lewiston. *H. simplicioides* apparently occurs both in the Clearwater and Snake Rivers, which join at Lewiston. Even though the validity of *rodocki* remains in doubt, it can not be synonymized without study of the types. *Heptagenia adequata* McD. was described from Cowley, Alberta. The junior author collected adults of this species from the Salmon River at Salmon, Idaho. From the same locality, larvae morphologically similar to *H. solitaria* were collected; probably these were the larvae of *H. adequata*. These specimens have not been located for the present paper.

The following key will separate the five species described herein. We emphasize that the keys are for mature larvae, and that the younger the larvae are the less likelihood of correct identification, but this is especially true of *elegantula* and *solitaria* since the length of the caudal filaments may be greater than body length in young *elegantula*.

Key to Mature Larvae

1. Filamentous portion of gill 7 present; claws adenticulate; setae on maxillary galea-lacinea ventral surface restricted to submedian row; pronotum widest near anterior margin 2
 - Filamentous portion of gill 7 absent; claws denticulate; setae on maxillary galea-lacinea ventral surface scattered, at least apically; pronotum widest in middle 3
 2. Caudal filaments 1.5× length of body; dorsal abdominal pattern as in Figs. 7a, 7b *solitaria*
 - Caudal filaments subequal to body in length; dorsal abdominal pattern as in Figs. 6a, 6b *elegantula*
 3. Dorsal abdominal pattern as in Fig. 5; cerci without setae on inner margins *petersi*
 - Dorsal abdominal pattern not as above; cerci with setae on inner margins 4
 4. Dorsal surface of fore femur with distally directed V-shaped pale area at middle, with numerous paddle-shaped setae (Fig. 3); dorsal abdominal pattern as in Fig. 1 *criddlei*
 - Dorsal surface of fore femur with undulate pale band at middle, with

sparse paddle-shaped setae (Fig. 4); dorsal abdominal pattern as in Fig. 2 *simplicioides*

Heptagenia criddlei McDunnough

Length.—Body 8–9, caudal filaments 8–9 mm.

Head.—Color brown with pale markings. Head wider than long, posterior margin straight or rarely slightly emarginate. Compound eyes of male separated by distance equal to or usually less than separation of lateral ocelli. Each galea-lacinia with 12–19 (usually 15–17) pectinate spinelike setae on crown; hair setae scattered on ventral surface, especially apically, of each galea-lacinia, not restricted to submedian row.

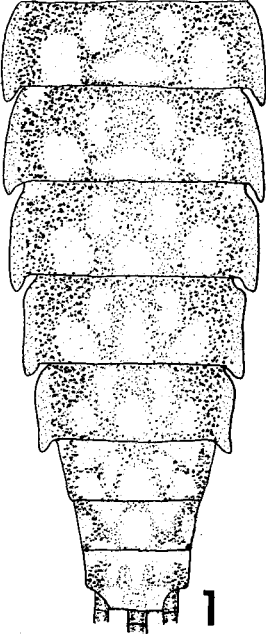
Thorax.—Color brown dorsally with pale markings, pale ventrally with median brown spot between fore leg bases and paired submedian brown spots between and posterior to middle leg bases. Pronotum width greater than or equal to head, widest in middle. Fore femora (Fig. 3) brown dorsally, each with distally directed V-shaped pale area at middle and pale spot in basal third; dorsal surface of each fore femur with numerous paddle-shaped setae; posterior margin with hair setae; anterior margin with sparse, small spinelike setae or without armature. Claws denticulate.

Abdomen.—Color brown dorsally with pale maculations (Fig. 1); terga 2–7 or 2–8 with paired submedian pale areas on anterior margins, rounded on anterior segments, elongate on posterior; 2–7 or 2–8 each with paired pale spots near posterior margin, approximately halfway between midline and lateral margins, median posterior pale dot sometimes present; 9 or 8–9 with continuous medial pale patch and paired posterior pale dots between midline and lateral margins. Color brown ventrally, each sternum paler posteriorly; sterna usually with paired dark longitudinal markings approximately halfway between midline and lateral margins. Posterolateral projections on segments 6–8. Filamentous portion absent on gill 7. Caudal filaments brown with paler articulations; cerci with setae on inner margins.

