

MAYFLIES FROM COLORADO

DESCRIPTIONS OF CERTAIN SPECIES AND NOTES ON OTHERS

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The mayflies described herewith were collected in Boulder and Gilpin Counties, Colorado, chiefly along the valley of South Boulder Creek from its head waters just below the Continental Divide, at eleven thousand feet or above, and eastward in the valley to the edge of the Great Plains, at about five thousand, five hundred feet.

The material covers three summers of collecting and ecological study of mayflies and other aquatic insects of that region, and an additional summer spent chiefly in determining life histories by rearing nymphs in cages. Much work during these summers was done by F. L. Hisaw, now of the Department of Zoology of Kansas Agricultural College, who was constantly associated with me in the ecological work.

Some of the species have been determined for me by Dr. J. G. Needham, to whom thanks are due. Others are doubtless new species, while of still other species it is difficult to tell whether they fit existing descriptions. A goodly number of the Colorado and other western species have been described by Eaton, from collections made by the Hayden Survey and other early naturalists, since which time hardly anything has been added. The nymphs in that region have been almost unstudied.

The list includes twenty-seven species, thirteen of which are known by both nymphs and imagos, twenty-four by imagos alone, and seventeen by nymphs only. Nine of these species have previously been described, fifteen are probably new and are described here. The thirteen life-histories were determined by rearing nymphs in cages.

Specific characters of mayfly imagos have so far not been satisfactorily defined. Eaton in his large work has made use almost wholly of coloration, as have most of the early workers. This has the disadvantage that most people do not know the

colors used, that they change more or less in dead specimens, that there is considerable variation, and that in alcoholic specimens they are lost, even the pattern of dark and light areas being considerably obscured after a time. For so small and fragile insects as mayflies alcoholic preservation is more practical than dry, and has the further advantage of less distortion of chitinous parts such as legs, genitals, etc., and for nymphs it is the only practical way.

The characters used in describing species should be, if possible, such that they can be recognized in either living, dried, or alcoholic specimens. I make no claim that my descriptions meet these requirements. I have merely tried to define the species found during my ecological work in such a way that they may be recognized by future students, and believe that, with the possible exception of some of the species of the genus *Baetis*, I have accomplished this. The whole subject, however, is in great need of thorough revision by one who can devote much time to it.

- Needham has made use of the male genitals, which seems a good feature but has the disadvantage of inapplicability to both sexes. In determining species I have been unable to be sure of my alcoholic specimens as compared with descriptions based on colors of dried ones. Accordingly I have included notes and figures of known species as well as of new ones, in an attempt to make it possible for future students to know definitely what species I have had. I have not tried to make full descriptions, but rather to select those features which are of service in recognizing forms. For the imago I have mainly used, length of body and cerci, length of fore and hind wing, venation in some cases, conspicuous coloration such as plain color pattern (light and dark areas which persist in alcohol), the male genitals and in some cases the female sub-anal plate. The male genitals appear to be quite specific and easily studied, and together with the size and general coloration, will usually serve to identify both male and female from a given locality. I have not tried to define sub-imagos. For the nymph, no one set of characters can be used for all species because of the adaptational variation of the nymphs. Each genus has its own set of specific character-

istics. In these immature stages there is the added difficulty of differences produced by age and the phase of the molting cycle.

Types of the new species described in this paper are to be found in the Academy of Natural Sciences of Philadelphia, as well as examples of most of the other species mentioned in the report.

DRUNELLA

This genus, separated by Needham from *Ephemerella* to accomodate *E. grandis* Eaton and his nymph, "Nameless ally of *Ephemerella*, No. 2," has appeared in my collections. It includes Eaton's nymph No. 2 and No. 3 and the imago from nymph No. 3.¹ These two nymphs are clearly related to *Ephemerella* on account of certain characters, but in other respects are so different from each other that one would hesitate to assign them to the same genus.

Drunella grandis (Eaton) (Figs. 1 and 2.)

Imago. Imagos of both sexes were easily reared from nymphs, between July 27 and August 11. This is the largest imago in my collections, and though the nymphs are abundant, only one imago has appeared in my series. The following notes, based upon my observations, may serve definitely to identify this interesting species for future collectors.

Length, 15 mm. Cerci, three, 12 mm. Fore wing, 15-17 mm. Hind wing, 3.5 mm. In the fore wing the venation is as in *Ephemerella* except that cu_2 arises from A_1 (fig. 1), instead of from an anastomosing vein as in *Ephemerella* (fig. 3). This is the character upon which Needham established the genus.²

Coloration (alcoholic). Thorax about uniform brown. Abdomen appears dark when strongly contracted, but at ordinary extension is ringed, showing each segment with a brown band and a light edge. Each dark ring has a light spot like an inverted "J" above the spiracle, with the hook directed caudad, and a small dorso-ventrally elongated light fleck on each somite just below the pleural line. There is also a pair of light spots near the mid-ventral line. This pattern is more prominent on the anterior than on the posterior segments.

¹ A. E. Eaton, A Revisional Monograph of Recent Ephemeridae or Mayflies. Trans. Linn. Soc. London, 2nd Series, Zoology, 1883-1888.

² J. G. Needham, N. Y. State Museum, Bull. 86, pp. 42-43, (1905).

