

# New York State Museum

FREDERICK J. H. MERRILL *Director*

Bulletin 47 September 1901

## AQUATIC INSECTS IN THE ADIRONDACKS

A study conducted at the Entomologic field station, Saranac Inn N. Y. under the direction of

Ephraim Porter Felt D.Sc. *State entomologist*

BY

JAMES G. NEEDHAM Ph.D.

*Professor of biology, Lake Forest university,*

AND

CORNELIUS BETTEN M.A. *Assistant*

|  | PAGE |  | PAGE |
|--|------|--|------|
| Preface .....  | 383  | Part 3 Insect life histories ( <i>cont'd</i> )                   |      |
| Part 1 Introductory: the undertaking, location, objects, methods and results ..... | 384  | Diptera .....  | 573  |
| Part 2 Life of Little Clear creek  | 400  | Notes on other orders .....                                      | 582  |
| Part 3 Insect life histories .....   | 410  | List and two new species of sawflies, by A. D. MACGILLIVRAY      | 584  |
| Plecoptera .....   | 412  | Original descriptions of new Diptera, by D. W. COQUILLET         | 585  |
| Ephemera .....   | 418  | Descriptions of five new parasitic Hymenoptera, by W. H. ASHMEAD | 586  |
| Odonata .....  | 429  | Explanation of plates .....                                      | 590  |
| Neuroptera .....   | 540  | List of text illustrations .....                                 | 597  |
| Trichoptera, by CORNELIUS BETTEN   | 561  | Index .....  | 599  |

ALBANY

UNIVERSITY OF THE STATE OF NEW YORK

1901

consisting of single, isolated filaments.<sup>1</sup> This subfamily includes the two tribes, Capnini and Nemourini of Banks.

### Order EPHEMERIDA

#### *May flies*

#### Family EPHEMERIDAE

The May flies are all aquatic. A few of the larger species, which suddenly appear in countless numbers on the shores of our larger bodies of water and as suddenly disappear again, are very well known. But most May flies, being less concerted in their period of adult life, emerging a few at a time, resting under cover and returning to the water in the twilight to oviposit, are little observed.

The nymphs live in all sorts of fresh water, and are almost everywhere abundant. They are differentiated into highly specialized groups, each finely adapted to its own peculiar situation. There is great apparent similarity among the imagos; but the nymphs of the several principal groups are strikingly unlike. The struggle for existence has fallen mainly on the nymphs, and they have specialized for themselves, more or less independently of adult life. On this account, the beginner will find the study of the group greatly facilitated by collecting the nymphs along with the adults.

Nathan Banks has twice published keys for the determination of the genera of our North American May fly imagos, in the *Transactions of the American entomological society*, 19:332 and 26:246-47. Nearly all our species are described in Eaton's monograph.<sup>2</sup> The following table will serve for the separation of the nymphs of the genera occurring in our fauna. It will also serve to indicate what I believe to be the three principal natural divisions of the family, corroborated by important characters pertaining to both adult and nymphal life. It is based in part on the figures and tables of Pictet<sup>3</sup>, Vayssiere<sup>4</sup>, Eaton<sup>2</sup>, and Schiller<sup>5</sup>, but mainly on my own breedings of New York May flies. So few species have as yet been reared that this table will doubtless need considerable revision when more of the nymphs are known.

1 Rarely developed. They are known from the European *Nemoura cinerea* Oliv., in which species there are six separate filaments at the front end of the prothorax beneath. An undetermined species of *Nemoura*, bred by me at Ithaca N. Y. possessed no gills whatever. I also bred at Ithaca an undetermined species of *Taeniopteryx* the nymph of which had attached to the posterior side of each coxa a single, tapering, three jointed, telescopic, gill filament.

In the Perlinae, the number of filaments in a tuft often increases with the age and size of the nymph.

