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JOHN M. CLARKE Director

EPHRAIM PORTER FELT State Entomologist

Bulletin 86

ENTOMOLOGY 23

MAY FLIES AND MIDGES OF NEW YORK

THIRD REPORT ON AQUATIC INSECTS

A study conducted at the entomologic field station, Ithaca N. Y. under the direction of
EPHRAIM PORTER FELT D.Sc.

BY

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SIR: I beg to transmit herewith, for publication as a bulletin of this division, a third report on aquatic insects, entitled *May Flies and Midges of New York* by Dr J. G. Needham, Special Assistant to the State Entomologist.

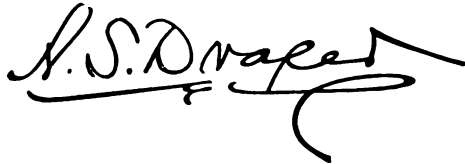
Very respectfully

JOHN M. CLARKE

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Approved for publication Oct. 24, 1904

A handwritten signature in black ink, reading "A. S. Draper". The signature is written in a cursive style with a long, sweeping underline that extends to the right and then loops back under the name.

Commissioner of Education

PREFACE

This, the third report upon work begun in 1900, like its predecessors, marks an important advance in knowledge. The first report, State Museum Bulletin 47, consisting of 230 pages and 36 plates, gave the life histories of about one hundred aquatic forms and characterized ten species and two new genera. The most important portion of this work was the monographic account of the larger dragon flies (Odonata Anisoptera). There were also valuable additions to our knowledge of the stone flies (Plecoptera) and the May flies (Ephemeroidea), and the admirable account of the Caddis flies (Trichoptera), by Mr Betten, deserves special mention because of its careful biologic treatment of a heretofore much neglected group. The second report, State Museum Bulletin 68, comprised 419 pages and 52 plates and was a continuation of the preceding. The monograph of the Odonata is completed by an exhaustive account of the smaller dragon flies (Zygoptera). Among the important contributions may be mentioned: The key to Coleopterous larvae with an account of some aquatic Chrysomelidae by Dr MacGillivray, the discussion of certain aquatic nematocerous Diptera by Dr Johannsen, and a monograph on the Sialididae of the Western Hemisphere. The present report is a continuation of the work, and among its valuable features should be noted the monographic account of our May flies, a group of great importance as food for fish. The small midges, belonging to the Chironomidae, are very important as fish-food and have been treated exhaustively by Mr Johannsen. These three publications mark a most decided advance in our knowledge of aquatic forms and, with the publication of the monograph on stone flies now in preparation, a large fund of information will be available for the student of aquatic forms.

This study, as was pointed out in the introduction to the first report, has been made upon broad lines with the avowed purpose of producing something of value to the fish culturist, who must first of all be able to identify aquatic forms, something well-nigh

impossible, before these reports were made public. The investigations of Dr S. A. Forbes of Illinois convinced him that nearly one-fifth of the entire amount of food consumed by all adult fishes examined by him consisted of aquatic neuropteroid larvae, the greater part of them being the young of May flies. It may never be possible to rear aquatic insects for the purpose of feeding fish, but it certainly is feasible in some instances to provide conditions adapted to multiplication of aquatic insects, and therefore valuable as feeding grounds for fish. The history of the shellfish industry gives a little idea of the possibilities along this line. A number of years ago it was at a very low ebb, owing to unscientific methods in vogue and the lack of individual control. This has been changed and we now have a thriving industry producing over two million dollars (\$2,309,758) worth of products, according to the report of the United States Fish Commission for 1900. It is exceedingly difficult to obtain figures relating to the value of our fresh-water fishes, but a compilation from the report of the United States Fish Commission for the year 1900 gives the total value of fresh-water fish in the Hudson river valley and Long Island at over one million dollars (\$1,192,544), and the report for 1901 places the value of fresh-water fish obtained in the State from the Great Lakes at nearly one-fourth a million (\$241,916). These figures, it will be observed, give no idea of the value of fresh-water fish taken in various lakes and streams throughout the State, aside from the areas mentioned above. Comparing the water areas available for shellfish culture and those suitable for the development of fresh-water fish, it will be seen that there is a considerable discrepancy in favor of the latter and yet the value of the product is much smaller. It is stated that a large proportion of the market fish of China are grown in ponds, and that carp culture is an important industry not only in China but in Germany, and that formerly carp were extensively reared in England. Germany and Sweden, and lately France, have also done considerable along this line.

It is hardly likely that this country will adopt Chinese methods, because the great difference in the price of labor makes it impracticable; still the proper knowledge of the conditions suitable

for the growth and multiplication of fish may put it within the power of many to make substantial additions to the productivity of areas under control, without great increase in the cost of management. These investigations have been conducted primarily to ascertain the relations existing between fish and insects they feed upon, and the conditions necessary for the development of large amounts of fish-food. Much of the preliminary work has been accomplished, and the data already obtained should prove of great service to parties interested in fish culture, especially in making heretofore barren waters productive.

E. P. FELT
State Entomologist

New York State Museum

JOHN M. CLARKE Director

Bulletin 86

ENTOMOLOGY 23

MAY FLIES AND MIDGES OF NEW YORK

I. INTRODUCTION.

BY JAMES G. NEEDHAM

This bulletin includes further results of the study of material gathered under the auspices of the New York entomologic field station, and is therefore complementary to bulletins 47 and 68 of this same series. Bulletin 47 contains the more general results of the first field season spent at Saranac Inn, introductory keys to aquatic insect larvae, numerous life histories, and a detailed report of the dragonflies (*Odonata-Anisoptera*) of New York State. Bulletin 68 contains the main results of the second field season spent at Ithaca, further life histories, detailed reports on the damselflies (*Odonata-Zygoptera*) of the state, on aquatic plant-beetles (*Chrysomelidae*), on certain families of nematocerous diptera, and on American *Sialididae*; also, an account of the food of the brook trout in Bone pond.

This bulletin contains the work of three collaborators who have labored apart on the remaining material gathered for the station. Mr O. A. Johannsen furnishes the major part, in the form of a completed review of the *Chironomidae*. Notwithstanding that these little gnats are enormously abundant everywhere and are of first importance among insects affecting fish culture, this is the first American monograph we have had dealing with the family to which they belong. It is a generic treatment of the world fauna, together with detailed descriptions and life histories (mostly new) of our known species. It is a

work of first importance, and will doubtless serve as a basis for future studies in this long-neglected family.

Mr K. J. Morton of Edinburgh contributes a paper on the micro-caddisflies of the family *Hydroptilidae* of *Trichoptera*, which is practically the beginning of the study of this group in America.

My own part in this bulletin is a second contribution to the knowledge of our may-flies. Because of the great economic importance of this group also, I have thought it worth while to attempt to provide American students with a better introduction to the study of the group than has hitherto been generally available. Hence, in addition to new life histories, I have prepared new generic keys to both nymphs and adults, which, with the detailed explanations and figures, should enable even a novice to take up the study of this neglected group with some hope of success.

I have also prepared a brief report on the summer food of the bullfrog (*Rana catesbiana* Shaw) at Saranac Inn, and in the discussion of that food have included a number of ecological and systematic notes, among which is a new key to our genera of *Hemerobiidae*.