Pleura of ninth abdominal segment with a prominent acute angle at caudal end, and eighth with a rounded suggestion of this angle. Male subgenital plate has a low rounded extension between the bases of forceps. Forceps, three-jointed: first, short, cylindrical; second, long, curved, inner surface closely tuberculate and sharply concave at its middle, the outer margin is convex throughout, but more sharply curved at about two-thirds of its length; third segment about two-fifths as long as second, of about uniform thickness, concave and tuberculated on the inner surface. Penes united nearly to tip and curved dorsad, with sharp V-shaped notch at tip, bringing openings of the two sperm ducts close together (fig. 2).

There seems little question but this species is the same as *Ephemerella grandis* Eaton, based upon specimens from Colorado and the Yellowstone. His description is based largely upon the coloration of dried females, which he said could not be wholly trusted, and males are wanting. Thus, we have little more than agreement of wing characters, size and locality, by which to judge identity.

Nymph. This is the striking nymph described by Eaton in his Monograph under the heading "*Nameless nymph allied to Ephemerella, No. 3,*" and figured in plate 39. The locality given is, "Colorado, in a brook at Idaho (Idaho Springs?) adhering to the under side of a board, 5th of July; Roaring Water Fork, Colo., 2nd Aug., Lt. Wheeler."

I have found it very commonly in swift streams, both small brooks and good sized creeks in South Boulder Canyon, at elevations between six thousand, seven hundred and ten thousand, five hundred and eighty feet. It lives among rocks and coarse gravel of stream beds, but neither on the surface of rocks exposed to great force of water or among shifting gravel.

Eaton's description is full and accurate and leaves no doubt as to the identity of the nymph. Only a few additional notes are desirable. This is by far the largest nymph in the region where it occurs. The common length of the nature nymph is 13 mm., with a thorax 4.5 mm. wide and of considerable dorso-ventral thickness. Its most striking feature is the setose sucking pad with which the ventral side of the abdomen is provided. The sterna of segments two to nine are densely hairy, especially at the lateral margin, making of the eight sterna involved an oval

sucking disc quite different from the sucker of some other nymphs composed of overlapping gill lamellae. This is really an adhesive organ of considerable power, as shown by the strength with which living nymphs adhere to rocks or aquaria.

Drunella species

Nymph. Length, 13 mm. I have collected this nymph in South Boulder Creek, Colorado from 5,900 to 8,500 feet. A very similar nymph is described by Eaton as "*Nameless nymph allied to Ephemerella*, No. 2," and figured in Plate 38, from Klikitat Valley, Washington. Needham finds material from Colorado and New Mexico differs slightly from Eaton's figures of the type material from Washington. The difference seems to be in the tubercles of the thorax, in which respect my observations agree with Needham's figures. My material differs from both, however, in that the dorsal abdominal spines occur in regularly increasing series on segments two to nine, instead of being nearly equal throughout, as in the drawings of Eaton and Needham. It is quite probable that Needham's nymphs belong to the same species as mine, and that Eaton's slightly different material from Washington may represent a different species.

Needham has spread the wings of specimens from New Mexico, and on this evidence assigned the nymph to the genus *Drunella*, and further indicates the probability that this is the nymph of *Ephemerella grandis* Eaton. I have not reared the nymph, but since imagos from a different nymph agree so far as can be determined, with *Ephemerella grandis*, I prefer to apply the name to that nymph rather than to this one. The large size of both imago and nymph to which I have applied the name, and the somewhat smaller size of this one, are about the only bits of evidence for my use of the name, inasmuch as I cannot positively identify my imagos by Eaton's description.

EPHEMERELLA

Ephemerella coloradensis new species (Figs. 3 and 4.)

Imago. Imagos were reared in abundance from nymphs, taken at 9,300 feet, during the last week of July, but imagos of this species have not appeared in my general collections of mayflies from this region.

♂. Length, 12 mm. Fore-wing, 12 mm., typical for the genus (fig. 3). Hind wing, 3.5 mm. Cerci, three, a little longer than the body.

Male sub-genital plate about straight across between the bases of the forceps (fig. 4). Forceps three-jointed; first joint short; second joint more than three times as long as first, moderately and uniformly curved, and thinner about the middle than at the ends, tuberculate on inner surface; third joint about equal to first, slender, slightly expanded distally, and tuberculate on inner surface. Penes united and expanded distally, with only a low indentation between them at the tip, sperm ducts open far apart and each bears a dilatation just before end. Ninth pleura has slight point at posterior angle, others without angles except in strong contraction when slight points show on others.

Coloration (alcoholic). No striking marks: Thorax dark brown, abdomen about uniform dark brown, except for light pleural stripe and light bands between segments when body is extended.

Type.—♂; reared from nymph, Tolland, Colorado, July, 1921.

Allotype.—♀. Same locality as ♂.

Description of male holds except for special sexual structures.

Nymph. A common form in South Boulder Creek and tributaries, 6,700 to 9,500 feet.

Length, 11 mm. Head with face vertical and flattened in front between the lateral eyes. Face and top of the head made rough by numerous low knobs. Thorax stout. Abdomen with small flat pleural expansions, each with a posterior angle, hardly noticeable on the anterior segments and increasing posteriorly, but never becoming prominent except on the ninth segment. Each segment bears on the dorsal posterior margin a pair of small, acute tubercles, directed caudad and somewhat larger on the posterior than on the anterior segments. Legs stout, femur somewhat flattened, posterior margin with a few spines and many hairs, anterior margin of the first femur with several tubercles, each bearing spines on its tip. Tibia with thumb-like end, claw short and curved with a few short teeth. Gills on third to seventh abdominal somites, of the usual type for *Ephemerella*. Cerci, three, about as long as the abdomen, each with two light and two dark color bands.