Diagnosis.—*Heptagenia criddlei* larvae may be distinguished from *H. simplicioides* by the more extensive armature and the nature of the pale maculations on the dorsal surface of the fore femur (Figs. 3, 4). Pale tergal markings in *H. criddlei* are also helpful (Fig. 1).

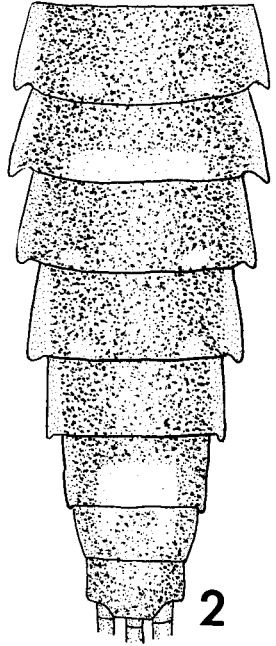
Ecology.—*Heptagenia criddlei* larvae have usually been collected in Utah on smooth rocks in a variety of clear and silted mountain streams between 1370–2600 m. Prior to emergence, larvae have primarily been found on large, partially submerged boulders at stream margins in negligible current.

Distribution.—Type locality.—Yellowstone National Park, Wyoming. *Heptagenia criddlei* is reported from Alberta (Traver, 1935), Arizona (Allen and Chao, 1978), Colorado (Traver, 1935; Edmunds, 1952), Idaho (Edmunds, 1952; Jensen, 1966), Montana (Traver, 1935), Nevada (see below),



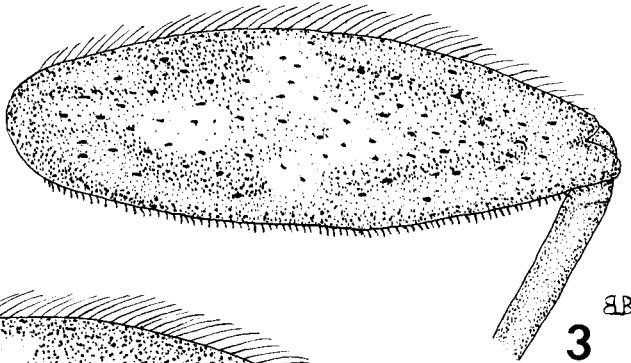
1

♂B



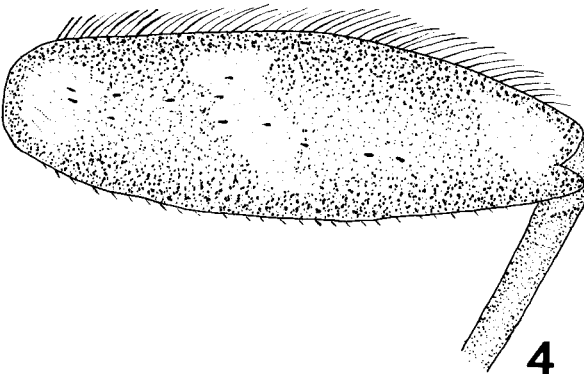
2

♂B



3

♂B



4

♂B

New Mexico (Allen and Chao, 1978), Oregon (Allen and Edmunds, 1956), Utah (Edmunds, 1954), Washington (Traver, 1935), and Wyoming (McDunnough, 1927, type; Edmunds, 1952).