I planned also to include herein a report on the stoneflies (*Perlidae*) and did much work to that end: but the station collections are large, and much material has come to me from friends outside, and my manuscript has grown until it now seems better not to include it herein, but to make a separate bulletin of it. I am therefore continuing the work with the purpose of making the next station bulletin a monograph of North American *Perlidae*. I should be greatly obliged if American collectors who have even a few specimens would send me them for study.

In this place I may add a note supplementary to bulletin 68. The "unknown tipulid larva from a spring" described on pp.285-286 and figured in pl.10, figs.4-5. is *Pedicia albivitta* Walker. Had Beling's third paper on Tipulid larvae (*Verh. zool.-bot. Ges. Wien*, vol.36) been available to me when I was studying this larvae, I should have been able to determine it from his keys and description. The "unknown leptid larva from rapid streams" of p.286 and pl.10, fig.1, is doubtless a

species of *Atherix*, as has been kindly indicated to me in correspondence by both Professor A. Giard of Paris and Dr R. Lauterborn of Ludwigshafen.

THE SUMMER FOOD OF THE BULLFROG (*RANA CATES-
BIANA* SHAW) AT SARANAC INN

(With plate 1)

BY JAMES G. NEEDHAM

Bullfrogs are common at Saranac Inn. Any warm evening their sonorous notes may be heard reverberating through the tamarack swamps, echoing and reechoing across Little Clear pond between Green hill and the outlet, or rising with a startling crescendo near at hand from the shallows of the reedy creek, setting the thread-rushes trembling, and fretting the face of the water with infinitesimal wavelets, striking with wonder and admiration the ears of the stranger accustomed only to the vocal powers of the lesser civilized frogs. By day they sit in the edge of the water, stolidly basking in the sunshine, picking a straying bee or dragonfly out of the air, or lapping a floating ant or an emerging caddisfly from the surface of the water, eating much or little according to the bestowal of Providence, and when alarmed by our too close approach, plunging away with a single dilatory and awkward leap into deeper water. Their tadpoles, likewise of phenomenal size, are to be seen about the submerged timbers in Little Clear pond and creek. They are oftenest observed resting upon the logs in the sunshine. Frequently, when crossing the bridge over Big Clear creek on the Otisville road during our first field season, I stopped to watch them sunning themselves on the submerged bridge timbers, and often dropped pebbles upon them to see them swim away. They would wriggle and sidle and slide off the timbers, and then with a motion that appeared most deliberate strike a straight course obliquely downward far away across the clear deep waters of the stream, moving slowly forward by sculling undulations of the enormous banner-like tail.

During July and August, 1900, I preserved the food of a number of adult bullfrogs from Little Clear creek, taking the stomachs of chance specimens that were killed for food and preserving and

dd No closed cell in the first fork of the radial sector before the base of the second division of the sector (pl.3, fig.3); coxae of fore legs shorter than femora

Palmobius n. gen. type *H. amicus* Fitch

cc First of the three or four divisions of the radial sector arising well beyond the basal subcostal crossvein (pl.2, fig.1); in the hind wing vein M_{1+2} is more or less confluent with the base of the radial sector, eliminating or reducing the crossvein between

Hemerobius

EPHEMERIDAE

BY JAMES G. NEEDHAM

Since the publication of Museum Bulletin 47 little attention has been given by the workers at the Entomologic Field Station to the collection and rearing of mayflies. Incidentally, however, a number of new and most interesting forms have been brought together, and nine additional species representing as many additional genera have been reared—mostly by Mr Betten and myself during the summer of 1901 at Ithaca. It is the purpose of this paper to give the results of new life history studies, and also new keys for both adults and nymphs, that shall serve as a better introduction to the study of this interesting group.

That the group is of great economic importance in water culture there can be no doubt. Past food studies have demonstrated this; and every aquatic collector has found the waters teeming with the immature stages. There are mayfly nymphs for every sort of situation in fresh water, and they are almost everywhere abundant. These are perhaps the dominant insect herbivores of fresh water. Notwithstanding their ecological interest, the wonderful ways in which they have adapted themselves to diverse modes of life in different sorts of places, and their singular, though fragile, beauty, their study is very much neglected among us. It is in the hope of interesting more of our field workers in them that I have added to the life histories and descriptions, the keys and text figures of the present paper.

Few life histories of American species, whose nymphs have been positively determined by rearing, have as yet been written. The singular nymph of *Baetisca obesa* Say has long been

known, having been described by Walsh, its discoverer, and by Vaysiere and Eaton. In bulletin 47 I described the nymphs (having in each case bred the species) of *Heptagenia pulchella* Walsh, *Baetis pygmaea* Hagen, *Siphurus alternatus* Say, *Ephemerella excrucians* Walsh, *Caenis diminuta* Walker, *Hexagenia variabilis* Eaton, and *Ephemerella varia* Eaton. In the *American Naturalist* for 1903, pp.25-31 of vol.37, Mr Edward W. Berry described the nymphs of ?*Habrophlebia americana* Banks, *Blasturus cupidus* Say and *Callibaetis ferruginea* Walsh, and in Bulletin 68 I described the nymph of *Callibaetis skokiana* Needham. That is all the bred species that have hitherto been described in America, so far as I know.

In the following pages I describe the nymphs of the following eight bred species, representing as many genera: *Chironetes albomanicatus* sp. nov. *Choroterpes basalis* Banks, *Leptophlebia praepedita* Eaton, *Caenis allecta* sp. nov., *Ameletus ludens* sp. nov. *Ephemerella bispina* sp. nov., *Heptagenia interpunctata* Say, and *Ecdyurus maculipennis* Walsh, Mr W. E. Howard furnishing an account of the life history of *Polyntarcys albus* Say, which he has studied at Ottawa Ill., but which I have not seen at large. I add thereto descriptions of five additional species which have not been bred, but to which the names of native genera are assigned tentatively.

Some of the above descriptions are generic rather than specific: the study of the nymphs in some genera has hardly gotten down to the species as yet. Representatives of all these genera are described and figured in Eaton's *Monograph of Recent Ephemeridae*, at least two of them being tentatively referred to the wrong genera, however. But the excellent and copious figures of that work make it possible to refer the five species of unbred nymphs to their genera with some degree of assurance.

I have published directions for collecting and rearing nymphs of mayflies elsewhere,¹ but while speaking of life histories I would not omit to mention how easy it is to get life-history material in

¹Part 0 of Bull. 39, U. S. National Museum.

this group. As is well known, there is with mayflies one moult during adult life. The nymph, transforming, leaves the water as a subimago, and later moults again and becomes the imago. The subimago stage lasts but a little while—but a few minutes with the most ephemeral species, about a day with the majority of species, two days with *Siphurusa alternatus* kept indoors—being much more brief than is the period of transformation of even those species that are most concerted in time of appearance on the wing. It follows from this that when one finds subimagos flying, he can go to the water whence they came and be rather sure of finding, with proper searching, the full-grown nymphs. The subimagos may be recognized by their generally duller coloration, and the possession of fringes of hairs around the wing border (present in the imago of *Cenis* only among our forms). Grown nymphs may be placed in any sort of a dish of water near a window out of the direct sunlight to transform. The subimagos picked from the window later may be put in paper bags and left to moult again. All stages are best preserved directly in alcohol of about 80 per cent strength.