2 Eaton. Revisional monograph of recent Ephemerinae. Linn. soc. Lond. Trans. (2) 3, 1888.

3 Pictet. Histoire naturelle des neuropteres: Ephemer. Paris 1848.

4 Vayssiere. Organization des larves des Ephemerines. Sci. nat. zool. Ann. (6) 11, 1881.

5 Schiller. Die Ephemeriden-larven Sachsens. Sitz. u. abh. der. naturwiss. ges. Isis in Dresden. 1890. p. 44-49, 2 pl.

GENERA OF EPHEMERID NYMPHS IN EASTERN UNITED STATES

- a Body flat, widest across the rear of the head; eyes dorsal; legs depressed; adapted for clinging closely to flat surfaces. (Imagos have five freely movable segments to the hind tarsi)
  - (HEPTAGENINAE) *Heptagenia*, *sens. lat.*
- aa Head not so wide as succeeding parts of the body; eyes lateral; (imago with but three or four freely movable segments to the hind tarsi, the basal segment at least coherent with the tibia)
  - b Body widest across the mesothorax; legs of the first and second pairs about equidistant at the base. (Imagos have the cubitus and the first anal vein nearly parallel toward the base) (BAETINAE)
  - c Gills completely concealed under the enormously enlarged, conspicuously four spined mesonotum ..... *Baetisca*
  - cc Gills exposed; mesonotum normal
    - d Outer caudal setae fringed only on the inner sides; gills on abdominal segments 1-7; agile swimmers
      - e Gills simple
        - f Gills oval in outline, obtuse at the apex..... *Baetis*
        - ff Gills lanceolate in outline, acute at the apex.. *Centroptilum*
      - ee Gills double, at least the anterior pairs
        - f Antennae hardly longer than the head; the thin lateral margin of the eighth abdominal segment produced posteriorly in a very large flat tooth; ocelli on the face..... *Siphurus*
        - ff Antennae longer than half the body; the posterolateral angles of the eighth abdominal segment not forming a conspicuous tooth; ocelli generally on the top of the head
          - g Antennae shorter than the body; gill tracheae pinnately branched  
*Callibaetis*
          - gg Antennae longer than the body; gill tracheae palmately branched  
*Cloeon*
    - dd Outer setae fringed on both sides
      - e Gills on abdominal segments 1-7, double, similar
        - f Divisions of the gills narrowly linear..... *Leptophlebia*
        - ff Divisions of the gills leaflike, each with a terminal filament  
*Blasturus*
      - ee Gills absent from one or more of abdominal segments 1-7, one pair more or less elytroid, covering those behind it
        - f Gills present on the seventh abdominal segment, elytroid on the third or fourth segment; a pair of minute tubercles at the apical margin of each abdominal segment beside the median line  
*Ephemerella*
        - ff Gills absent from the seventh abdominal segment, elytroid on the second segment; no dorsal abdominal tubercles..... *Caenis*
- bb Body somewhat compressed, widest across the base of the abdomen; legs of the first pair much more closely approximated at the base than those of the second pair; all the legs appressed against the sides of the body and adapted for burrowing; mandibles usually produced anteriorly in a long, curved tusk. (Imagos have the cubitus and the first anal vein strongly divergent toward the base) EPHEMERINAE
- c Head without frontal prominence; gill rudiment on the first abdominal segment simple..... *Polymitaenys*

cc Head with a frontal prominence; gill rudiment on the first abdominal segment bifurcated, shaped like a tuning fork

d Frontal prominence rounded; the flattened fore tibia with a broad, rounded lobe at its apex, close behind the apical burrowing hook

Hexagenia

dd Frontal prominence bispinous; no conspicuous lobe at the apex of the fore tibia behind the apical burrowing hook... Ephemera

I describe below the nymphs of seven species of May flies, representing as many genera, bred at Saranac Inn. The only bred North American nymph of which I find description is the singular *Baetisca obesa* Say, which is figured by Walsh, Vaysseire and Eaton. A number of undetermined American nymphs, mostly from the Cambridge museum of comparative zoology, are figured and described in Eaton's monograph. One of these I have been able to identify as *Ephemerella excrucians*, described below.

### *Heptagenia pulchella* Walsh

Plate 15, figure 15

- 1862 *Palingenia pulchella* Walsh, Acad. nat. sci. Phil. Proc. p. 375 (original description)  
 1863 *Palingenia pulchella* Hagen, Ent. soc. Phil. Proc. 2:177 (note)  
 1863 *Palingenia pulchella* Walsh, Ent. soc. Phil. Proc. 2:203 (note)  
 1863 *Heptagenia pulchella* Walsh, Ent. soc. Phil. Proc. 2:204 (merely refers it to *Heptagenia*)  
 1871 *Heptagenia pulchella* Eaton, Ent. soc. Lond. Trans. p. 141 (description in Latin from the original by Walsh)  
 1885 *Heptagenia pulchella* Eaton, Linn. soc. Lond. Trans. (2) 3:299 (a very full description)  
 1892 *Heptagenia pulchella* Banks, Am. ent. soc. Trans. 19:347 (listed)

Imagos of this species were common in the hatchery windows throughout our session, and during the month of June were most abundant there. A few, mostly males, were taken regularly in the trap lanterns when the weather was favorable. A few others were seen, flying in the twilight. The species was little in evidence, common as it was.

The nymphs were abundant in Little Clear creek, specially in the more rapid places, clinging closely to flat surfaces of boards, sticks, stones, etc. To collect them one needed but to lift these obstructions from the stream and pick the nymphs from them with forceps. Within a few days after our arrival we had reared some of the nymphs, and others were reared repeatedly after that. Oviposition was not observed. I dissected a female subimago, and counted the eggs in her ovaries in part, and, on the basis of this count, estimated the whole number at about 1340. Imagos and subimagos thrown on the surface of the fish ponds

were snapped up eagerly by the trout. The membrane of the wings of the imago is in this species finely iridescent.

**Nymph.** Pl. 15, fig. 16 Length of body 10 mm; setae, male 12, female 15 additional; abdomen, male 6.25, female 7.

Body flat; lateral margins of the head and prothorax thin, sharp edged, flaring, that of the head projecting distinctly beneath the eyes, antennae reaching the tips of the extended fore femora; all femora flattened, sharp edged, edges very convex and fringed with hairs.

Color yellowish or greenish brown, mottled, paler below, and dorsally marked with paler spots as follows: an inverted, mushroom-shaped spot before the middle ocellus, a triangular patch between each reniform, lateral ocellus and the eye, a transverse band at the rear of the head; an oblique band each side of the prothorax, a large lateral spot each side of each of the intermediate abdominal segments with a black mark at its hind margin. The femora and tibiae show very indistinct transverse banding of color.

Abdomen with sharply toothed posterolateral angles on its hindmost segments, the tooth largest on the eighth segment, where it surpasses the middle of the ninth segment, smaller on the seventh and ninth, and a mere sharp angle on the sixth segment. Setae sparsely fringed with hairs for a third of their length.