Coloration (alcoholic). Light brown with light areas. Whole animal has a mottled appearance due to bands on legs and cerci, certain irregular markings on body, and pattern of gill covers.

Description based on a nymph from Tolland, Colorado, July 1921.

Ephemerella nymph no. 1.

Though attempts to rear this nymph have been unsuccessful, and its imago is consequently unknown, it seems desirable to describe it, on account of its importance in the mayfly fauna of streams in this region. It was collected from South Boulder Creek at the edge of the stream among roots, at 9,000 feet. About thirty nymphs of this species in our collections include no males.

Length, 7 mm. Head rounded, prothorax and mesothorax in mature nymphs long, and with no special features. Abdomen broadest at about the fourth segment; segments with small pleural expansions, each with a small posterior angle growing slightly larger caudad. These flat margins bear a row of club shaped spines. Each segment bears on the dorsal posterior margin a pair of acute tubercles, larger on the middle segments. Legs fairly stout, with femur somewhat flattened, each with a row of curved spines bearing blunt points on posterior margin. The first femur with a few similar spines of larger size on anterior edge also. Tibia without thumb; claw slender, curved, with about ten short spines on the concave side. Gills typical for the genus.

Coloration (alcoholic). Legs banded, especially plain on the tibia and tarsus. Body with no prominent markings except a light longitudinal mid-dorsal stripe between the abdominal tubercles, the conspicuous mark of the nymph, but more prominent in living than in alcoholic specimens. Ventral surface of each abdominal segment has a pair of elongated dark flecks, about midway between mid-line and pleura.

Ephemerella nymph no. 2.

This nymph is common in South Boulder Creek and its tributaries, at 8,000 to 9,000 feet, and though its imago is unknown, it seems desirable to describe the nymph.

Length, 9 mm. The nymph is characterized by the broadly expanded edges of the abdominal segments, each forming a broad lamella with a prominent angle at its posterior end, largest on the eighth segment. The edge of this lamella bears a row of blunt spines. Legs moderately stout. Femur somewhat flattened, with the usual armament of spines. Claw slender, somewhat curved, and bearing about ten blunt spines.

Coloration (alcoholic). Head, thorax, abdomen and legs well pigmented, with liberal light areas, giving a mottled appearance. Cerci with about ten alternating light and dark bands.

Described from a nymph from Tolland, Colorado, July, 1921.

CALLIBAETIS***Callibaetis fusca*** new species (Figs. 5 and 6.)

Imagos of both sexes were collected in abundance during late June and July, at 8,200 to 9,500 feet, in South Boulder Valley.

♂. Length, 8 mm. Cerci, 16 mm. Fore-wing, 10 mm., with liberal pigmented areas at front margin as far back as radius; cross-veins all along the costal space. Hind-wing, 2 mm., with numerous cross-veins, and pigmentation at base, as far as humeral prominence (fig. 6). Male forceps three-jointed (fig. 5): first stout and slightly tapering; second long, curved, thinner at middle than at ends; third the shortest, its greatest thickness a little less than half its width, its distal half with a swelling on inner surface.

Coloration (alcoholic). Thorax brown with light areas, some of which are marked with dark stippling. Abdomen with a light ground color and dark stippling, about equally dense on all segments; a pair of larger spots near mid-ventral line on each segment; a dark stripe along pleural line, and certain irregular light and dark areas on dorsal surface. Femora of second and third legs are plainly banded, the first less distinctly so.

Type.—♂; Tolland, Colorado, July, 1915.

Allotype.—♀, from same collection as type.

Description of male holds except for special sex differences common to the genus.

Nymph. This species is very common in Park and Teller Lakes in South Boulder Valley at about 9,000 feet, where it is at home on dirty portions of the bottom.

Length, 12 mm. Cerci, 3, about half the length of the body, with hairs well developed forming a good swimming organ. Head large and rounded in front; thorax moderately stout; abdomen long, with the edges of segments somewhat expanded and bearing a small point at posterior angle; legs slender, claws nearly straight with a comb of twenty-five slender teeth increasing in length and steeply inclined toward tip. Gill lamellae on segments one to seven with large and small lobe and on one and two an additional smaller lamella under the larger one.

Described from a nymph from Tolland, Colorado, July, 1915.

Callibaetis vitrea new species (Figs. 7 and 8.)

Imago. This species is represented by one specimen, collected at about 11,000 feet.

♂. Length, 6.5 mm. Cerci, 13 mm., with short, unsegmented stub of the middle one. Fore-wing, 6.3 mm., without pigmented areas. Cross-veins throughout the wing are few, and in only

distal half of costal space. Hind wing, 1.5 mm., without pigmented areas. Has three longitudinal veins, a few vestigial cross-veins and one free intercalary (fig. 8). Forceps three-jointed: first short, tapering, with spinose pad at inner distal angle; second long, curved, thinner at the middle, basal fourth with definite wrinkles on inner side; third thicker in its distal half, its greatest thickness at about one-half its length (fig. 7).

Coloration (alcoholic). Thorax light brown, with light areas at sutures of plates. Abdomen: dorsal surface light gray-brown except on segments seven to ten, which are red-brown; ventral surface light, with dark stippling growing less dense caudally to sixth or seventh, beyond which there is none. Also one pair of dark flecks on ventral surface of each segment.

Type.—♂; Tolland, Colorado, July, 1921.

ECDYURUS

Ecdyurus ramaleyi new species (Figs. 9 and 10.)

Imago. Imagos of both sexes were reared from nymphs in early August, and have not appeared in my general collections, in spite of the fact that the nymph is the most abundant species in streams between 8,000 and 11,000 feet.