Besides the material for this paper collected by myself and Mr Betten at Ithaca N. Y. and Lake Forest Ill., and that furnished me from the State Museum collection by Dr Felt, I have received material used herein from Professor T. D. A. Cockerell collected at Pecos New Mexico, from the late Mr R. J. Weith, collected at Elkhart Indiana, from Mr Chauncey Juday, collected at Twin Lakes Colorado, and from Mrs Mary Rogers Miller, collected at Thousand Island Park N. Y., for all of which I return grateful acknowledgment.

For the use of the following keys a little more knowledge of mayfly structure is likely to be required than the average text-book of entomology affords. A knowledge of the names of the parts of the body and legs of the typical insect will be assumed; also, of the principal mouth parts and antennae. It should be known that the male is readily distinguished from the female by the possession of much larger compound eyes, these always being remote from each other in the female, and by the possession of a pair of jointed appendages called forceps that project backward from beneath the penultimate segment of the abdomen. The two

or three filiform appendages which terminate the abdomen are here called caudal setae.

The tarsi are typically five-jointed in the adult, though one or two basal joints show a marked tendency to fuse with the end of the tibia, and the last joint bears two claws of variable form (Fig.5); in the nymph the tarsus is one-jointed and bears a single claw (Plate 6, fig. 7 and 8). The mouth parts in the adult are atrophied and functionless, while in the nymph they are highly developed. But one feature of them needs mention here, however; that is the armature of the mandible. By comparing pl.6, fig.4, and pl.8, fig.6, it will be seen

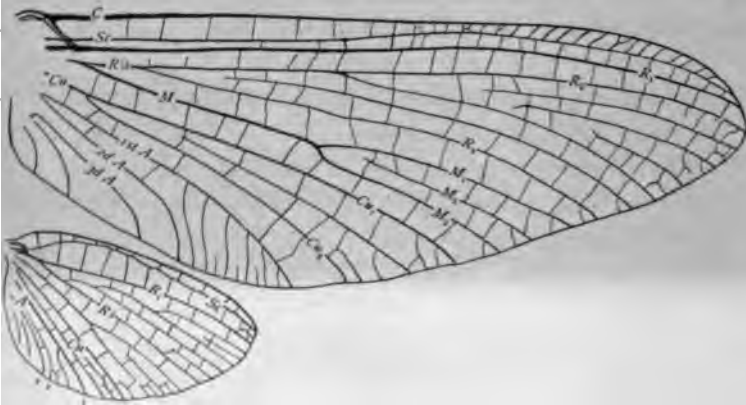


Fig. 1 Venation of the wings of *Siphonurus*; lettering explained in text

that each mandible bears on its inner side a broad more or less corrugated *molar surface*, and at its antero-lateral angle several variable *canines*.¹

To the venation of the wings the student who aspires to an acquaintance with mayflies would do well to pay special heed. This is of chief importance because 1) the venation is perfectly definite and easily observed; 2) it suffers least distortion in preserved specimens; 3) it remains the same through the different developmental stages, and 4) the wings are better retained than the other appendages, and progress is better in using a key if the structures mentioned in it have not been lost. The main features

¹Following the terminology of Vayssiere for these parts. *Organisation des larves des Ephémérides*: Ann. Sci. Nat. (6) vol.13. 1882.

of the venation are easily learned, and afford a ready clue to the relationships. Eaton says, "Unstable in minutiae, so closely is the essential plan of the neuriation adhered to by nearly related mayflies that the general facies of the wing is an important aid to their classification, affording characteristics as easily recognizable as the style of branching in the case of trees."

By reference to figs.1, 2 or 3, or any of the wing figures of the plates, it will be observed that there are three nearly parallel veins extending along the front or costal margin of the wing, costa (*C*), subcosta (*Sc*), and radius (*R*₁). These three are followed by three forking veins that occupy the greater part of the wing area, the radial sector (*Rs*), the media (*M*) and the cubitus (*Cu*). The middle one of these, the media, forking usually far-

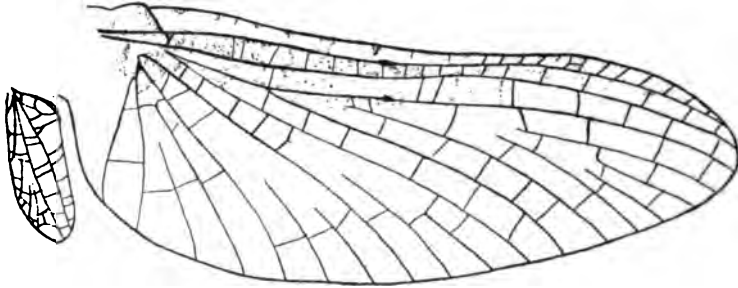


Fig.2 Wings of *Callibaetis*

ther outward than the others and being more constant in form, is one of the best landmarks of the wing. All that lies between it and vein *R*₁ is radial sector, which, in the fore wings of mayflies, is entirely detached from the radius and functions as a separate vein. The only place in the series where there is likely to be any difficulty in recognizing the media is in the few genera closely allied to *Baetis* (see fig.2) in which both the media and the cubitus are apparently simple; but it will be readily observed by carefully noting the number and relation of the longitudinal veins that the hinder branch of the fork of these two veins is detached, and appears as an independent sector standing on the hinder side; the relative lengths of these veins enable one to recognize them all, even when detached, or when, through shifting of cross veins at their bases, they appear to have formed attachments of a contradictory sort (see vein *Cu*₂ in pl.8, fig.9). These

three forked veins are followed by three typically simple veins, the first, second and third anal veins, which occupy the smaller area of the hind angle of the wing. There is much variability in this region in the different genera, and it is highly important that these three veins be certainly recognized; to do this it is only necessary to count off the three longitudinal veins of the cubitus—the two branches (Cu_1 and Cu_2) and the bisector of the cubital fork—back of the media, and these three will be the three best developed veins remaining. In the keys the short, inconstant interpolated longitudinal veins are called *intercalaries*, and that whether they become attached to principal veins or branches or remain independent; and the irregular veins about the margin

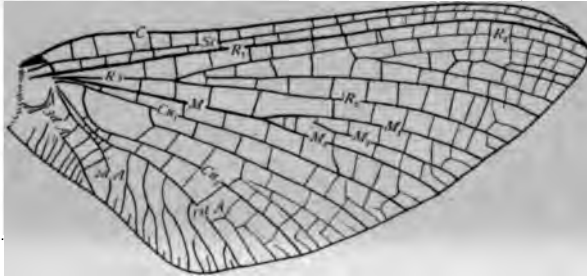


Fig. 3 Venation of the fore wing of *Ephemera*

of the wing are called veinlets. The length of the media is measured on vein M_2 . The fore wing is meant in the key except where the hind wing is specified. Fig. 3 shows the unilateral forking of the cubital vein and the divergence of the cubital and first anal veins at base, characteristic of the subfamily *Ephemerae*.

