THE ROCKY MOUNTAIN SPECIES OF THE MAYFLY GENUS EPHEMERELLA.

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Ever since the publication in 1884 of that part of Eaton's *Revisional Monograph of Recent Ephemeridæ* treating of the genus Ephemerella, the Rocky Moutain region has been known as the source of some of the most remarkable of Mayflies. The strangest of these Eaton knew only as nymphs. These he described and figured. The incomplete results of rearings that were published by myself in 1905 and by Dodds in 1923 left matters in some confusion, as was pointed out by Lestage in his comprehensive review of the group in 1925. For some time there has been obvious need of more careful life-history work on these forms, such as could only be done in the place where they live.

In the summer of 1926 I had an opportunity, during a six weeks stay in Northern Utah, to live beside Logan River, and to rear many of the aquatic insects of that beautiful mountain stream. There I reared four of Eaton's species belonging to the Ephemerella group; and on a concluding trip to mountain streams farther southward I collected others as nymphs. For the first time material is at hand adequate for learning the identity of these curiously diverse forms.

In this group it is easy to find striking differences among the nymphs, while the corresponding differences among the adults seem trivial, and hardly of generic value. In this paper I shall treat Ephemerella as a single genus, having four subgenera in the Rocky Mountain region.* The seven species that I have obtained thence divide into four groups as follows:

* This omits Chitonophora Bengtsson (1909) and Torleya Lestage (1917), because I cannot fit the American species to the combination of characters given in the definition of these very minor groups. It may be worthy of record here that Ephemerella nymphs of the Torleya type as described by Lestage, having compact bodies and stout, bristle-whorled tails, occur also in America. I have some specimens that were collected in 1923, in San Antonio Canyon, near Claremont, California, by Miss Theresa M. Robinson.

KEY TO THE SUBGENERA OF EPHEMERELLA.

Adults.

1. Intercalary veinlets between veins Cu_2 and 1st A conjoined into two strong forks that are attached basally to the former.....2
   These intercalaries weak and in part unattached basally...**Ephemerella** Walsh.
2. Veins Cu_2 and 1st A usually conjoined basally by a cross vein (sometimes touching at a single point); ♂, inner margin of long 2nd joint of forceps gently curved; ♀, 9th ventral segment bilobed at apex.....**Drunella** Ndm.
   Veins Cu_2 and 1st A fused for a distance basally; ♂, inner margin of 2nd joint of forceps angulate; ♀, 9th ventral segment of abdomen entire at apex, **Eatonella** n. subg.

Nymphs.

1. Head with a broad frontal shelf.....2
   Head with no broad frontal shelf.....3
2. Frontal shelf entire; body flat, hairy.....**Timpanoga** n. subg.
   Frontal shelf notched at sides for reception of the antennæ; body plano-convex, smooth.....**Eatonella**
3. Head with high dorsal spines or tubercles.....**Drunella** 4
   Head with low dorsal spines or none.....**Ephemerella** 5
4. Mesothorax with no dorsal spines.....**E. grandis** Etn.
   Mesothorax with high dorsal spines.....**E. spinifera** sp. n.
5. Front femora toothed on front edge.....**E. coloradensis** Dodds
   Front femora not toothed on front edge.....6
6. Gills on abdominal segments 3–7; 2nd joint of antenna black..**E. inermis** Etn.
   Gills on abdominal segments 4–7; 2nd joint of antenna pale..**E. margarita** sp. n.

Ephemerella grandis Etn.

I especially desired to find and rear this species because of the doubt existing as to the identity of the nymph. So I was glad to find it common in Logan River. I reared thirteen specimens on eleven different dates ranging between June 18th and July 18th. Nine of these were males and four were females. About half of them are fully matured, finely colored specimens.

Neither imagos nor subimagos were seen at large.

It is the adult, rather than the nymph that is in need of completer description, since the male has not been made known, and Eaton's figures of the nymph leave, for that stage, little to be desired.

Adult male.—Length 14 mm.; tails 19–21 mm. additional.