Gills present on segments 1-7, similar on 1-6, though becoming smaller posteriorly. Anterior gills double, the anterior leaf thickened, trapezoidal with the angles all obtuse, a sparse fringe of slender hairs around the distal half of its border, a strong oblique, longitudinal ridge on its anterior face near its ventral edge; posterior leaf thin and delicate, covered by the anterior, smaller than the anterior, cordate triangular in general outline, cut into a peripheral fringe of long respiratory filaments which are once or twice forked or simple, the fringe being as long as the body of the leaf. Gill of the seventh segment simple (corresponding to the anterior leaf only), lanceolate, fringed along its entire margin, its apex surpassing the lateral tooth of the eighth abdominal segment.

This species is known from Rock Island Ill., Maryland, New York and Quebec.

There is in the Museum of comparative zoology a specimen of another species labeled "Adirondacks, New York, Aug. 1872" in Dr Hagen's handwriting, which agrees entirely with other specimens in the same museum bearing the name *Heptagenia vicaria* Walker.

### *Baetis pygmaea* Hagen

Plate 15, figures 13, 14

- 1861 *Cloe pygmaea* Hagen, Synopsis Neur. N. Am. p. 54 (original description)
- 1863 *Cloe pygmaea* Hagen, Ent. soc. Phil. Proc. 2: 178-79 (notes, "It is the smallest ephemeropterous species known.")
- 1871 *Baetis pygmaeus* Eaton, Ent. soc. Lond. Trans. p. 122 (original description, repeated in Latin)

- 1885 *Baetis pygmaeus* Eaton, Linn. soc. Lond. Trans. (2) 3:170 (a new description of the fragments remaining of the type)  
1892 *Baetis pygmaea* Banks, Am. ent. soc. Trans. 19:348 (listed)

All the above are bare descriptions of the single female specimen in the Hagen collection from the St Lawrence river.

I studied this fragmentary type specimen in Cambridge Aug. 25 and 28. There remains of it a bit of the thorax, bearing the greater part of one fore wing. The venation of this wing furnished the only points for critical comparison with my specimens. The descriptions and the type specimens agree fairly well with the smallest of my specimens. I could not see the brownish color of the veins described by Eaton either in my specimens or in the type. Also the veins in the pterostigmatic space vary in number in my specimens from 5 to 12, and from being simple and straight to being forked and anastomosing.

This species, like the preceding, was common in the hatchery windows, was taken often sparingly in the trap lanterns, and was seldom seen at large. Imagos occurred more sparingly, however, through the earlier part of the season, but they became very abundant in August. From the window in the hatchery nearest the mouth of the inflow pipe carrying surface water, hundreds of imagos and subimagos could be picked at a time. These were preyed on in great numbers by spiders which lurked in the crevices of the window casings. Not a few flew against the window panes when these were wet with condensations in the mornings, and, striking their wings, adhered, and were unable to free themselves. When the moisture evaporated, these were dried down on the glass. Among these I noticed a number of females which had discharged the contents of their ovaries on the pane in masses of about 200 eggs each.

Nymphs of this species were found most abundantly among the cases of *Simulium* pupae in swiftly flowing water; a few could be taken at any time from the hatchery troughs.

This is the daintiest, and one of the prettiest of our May flies. It is still so insufficiently known that I will append hereto complete descriptions of the stages known to me.

**Male imago.** Length 3-5 mm; setae 7 mm additional. Colors black and white varied with reddish brown and yellowish red. Head yellowish, with the ocelli and the inferior part of the eyes black, turbinate superior part of the eyes yellowish red on the sides, reddish brown on the superior, corneal surface.

Thorax black, paler on the lateral sutures. Legs, antennae and setae pale yellowish white; fore legs darker on the sutures. Wing very transparent with a faint wash of yellow on the extreme base. Hind wing bivenulate, sometimes with a short third vein.

Abdomen black and white; segments 2-5 pure white (in old males) with black spiracles; segment 6 yellowish; segments 7-10 black, paler below.

**Male subimago** (undescribed). Differs only in having the setae about 5 mm long (as in the female); and in lacking strongly contrasting black and white colors on the abdomen, all the colors being duller, the wings merely translucent, with a fine fringe of hairs.

**Female imago.** Length 3-5 mm, setae 5 mm. Color reddish brown, darker on the thorax and paler beneath the body; discoloring badly when pinned. Head and thorax brownish with ocelli paler and eyes black. Thoracic dorsum brown, darker on the ridges, with a pair of oblique pale stripes extending from the hind angles of the prothorax to the wings, and a pair of narrow, submedian, longitudinal stripes on the mesothorax.

Abdomen reddish brown, apical segments paler.

**Female subimago.** Differs in obscurer coloration; on the top of the mesothorax there is a single wide middorsal longitudinal stripe.

Known only from the St Lawrence river and Saranac Inn. Specimens are deposited at Cambridge in the Museum of comparative zoology and in the New York state museum.

**Nymph.** Measures 4-5 mm; setae 2.3-2.5 mm additional; antennae 2.2 mm.

Body slender, graceful, smooth, clean; brownish above, yellowish beneath and on the sutures; a narrow middorsal yellowish line, dilated on the middle of the mesothorax, and expanded again into a quadrate spot at the front of the prothorax; paired yellowish markings beside this line, and numerous small yellowish spots nearer the sides; legs and antennae yellowish. Setae with a brownish shade near the bare tip; all fringes short; the two outer setae fringed only on the inner side.