♂. Length, 8 mm. Cerci, two, 20 mm. Fore-wing, 10 mm. Hind-wing, 4 mm. Male forceps four-jointed, slender, about uniformly tapering, except first joint which is short (fig. 9). Subgenital plate between the forceps, slightly arched. Penes not united, each with lateral expansion at the tip, and smaller lobe directly at the end, the two suggesting a pair of blunt-toed boots with the toes directed outward. Each bears a slightly curved spine on mesial surface near end.

Type.—♂; Tolland, Colorado, August, 1921.

Allotype.—♀, from same lot as type.

Description of male holds except for special sex differences. Female sub-anal plate about half as long as wide, its margin composed of two rounded lobes, separated by a shallow, rounded depression.

Nymph. The most abundant nymph of South Boulder Valley from 8,000 to 11,000 feet, where it lives among rocks on the bottoms of swift streams, clinging to the surface, among and under them, but not on the surface exposed to the direct force of the swift water. It has also been found in two lakes at high altitude.

Length, 11 mm. Cerci, three, a little longer than the body. Head and body flattened, head with expanded margin, widest at about the middle. Labrum transversely elliptical, with line of attachment about half of its greatest width. Femur short and flattened, tibia and tarsus slender, claw abruptly hooked near the end, and bearing four short teeth in a lateral position in the third quarter of its length. Gills lamelliform, with one to three small filaments at base of most of them. Lamellae large, each extending back over more than two segments.

Coloration (alcoholic). Head uniform brown. Prothorax and mesothorax about the same shade, or successively lighter. Abdomen about uniform brown on dorsal surface except that the last two segments are white, a conspicuous mark in living animals as seen in the streams. Each of the other segments one to eight is slightly lighter in the mid-dorsal line and has a pair of dorsal light spots. Ventral surface pale. Femur has a plain mark like an L with the horizontal bar short and broad (fig. 10).

Described from a nymph from Tolland, Colorado, August, 1921.

RHITHROGENA

Rhithrogena elegantula Eaton (Fig. 11.)

This species, described by Eaton and recorded by him from Arkansas Canyon, Colorado, and Arizona, has appeared in my collection from South Boulder Valley between 5,200 and 11,000 feet. Inasmuch as his description is from dried material, a few notes from alcoholic specimens should be made.

Length of body, 9 mm. Cerci about twice length of body. Fore-wing, 10 mm. The body is slender and without dark coloring except the eyes. The male sub-genital plate is slightly and evenly arched caudad between the bases of the forceps (fig. 11). Forceps four-jointed: first joint short and tapering to size of second segment; segments two, three and four of nearly uniform diameter; three and four of about equal length, their combined length equal to about half the second. Penes separate and curved outward at the ends, each somewhat expanded at tip, with two lobes of about equal length; inner margin with two spines, a distal smaller one sharply curved, and a proximal one, larger and also sharply curved near base, these latter at the level where the two penes separate. The female subgenital plate nearly semicircular; subanal plate semicircular, sometimes with a slight indentation at the end.

Nymph, unknown.

Rhitrogena robusta Needham (Fig. 12.)

Imago. Imagos of both sexes are common in South Boulder Valley, at 9,000 to 10,400 feet. The species was established by Needham from specimens sent him from this locality.

Length, 12 mm. Cerci nearly three times the length of the body. Fore-wing, 14 mm. Male penes separate, curved inwards at tip; each bears near tip two small and one long spine, all directed mesad, and a large one on outer surface, at about half length of penes (fig. 12).

Nymph. Not abundant anywhere, but found under stones in swift streams, South Boulder Creek and tributaries, 5,000 to 10,400 feet. Very sensitive to lack of oxygen, and die quickly in stagnant water. The following nymph was identified with the preceding imago by rearing in cage.

Length, 12 mm. Cerci, 10 mm. Head flattened, with expanded margins, elliptic in outline, with greatest dimension transverse, a little back of the middle. Legs stout, femur flattened, with fringe of short hairs on posterior margin, and small spines on the anterior; claws stout, curved, with two small, blunt teeth at about two-thirds of their length and a larger one at about one-third. Gills on abdominal segments one to seven, each consisting of a tracheate lamella with a tuft of filaments at its base; the first lamellae are very large, much broader than any of the others, and extend forward from the point of attachment and arch toward the median line until they touch, the widest part of the lamella being at the anterior end where they meet. Gills two to six are about alike, each with a somewhat oval outline; the seventh small and narrow and curved under the body until they nearly meet. Thus the lamellae form a sucking organ. Each lamella bears on its ventral surface a setose line dividing the gills approximately into halves, but diagonally to axis of gills, in such a position that the lines on successive gills make a nearly continuous setose line, oval in shape. Tracheae branch freely in the part of the lamella proximal to the setose line, but do not extend beyond it. Labrum rounded in outline, forming less than half a circle, and bearing a slight indentation at the mid line. Mandibles and other mouth parts seem to have nothing specifically diagnostic, being not only in form but in detail very similar to those of *Ecdyurus*. Of interest are the elaborate diatom rakes especially well developed on end of maxilla, composed of about ten combs, each with several teeth.

Coloration (alcoholic). No useful marks have been observed, but I would note that in this stream two color forms have been seen, one with dark red gills and the other with them

colorless. The latter were the ones from which this life history was determined.

The nymph here described was from Tolland, Colorado, July, 1921.

Rhitrogena hageni Eaton (Fig. 13.)