KEY TO THE GENERA OF MAYFLIES OF NORTH AMERICA

Imagos

- a The cubital and first anal veins strongly divergent at the base (fig. 3).
Venation never greatly reduced. *Ephemerae*
- b The fork of the median vein very deep, almost reaching the wing base; two long simple intercalaries between the first and second anal veins. In the hind wing the vein R_1 separates from vein R_2 close beside and therefore is little longer than the next branch of the radial sector. *Campsurus*
- bb The median vein forked for not more than three fourths of its length; in the hind wing the vein R_1 arises much in advance of other branches of the sector, being much longer than any of them

- c Between the first and second anal veins is a bunch of 3-4 long, straight intercalaries, conjoined basally before their attachment to the principal veins; the second anal vein nearly straight and unbranched *Polymitarcys*
- cc Between the first and second anal veins are only shorter, sinuate, and sometimes forking intercalaries, attached directly to the first anal; the second anal vein sinuate and often branched (fig.3)
 - d The median vein forked $\frac{2}{3}$ to $\frac{3}{4}$ its length; vein Cu_2 not more strongly bent at base than the first anal..... *Euthyplocia*
 - dd The fork of the median vein occupying not more than half its length; vein Cu_2 more strongly bent at base than is the first anal (fig.3)
 - e The third anal vein simple, but attached to the hind margin by a number of crossveins; in the narrow first fork of the median vein there are one or more crossveins before the origin of the vein M_2 ; male forceps four-jointed
 - f Caudal setae 3, ♂ and ♀; fore tarsus of female imago $\frac{3}{4}$ as long as the tibia..... *Ephemera*
 - ff Caudal setae 2 in ♂ and 3 in ♀; fore tarsus of ♀ $\frac{2}{3}$ as long as the tibia..... *Pentagenia*
 - fff Caudal setae 2, ♂ and ♀; fore tarsus of ♀ as long as the tibia *Hexagenia*
- ce The third anal vein with a simple terminal fork and unattached to the hind margin, although a few isolated short intercalaries lie between; in the wider first fork of the median vein there is no crossvein before the origin of vein M_2 ; male forceps 3-jointed *Potamanthus*
- aa The cubital and first anal veins parallel at base (in a few forms with reduced and scanty venation, appearing a little divergent)
 - b Eyes of the male simple and remote; hind tarsi with 5 freely movable segments; venation never greatly reduced; intercalary veins between the first and second anal veins unattached basally and in two pairs, of which the pair nearer the hind angle is the longer (pl.4, figs. 3 and 4)..... *Heptageninae*
- c Basal segment of the male fore tarsus not surpassed in length by any of the succeeding segments
 - d Second segment about as long as the first and longer than the third *Epeorus*
 - dd Second segment shorter than the first and about equal to the third *Iron*
- cc Basal segment of the male fore tarsus shorter than some of the succeeding segments
 - d Basal segment of the male fore tarsus longer than the fifth segment, the second and third segments of unequal length
 - e The second segment longer than the third..... *Ecdyurus*
 - cc The second segment shorter than the third..... *Cynigma*
 - dd The basal segment of the male fore tarsus shorter than the fifth segment, and the second and third segments of about equal length

- e* Basal segment of the male hind tarsus longer than the third segment *Rhithrogena*
- ee* Basal segment of the male hind tarsus shorter than the third segment *Heptagenia*
- bb* Hind tarsi usually with but four freely movable segments, the basal segment being more or less completely consolidated with the tibia; eyes of the male enlarged, often approximated on the dorsal side and divided into superior and lateral portions with corneal facets of different size; venation various, sometimes greatly reduced; intercalary veins between the first and second anal never as in *b* above..... *Baetinae*
- c* The three anal veins nearly parallel to the hind margin of the wing and to each other, ending in the outer margin; in the hind wing the branches of the radial vein are strongly unilateral on the anterior side *Baetisca*
- cc* Anal veins strongly divergent distally, usually both the second and the third ending in the hind margin; forks of the radial vein in the hind wing more symmetrical
- d* The median vein with a normal fork; hind wings, when present, usually but little longer than broad and with a copious venation
- f* The intercalaries between the first and second anal veins variable, but usually more or less independent, and not directly dependent from the first anal; three well-developed caudal setae (except in *Blasturus*, in our fauna)
- g* Hind wings present
- h* Vein M_2 and bisector of the cubital fork independent; between the latter and vein Cu_2 no intercalaries; vein Cu_2 in the hind wing rarely preserved; caudal setae generally much longer than the body; penultimate segment of the male forceps shorter than the antepenultimate
- i* In the hind wing the subcostal vein reaches nearly to the wing apex; male forceps three-jointed
- j* Hind wing with a slight concavity at the middle of costal margin; 5-6 longitudinal veins between R_2 and R_6 ; veinlets numerous about the wing margins and crossveins numerous in the hind wings
- k* Third anal vein of the hind wing wanting; caudal setae of about equal length. . . . *Leptophlebia*
- kk* Third anal vein of the hind wing present, and often followed by one or two additional intercalaries; median caudal seta distinctly shorter than the others *Blasturus*
- jj* Hind wing with an angular lobe projecting forward from the middle of the costal margin; 4 longitudinal veins between R_2 and R_6 ; wing margins free from veinlets, and few crossveins in hind wing

Habrophlebia

- ff** In the hind wing the subcostal vein terminates in the costa at hardly more than half the length of the wing, just beyond the obtuse angulation having a thickened margin; forceps of male more or less distinctly four-jointed *Choroterpes*
- hh** Vein M_2 and the bisector of the cubital fork both tending to attach themselves to the posterior branch of their respective forks; between the latter and vein Cu_2 are generally some short intercalaries (the cubital region thus being better developed than in group *h*); caudal setae about as long as the body; penultimate segment of the male forceps longer than the antepenultimate
- i** Veins Cu_2 and 1st *A* separate to base. *Ephmerella*
- ii** Veins Cu_2 and 1st *A* fused toward the base
Drunella gen. nov.
- gg** Hind wings absent..... *Caenis*
- ff** The intercalaries between the first and second anal veins represented by a series of veinlets, often sinuous or forking, extending directly from the first anal to the wing margin; costal angulation of hind wing close to the base; but two well-developed caudal setae, the median one being rudimentary or wanting; basal joint of hind tarsi evident but not well developed
- g** Median caudal seta a distinctly segmented rudiment (pl. 6, fig. 1); forceps of male three-jointed; posterior prolongation of sternum of ninth segment of abdomen of female bifid at tip
- h** Basal segment of fore tarsus of male shortest; claws of each tarsus unlike each to each; hind wing with the costal angulation acute, and the fork of the median vein occupying two thirds the length of that vein
Coloburus
- hh** Basal segment of fore tarsus of the male longest; claws of each tarsus alike; hind wing with the costal angulation obtuse, and the median vein forked through one third its length..... *Chironetes*
- gg** Median caudal seta more rudimentary or wanting; forceps of the male distinctly four-jointed; posterior prolongation of the sternum of the ninth abdominal segment in the female entire at tip
- h** Claws of each tarsus alike; caudal setae at least one half longer than the body..... *Siphurus*
- hh** Claws of each tarsus unlike; caudal setae about as long as the body in both sexes..... *Ameletus*
- dd** Median vein apparently simple, its posterior fork (M_2) being detached and appearing as an intercalary; hind wings when present at least twice as long as wide, and provided with but 1-3 longitudinal veins

- e Hind wings present
 γ Fore wings with numerous costal crossveins before the bulla; hind wings with a moderate number of crossveins
 Callibaetis
 ff Fore wings without costal crossveins before the bulla; hind wings without crossveins or with but 1-3 of them
 g Marginal intercalary veinlets in pairs; hind wings oblong, with a short costal angulation.....Baetis
 gg Marginal intercalary veinlets of the fore wing single; hind wings linear, with a spur-like costal angulation
 Centroptilum
 ee Hind wings absent.....Chloeon