Gills present on abdominal segments 1-7. small, separate, widely extended and fully exposed; each leaf obovate, a little oblique, with a chitinous thickened inferior border, this border, short on the foremost gill leaf, reaches the apex on the sixth one, and comprises the greater part of the narrow, reduced seventh one.

The face is vertical, with the ocelli in front, somewhat as in *Siphurus*.

The nymph is an exceedingly agile, little fellow, darting hither and thither with astonishing speed when one tries to pick it up.

A few specimens of a larger, undetermined species of *Baetis* were taken at the hatchery windows.

### *Siphurus alternatus* Say

Plate 11, figure 7

- 1824 *Baetis alternatus* Say, Godman's western quart. reporter, 2:304  
 1859 *Baetis alternatus* Leconte (ed.), Complete writings T. Say, 1:204  
 1861 *Baetis alternatus* Hagen, Synopsis Neur. N. Am. p. 49  
 1862 *Baetis alternatus* Walsh, Acad. nat. sci. Phil. Proc. p. 369  
 1863 *Baetis alternatus* Hagen, Ent. soc. Phil. Proc. 2:169

- 1863 *Baetis alternatus* Walsh, Ent. soc. Phil. Proc. 2:189  
 1853 *Baetis annulata* Walker, List Neur. ins. Brit. mus. 3:567  
 1861 *Baetis annulata* Hagen, Synopsis Neur. N. Am. p. 48  
 1876 *Baetis femorata* Provancher, Nat. Canadienne. 8:267  
 1877 *Baetis femorata* Provancher, Faun. ent. du Canada. 2:83  
 1871 *Siphylurus annulatus* Eaton, Ent. soc. Lond. Trans. p. 127 (description in Latin: figures of forceps of male, and ventral abdominal markings in pl. 6, fig. 4 and 4a)  
 1871 *Siphylurus alternatus* Eaton, Ent. soc. Lond. Trans. p. 129  
 1877 *Siphylurus alternatus* Provancher, Faun. ent. du Canada. 2:83  
 1885 *Siphylurus alternatus* Eaton, Linn. soc. Lond. Trans. (2) 3:219  
 1892 *Siphylurus alternatus* Banks, Am. ent. soc. Trans. 19:346 (listed)

This handsome brown species was not observed at large, was not taken in our trap lanterns, and was only obtained by rearing nymphs. These were not uncommon in shallow water about the outlet of Little Clear pond among the debris of fallen brushwood. Doubtless the imagos might have been found at large, had careful search been made of the shores about these same places.

The nymph is a graceful creature, and exceedingly agile. The beautiful fringes on the abdominal setae constitute a powerful tail fin, one stroke of which sends the nymph through the water with a speed the eye can hardly follow. It is exceedingly difficult to pick up one of the nymphs, when confined in a little dish of water, with a forceps, so quickly will they dart away. In a water net of some size they are easily taken, however, apparently not finding themselves ensnared till lifted from the water. A good many specimens were taken in shallow water behind a large hummock overgrown with cattails (*Typha*) to the north of the outlet of Little Clear pond. These transformed July 21, 22 and 23, and remained in the subimago stage for more than 48 hours in every case, undergoing the final molt during the second day after emergence from the larval skin.

This species is widely distributed throughout the eastern United States.

**Nymph.** Pl. 11, fig. 5, 6 Length of body 15 mm; setae 6.5 mm additional; abdomen 9.5 mm; antennae 1 mm.

Body arched, tapering, very graceful and exceedingly well adapted for swimming. Abdomen somewhat depressed and upcurved at the tip. Face vertically elongated, with an aspect singularly like that of the face of the common grasshopper.

Head and prothorax short, each about twice as wide as long; mesothorax large and prominent; abdomen a little wider in the middle, tapering slightly to the end; serrated on each side by the prolongation of the posterolateral angles of segments 1-9 in sharp, single, backwardly directed teeth, which become largest on the sides of the 8th segment, and sharpest and thinnest on the sides of the ninth: 10th segment cylindrical, two thirds as wide as the ninth.



Color yellowish or greenish brown, mottled with blackish brown on the dorsal side in a pattern of short streaks. Legs yellowish: femora with a band of brown just beyond the middle; other brownish marks beside or on all the leg sutures; tibia shorter than the tarsus without its claw.

Setae yellow, with a whitish fringe of hairs of silky aspect; a transverse band of brown across them just beyond the middle, and a brownish shade near the tip.

Gills present and double on segments 1-7; the posterior leaf with a chitinous ridge on its ventral (external) margin, not reaching the apex, relatively shortest on the first gill; the posterior leaf trilobed on segment 1, bilobed on segments 2-6, and simple on segment 7; the smaller, thinner and more delicate anterior leaf bilobed on segments 1 and 2, simple on segments 3-7, becoming very small on the seventh segment.

In contrast with the gills of *Heptagenia*, in which the anterior leaf of the gill is thickened and protects the delicate posterior one, we have in *Siphurus* the anterior leaf thin and delicate, the posterior one thickened. The latter, having muscles attached to it internally, thus becomes a swimming organ, capable of a smart backward stroke. Each acts in concert with its fellows and with the tail fin, producing a racing speed for a succession of short dashes through the water. The respiratory gill leaf, being placed at the front, is out of the way of the stroke.