Reported by Eaton from the Sierra Nevadas at Truckee, and appearing in my collection from South Boulder Valley from 8,000 to 9,500 ft. As Eaton's figure of male genitals is from dried material, it may be well to describe the alcoholic specimens. The male subgenital plate between the bases of the forceps bears two blunt lobes. Forceps four-jointed, slender. Penes not united, round at the end, each bearing a good sized spine on outer surface near base, a saw tooth on inner surface a little farther from base and two small sets of serrations on ventral surface about midway between this and the tip (fig. 13).

LEPTOPHLEBIA

Leptophlebia pallipes Hagen (Fig. 14.)

Imagos. ♂ and ♀. Collected in South Boulder Valley, 5,800 to 10,580 ft.

The male subgenital plate bears two triangular lobes which occupy the space between the bases of the forceps (fig. 14). Forceps three-jointed; first curved mesad in distal fourth, otherwise straight; second short, much thicker at distal than proximal end; third about as long as the second, but much more slender, with swelling on inner surface a little beyond the middle; all segments of forceps bear on the inner surface, short club-shaped spines.

Nymph. Not known.

SIPHLURUS

Siphlurus occidentalis Eaton (Fig 15.)

Imago. ♂ and ♀. South Boulder Valley, 5,800 to 10,000 feet.

Length of body, 11 to 13 mm. Fore-wing, 12 to 13 mm. Male subgenital plate between the bases of the forceps consists of two very low arches. Forceps four-jointed: first short, thick, cylindrical; second, third and fourth more slender, tapering about uniformly to the tip; second long, with third and fourth successively shorter. Penes do not protrude beyond the subgenital plate and are not fused. Each consist of two parts,

(a) a finger-like, slightly curved part, at the end of which the sperm duct opens, and (b) on the ventral side of this a pointed scale, bearing on its mesial edge in first half, several small serrations, with points directed toward tip. The two parts are not recognizable without dissection (fig. 15).

Coloration (alcoholic). A conspicuous color pattern persists on the abdomen of alcoholic specimens which seem to agree with Eaton's description from dried specimens.

Nymph. Common in ponds and lakes with dirty bottoms, from 8,000 to 10,000 feet in South Boulder Valley. Swims actively or lies in the loose silt with its large gills above the silt, fanning briskly.

Length, 15 mm. Cerci, three, about two-fifths of length of body. General form of body typical for the genus. Pleural lamellae of abdomen broad, with decided angles at caudal end. Gills very large; the proximal part of ventral margin of each gill thickened and spinose.

Described from a nymph from Tolland, Colorado, July, 1921.

AMELETUS

Ameletus subnotatus Eaton

A few specimens have been found in South Boulder Valley, exact locality unknown.

Ameletus velox new species (Figs. 16 and 17.)

Imago. Imagos of both sexes have been collected in considerable numbers in South Boulder Valley, between 8,800 and 11,250 feet.

♂. Length, 12 mm. Cerci, two, longer than the body. Forewing, 13 mm. The male subgenital plate, between the bases of the forceps, has a triangular prominence on either side, between which is an indentation with a straight or slightly arched bottom (fig. 17). Forceps four-jointed; first short and somewhat thickened, second long, third and fourth successively shorter and a little more slender. Penes separate, slender, distinct, each curved mesad in terminal third.

Coloration (alcoholic). No conspicuous marks. Thorax moderately pigmented and abdomen less so.

Type.—♂; Tolland, Colorado, July, 1915.

Allotype.—♀, from same locality as type.

Description of male holds except for distinctive sex difference. Female sub-anal plate shorter than a semicircular extension,

with a small notch in the middle of the free margin. Subgenital plate truncate, hardly at all extended.

Nymph. Common in South Boulder Creek and its tributaries where water is not very swift, between 5,500 and 11,000 feet. It also lives in lakes and ponds with clean bottoms. It is a very strong swimmer, being found in swifter water than any other swimming form of this region.

The nymph agrees well in general characters with *A. ludens* Needham, the genotypic species. As pointed out by Needham³ it resembles closely the one figured by Eaton on plate 49 of his Monograph, and referred doubtfully to *Chironetes*. It is to be noted that Eaton's nymphs are not fully matured, and that some of them were from New York State, and one from the foothills of Colorado. It is wholly possible that this one represents *A. subnotatus*, and the New York specimens the smaller species described by Needham.

Length, 13 mm. Cerci, three, less than one-half the length of body, stout, with long hairs, making a good swimming paddle. Head large in proportion to thorax, the appearance of size being partly due to long labrum and large mandibles. Abdomen cylindrical or sub-cylindrical, tapering, with a very slight pleural ridge, terminating posteriorly in a small but sharp spine on each segment. Legs small in proportion to body; claw without teeth. Labrum a little broader than long with slight median indentation. Mandibles and labium do not differ notably from those figured by Eaton, outer and inner canines of mandibles being of same length. The maxilla agrees except that the pectinate hooks number about twenty-five, instead of sixteen as in the species figured by Eaton and Needham. The tongue has its middle lobe trilobed (fig. 16). Gills obovate, richly tracheate; each except the first two pairs, where they are less developed, has a thickened, spinose margin and a dark stripe running diagonally from the base of the gill, about one-fourth width of the gill from dorsal margin.

The nymph described from Tolland, Colorado, July, 1921.

CYNIGMA

Cynigma mimus Eaton ? (Fig. 18.)

Imago. ♂. The male of this species has been collected just below the Continental Divide for a distance of about twenty miles, in Boulder and Gilpin counties, between 10,500 and

³ J. G. Needham. N. Y. State Museum, Bull. 86, pp. 36 to 38.