Nymphs

- e Mandibles with an external tusk-like ramus, visible from above; gills on abdominal segments 1-7 (often rudimentary on 1), double, flattened, linear, the margins fringed with respiratory filaments
 Ephemerinae
 b Mandibular tusks longer than the head (burrowing species)
 o With no frontal prominence
 d Legs increasing in length posteriorly; gills of the first abdominal segment simple; labrum longer than wide; maxillary palpus two-jointedPolymitaerays
 dd Legs decreasing in length posteriorly; labrum wider than long; maxillary palpus three-jointed.....Euthyplocia
 cc With a conspicuous frontal prominence
 d Frontal prominence roundedHexagenia
 dd Frontal prominence bifid at tip.....Ephemera
 bb Mandibular tusks shorter than the head, inconspicuous, only their tips visible from above.....Potamanthus
 bbb UnknownCampsurus and Pentagenia
 aa Mandibles without projecting tusk-like ramus; gills not as in a
 b Eyes dorsal; body strongly depressed; tarsal claws with lateral teeth; dwellers in rapid streams and on wave beaten shores; adopted to clinging to flat surfaces of rocks, timbers, etc..Heptageninae
 c Gills represented on abdominal segment 7 by simple, lanceolate or linear filaments, differing markedly from the lamellae of the preceding segments.....Heptagenia
 cc Gills of the seventh abdominal segment lamelliform, like those before them, but smaller
 d Gills on all the segments divaricate in pairs.....Ecdyurus
 dd Gills of segments 1 and 7 approximated at their tips, being decurved beneath the abdomen, those of segment 1 much enlarged
 c Head widest toward the front; mandible with its outer canine linear, truncate and denticulate on the end; labrum retracted far back from the flaring margin of the frons; maxilla with its palpus hairy and the tip of its lacinia armed with three large teeth.....Iron

- ee* Head widest toward the rear; mandible with its outer canine shaped like a shoemaker's last, the heel pointing laterally and the long, slender, acute toe obliquely forward; labrum pendent from the flaring but notched edge of the frons; maxilla without strong teeth at tip of its lacinia and without long hairs on its palpus.....*Rhithrogena*
- bb* Eyes lateral; form of body various; claws smooth or toothed below
- Baetinae**
- c* Gills completely concealed under an enormously enlarged, four-spined dorsal thoracic shield.....*Baetisca*
- cc* Gills exposed; thoracic dorsum normal
- d* Outer caudal setae fringed on both sides
- e* Gills on abdominal segments 1-7, double
- f* Gills filamentous
- g* Each a pair of simple filaments.....*Leptophlebia*
- gg* Each a pair of clusters of slender filaments
- Habrophlebia**
- ff* Gills lamelliform, at least on the middle segments
- g* Lamellae of each gill similar.....*Blasturus*
- gg* Lamellae of each gill markedly differing in form at tip (see pl.8, fig.8).....*Choroterpes*
- ee* Gills absent from one or more of segments 1-7; one pair more or less elyroid, covering those behind it
- f* Gills present on the seventh abdominal segment, elyroid on the third or fourth segment; a pair of tubercles on the apical margin of each segment beside the middorsal line
- g* Head smooth above.....*Ephemera*
- gg* Head armed above with a pair of erect occipital tubercles
- Drunella, gen. nov.**
- ff* Gills absent from the seventh abdominal segment, elyroid on the second segment; no dorsal abdominal tubercles
- Caenis**
- dd* Outer caudal setae fringed only on the inner side
- e* Posterolateral angles of the hinder abdominal segments prolonged into thin, flat, sharp lateral spines
- f* Fore legs conspicuously fringed with long hairs; gill tufts present upon the bases of maxillae and front coxae and at bases of lamellae on abdomen.....*Chironetes*
- ff* Fore legs without conspicuous fringes; no maxillary or coxal gills; no gill tufts at base of lamellae on abdomen
- g* Gills double on the basal abdominal segments; end of maxilla fringed with simple hairs.....*Siphurus*
- gg* Gill lamellae all single; end of maxilla fringed with pectinated hooks.....*Ameletus*
- cc* Posterolateral angles of the hinder abdominal segments hardly more than acute—not prolonged in thin flat lateral spines
- f* Gill lamellae simple
- g* Lamellae obtuse at apex; maxillary palpus rounded at the apex.....*Baetis*
- gg* Lamellae acute at apex; end of maxillary palpus truncated.....*Centroptilum*

- ff* Gill lamellae double, at least on some of the anterior abdominal segments
- g* Antennae shorter than the body; tracheae of gill lamellae pinnately branched *Callibaetis*
- gg* Antennae longer than the body; tracheae of gill lamellae palmately branched *Oloeon*
- eee* Unknown *Coloburus*

In the preparation of the foregoing keys I have used freely Eaton's *Monograph of Recent Ephemeridae*, that great storehouse of information concerning the structure of mayflies. Although in a few minor details I have not been able to accept the classification therein given, I wish to acknowledge my obligation at every turn to its great wealth of illustration, and to express my admiration for the spirit in which its classification is set forth: "It is only by taking cognizance of points of difference and agreement in many details, in the anatomy and the mode of development and the habit of leading representatives of the various alliances of genera, at different periods of their lives, before and after their exclusion from the egg, that the mutual affinities of the several associations of genera to one another can be demonstrated adequately. Until such comparisons can be and shall have been carried out, the whole question of their arrangement can only be dealt with in a tentative and experimental manner; and it will be fortunate if error be avoided in the necessary grouping of the genera into provisional alliances of apparently kindred forms, preparatory to the study of their affinities. It is far more easy to demonstrate defects in proposed methods of classification than to devise a trustworthy system in their stead."

I have correlated nymphal and adult structures, and have expressed that correlation in the foregoing keys, wherein all the major divisions are strictly parallel for the two stages. That this is now possible is a sign of progress toward a natural system of classification. The one serious incongruity in Eaton's system—the interpolation of *Jolia* in the subfamily *Ephemerinae*; an incongruity that grew out of a previous error, inherited from Joly—the breeding of *Chironetes* has enabled me to remove. The nymph "*Jolia roeseli*" is doubtless that of the sole European species of *Chironetes*, *Ch. ignotus* Walker. A comparison of the figures

of pl.27 of Eaton's Monograph with those of my pl. 5 and 6 will show the close agreement of it with *Ch. albomanicatus*, and demonstrate its generic position. The adult which Joly furnished Eaton as having been bred from this species of nymph was doubtless a poor specimen of *Polymitarcys virgo* Oliv. This was suspected by Eaton and yet he allowed the adult to determine the position of the species in his system. Doubtless the nymph *Jolia* furnished a reason for including *Oligoneuria* and its allies in the *Ephemerinae* also. The nymph of *Oligoneuria* is certainly nearest *Chironetes* of all forms hitherto described; and it has not yet been shown that the very degenerate imagos may not as well have descended from this part of the series, and belong in the *Baetinae* as here understood. My present ideas of the major natural complexes of the order may be expressed as follows:

- 1 Subfamily *Ephemerinae*; a fairly homogeneous series.¹
- 2 Subfamily *Heptageninae*; a very homogeneous series.
- 3 Subfamily *Baetinae*; a very heterogeneous series, only definable as lacking the characteristics of the other two, and including five fairly distinct groups, some of which may be found worthy to rank as equivalents of 1 and 2 above:
 - a) The group of *Oligoneuria* (*Oligoneuria* to *Homeoneuria* of Eaton; pls. 3 and 26 of his monograph); five genera, represented in tropical America and in the old world
 - b) The group of *Baetis*, including all our genera of *Baetinae* except *Baetisca*, and many exotic genera
 - c) The group of *Baetisca*, including *Baetisca* only
 - d) The group of *Prosopistoma*, including the exotic *Prosopistoma* only
 - e) The group of the nameless Chilean nymph figured on pl.53 of Eaton's Monograph

¹These three subfamilies, which I indicated parenthetically in my key to nymphs published in bulletin 47, I had already recognized in 1897. Shortly afterward my friend Mr C. A. Hart, of the Illinois State Laboratory of Natural History, sent me a manuscript key in which these major divisions were plainly indicated, and also a number of minor divisions, including the tribes *Baetini* and *Caenini* of Banks (*Trans. Amer. Ent. Soc.* 26:247. 1900). This key was then already in use by entomological students at the University of Illinois, the basis for these divisions having been recognized independently and, perhaps, prior to my own recognition of them.