Two specimens of *Callibaetis ferruginea* were taken at the hatchery windows during the month of August.

### ***Ephemerella excurcians* Walsh**

1862 *Ephemerella excurcians* Walsh, Acad. nat. sci. Phil. Proc. p. 377  
(original description)

1863 *Ephemerella excurcians* Hagen, Ent. soc. Phil. Proc. 2:178 (note)

1885 *Ephemerella excurcians* Eaton, Linn. soc. Lond. Trans. 3:130 (a full description)

1892 *Ephemerella excurcians* Banks, Am. ent. soc. Trans. 19:347  
(listed)

1871 *Ephemerella invaria*, in part, Eaton, Ent. soc. Lond. Trans. p. 100

Very few imagos of this interesting species were obtained, notwithstanding the nymphs were common in Little Clear creek and even in the hatchery troughs during the month of July. A single pair was bred July 10, transforming to imagos the following day. Specimens were taken at the trap lantern and from the hatchery windows. The species is known from New York, Illinois and Michigan.

The nymph is no. 5 of Eaton's monograph.<sup>1</sup> This being the type species of the genus *Ephemerella*, a genus the nymphs of which show considerable differences, it is the more desirable that the immature stages should be made known.

<sup>1</sup>Linn. soc. Lond. Trans. 1885. 3:133-34, pl. 40, fig. 18-20, and pl. 64, fig. 3-7. Unknown genus "allied to *Ephemerella*."

**Nymph.** Length 8 mm; setae 4 mm additional; abdomen 4.5 mm; antennae 1.5 mm.

Head twice as wide as long; thorax convex; legs short; tibia about equal in length to the tarsus without its claw; abdomen depressed, widened on the fourth to ninth segments, with thin lateral margins, produced at the hind angles into thin, flat teeth, which appear in outline like the teeth of a circular saw; third segment with a minute tooth, first and second segments with none at all, roth segment with a low, longitudinal, lateral carina; setae fringed in the middle, nearly naked at both ends.

Color dirty yellowish, darker above, paler beneath.

Gills double, well developed on the fourth to the sixth segments, rudimentary on the first and seventh, and absent from the second and third; the opercular anterior leaf on the fourth segment covers all the gills posterior to it; on the fifth and sixth segments the anterior leaf is similar in form but smaller and much thinner; the delicate posterior leaf on the fourth, fifth and sixth segments is two parted; on the first segment is a simple cylindric rudiment, jointed on a low pedicel; on the seventh segment the rudimentary gill is leaflike, single, six lobed.

July 19 quite a number of nymphs were obtained, both from Little Clear creek beside the hatchery and from the hatchery troughs.

### ***Caenis diminuta* Walker**

1853 *Caenis diminuta* Walker, List neur. ins. Brit. mus. 3: 584

1861 *Caenis diminuta* Hagen, Synopsis Neur. N. Am. p. 55

1861 *Caenis amica* Hagen, Synopsis Neur. N. Am. p. 55

1871 *Caenis diminuta* Eaton, Ent. soc. Lond. Trans. p. 95 (description in Latin)

1885 *Caenis diminuta* Eaton, Linn. soc. Lond. Trans. (2) 3: 147 (a full description)

1892 *Caenis diminuta* Banks, Am. ent. soc. Trans. 19: 348 (listed)

This dumpy, little, nocturnal species was taken abundantly in a trap lantern hung on the side of the boathouse at the outlet of Little Clear pond. 15 to 50 specimens were taken at a single lantern each evening from the 14th to the 18th of July. This appeared to be the season of greatest abundance for the species. It is quite variable in size and in coloration: the best colored of my specimens agree well with Eaton's detailed description; but the size is often much larger, reaching 5-6 mm in length. This may be due to the taking of published measurements from dried specimens, which are always shriveled considerably. The species is generally distributed over the eastern United States.

The nymphs are common among the trash on the bottom in all quiet waters. Their inconspicuous coloration and trashy covering protect

them well. They cling closely to twigs, bark, etc., and will allow themselves to be lifted from the water without stirring.

**Nymph.** Length 5.5 mm; setae 3.4 mm additional; abdomen 2.5 mm; antenna 2.3 mm.

Body stout, with thick thorax, and short and rapidly tapering abdomen.

Color pale brownish, darker above, obscured by adherent silt, by diatoms, vorticellae, hydras, and other adherent organisms.

Abdomen with large and sharp, flat teeth, made by the projecting posterolateral angles of the third to the ninth segments, largest on segment 7, smallest on segment 3.

Gills present on segments 1-6; on segment 1 minute rudiments; on segment 2 thick, elytroid, covering the functional gills, squarish, the distal and external angles rounded, the basal-internal angle square; there is on the anterior face a piliferous carina, regularly arcuate, near the external margin, extending from the outer basal to the inner distal angle. The gills on segments 3-6 diminish in size posteriorly; they have the shape of the hind wing of a pierid butterfly, and bear a long dense peripheral fringe of respiratory filaments. These filaments are unilaterally several times branched on the anterior side, and are so closely crowded that they overlap in regular series around the margin of the gill leaf. They are longest at the distal end, where they exceed the length of the gill leaf itself.

Setae slender, thinly fringed along both margins, the middle one apparently a little shorter in the males, a little longer in the females than the other two.