11,650 feet. The female has not been collected. The material is questionably referred to this species; it agrees in size, the type is from Manitou, Colorado, and also the figures of genitals for *C. germinatum* and *C. par* are clearly different from ours. Nothing can be determined by comparing my alcoholic colors with Eaton's descriptions.

Length, 10 mm., 20 mm. Cerci. Fore-wing, 11 mm. Hind-wing, 2.5 mm. The penes are distinct, slightly expanded at tip into two rounded lobes; each bears two spines slightly curved at the tip, the one on the outer side nearly twice as long as the one on the inner (fig. 18). In the earlier stages the spines both arise from the outer margin, are directed outward and the two lobes inward. In still younger specimens the two penes are not evident, and the four spines project radially from a common mass. Legs: third tarsus shorter than the tibia: first and second joints of tibia about equal, third and fourth successively shorter and the fifth longer than the fourth. Male, first tarsus: joints as 17: 24: 27: 22: 8.

Coloration (alcoholic). Brownish, with thorax darker than abdomen, and wing veins well pigmented.

IRON

Iron longimanus Eaton (Figs. 19 to 22.)

Imago. Both sexes of this species have been collected frequently along South Boulder Valley, from 8,800 to 10,280 feet.

Eaton's description of dried specimens from Manitou, Colorado, should be supplemented by the following notes from alcoholic specimens. Proportionate lengths of joints of male first tarsus 24: 26: 22: 17: 7, with some variation in the exact proportions, but the second is slightly longer than the first, and the third shorter than the first, though their difference is slight. The male genitals appear different in varying degrees of expansion. When fully expanded the penes are separate some distance back from the end, each partially divided into two rounded lobes, and bearing a small curved spine on the outer surface near the end and a larger one on the inner surface near the base (fig. 22). A common earlier phase shows the penes of somewhat different form and bound together by a membrane (fig. 21). This phase is evidently the one figured by Eaton in plate 65. The male subgenital plate is evenly and moderately curved. The female sub-anal plate is semicircular, with a small notch in the middle of the free margin.

Nymph. Lives among rocks on the bottom of swift streams of South Boulder Valley. Has been collected between 9,000 and

10,000 feet, but doubtless has a much wider range. Very sensitive to lack of oxygen and dies quickly in collecting vessels, but lives readily and transforms in screen cages in running water.

Length, 10 mm. Cerci, 10 mm. Has usual flattened head and body characteristic of the genus, with the head expanded at the edge and widest near the fringed front. It has the usual sucker formed by the gill lamellae, the first and seventh of which curve under the body. Each lamella has the customary tuft of filaments at its base. Special feature of gills of this species as follows: first pair of gills only moderately enlarged in front, and lack much of meeting in the mid line (fig. 19). All lamellae except the first and seventh decidedly elliptical, about the same length, but successively narrower posteriorly, the ratio of length and width changing from 3:2 to 7:4. Each has a thickened, setose, ventral margin extending nearly to the base, and just inside this, an opaque, brownish zone which extends from tip to base and a short distance from base on dorsal edge of lamella. The seventh is about the same shape as the sixth but smaller and folded, so that its tip curves under the abdomen. The first has also the setose margin, but the brownish zone of this gill is somewhat L-shaped and does not include the anterior lobe.

Coloration (alcoholic). General color effect grayish. Mesothorax has a plain pattern not wholly obscured by changes in intensity with phase of molting cycle, consisting in the main of a light, lanceolate mark, broadest in front, flanked by a pair of somewhat triangular light areas with long side inward (fig. 20). Femur has a broad light area on proximal half extending to posterior margin just short of middle of segment.

Described from a nymph from Tolland, Colorado, July, 1921.

Iron nymph no. 1. (Figs. 23 and 24.)

The following nymph (imago unknown) is found in South Boulder Creek between 9,000 and 11,000 feet, among stones in swift portions of the stream. It differs from the nymph of *Iron longimanus* as follows:

Length, 7 mm. Gill lamellae two to seven are much less elongated than those of the former species, the second being wider than long, the others successively narrower, but always proportionately wider than in *I. longimanus*. The first gill has a greatly enlarged anterior lobe, so that the right and left gills meet in the mid ventral line (fig. 23). The setose margin of gills is as in the former species, but the opaque area is wanting from the first pair, and on the others there is a space between it and the setose border.

Coloration (alcoholic). Brownish. Mesothorax generally dark, with main light areas in the form of two bands running forward and outward from mid line in caudal half of segment (fig. 24). Femur with broad light area in proximal half with expansion connecting to posterior margin just short of middle of segment, as in *I. longimanus*, with the addition of a very definite dark spot opposite, this expansion.

Described from a nymph from Tolland, Colorado, July, 1915.

Iron tollandi new species (Fig. 25.)

Imago. Collected in South Boulder Valley, 9,000 to 11,000 feet.

♂. Length of body, 8 mm. Cerci, two, 20 mm. Fore-wing, 10 mm. Hind wing, 4 mm. Relative length of joints of tarsus, 24:31:30:24:9. The distinctive features are found in the male genitals. Penes separate, each ending in two bluntly pointed lobes directed mesad. Each bears near the end a good sized spine ending in a blunt hook (fig. 25).

Coloration (alcoholic). Gold brown with no dark parts.

Type.—♂; Tolland, Colorado, July, 1915.