While the breedings of mayflies now to be reported upon are not very numerous, they could hardly be better distributed for the purpose of supplementing existing knowledge. The *Chironetes* life history is the most important, because of the difficulties and discord it clears away. It is well supplemented by the breeding of *Ameletus*, which shows that to this genus belongs the nymph that Eaton referred by supposition to *Chironetes* (Monograph, pl.40). Furthermore, the other new life histories represent additional genera or very striking species. A few notes are added concerning species whose life histories have been previously known.

The following notes and descriptions follow no systematic order of arrangement, but are ordered as was convenient in writing them:

Baetisca obesa Walsh

This singular mayfly, known hitherto from Rock Island, Illinois and Indiana, the place of its discovery, has been found at

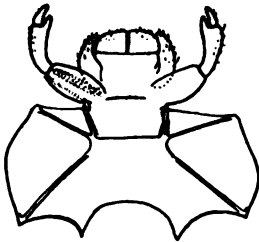


Fig. 4 The nymal labium of *Baetisca obesa* Say. (The two muscle bands indicated by dotted lines in the basal segment of the left palpus are the same that move the lateral lobe of the dragonfly labium)

two places in New York State: In the Niagara river, by Mr E. P. Van Duzee of Buffalo, and at Newport, where a single nymph was taken May 30, 1902, by Mr D. B. Young and is now in the New York State Museum collection. I have also received specimens from Mr R. J. Weith, taken in the St Joe river at Elkhart, Indiana, but only a few subimagos, however. The rather striking color pattern of the wing of the male subimago (in the imago

the wing is wholly hyaline) is well shown in the accompanying figure reproduced from a photograph (pl.4 fig.1). I present on the same plate (fig.2) a new figure of the nymph also. It is absolutely unique among mayfly nymphs. Its huge four-spined carapace is formed by a backward prolongation of the thoracic dorsum. It meets a conspicuous pyramidal elevation on the middle of the abdomen to inclose a respiratory chamber, within which the gills are included. The labium (fig.4) is most inter-

esting also, because it offers a transition form to the Odonata. A comparatively slight degree of consolidation of the labial parts here present, and a slightly better development of the two points at the tip of the palpus (of which the last joint is homologous with the movable hook, and the internal prolongation of the preceding joint equals the end hook of the Odonata), would give the grasping labium, so characteristic of the nymphs in that order.

Much has been written concerning the anatomy of this interesting species—especially the anatomy of the nymph. A full bibliography and a new description with some excellent figures are given in Eaton's Monograph, pp.226-229, pl.21 and 42.

Less is known concerning its manner of life. In a general way it may be said to inhabit the more rapid portions of our larger rivers and to be very local. It is rare in collections.

Chirotenetes albomanicatus sp. nov.

*The white-gloved howdy*¹

Plates 5 and 6

This is the common Ithaca species, whose nymph is figured on page 87 of Comstock's *Manual for the Study of Insects*. It has been referred hitherto to *Ch. siccus* Walsh. It differs from Walsh's description of that species in its larger size, later season of appearance, separateness of eyes in male subimago, coloration of front tarsi and of forceps and in conspicuous black transverse apical lines on abdominal segments. It agrees better with Eaton's description and fairly well with his figure of that species, but I doubt whether Eaton had the species of Walsh. Pending the reidentification of Walsh's species, I think that less confusion will result if this one be kept apart under a new name.

This species is abundant in all the rapid streams about Ithaca. I have observed the nymph, especially in those places where the creek bed is flat shelving rock over which the water streams in a thin sheet. In such places the flat, rocky floor of the stream is

¹Lest it be not discerned, I will state openly that the common name "howdy," which I apply to the members of this genus, is a very free translation into western vernacular of the generic name.

covered with a thin, filmy growth of algae, with abundant nets of the caddisfly seine-maker, *Hydropsyche*; and the broken edges of the floor ledges are fringed with black masses of black fly larvae, *Simulium*. *Simulium* and *Hydropsyche* are fixed in their places, but *Chironetes* wanders about freely over the ledges, clinging securely even in the swiftest water, keeping of necessity head up stream, moving by short quick dashes, effected by sharp strokes of its powerful tail fin and gill covers, moved synchronously. It is also found in the stiller pools at the sides of the current, in which dwell other mayflies of the genera *Caenis* and *Baetis*; and also among the rocks in the current, under which cling other nymphs of *Heptagenia*, *Blasturus* and *Choroterpes*.

Measurements. Length, imago and subimago, ♂ 11-12 mm.; ♀ 12-13.5 mm.; setae additional, subimago, ♂ 13; ♀ 11; imago, ♂ 23; ♀ 20; fore leg of ♂ and ♀ subimago and of ♀ imago two thirds as long as body, of ♂ imago seven eighths as long as body.

Subimago. Color brownish tinged, with tawny changing to rufous with age, with a pale middorsal line the entire length of the body dilated and overspreading the dorsum of the mesothorax. Fore legs rufous, with whitish or pale lutescent tarsi, of which the sutures are narrowly marked with brown in the male. Middle and hind legs wholly pale. Wings subhyaline, paler on the inner margin, all crossveins bordered with ashy brown (pl.5, fig.2). Abdominal segments pale brown, the apical margin with a transverse apical line and the lateral margins with a longitudinal dash of darker brown; last segment and setae and appendages wholly pale. The ventral prolongation of the ninth segment in the ♀ is bifid apically as in the imago, but not declined at the tip. The eyes of the male are not contiguous, and the forceps limbs are straight, and surpass the tip of the rudimentary middle seta by the length of the latter.

♂ imago. Thorax brownish, abdomen rufescent; head pale lutescent below, rufescent above between the black-ringed ocelli and the eyes. Thorax darker brown above and below and paler along the sides, but without definite markings. Fore legs bright rufous, with wholly white tarsi; middle and hind legs wholly pale whitish. Wings hyaline. Abdominal segments rufous, transverse apical carinae and lateral margin distinctly lineate with blackish brown; segment 10 paler, yellowish rufescent, strongly produced backward above in a broad obtusely truncated superior

lobe. Along the sides of the abdomen is an interrupted line of black dashes on the lateral margin and there is a minute black dot above the anterior end of each dash on either side of each segment. Setae white, slightly tinged with yellowish on basal segments, but not ringed. Forceps (pl.6, fig.1) long and arcuate, the basal segment of each limb feebly differentiated; coloration pale yellowish white, slightly infuscated in the middle.