Material examined ("L" = Larva).—COLORADO: Gunnison Co., Iola, Gunnison R., 1L, 16-VIII-1949 Higgins; Montrose Co., Buckeye Res., 1L, 3-IX-1946 Edmunds; IDAHO: Gooding Co., Hagerman, 1L, 16-VIII-1945 Harmston; Idaho Co., Whitebird Cr., Jct. Salmon R., 2L, 16-VIII-1964 Nebeker, Petty; NEVADA: Elko Co., Franklin R., Hwy. 11, 3L, 19-IX-1957 Edmunds, Allen; Washoe Co., Truckee R., Verdi, 2L, 21-IX-1957 Edmunds, Allen; Truckee R., Lawton, 6 mi W Reno, 6L, 21-IX-1957 Edmunds, Allen; OREGON: Baker Co., Camp Cr., 68 mi N Vale, 7L, 20-VIII-1954 Edmunds; S Fk. Burnt R., 2 mi W Unity, 7L, 20-VIII-1954 Allen; Benton Co., Corvallis, Willamette R., 5L, 26-VIII-1954 Edmunds; Clackamas Co., Molalla R., 3 mi E Molalla, 3L, 26-VIII-1954 Allen; Douglas Co., Umpqua R., Milo, 6L, 24-VIII-1954 Allen; Grant Co., Canyon Cr., John Day, 6L, 21-VI-1954 Allen; Upper W Fk. John Day R., 9L, 21-VIII-1954 Edmunds; UTAH: Abajo Mts., Indian Cr., 7L, 10-IX-1946 Edmunds; Salt Lake Co., Salt Lake City, Parleys Can., 4L, 23-VII-1945 Edmunds; Parleys Can. at Wasatch Blvd., 1L (reared cast), 10-VIII-1962 Anderson; San Juan Co., Upper La Sal Cr., 3L, 8-IX-1946 Edmunds; Devil Canyon, 12 mi S Monticello, 1L, 28-VI-1947 Downey; Utah Co., Pleasant Grove, 9L, 16-VIII-1944 Edmunds; Washington Co., Zion Natl. Pk., 10L, 14-VII-1947 Edmunds; WYOMING: Washakie Co., Ten Sleep Can., 8L, 16-VIII-1947 Harmston.

Heptagenia petersi Allen

Length.—Body 6–7, caudal filaments 6 mm.

Head.—Color light brown with pale areas laterad of compound eyes and freckled, brown dots anteriorly. Head wider than long, posterior margin slightly emarginate. Compound eyes of male separated by distance greater than separation of lateral ocelli. Each galea-lacinia with 14–17 pectinate spinelike setae on crown; maxillary hair setae scattered on ventral surface, especially apically, of galea-lacinia, not restricted to submedial row.

Thorax.—Color light brown dorsally with pale markings, pale ventrally. Pronotum less than or equal in width to head, widest in middle. Fore femora pale dorsally, each with distally directed V-shaped light brown area in distal half and paired light brown areas in basal half, sometimes connected forming distally directed V-shaped area; dorsal surface of each fore femur with sparse

←

Figs. 1–4. Figs. 1–2. Abdomen, dorsal view. Fig. 1. *Heptagenia criddlei*. Fig. 2. *H. simplicioides*. Figs. 3–4. Fore femur. Fig. 3. *H. criddlei*. Fig. 4. *H. simplicioides*.