### *Hexagenia variabilis* Eaton

Plate 16

- 1843-45 *Palingenia limbata* Pictet, Hist. nat. Neur. v. 2 (Ephem.) p. 146, pl. 12 (the original description: this was Serville's name for another species)
- 1853 *Palingenia limbata* Walker, List neur. ins. Brit. mus. 3: 548
- 1861 *Palingenia bilineata* Hagen, Synopsis Neur. N. Am. p. 41 (a full description)
- 1862 *Palingenia limbata* Walsh, Acad. nat. sci. Phil. Proc. p. 373
- 1863 *Palingenia limbata* Hagen, Ent. soc. Phil. Proc. 2: 176
- 1863 *Palingenia limbata* Walsh, Ent. soc. Phil. Proc. 2: 197-99 (makes the species the type of his new genus *Hexagenia*)
- 1868 *Hexagenia limbata* Eaton, Ent. mo. mag. 5: 85
- 1871 *Hexagenia limbata* Eaton, Ent. soc. Lond. Trans. p. 65, pl. 1, fig. 7, and pl. 4, fig. 3 and 3a (description in Latin)
- 1885 *Hexagenia variabilis* Eaton, Linn. soc. Lond. Trans. (2) 3: 55, pl. 7, fig. 11c
- 1890 *Hexagenia variabilis* Hagen, Stett. ent. zeit. 51: 11-13 (distinguishes this species from *bilineata* Say by the form of the forceps of the male)
- 1892 *Hexagenia limbata* Banks, Am. ent. soc. Trans. 19: 345 (listed)

1888 *Hexagenia* sp.? (probably *variabilis* and *bilineata*) Forbes, State lab. nat. hist. Bul. 3. 2:484-85 (estimate of the value of *Hexagenia* larvae as food for fishes, based on the examination of the stomach contents of 1221 fishes, representing 87 species, 63 genera, and 25 families: *Hexagenia* larvae constitute nearly one tenth of all the food taken). Summary in Insect life. 1888. 1:158-61

This species was much less numerous than the other six whose life histories are discussed here. It was found only along Little Clear creek. An occasional subimago was seen in early morning leaving the water and flying weakly to some neighboring tree trunk to rest. A single specimen was taken on the outside of a trap lantern in the morning twilight. A few were picked from the sides of the hatchery building, where they were conspicuous on account of their size.

The nymphs were easily obtained from the bottom of the creek with a sieve net. They were obtainable throughout the season, this species not having a limited period of emergence, as *H. bilineata* seems to have. Nymphs taken incidentally while collecting, were reared at various times from June 26 to Aug. 1. They were associated in the creek bed with *Ephemera varia*, described below, but were very much less numerous. In our breeding cages the subimago emerged one night and transformed to the imago the night following.

**Nymph.** Pl. 16, fig. 2, 3. Length of body 27 mm; setae 12 mm more; abdomen of male 18, of female 21 mm; antenna 4.5 mm.

Color yellow, with some paler longitudinal markings on the thorax; a series of mushroom-shaped marks on abdominal segments 6-9.

Head compressed; a shelf like prominence above the base of each antenna, straight on its front border, round on its exterior side; the frontal prominence semi-elliptic; mandibular tusks long, stout, upcurved, with a line of hairs on their supero-external margin.

Antennae at base, and the sharp edges of the legs, and the lateral margins of the prothorax, densely clothed with long yellowish hairs. The antennae are bare at the tips and do not surpass the extended fore tarsi.

Legs (pl. 16, fig. 3) short, stout, twisted, flattened, closely applied to the sides of the body, and well adapted for burrowing; femora and tibiae scapulate; the tibia produced at its apex into a terminal burrowing hook and scraper, the edges bearing a stiff line of hairs; the hind foot chelate, the distal angle of the tibia forming with the opposed tarsus a pincer.

Gills on segments 1-7; gill of the first segment small and shaped like a tuning fork; of the six following segments large, of a rich purplish color, two leaved, the leaves similar, lanceolate, and densely fringed with minute linear respiratory filaments, which are as long as the greatest width of the gill leaf. On the flat side of each gill leaf is a yellow, longitudinal median line closely bordered on either side by a line of black. All the gills are directed over the back, where they are gently waved back and forth in intermittent, graceful motion.

One of the largest of our May flies; generally distributed over the United States east of the Rocky mountains.

**Ephemera varia** Eaton

Plate 11, figures 3, 4

1861 *Ephemera decora* Hagen, Synopsis Neur. N. Am. p. 38 (*decora* was Walker's name for another species)

1875 *Ephemera decora* Hagen, Rep't U. S. geol. sur. terr. for 1873; p. 578

1885 *Ephemera varia* Eaton, Linn. soc. Lond. Trans. (2) 3: 69-70, pl. 63, fig. 12h

1892 *Ephemera decora* Banks, Am. ent. soc. Trans. 19: 345 (listed)

This dainty New England species was common about Little Clear creek, associated with the preceding species, with which it agrees quite closely in habits. Imagos, while not sought outside our cages, were often seen sitting lightly on the bushes near the banks of the creek. The nymphs were abundant in the bed of the creek till the first of August.

**Nymph.** Pl. 11, fig. 1, 2 Length of body 18 mm; setae 8 mm additional; abdomen 11 mm; antennae 4.5 mm.

Color yellowish; abdomen with a pair of submedian, longitudinal, brown streaks, laid on yellow ones, which they divide.