Color of body dark brown above and below, phalerate with paler on most of the sutures. Abdomen conspicuously ringed with paler, and with pale lateral line, and a pale apical border across the 10th segment. Fore legs brownish, becoming paler towards the tip of the tarsi. Other legs all pale, except for a wash of brownish on femora beyond their bases. Tails blackish at base gradually becoming paler toward their long and very slender tips.

Body very stout. Wings hyaline, principal veins dark brown. Crossveins obsolete in the costal, subcostal and basal part of first radial spaces, heavy along the middle of the wing. Generally there is a crossvein joining the base of vein Cu_2 with the 1st anal vein, but occasionally a slight fusion of the two veins occurs at this point, eliminating the crossvein.

Abdomen slowly tapering. The ninth segment bears a short, sharply triangular lateral spine that is about as long as the forceps basis, and there is a trace of a spine in corresponding position on segment 8. The basal joint of the forceps is much wider than long; the second joint is long, smoothly curved and widened to both ends; the third joint is blunt, incurved and about a fourth as long as the second. The penes are unarmed, fused together, parallel sided, with a wide V-shaped apical notch between their apices.

The subimago is similar, but duller in coloration, and on the wings a bit darker owing to heavier pigmentation along the veins.

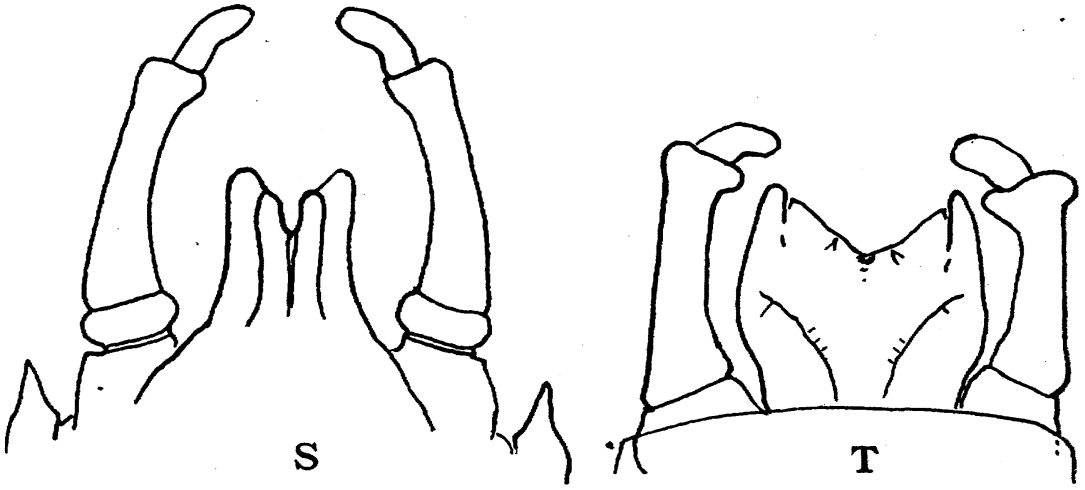

FIG. 1. Male genitalia: *S*, of *Ephemerella grandis*, and *T*, *of E, inermis*.

The statement in Eaton's description of the female, "Ventral lobe of segment 9 emarginate; the pleural points short and acute", leaves no doubt as to the identity of this species.

Eaton was right in considering the basal fusion of vein Cu_2 and 1st A in this species unusal (Monograph. p. 330) I was in error (1905, p. 43) in saying that he described it as characteristic of the species. I find that it occurs in but one of my adult specimens, and on one side only in that one. It was misleading that the single nymphal wing I then had for examination showed that fusion. However, when this fusion occurs, it is limited to a single point; whereas, in the species that Dodds (1923) reared and took to be *F, grandis*, the two veins coalesce for a short space.

The nymph of this species was adequately illustrated in Eaton's Monograph Pl. 38, Figs. 11 to 13. A few supplemental descriptive notes may be added here.

The length of grown specimens is 12.5 mm., with tails 7 mm. additional.