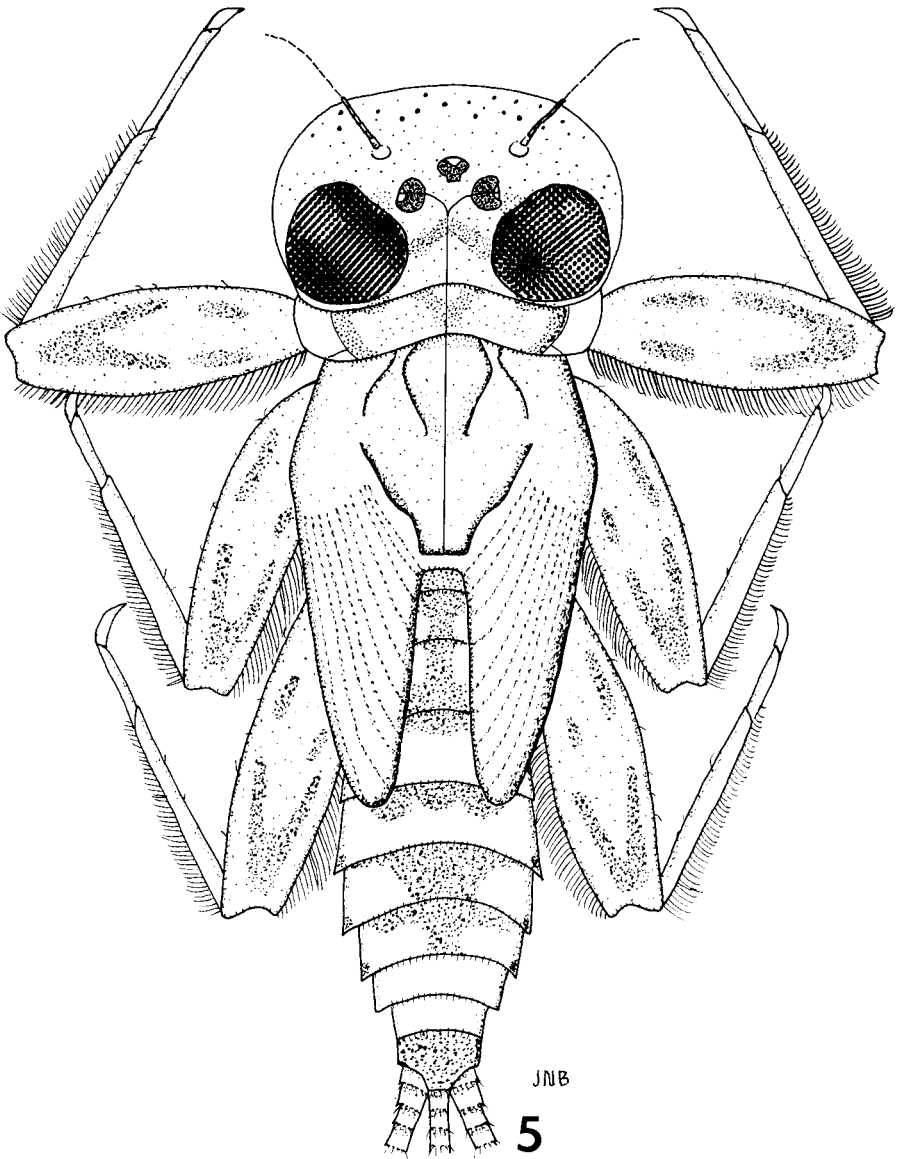


Fig. 5. Dorsal view. *Heptagenia petersi*.

paddle-shaped or slightly acute setae; posterior margin with hair setae; anterior margin with sparse, small spinelike setae. Claws denticulate.

Abdomen.—Color light brown dorsally with pale maculations (Fig. 5); terga 1–9 each with lateral pale areas and pair of brown spots in posterolateral corners; 4–5 each with large median pale areas in posterior two-thirds; 6 predominantly light brown, sometimes with paired pale submedian areas in posterior half; 7 with paired pale submedian areas or entirely pale in posterior two-thirds; 8–9 predominantly pale; 10 predominantly brown; 1–8 sometimes with brown longitudinal sublateral markings. Color pale ventrally; sterna 7–8 each sometimes with median transverse brown markings near anterior margin. Posterolateral projections on segments 6–8. Filamentous portion absent on gill 7. Caudal filaments light brown or yellow, articulations spinous; cerci with setae absent on inner margins.

Diagnosis.—*Heptagenia petersi* larvae may be easily distinguished from other western *Heptagenia* by the distinctive dorsal abdominal color pattern (Fig. 5).

Ecology.—*Heptagenia petersi* larvae have been collected on silt covered rocks in medium-speed riffles in rather warm, medium-sized rivers.

Distribution.—Type locality.—Little America, Sweetwater Co., Wyoming (Allen, 1966). *Heptagenia petersi* has also been reported from Utah (Allen, 1966).