Antennae sparsely hairy, much surpassing the tips of the tarsi. Mandibular tusks, approximate, slender, bare, gently up curved and divergent at the tips; femora and tibiae moderately dilated and bearing on their flattened edges copious fringes of hairs.

Gills as in *Hexagenia*, but slenderer, and less deeply tinged with purple color.

## Order ODONATA

*Dragon flies*

The dragon flies are all aquatic. They frequent fresh water in all sorts of situations, and are probably the most important predatory aquatic insects. They are strictly carnivorous in all stages. The adults feed on a great variety of insects, and the larger dragon flies habitually eat the smaller ones. The nymphs are very voracious, and in many species cannibalistic, the larger nymphs eating the smaller ones; but they eat chiefly other aquatic insects, worms, crustaceans, fish fry, and tadpoles.



Fig. 6 Face of nymph of *Symptetrum illotum* Hagen, showing the enormous mask shaped labium

The nymphs may be conveniently grouped according to habits as follows.

- a* Burrowing nymphs, with depressed, wedged-shaped heads, abbreviated and flattened antennae, approximated fore legs, and external burrowing hooks at the ends of the fore and middle tibiae. These burrow along on the bottom of the pond or stream, just beneath the layer of silt, with the tip of the abdomen turned upward and reaching the water for respiration (*Gomphinae*)

## PLATE 11

**Ephemera varia** Etn., and **Siphylurus alternatus** Say

FIG.

- 1 Lateral view of the nymph of *E. varia*
- 2 Dorsal view of the nymph of *E. varia*
- 3 Lateral view of the male imago of *E. varia*
- 4 Dorsal view of the male imago of *E. varia*
- 5 Lateral view of the nymph of *S. alternatus*
- 6 Dorsal view of the nymph of *S. alternatus*
- 7 Lateral view of the male imago of *S. alternatus*

## PLATE 12

**Climacia dictyona** Needham, nov. sp., and **Sisyrta umbrata**  
Needham, nov. sp.

FIG.

- 1 Imago of *C. dictyona*, lateral view, x 4
- 2 Imago of *C. dictyona*, dorsal view, x 3
- 3 Larva of *C. dictyona*, dorsal view, x 6
- 4 Pupal cases of *C. dictyona*, in situ, natural size
- 5 One of the same, enlarged, showing the hexagonal meshes of the outer covering
- 6 Imago of *S. umbrata*, lateral view, x 4
- 7 Imago of *S. umbrata*, dorsal view, x 3
- 8 Two newly formed pupae of *S. umbrata*, lateral and ventral views, x 6
- 9 *Macronychus glabratus* Say (Coleoptera: Parnidae); an associate of the sponge fly larvae, on submerged timbers
- 10 Fresh-water sponges (*Spongilla ? fragilis* Leidy) in situ, with the sponge fly larvae crawling about over them
- 11 Two pupal cases of *S. umbrata*, showing the closely woven outer covering, natural size

## PLATE 13

**Molanna cinerea** Hagen and **Polycentropus lucidus** Hagen

FIG.

- 1 Dorsal view of larva of *Molanna cinerea*, x 4
- 2 Lateral view of larva of *M. cinerea*, x 5
- 3 Lateral view of the pupa of *M. cinerea*, x 4½
- 4 Dorsal view of imago of *M. cinerea*, x 4
- 5 The accustomed resting position of the imago of *M. cinerea*
- 6 Ventral view of the flat larval case of *M. cinerea*, x 2
- 7 Lateral view of larva of *Polycentropus lucidus*, showing the very long anal prolegs, and the absence of gill filaments, x 5
- 8 Lateral view of pupa of *P. lucidus*, x 6
- 9 Dorsal view of imago of *P. lucidus*, x 3½
- 10 Larval case of *P. lucidus*; tube composed of sand and silk; the enlargement near the end is two layered, and contains the pupa.
- 11 Eggs laid by *P. lucidus* female on a stick protruding from the water in a breeding cage

## PLATE 14

**Sepedon fuscipennis** Loew and **Tetanocera pictipes** Loew

FIG.

- 1 Larva of *S. fuscipennis*, dorsal view, x 5
- 2 Larva of *S. fuscipennis*, lateral view, x 6
- 3 Puparium of *S. fuscipennis*, dorsal view, x 5
- 4 Puparium of *S. fuscipennis*, lateral view, x 5
- 5 Open puparium of *S. fuscipennis*, x 5
- 6 A seed floating which the puparium simulates, x 5
- 7 Imago of *S. fuscipennis*, dorsal view, x 5
- 8 Imago of *S. fuscipennis*, lateral view, x 5
- 9 Larva of *T. pictipes*, dorsal view, x 6
- 10 Larva of *T. pictipes*, lateral view, x 6
- 11 Puparium of *T. pictipes*, lateral view, x 6
- 12 Puparium of *T. pictipes*, dorsal view, x 5
- 13 Imago of *T. pictipes*, dorsal view, x 5
- 14 Imago of *T. pictipes*, lateral view, x 5

## PLATE 15

**Simulium** Society

*Simulium venustum* Say, *Hydropsyche* sp.?, *Heptagenia pulchella* Walsh, *Baetis pygmaea* Hagen, *Leuctra tenella* Provancher and *Roederiodes juncta* Coquillett.

FIG.