The coloration is usually obscured by the darkening of age and accretions of silt; but recently moulted specimens show an uneven pale middorsal line the entire length of the body, much widened on the 8th abdominal segment, and the lateral spines of the abdomen also pale. Legs broadly but obscurely ringed with brown, two rings on each femur and one on each tibia. Tails alternately brown and yellow at about six unequal intervals of each color; their joinings are sparsely beset with fragile, deciduous hairs.

The pale antennæ are shorter than the head is wide. Underneath the prothorax between the bases of the fore legs there is a flat hoof-shaped tubercle adjacent to the rear of the head. The dorsal tubercles are well developed. The stout pair on the top of the head has a backward slant. The rounded pair on the top of the prothorax has a smaller supplemental pair behind it, and the tubercle on each side of the prothorax has a smaller supplementary one before it. The paired, sharp, thorn-like, backward curving tubercles on abdominal segments 2 to 9 are longest on segments 8 and 9, but the length is increased gradually from segment 2 onward. The thin, flat, sharp lateral spines on segments 3 to 9 begin obscurely and increase in length to the 8th segment. On the narrowed 9th segment they are straghter, less incurved, but about as long as on the 9th. The 9th sternite is bilobed apically in the female; four-lobed in the male.

Besides the specimens from Logan River and those from Pecos, N. Mex., described by me in 1905, I have others from Santa Fe, N. Mex., collected by P. B. Paul and from Twin Lakes, Colorado, collected by Chancey Juday. Clemens records the occurrence of the genus in Ontario.

Ephemerella spinifera n. sp.

This is a smaller species than *D. grandis*, and with a much more remarkable development of spines upon the back. Only the nymph is known.

The nymph apparently grown measures in length 8 mm.; tails 5 mm. additional.

Color pale brownish with hardly a suggestion of pattern, though there is a succession of somewhat lighter areas on the tails. The head and body bear tubercles as follows: a huge pair on the top of the head, nearly doubling its height, aslant backwards; a smaller slender twin pair on each side of the pronotum; four pairs on the mesonotum, the median one of these largest, very prominent, aslant backward, two small sudmedian pairs, one at the front and one at the rear, the latter smallest and confluent, and outside the anterior pair is the fourth pair which is slender and of intermediate height. Then on the abdomen there are eight pairs, representing, the usual double line of dorsal hooks. These are on segments 2 to 9. They are all thorn-like, sharp-pointed and curved backward. They are subequal on segments 2 to 7, and on 8 and 9 they are three times as large and beset with scattered fragile bristles.

The pale antennæ are about as long as the head is wide. The front femora are swollen, widest across the basal third, carinate and broadly lobed in front, and carinate also above, where fringed with fragile setae. The "thumb" of the front tibia is two-fifths as long as the tarsus. There are flat lateral spines on abdominal segments 3 to 9, minute on 3 and gradually increasing in prominence to 7, 8 and 9. Gills on segments 3 to 7 in a regularly overlapping series.

Four nearly grown nymphs from Blackfoot River near Potomac, Montana, collected on June 20th, 1906 by Frank C. Barry, and a single younger nymph collected by myself in the north fork of Ogden River, Utah, on July 27th, 1926.

I have another nymph that will go in the subgenus Drunella, sent me by Chancey Juday, collected by him in the South Fork of the Keweah River, California, July 13, 1904

Ephemerella doddsii n. sp.

This is a species of large size that is known to some of the fishermen on Logan River as the "Ginger quill". In superficial appearance it is strikingly like *E. grandis*, despite remarkable differences in their nymphs.

Dodds reared a single specimen; and, finding in the wings a basal fusion of veins Cu_2 and 1st A, he naturally referred it to the only species in which that fusion was then known to occur, *E. grandis*. He published good figures of the nymph and of the gentalia of the male imago, and gave an excellent account of its habitat and habits.