Material examined.—WYOMING: Sweetwater Co., Blacks Fk. R. at Granger, 1L, 22-VII-1971 Jensen, Provonsha; Blacks Fk. R. at I80, 6 mi E Little America, 5L, 22-VII-1971 Jensen, Provonsha; Uinta Co., approx. 4 mi E Lyman, Smith Fk. R., I80, 1L, 3-VIII-1968 McCafferty, Koss.

Heptagenia simplicioides McDunnough

Length.—Body 8–12, caudal filaments 7–9 mm.

Head.—Color brown with pale markings. Head wider than long, posterior margin usually straight. Compound eyes of male separated by distance less than or equal to separation of lateral ocelli. Each galea-lacinia with 15–17 pectinate spinelike setae on crown; hair setae scattered on surface, especially apically, of galea-lacinia; not restricted to submedian row.

Thorax.—Color brown dorsally with pale markings, pale ventrally with brown markings. Pronotum greater than or equal in width to head, widest in middle. Fore femora (Fig. 4) brown dorsally, each with basal and distal pale spots and pale median undulate band; dorsal surface of each fore femur with paddle-shaped setae present but sparse; posterior margin with hair setae; anterior margin with sparse, small spinelike setae or without armature. Claws denticulate.

Abdomen.—Color brown dorsally with pale maculations (Fig. 2); tergum 1 pale; 2, 5–7 uniformly brown or with posterior paired pale spots; 3–4 with

posterior paired pale spots; 4 usually with pale posterior margin; 8 mostly pale; 9 mostly brown with anterior paired pale submedian marks; 10 mostly dark brown; 4–10 sometimes entirely brown with pale markings obscured. Color ventrally usually uniformly brown. Posterolateral projections on segments 6–8. Filamentous portion absent on gill 7. Caudal filaments brown with paler articulations; cerci with setae on inner margins.

Diagnosis.—*Heptagenia simplicioides* may be distinguished from *H. criddlei* as indicated under the latter species. [*H. simplicioides* larvae were keyed and included in a verification table by Traver (1935) but have not been previously described.]

Ecology.—*Heptagenia simplicioides* larvae have been collected among rocks and gravel in warmer, often silted, rivers and streams below 2130 m elevation.

Distribution.—Type locality.—Waterton Lakes, Alberta. *Heptagenia simplicioides* is reported from Alberta (McDunnough, 1924, type; Traver, 1935), Arizona (Allen and Chao, 1978), Colorado (see below), Idaho (Jensen, 1966), Montana (Edmunds, 1952), Nevada (see below), Oregon (Allen and Edmunds, 1956), Utah (Edmunds, 1954), and Washington (Traver, 1935).

Material examined.—COLORADO: Boulder Co., St. Vrain Cr., Hygiene, 2L, 17-VII-1975 Ward; IDAHO: Lemhi Co., Pahsimeroi R., 4 mi NW May, 1L, 25-VII-1964 Edmunds; Lincoln Co., Big Wood R. at Jct. U.S. Hwy. 93, 17 mi N Shoshone., 2L, 24-VII-1964 Jensen, Lombardi, Isenberg; Payette Co., Payette R. at Jct. Id. Hwy. 52, 9.8 mi E Payette, 1L, 22-IX-1963 Jensen. NEVADA: Elko Co., Deeth, Humbolt R., 1L, 18-VI-1966 Edmunds.

Heptagenia elegantula (Eaton)

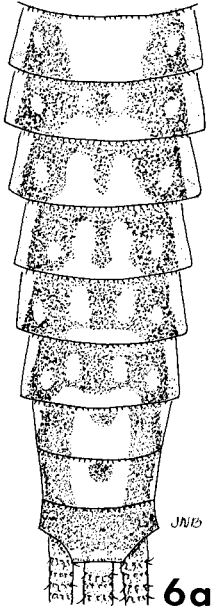
Length.—Body 10–12, caudal filaments 10–12 mm.

Head.—Color brown with pale markings. Head wider than long, posterior margin straight or slightly emarginate. Compound eyes of male separated by distance greater than separation of lateral ocelli. Each galea-lacinia with 9–14 (usually 9–11) pectinate spinelike setae on crown; maxillary hair setae on surface of galea-lacinia forming submedial row.