BAETIS

This genus is a difficult one with which to deal. The insects are small and the species hard to distinguish. Characteristics based upon coloration seem to be of no use whatever where alcoholic specimens must be used. Other characteristics must be relied upon, preferably structural differences large enough to be readily seen and not subject to great variation. Accordingly in the following notes there are described only a few points, for the imago, chief among them, size, peculiarities of hind wing and male forceps. The nymph is equally difficult, with the added uncertainty of change due to age and phase of molting cycle. Here, the characters that seem to give most useful distinctive features are size of mature nymph, number and length of cerci, size and form of gill lamellae. The color pattern persists fairly well for a while in alcohol (i. e. arrangement of light and dark areas) and has given confirming evidence. In case of both nymphs and imagos, however, there is no high degree of certainty as to the accuracy of specific lines—the group one calls a species may include more than one species or he may have divided a species by the use of variable characters.

Baetis bicaudatus new species (Figs. 26 to 28.)

Imago. Reared from nymph, 1921. Character of female as follows. Male not known.

♀. Length of body, 4.5 mm. Cerci, 9 mm. Fore-wing, 6.5 mm. Hind-wing, 0.75 mm., with prominent humeral point and two longitudinal veins arising from a common stalk just proximal to the arched vein (fig. 26). Coloration (alcoholic) uniform, light brown.

Type.—♀; reared from nymph, Tolland, Colorado, August, 1921.

Nymph. Streams of South Boulder Valley, 9,000 to 11,000 feet. Lives in very swift water, especially earlier stages. Nymphs cling to surface of rocks over which water runs with great speed, or even where water pours upon a rock with considerable force, so that no other mayfly nymph can live there.

Length of body, 6 mm. Head and body of usual form for the genus. Legs without special features, fairly stout, femur flattened. Claw with about ten teeth increasing in length toward the tip. Gills on segments one to seven, of single lamella, with tracheae showing only faintly. Each gill covers only the base of the next gill (does not reach base of second gill even in strongly contracted specimens). Cerci, two, a little shorter than the body, with a short, unsegmented conical stump representing the third. Hairs on inner margin of cerci. Labrum wider than long.

Coloration (alcoholic). Distinct pattern on head and thorax, which seemingly differs from that of the other species, but it is doubtful if these patterns can be used as specific characters, because of change of intensity with phase of molt, which obscures and seemingly modifies the pattern. First femur with a J-shaped light mark (fig. 27) and second and third with a corresponding L-shaped mark (fig. 28). Abdominal terga with a color pattern hard to describe, but third, fourth and seventh are decidedly darker than the others.

Described from a nymph from Toland, Colorado, August, 1921.

Baetis intermedius new species (Figs. 29 to 33.)

Imago. Imagos of both sexes were reared from nymphs taken at 9,000 feet, and also were collected in South Boulder Valley from 8,800 to 11,000 feet.

♂. Length of body, 6 mm. Cerci, two, 10 mm., with a short rudiment of the third on a conical base. Fore-wing, 6.5 mm. Hind-wing, 1.1 mm., with two main longitudinal veins arising

from a short stalk, a third faint longitudinal vein extending from base to middle of hind margin, and one intercalary between this and the second longitudinal vein (fig. 29). Male forceps three-jointed: first short, stout, tapering; second long, about uniformly curved, basal fourth decidedly thicker than the remainder; third with its greatest thickness equal to about two-thirds its length and beyond the middle (fig. 30).

Coloration (alcoholic). Thorax, dark brown; abdomen, light brown.

Type.—♂; Tolland, Colorado, August, 1921.

Allotype.—♀, from same locality as type. Similar to male except for sex differences. Color, uniform light brown.

Nymph. Lives in swift water, but apparently not as swift as that frequented by *B. bicaudatus*. It clings to surface of rocks where water is swift, and lives in less rapid water among sedges, but not in sluggish parts of stream. Elevation of habitat, 8,500 to 11,000 feet.

Length, 6 mm. Cerci, three, the two lateral ones, 6 mm., with fringe of hairs on mesial side; the middle one is about one-sixth the length of the others, very slender and with very scant hairs. Gills on segments one to seven, each of a single lamella with tracheae showing only faintly, and each gill covering only the base of the next gill.

Coloration (alcoholic). A very definite color pattern, hard to describe, and varying somewhat with degree of pigmentation (fig. 33). First femur with light area like a letter J with the hook filled solid (fig. 31), the second with a corresponding L-shaped light area (fig. 32). Labrum about twice as wide as long. Abdominal terga nine and ten pale, the fifth somewhat less so.

Described from a nymph from Tolland, Colorado, August, 1921.

Baetis tricaudatus new species (Figs. 34 and 35.)

Imago. Imagos of both sexes were reared from nymphs taken at 10,500 feet. Collected generally in South Boulder Valley, 8,800 to 11,150 feet.

♂. Length of body, 7 mm. Cerci, two, 11 mm., at hind represented by a blunt stump with a minute rudiment of a cercus. Fore-wing, 7 mm. Hind-wing, 1.4 mm., with three longitudinal veins: first and second arise from a short stalk; third small and lying close to the basal half of the posterior margin; two intercalaries between second and third (fig. 35). Male forceps three-jointed: first short, stout, tapered; second long, uniformly curved on outer surface, inner surface with decided wrinkled thickening

on first fourth of length; third joint short, about as thick as second, elliptical, with greatest thickness about middle (fig. 34).

Type.—♂; Tolland, Colorado, August, 1921.

Allotype.—♀, from same locality as type. No special descriptions needed. Similar to male except for usual sex differences.

Nymph. Lives in moderately swift streams, but not in as swift parts as either of the preceding nymphs (*B. bicaudatus* and *intermedius*). In South Boulder Creek and its tributaries, 5,500 to 11,150 feet.