♀ imago. (Plate 5, fig.1). Head above whitish or very pale luteous; ocelli ringed with black; a black spot beneath each eye and another at its hind angle above upon a minute triangular backward prominence of the occipital margin. Thorax tawny yellowish brown above, the hind margins of the tergal sclerites narrowly margined with blackish brown; venter deeper brown. Wings and legs colored as in the male. Abdomen brownish rufescent, less rufous than in the male, but with the apical lateral margins more distinctly lineate with blackish brown. Segment 10 pale, produced above into a posterior rounded lobe. Segment 9 produced below in a long acutely bifid lamina, decurved at the apex, and surpassing the level of the tip of the superior lobe on segment 10.

A noteworthy feature of both subimago and imago, hitherto apparently unnoticed in any mayfly, is the persistence of the maxillary and coxal gill tufts of the nymph. These are present as conspicuous blackish tufts on the inner sides of the front coxae and at the sides of the atrophied maxillae. They are most conspicuous (probably because less dessicated) in the subimago, but the constituent filaments, filled with black pigment, are easily recognized in either.

The nymph. (Plate 5, figs. 3 and 4). Length of full grown female 13 mm., antenna 4 mm. and seta 7 mm. additional.

Body rather stout, thorax slightly compressed, abdomen strongly depressed and upcurved posteriorly, its sides parallel as far as the seventh segment, and distinctly wider than head and thorax, then tapering to the base of the stout setae. Integument strongly chitinized.

Head short with vertical face, evenly contoured above, covered at the sides by the low, broad, well-rounded eyes. Middle ocellus directly in front but the other two visible from above. A median frontal vertical carina below the middle ocellus ends in a stout, sharp downwardly directed triangular spine. Antenna (Plate 6, fig.6) stout, naked, basal segment stouter and paler, the shorter segments immediately succeeding brownish, the succeeding segments again pale to the tip. Mouth parts unusually hairy, the

somewhat quadrangular labrum covered above with stout bristles and fringed beyond the bristles around its border with copious soft yellowish hairs (pl.6, fig.2). Labium with two jointed palpi of singular form, the basal joint of each cylindrical, naked; the second joint twice as long, flattened, its inner margin straight, its outer margin arcuate, its exterior border closely beset with a single linear series of long thin setae, its apex bearing a minute obtuse inwardly directed prominence, set off by a minute notch from the inner margin, and perhaps representing the remains of a palpal segment (pl.6, fig.3). Galea and lacinia hairy beneath, the latter less than half as large as the former and more triangular in outline. Mandible naked (pl.6, fig.4); the outer canine tridentate at tip, the inner one spine-like, but with a flat margin on one side below overlapping the palp. Maxilla (pl.6, fig.5) with palpus two-jointed and similar in form to the labial palpus; end of lacinia terminating in a long straight spine; a copious tuft of gill filaments takes origin under the base of the stipes.

Thorax strongly arched dorsally and slightly flattened laterally. Legs short and stout, the tibia longest in the fore leg, where one third longer than the femur, decreasing in length successively on middle and hind legs. Fore legs with a remarkable development of stiff fringes of tawny hairs, a single ventral fringe on the femur, a double fringe beneath the tibia, the basal portion containing hairs as long as the combined tibia and tarsus, but the length of the fringe diminishing apically, and a much shorter single fringe beneath the tarsus. There is also on the fore leg a single elongate and flattened tibial spur, more than half as long as the tarsus, and strongly recalling by its form and structure the flat spur on the swimming legs of the diving beetle *Cybister* (pl.6, fig.7). The single tarsal claw is short and arcuate and denticulate on its inferior margin; on middle and hind tarsi the claw acquires a special convexity on the basal part of its inferior denticulate surface, especially marked in the hind tarsus (pl.6, fig.9). There is a large tuft of several times forked gill filaments attached to the base of the fore coxa within.

Abdomen cylindrical at base, becoming depressed and upcurved posteriorly and laterally carinate, the lateral margins on segments 8 and 9 ending in long, straight, sharp lateral spines, half as long as their respective segments. There are minute and inconspicuous lateral spines also on segments 1 to 7, hardly more than acute angles on 1-4. Gills on segments 1-7, covered by obovate protecting lamellae (Plate 6, fig.10), which are slightly oblique, increase slightly in size on segments 1-3 and are equal on 4-7. Each lamella has the front margin, the

base of the hind margin and a diagonal superior carina strongly chitinized. The purplish white-tipped gills are clustered in small flat tufts of 2-3 times branched filaments attached to the bases of the lamellae, and they are shorter than the shortest of the lamellae. Setae stout in basal half, with dense internal fringes of tawny hair. There is a darker band across the middle beyond which the tips are slenderer, and the fringes disappear, the whitish tips being bare.

Color, rich chocolate brown above, paler below and on sutures, a pale median stripe extending upward from the mouth over the head and ending upon the prothorax. Tibiae and tarsi pale with broad median rings of brown.

The fore legs are widest apart and the middle ones most approximate at base.

The dates of my bred specimens are July 12, 14 and 19, 1901. Transformation takes place at the surface of the water as in other species, and the subimago stage continues about 24 hours. On warm nights in midsummer subimagos swarmed into my trap lanterns above Fall creek, Ithaca, but no imagos came to them. Imagos were easily taken along the sides of the gorges anywhere, sitting rigidly, their white fore feet extending full length forward; so they would sit and allow themselves to be picked up with the fingers. This is a fine species, interesting for the agility of the nymph in the water and for the rich coloration and striking attitude of the adult.

Food. With a view to more accurately determining what is the food of this species I had microscopic mounts made of the cleared stomach contents of nine well-grown nymphs from Fall creek. Plant remains constituted in all cases fully half of the stomach contents—in some cases a much greater proportion. There were recognizable remains of numerous *Cyanophyceae* and other algae, and numerous stalked diatoms of the *Gomphonema* group (which may have been taken in with the larger plant stems to which they were attached), but the greater part was a brownish mass of remains of the decaying leaves of higher plants. That *Simulium* larvae had been eaten by four of the nymphs was determined by the presence of isolated rays of the fans. *Ecdyurus maculipennis* nymphs, common in the stream and of favorable size for the food of this species, had been eaten by at least seven of the speci-

mens examined, as evidenced by the presence of recognizable remains; the claw (fig.11) or the curiously coiled malpighian tubules, or the outer canine of the mandible (fig.13). Nymphs of some species of *Caenis* had been eaten by four, and a small platode and a very young nymph of *Chirotenetes* by a single specimen.

Ameletus ludens sp. nov.

The genus *Ameletus* has not hitherto been known eastward of the Rocky mountains. It is represented in the State Museum collection at Albany by a number of nymphs and two

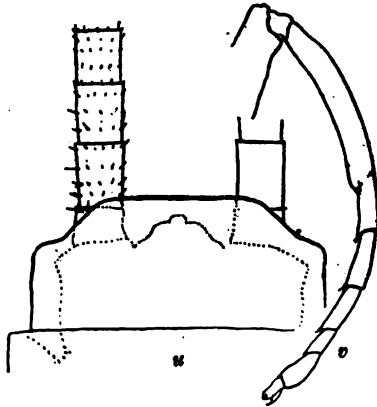


Fig. 5 *Ameletus ludens* sp. nov., female subimago; u, end of abdomen below, showing truncate apical lobe of the 9th sternum; v, fore tibia and tarsus

bred female subimagos taken by Mr. D. B. Young at Newport, N. Y. on the 22d of May 1902. They were found in the headwaters of a small, swift stream, elevation about 900 feet, in the Hasenclever hills, a spur of the Adirondacks.