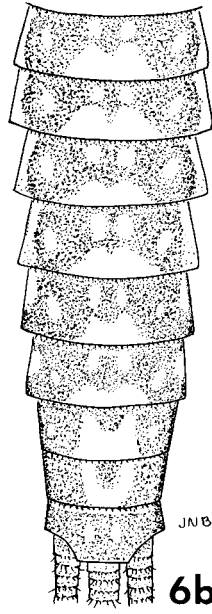
Thorax.—Color brown dorsally with pale markings. Pronotum greater than or equal in width to head, widest near anterior margin. Fore femora usually brown dorsally with pale undulate median band and large basal pale spot, often extending to median band, distal one sixth pale; fore femora some-

→

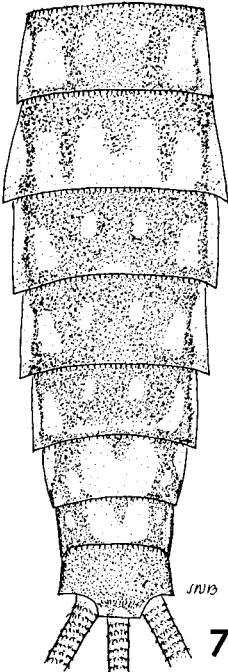
Figs. 6–7. Abdomen, dorsal view. Fig. 6. *Heptagenia elegantula*. Fig. 6a. "Typical," Fig. 6b. "Variant." Fig. 7. *H. solitaria*. Fig. 7a. "Typical." Fig. 7b. "Variant."



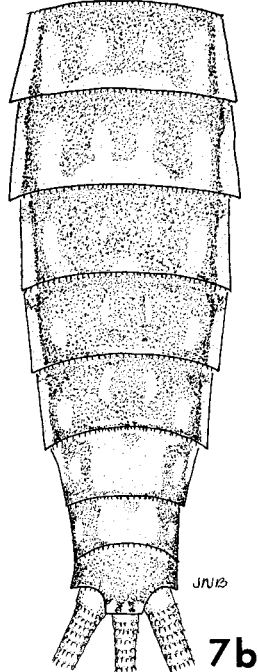
6a



6b



7a



7b

times pale dorsally with 2 yellowish brown bands; dorsal surface of each fore femur with oval and/or paddle-shaped setae; posterior margin with hair setae and spinelike setae; anterior margin with sparse small spinelike setae only. Claws adenticulate.

Abdomen.—Color brown dorsally with pale maculations (Figs. 6a, b); terga 2–7 each with paired submedian pale streaks arising at anterior margin, pale area medially at posterior margin, and pale markings, often round between submedian streaks and lateral margins; 2–8 with pale lateral margins; 8–9 each with median pale patch with brown median spot on anterior margin; 10 with pale area medially at anterior margin. Pale ventrally; sterna with small paired sublateral spots on anterior and posterior margins. Posterolateral projections absent on segment 8. Filamentous portion present on gill 7. Caudal filaments with alternate narrow light and dark bands; cerci with setae present on at least part of inner margins.

Diagnosis.—*Heptagenia elegantula* and *H. solitaria* are easily separated if the caudal filaments are present and unbroken, but unfortunately caudal filaments are frequently broken from larvae. With a series, the color pattern will usually allow separation of the two species (see Figs. 6a, b; 7a, b). [*H. elegantula* larvae were keyed and included in a verification table by Traver (1935) but have not been previously described.]

Ecology.—*Heptagenia elegantula* larvae are found in warmer silted streams and are the most common heptageniids of the silted Colorado River system. Individuals are most often collected on rocks or wood but are common in beds of *Potamogeton* in canals. Larvae have been collected in Utah at elevations between 1030–2010 m. Ecologically, *H. elegantula* and *H. solitaria* overlap to some degree, but in large rivers where trout are excluded by high temperatures *H. elegantula* frequently occurs, and *H. solitaria* is excluded. However, in some cases *H. elegantula* is found in trout waters.