Length, 7 mm. Cerci, three, the two lateral ones about 7 mm., with hairs on inner margin, the third about one-half as long and somewhat more slender, with fairly long hairs on both sides. Labrum wider than long. Gills on segments one to seven all single and with distinct tracheae; the fourth is the largest, the seventh larger than the first, and each gill overlaps the base of the second gill caudad of it.

Described from a nymph from Tolland, Colorado, August, 1921.

Baetis quilleri new species (Fig. 36.)

Imago. South Boulder Creek on the plains near the foothills (5,200 feet). Only females have been collected.

♀. Length of body, 4 mm. Cerci, two, about one and one-half times length of body. Fore-wing, 5 mm. Hind-wing, 0.8 mm., narrow, with prominent, curved humeral point, three longitudinal veins; first and second distinct and arising close together, but not from a common stalk; third faint and near hind margin, where it ends at about three-fourths length of wing. There are two faint cross-veins between second and third longitudinal veins (fig. 36).

Type.—♀; Boulder, Colorado, July, 1915.

Baetis moffatti new species (Figs. 37 and 38.)

Imago. Both sexes have been collected in South Boulder Valley, 5,900 to 11,000 feet.

♂. Length of body, 7 mm. Cerci, two, one and one-half times length of body. Fore-wing, 7.5 mm. Hind-wing, 1.4 mm., with three longitudinal veins: first and second strong and stalked; third faint and ending in hind margin at about middle (fig. 38). Male forceps (fig. 37) three-jointed: first stout, tapering; second long, about uniformly curved, first fourth thicker than the rest, the thickening being evident on both inner and outer margins; third

about as thick as second and nearly twice as long as its greatest thickness, which is beyond the middle of the joint.

Type.—♂; Tolland, Colorado, August, 1915.

Allotype.—♀, from same locality as type. Similar to male except for sex differences and greater size of female, its fore wing measuring 8.5 mm.

Baetis minimus new species (Fig. 39.)

Imago. Only the female is known. South Boulder Valley, 6,700 to 10,400 feet.

♀. Length, 5 mm. Fore-wing, 7.5 mm. (Note large wing for so small a body.) Hind wing, 0.8 mm., with three longitudinal veins: first and second strong and stalked; third faint and ending in hind margin at about middle (fig. 39). This species is much like *B. moffatti*, but differs in small size of body in relation to fore wing, and in small size of hind wing in relation to fore wing.

Type.—♀; Tolland, Colorado, August, 1915.

Baetis parvus new species (Figs. 40 and 41.)

Imago. Both males and females have been collected on South Boulder Valley, 9,000 to 10,500 feet.

♂. Length, 5.5 mm. Cerci, two, two and one-half times length of body. Fore-wing, 5.5 mm. Hind-wing, 0.95 mm., with three longitudinal veins: first and second are strong and stalked; second is forked at about one-third its length with one intercalary in fork; the third ends in the posterior margin a little beyond the middle (fig. 41). Male forceps three-jointed: first short and somewhat tapering; second long, its basal thickening extending to about half its length, tapering gradually to its end, where a slight, abrupt contraction takes place; third joint with greatest thickness equal to one-third its length, its proximal half being about uniform in thickness and a swelling is present on inner surface of distal half (fig. 40).

Type.—♂; Tolland, Colorado, July, 1915.

Allotype.—♀, from same locality as type. Similar to male except for usual sex differences.

EXPLANATION OF FIGURES

- Fig. 1.—*Drunella grandis*. Fore wing.
 Fig. 2.—*Drunella grandis*. Male genitals.
 Fig. 3.—*Ephemerella coloradensis*. Fore wing.
 Fig. 4.—*Ephemerella coloradensis*. Male genitals.
 Fig. 5.—*Callibaetis fusca*. Male forceps.
 Fig. 6.—*Callibaetis fusca*. Hind wing.
 Fig. 7.—*Callibaetis vitrea*. Male forceps.
 Fig. 8.—*Callibaetis vitrea*. Hind wing.
 Fig. 9.—*Ecdyurus ramalei*. Male genitals.
 Fig. 10.—*Ecdyurus ramalei*. Femur of nymph, showing coloration.
 Fig. 11.—*Rhitrogena elegantula*. Male genitals.
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 Fig. 13.—*Rhitrogena hageni*. Male genitals.
 Fig. 14.—*Leptophlebia pallipes*. Male genitals.
 Fig. 15.—*Siphilurus occidentalis*. Male genitals.
 Fig. 16.—*Ameletus velox*. Tongue of nymph.
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 Fig. 18.—*Cynigma minus?* Male genitals.
 Fig. 19.—*Iron longimanus*. Ventral view of abdomen of nymph.
 Fig. 20.—*Iron longimanus*. Head and thorax of nymph.
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 Fig. 27.—*Baetis bicaudatus*. First femur of nymph.
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 Fig. 29.—*Baetis intermedius*. Hind wing of imago.
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 Fig. 33.—*Baetis intermedius*. Dorsal view of nymph without legs.
 Fig. 34.—*Baetis tricaudatus*. Male forceps.
 Fig. 35.—*Baetis tricaudatus*. Hind wing.
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 Fig. 37.—*Baetis moffati*. Male forceps.
 Fig. 38.—*Baetis moffati*. Hind wing.
 Fig. 39.—*Baetis minimus*. Hind wing.
 Fig. 40.—*Baetis parvus*. Male forceps.
 Fig. 41.—*Baetis parvus*. Hind wing.