The nymph is altogether unique in having developed out of the under side of the broad abdomen a powerful sucking

disc by means of which it can stoutly adhere to the surface of smooth stones in the current. This disc adheres so firmly that a sudden pull on a leg will break the leg off before the disc will let go; but the nymph may be pushed about over a smooth surface without releasing the disc, and it probably creeps by means of the disc.

The species is common in Logan River. I reared fourteen specimens on five different dates between the 19th and 28th of June, and collected at large eight others as subimagos, two of which were reared to the full adult condition. The subimagos were all taken as they flew from the river at nightfall. No imagos were seen at large.

The adult measures in length of body, ♂, 13 mm., ♀, 14 mm.; tails, ♂, 11 mm., ♀, 14.5 mm. Fore leg, ♂, 12.5 mm., ♀, 8 mm. Fore wing, ♂, 14mm., ♀, 14.5 mm.

Adult male.—Coloration strikingly like that of the preceding species, brown, with paler sutures, giving a phalerate appearance to the sides of the thorax and a ringed appearance to the abdomen, whereon runs the same pale midlateral line and border around the apical margin of the last segment. The tails are notably shorter, but have the same dark bases and pale slender tips. The dark fore legs grow graually paler toward the tips of the tarsi, and the brown on middle and hind legs is less extended than in *E. grandis*.

The wings are similar except for a constant and more extended fusion of vein Cu_2 at base with the 1st anal vein.

The lateral spines at the apex of the 9th segment are much larger, and reach the level of the base of the 2nd segment of the forceps. Basal segments of the forceps as wide as long; 2nd segment constricted and bent, almost angled, in the middle; 3rd segment blunt, about a third as long as the second.

Adult female.—The female is much paler than the male but shows a similar color disposition on the sides of the body, legs, wings, and tails. Except at its ends the abdomen appears wholly dark, due to contained eggs. The entire top of the thorax is pale tan color.

On the lateral margin of the abdomen segment 8 is angled at the apex and 9 bears a sharply triangular lateral spine that extends backward as far as the apex of the 10th segment. The apex of the 9th sternite is produced beyond 10 into an oval, entire lobe.

The subimago is similar in appearance but paler of body and darker of wing, the veins of the wing being heavily shaded with fuscous.

The nymph measures in length 11.5 mm.; tails 4 mm. additional.

The nymph of this species, also, was adequately illustrated in Eaton's Monograph, plate 39, figs. 1-22. This species totally lacks dorsal spines. It is altogether unique in the broad

frontal shelf on the head notched at the sides for the reception of the antennae and in the broad sucking disc that is developed beneath the abdomen.

The back is smooth, broadly rounded, the body being plano-convex. The color is yellowish or tan, darkening on the eyes, on the wings, on the gills, and the bases of tarsi and tails; also some pigment tends to overspread the middle of the terminal abdominal segments, but there is no definite color pattern.

Besides the specimens from Utah, I have nymphs that appear to be the same species from Potomac, Montana, collected by F. E. Barry; from Yellowstone Park, collected by R. Muttkowski; from South Fork of Keweah River, Califorina, collected by Chancey Juday; and from Goat Creek, Ashford, Washington collected by Miss Hortense Butler.

These two species, *E. grandis* and *E. doddsii*, form a remarkable pair. Here are two forms so alike in the adult stage as to be easily mistaken the one for the other, their nymphs totally unlike in appearance. The one nymph represents the highest development of spines upon back; the other, the extreme of smoothness. The one is black and dirty; the other, yellow and shining. The one clings by feet only; the other, by a highly developed ventral sucking disc.

The one lives in the edges of the stream, the other out in the swift current.

Ephemerella coloradensis Dodds.

This species was so adequately treated by Dodds (1923, p. 97, Pl. 8, Figs. 3 and 4, and 1924, p. 146,)* that I have only to add a few local notes. It is one of the commonest species in the rivers of Northern Utah, especially in their upland reaches, above 5,000 feet.

I have nymphs , also, from Yellowstone Park, Wyo., collected by Paul R. Needham; from Pecos, N. Mex., collected by Professor T. D. A. Cockerell; and from Volcano Co., Calif, collected by Chancey Juday.