Distribution.—Type locality.—Arkansas Canyon, Colorado. *Heptagenia elegantula* is also reported from Alberta (McDunnough, 1924), Arizona (Eaton, 1883–88), Colorado (Eaton, 1883–88, type; Traver, 1935; Edmunds, 1952), Idaho (Jensen, 1966), New Mexico (Allen and Chao, 1978), Saskatchewan (Edmunds, 1952), and Utah (Needham and Christenson, 1927; Edmunds, 1954).

The description of *H. elegantula* by Daggy (1945) in Minnesota does not agree with our specimens and is referable to *Heptagenia diabasia* Burks. Records of *H. elegantula* from Iowa (Daggy, 1945), Kansas (Traver, 1935), and Nebraska (Traver, 1935) are also likely the latter species.

Material examined.—COLORADO: Grant Jct., Colorado R., 2L, 1-V-1962 Knight; NEVADA: Clark Co., Virgin R. nr. Mesquite, 2L, 4-IV-1970 Edmunds; NEW MEXICO: Confluence San Juan and Pine R., 1L, 25-V-1949 Higgins; OREGON: Quinalt R., 1L, 22-V-1947 Needham; UTAH: San Juan Co., Colorado R., 2 mi below Ticaboo Can., 4L, 7-VII-1958 Musser;

Colorado R., 113 mi N Lees Ferry, 1L, 16-VII-1958 Smith, Musser; Uintah Co., Brush Cr., 3 mi N Jensen, 1L, 4-VII-1968 Koss; WYOMING: Albany Co., Big Laramie R. at Laramie, 5L, 18-19-VI-1977 Edmunds; Sweetwater Co., Blacks Fk., 1 mi above Jct. Green R., 4L, 10-VII-1959 Smith, Musser; Blacks Fk. R. at 180, W Green R. City, 5L, 2-VIII-1969 Provonsha; Green R. 12L, 29-VI to 4-VII-1959 Smith, Musser.

Heptagenia solitaria McDunnough

Length.—Body 11, caudal filaments 19 mm.

Head.—Color brown with pale markings. Head wider than long, posterior margin straight or slightly emarginate. Compound eyes of male separated by distance equal to or greater than separation of lateral ocelli. Each galealacinia with 11–15 pectinate spinelike setae on crown; maxillary hair setae on surface of galealacinia forming submedial row.

Thorax.—Color brown dorsally with pale markings, pale ventrally. Pronotum greater than or equal in width to head, widest near anterior margin. Fore femora brown dorsally with subproximal, median, and distal pale undulate crossbands, subproximal band sometimes incomplete; dorsal surface of each fore femur with paddle-shaped and/or oval setae; posterior margin with hair setae and spinelike setae; anterior margin with sparse, small spine-like setae only. Claws adenticulate.

Abdomen.—Color mostly brown dorsally with pale maculations (Figs. 7a, b); tergum 1 predominantly pale; 2–7 brown, each with paired submedian spots, occasionally elongate anteriorly, and pale spots halfway between midline and each lateral margin; 4 pale on posterior margin; 8–9 each with large pale median patches and brown median spot near anterior margin; 10 mostly brown with narrow anterior pale area. Sterna pale; 2–8 each with light brown sublateral dots at anterior margin; 9 brown on lateral margins. Posterolateral projections absent on segment 8. Filamentous portion present on gill 7. Caudal filaments alternately pigmented, 2 dark and 2 pale; cerci with setae on inner margins.

Diagnosis.—*Heptagenia solitaria* larvae may be distinguished from *H. elegantula* as indicated under the latter species.

Ecology.—*Heptagenia solitaria* larvae have been collected on large smooth rocks in large, often silted, mountain streams, usually at elevations between 1670–2290 m.