- 1 Two imagos of *Hydropsyche* sp.?, at rest, natural size
- 2 Imago of *Hydropsyche* sp.?, lateral view, x 6
- 3 Larva of *Hydropsyche* sp.?, lateral view, x 3½
- 4 Pupal case of *Hydropsyche* sp.?, x 2
- 5 Imago of *Roederiodes juncta*, lateral view, x 10
- 6 Larva of *Roederiodes juncta*, lateral view, x 5
- 7 Pupa of *Roederiodes juncta*, lateral view, x 5
- 8 Pupa of *Roederiodes juncta* in an habitual position in the abandoned pupal case of *Simulium venustum*
- 9 Egg masses of *S. venustum*, and two females ovipositing
- 10 Pupae, empty pupa skins, and pupal cases of *S. venustum*
- 11 Larva of *S. venustum*, x 5
- 12 Male imago of *Leuctra tenella*, dorsal view, x 4
- 13 Imago of *Baetis pygmaea*, lateral view, x 5
- 14 Imago of *Baetis pygmaea*, dorsal view, x 5
- 15 Imago of *Heptagenia pulchella*, x 2
- 16 Nymph of *Heptagenia pulchella*, natural size
- 17 Pupal cases of *Hydropsyche* sp.?, in situ, natural size
- 18 Pupae of *Simulium venustum*, in situ
- 19, 20 Larvae of *S. venustum* in situ

## PLATE 16

**Hexagenia variabilis** Eaton

FIG.

- 1 Female imago, natural size. Photo from life by J. G. Needham
- 2 Dorsal view of the head of the nymph
- 3, <sup>a</sup>Fore and <sup>b</sup>hind feet of the nymph; <sup>f</sup>femur; <sup>t</sup>tibia

## PLATE 17

**Dragonflies**

FIG.

- 1 *Aeschna constricta* Say
  - 2 *Gomphus scudderi* Selys
- Natural size: photos from life by J. G. Needham

## PLATE 18

Dragonfly nymphs: photos by J. G. Needham

FIG.

- 1 *Dromogomphus spinosus* Selys
- 2 *Gomphus scudderi* Selys
- 3 *G. brevis* Selys
- 4 *G. spicatus* Selys
- 5 *Ophiogomphus aspersus* Morse
- 6 *Lanthus parvulus* Selys
- 7 *Hagenius brevistylus* Selys
- 8 *Didymops transversa* Say

Fig. 1 to 7 are from cast skins.

## PLATE 19

Eggs of nine genera of dragonflies (Odonata-Anisoptera)

FIG.

- 1 Egg of *Anax junius* Dru: the line k-k indicates the depth of its insertion into cat-tail (*Typha*) stems.
- 2 Egg of *Hagenius brevistylus* Selys
- 3 Egg of *Gomphus descriptus* Banks var. *borealis* Ndm.
- 4 Egg of *Cordulia Shurtleffi* Scudd.
- 5 Egg of *Plathemis lydia*
- 6 Egg of *Leucorhinia glacialis* Hagen
- 7 Egg of *Celithemis eponina* Dru.
- 8 Egg of *Perithemis domitia* Dru.
- 9 Egg of *Tramea lacerata* Hagen

Gelatinous envelops (g) are indicated for all the figures except 1 and 8: all are magnified about 50 diameters.

## PLATE 20

**Gomphinae**

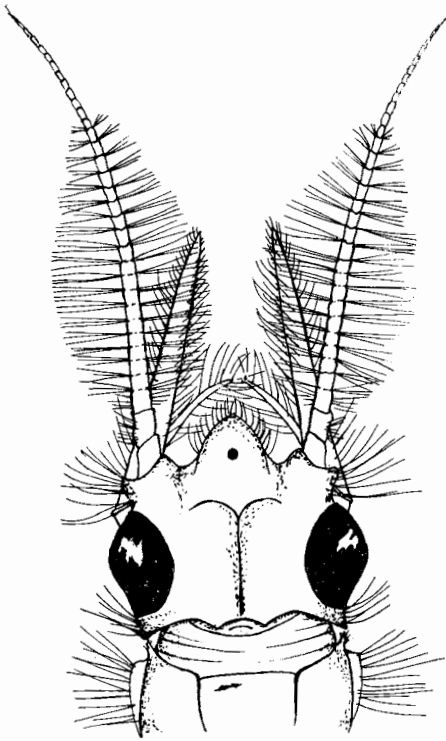
FIG.

- 1-4 Occiput of the female of *Ophiogomphus carolus* Ndm., seen from the front, showing variations in occipital spines
- 5 Genital hamules of *O. johannus* Ndm., from the left side, inverted

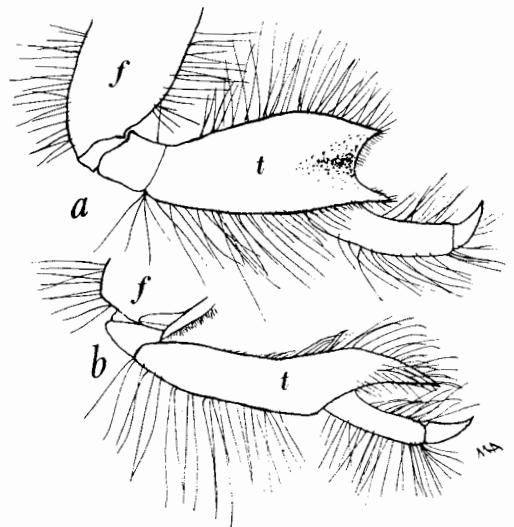




1



2



3

*Hexagenia variabilis* Etn.