On examining the stomachs of three native trout taken near the head of Logan River at about 7,000 feet, I found that this species made up about half of their food.

* Dodds does not note that Eaton had already figured the nymph of this species in his Revisional Monograph (Plate 38, Figs. 1–10).

Ephemerella inermis Etn.

This species was very common in all the streams of Northern Utah, associated with the preceding one. I reared fourteen specimens on five different dates ranging from June 25th to July 29th, and have fully matured males and females that seem to agree well with Eaton's description of the adult. I present a figure of the genitalia of the male and a description of the nymph. This is Dodds' Ephemerella nymph No 2.

The grown nymph measures in length 9 mm.; tails 4 mm. additional. Color very variable; blackish, often reddish brown, sometimes with indications of a middorsal pale line. Pale specimens show extensive mottling of the dorsum in a complicated pattern of curved pale markings upon the brown of the thorax and of dots and dashes upon the abdomen. The antennæ are pale except for a black second segment and a slight darkening of their slender tips. Legs dark, with three obscure rings of paler on each of the principal segments. Tails obscurely marked in five or six alternating areas of brown and paler.

The head is without tubercles above and the front femora are smooth. The front tibia is prolonged at apex in only a very small rounded lobe. Under the claw are eight to ten close set teeth.

The abdomen has no dorsal tubercles or hooks, but in their place is a double row of pale dots, one pair on each segment. There are the usual thin flat lateral spines on segments 4 to 9, increasing in length and sharpness on 4 to 8, less pointed on the narrower ninth segment. The gills on segments 3 to 7 are regularly overlapping. The joints of the tails are ringed apically with a whorl of short spinules and thickly fringed with slender pale hairs.

I have nymphs of this species collected by John T. Needham in The Yellowstone Park, August 8th, 1921.

Ephemerella margarita n. sp.*

This pretty nymph I did not find in Logan River but it was common farther southward. I collected it in Box-Elder (Brigham) Canon, in Weber River at the Devil's Slide, at Wanship, and at several points along Provo River where it was most common, especially in the upper reaches of that stream. These places, being visited only at the time of my departure from Utah, I had no chance to rear it. Only the nymph is known.

It superficially resembles the nymph of the preceding species being of the same slender graceful form, but it lacks

* Named for little Miss Margaret Hawley, of Salt Lake City.

gills on segment three of the abdomen, it has a single conspicuous cross band of black across the middle of the tails, its color pattern is different and its antennæ are wholly pale.

The fullgrown nymph measures in length 9.5 mm., and tails 2 mm. additional.

A slender prettily colored nymph with smooth thorax, and depressed, thin-margined abdomen. Color brownish olivaceous, with distinct blackish markings as follows: a median blackish spot on segments 2 and 3, another one on segments 5 and 6; a black streak across the apical margin of 8. Segment 9 wholly blackish above except its pale lateral spines and a pair of included submedian apical pale dots. Tails black and white; the black forming a bar across the middle and covering the tips, where it is less distinct. Legs pale, with dark bands on middle of tibiæ and tarsi and on tips of tarsi.

The head is smooth above. The front femur is entirely smooth. The front tibia bears no "thumb" but only a slight triangular prolongation beside the base of the tarsus. The claw is armed beneath with half a dozen slender teeth in a graduated series, the distal one longest.

The usual double row of dorsal hooks is represented by minute paired spinous tubercles. The lateral spines on abdominal segments 4 to 9 are thin flat, sharp and transparent, broadest on segment 7, where the abdomen too is broadest, and longest on segment 9. The gills are incompletely operculate.

This is the most generalized member of that group of species which has the gills beginning on the 4th abdominal segment with an operculate pair. The next following, *E. hecuba*, is the most specialized of that group. The two species occur together in Provo River.

Ephemerella hecuba Etn., (Hagen Ms.)