Distribution.—Type locality.—Waterton Lakes, Alberta. *Heptagenia solitaria* is reported from Alberta (McDunnough, 1924, type); Arizona (Allen and Chao, 1978), Colorado (McDunnough, 1926; Traver, 1935; Edmunds, 1952), Idaho (Jensen, 1966), Montana (Traver, 1935; Edmunds, 1952), Nevada (see below), Oregon (Allen and Edmunds, 1956), Utah (Edmunds, 1954); and Wyoming (Edmunds, 1952).

Material examined.—IDAHO: Franklin Co., Bear R., Jct. Id. Hwy. 34, 4 mi N Preston, IL, 20-VI-1964 Jensen, Richardson; NEVADA: Elko Co., N Fk. Humbolt R., 15 mi E Elko, 4L, 23-IX-1957 Edmunds, Allen; UTAH: Duchesne Co., Strawberry R. above Starvation Res., 5L, 1-IX-1974 Edmunds; E Fk. Sevier R., Osiris, 1L, 14-VII-1947 Edmunds; Summit Co., Weber R. at Peoa, 2L, 14-X-1970 Boreham; Uintah Co., Vernal refuge, 3 mi S. Vernal, 3L, 16-VI-1949 Bell; WASHINGTON: Spokane Co., Little Spokane R., Dartford, 3L, 13-VI-1955 Allen; WYOMING: Sublette Co., Green R., Big Piney, 2L, 9-VIII-1949 Higgins.

Acknowledgments

We acknowledge Emma L. Bednarik and Julia N. Bailey for preparing the illustrations appearing in this paper.

Literature Cited

- Allen, R. K. 1966. New species of *Heptagenia* from western North America (Ephemeroptera: Heptageniidae). *Can. Entomol.*, 98:80–82.
- Allen, R. K., and E. S. M. Chao. 1978. Mayflies of the Southwest: new species and records of Heptageniidae (Ephemeroptera). *Pan.-Pac. Entomol.*, 54:311–315.
- Allen, R. K., and G. F. Edmunds, Jr. 1956. A list of the mayflies of Oregon. *Proc. Utah Acad. Sci. Arts Lett.*, 33:85–87.
- Daggy, R. H. 1945. New species and previously undescribed naiads of some Minnesota mayflies (Ephemeroptera). *Ann. Entomol. Soc. Amer.*, 38:373–396.
- Day, W. C. 1956. Ephemeroptera. In: *Aquatic insects of California*, R. L. Usinger, ed., Univ. Calif. Press, Berkeley., pp. 79–105.
- Eaton, A. E. 1883–1888. A revisional monograph of recent Ephermeridae or mayflies. *Trans. Linn. Soc. London, Sec. Ser. Zool.*, 3:1–352.
- Edmunds, G. F., Jr. 1952. Studies on the Ephemeroptera Part II. The taxonomy and biology of the mayflies of Utah. Unpubl. Ph.D. Thesis, Univ. of Mass., 399 pp.
- Edmunds, G. F., Jr. 1954. The mayflies of Utah. *Proc. Utah Acad. Sci. Arts Lett.*, 31:64–66.
- Edmunds, G. F., Jr., and R. K. Allen. 1957. A checklist of the Ephemeroptera north of Mexico. *Ann. Entomol. Soc. Amer.*, 50:317–324.
- Jensen, S. L. 1966. The Mayflies of Idaho (Ephemeroptera). Unpubl. MS thesis, Univ. of Utah., ix + 367 pp.
- McDunnough, J. 1924. New Canadian Ephermeridae with notes, II. *Can. Entomol.*, 56:90–98, 113–122, 129–133.
- McDunnough, J. 1926. New Canadian Ephermeridae with notes, IV. *Can. Entomol.*, 58:296–303.
- McDunnough, J. 1927. A new *Heptagenia* from the Yellowstone region (Ephemeroptera). *Can. Entomol.*, 59:261.
- Needham, J. G., and R. O. Christenson. 1927. Economic insects in some streams of northern Utah. *Utah Agric. Exp. Sta. Bull.*, 201:1–36.
- Traver, J. R. 1935. Part II, Systematic. In: *The biology of mayflies* by J. G. Needham et al., Comstock Publ. Co., Ithaca, pp. 239–739.