I much regret that I found this remarkable species only as I was leaving Utah and had no chance to rear it. The nymphs were grown and some of them fully ready for transformation as shown by the blackening wings. I found it only in Provo River where that stream washes the southern base of Mt. Timpanogas.*

Eaton's detailed figures of this species were made from a single cast skin. They adequarely represent structures. A few additional descriptive notes on color, made from whole nymphs, may now be added.

* I have taken a liberty with the name of that magnificent mountain, abbreviating it to make a convenient and euphonious subgeneric name.

The full grown nymph measures in length 14 mm.; tails 6 mm. additional.

Under the general covering of silt that is held by the long soft hairs that everywhere clothe the dorsal surface a few markings of darker brown may be discerned, varying the general color of light brown or tan. Blackish rings cover the basal half of all the tarsi, and faint rings are on the middle of each tibia, with sometimes a suggestion of two more upon each femur. There is a broad band of black crossing the tails at two-thirds their length, and there are one or two very narrow black rings crossing them near the base; usually, one on the middle tail and two on each of the laterals. Eyes and wing cases become blackened toward maturity. The lateral spines of the abdomen show a pale area before their sharp brown tips.

On the smoothe flat ventral surface of the abdomen there are more or less distinct bands of brown crossing the basal half of the segments.

Numerous specimens were collected in the Provo River on the 20th of July by Dr. H. J. Pack and myself. They were found clinging to the waterworn cobble stones in the edges of the stream, and not out in the current. They are utterly helpless when dislodged from the stones. They do not attempt to swim but sprawl stiffly and if overturned bend the venter convexly upward displaying the brownish crossbars of the underside.

This is the nymph of which in 1905 I published a rather poor photographic figure that was copied by Lestage in 1925 (p. 236). It represents the extreme of flattening and widening of the abdomen and lengthening of lateral spines: but it does not deserve to stand apart from the others so far as in Lestage's key; for it is only a specialized member of that group of species to which *E. margarita* belongs—the group that lacks gills on abdominal segment 3, and that has a single band of blackish color across the middle of the tails.

I have a specimen of it that was collected for me by my son Paul R. Needham in the Lanier River, Yellowstone Park, Wyoming, on August 8th 1921.

I have a nymph of still another species of Ephemerella from the Rocky Mountain region. It has high dorsal hooks on the abdomen, like a Drunella, but has none on the head or thorax. I have but one specimen and that broken. It comes from Big Blackfoot River, Potomac, Montana, and was collected there by Frank E. Barry on June 29th 1906. The tails are lacking, and all but one (hind) leg. The paired dorsal hooks on abdominal segments 3 to 9 and very long and slender, adding

about a third to the height of the abdomen. Their backwardly directed tips are sharp pointed. In front they stand erect, but gradually they incline backward until on segment 9 they point straight to the rear. The abdomen is marked with a heavy pattern of brown in three rows of large spots that lie upon the bases of the segments, one row mid-dorsal, and two lateral, largely covered by the gills. Broadly U-shaped transverse bars extend across the ventral side of the segments. All these spots widen to rearward, segment 9 being mostly brown. The gill plates on segments 3 to 7 extend obliquely toward the mid-dorsum, and are scarcely overlapped except the last pair which is smaller and paler. Around the bases of the legs are some more obscure brownish areas.

Figures of all these Utah nymphs that have not already been figured by Eaton and Dodds will be published shortly in a bulletin from the Utah Agricultural Experiment Station.

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THE EFFECT OF MONOCHROMATIC LIGHT ON FORMICA DAKOTENSIS SPECULARIS (EMERY).

C. E. Abbott.

Introduction.

Early attempts to study the color-vision of insects often led to erroneous conclusions. The absurd tests made with pieces of colored paper remind us how meager must have been the knowledge of the physics of color possessed by many experimenters in the past. As late as 1912, Seitz (4), in his own field a thoroughly competent entomologist, published a short paper that displayed a profoundly poor knowledge of physical optics.

But Lubbock (2), long ago, made reliable tests on the color-vision of insects. He had no way of equalizing the intensity of different sourses of light, but he overcame the