Female subimago. Length, 9 mm.; setae, 6 mm. additional; wing, 8 mm. Color obscure brownish, paler on the sutures and below; antennae darker toward the tip; incomplete dark-brownish rings about the ocelli; on the vertex a pair of longitudinal blackish marks, confluent in the middle; a broad median whitish tract upon the mesothorax, produced behind and dilated at the sides; subapical paler bands on the femora, the tips again darker; wings uniformly pale fumose, the venation is shown in pl.8, fig.9; brown marks on the ventral ganglia, becoming more evident posteriorly.

The accompanying text figures will facilitate the recognition of this species when more and better specimens are at hand.

This species is a typical representative of *Ameletus*, agreeing in close detail with the generic characters set forth in Eaton's Monograph p.210, but it is smaller than any of its congeners. Its nymph is apparently the one figured by Eaton on pl.49 of his Monograph, and referred to *Chirotenetes*.

The nymph. (Pl.7, fig.1.) Length, 9.5 mm.; antennae, 1 mm. and setae, 4 mm. additional. Body elongate, with vertical face, arched thorax, depressed and tapering abdomen. Antennae short,

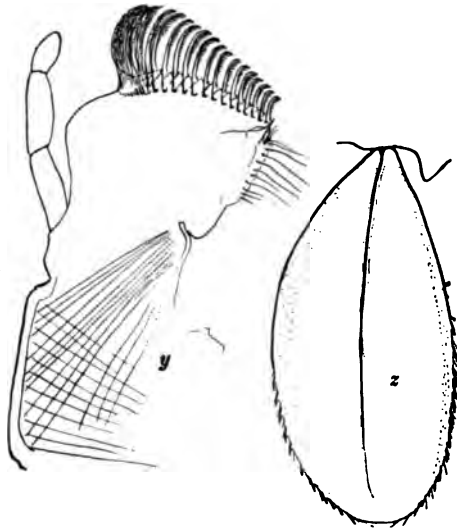


Fig. 6 Parts of nymph of *Ameletus ludens* sp. nov.; y, maxilla; z, single gill lamella from one of the middle abdominal segments

tapering, bare; ocelli in front; labrum quadrangular, a little longer than wide, emarginate in front, where fringed with fine plumose hairs. Mandibles stout, triangular beyond the molar surface, bearing the canines upon the prominent apex, outer canine more than twice as large as the inner, the latter preceded by a slender subulate spine on the distal margin. Maxilla with a very weak and slender and obscurely three-jointed palpus. The combined lacinia and galea obscurely trapezoidal, the tip of the former indicated by a short, slender and sharp spine, the distal border of the galea fringed densely with a series of strongly arched, regularly graduated and beautifully pectinated hooks (fig.6v). Labium with better developed, three-jointed palpi,

cultriform galeae, fringed with spinules externally, and broadly triangular laciniae, separate to the base.

Prothorax rather short, closely applied to the front of the large mesothorax; wing cases reaching the apex of the second abdominal segment. Legs rather short, stout, pale, with darker lines upon the sutures, the darkest one at the base of the claw.

Abdomen gradually tapering, gracefully upcurving in the rear. Gill laminae on segments 1-7, similar in form on all the segments (fig.6z); smallest on segment 1, largest on segment 6, obovate, with a somewhat thickened front margin, and a longitudinal dorsal chitinous ridge. There are no free gill filaments attached to lamellae. Lateral spines on segments 4-9 straight, sharp, increasing in size posteriorly. Setae rather short and stout, equal, fringed copiously within, traversed by a broad distinct band of brown which occupies their middle third, and slightly washed with brown again at the extreme tips.

This nymph differs from the one figured by Eaton (pl.49, Monograph) in having the middle lobe of the tongue (hypopharynx) bilobed. This genus differs from all others as yet known except *Thraulus* in the possession of a pectinated fringe on the distal border of the galea of the maxilla.

Choroterpes basalis Banks

This species I have studied in the Fall creek gorge beside the Cornell Insectary at Ithaca. It is a very common species there. The nymph is found among the smaller stones in the side currents of the creek in the bottom of the gorge, associated with other nymphs of *Ecdyurus maculipennis*, *Baetis*, *Caenis* etc. It clammers about under these stones, and when they are lifted out of the water it is easily picked off by hand. The form of the gill tips (Plate 8, fig.8) will instantly distinguish it from all others in the stream.

Imagos were abundant about the middle of July. My bred specimens are dated July 14, 1901. Not many imagos were observed at large except on early afternoons, when the sunshine was warm and bright. Then they would swarm out in the opening of the gorge, and dance high up in the air between the banks of green in myriads. Rising and falling in rapid undulations, moving in large companies up and down the gorge, they rarely descended low enough to bring the lowermost within the reach

of the net; and when by climbing on a big rock in the opening I captured a netfull of them I found they were all males. About the same time also subimagos swarmed into my trap lanterns that overhung Fall creek, and a few imagos with them.

The nymph. (Pl.7, fig.2.) Length, 7 mm.; antennae, 3 mm., and setae, 7.5 mm. additional. Body strongly depressed, widest across the rather prominent mesothorax. Head flattened above; eyes round, prominent, situated just before the hind margin. Antennae situated midway the length of the head, which before them is pilot shaped, dilated at the sides and sharp-edged. Ocelli three, rather large, situated in a nearly straight transverse row in the male, in a triangle in the female. Labrum half as long as broad, widened anteriorly, rounded on the anterior angles and deeply emarginated in front, where fringed with short stiff bristles (pl.8, fig.5). Mandible (pl.8, fig.6) stout, its two canines each tridentate on tip, its palp deeply bifid; on the inner margin just before the molar surface is a low conic tubercle. Maxilla (pl.8, fig.4) short and stout, the palpus two-jointed, the consolidated galea and lacinia squarish, the tip of the former ending in a long and distinctly pectinated spine, the inner and distal margins densely fringed with slender hairs. Labium (pl.8, fig.3) with three jointed palpi, the broad galeae and the narrow laciniae with their tips on a level, and densely fringed with spinules, the spinules on the laciniae being stouter.

Thorax depressed, increasing in width to the bases of the wings. The wing cases reach the base of the fifth abdominal segment. The legs are rather short and stout, with flattened and dilated femora and slender tibiae, pale with a more or less complete brownish ring beyond the middle of the femora and some fainter markings at the knees.

Abdomen depressed, regularly tapering from the third segment to the end, segments slightly increasing in length to the ninth, the tenth somewhat more than half as long as the ninth, produced above in a rounded lobe with a narrow blackish border that is interrupted by paler in the middle of the margin. There are sharp, triangular lateral spines on segments 4-9, increasing in length and sharpness on the succeeding segments, represented on segments 2 and 3 by mere angles of the flat margin, on 8 one fourth as long as the segment. Gills very peculiar; on segment 1 a simple linear or slightly tapering filament (pl.8, fig.7) that is fully as long as the succeeding lamellae; on 2-7 double, lamelliform, with pinnately branching tracheae; each of the pair of lamellae is typically three-lobed; the middle lobe of the uppermost lamella is itself lamelliform, oval or oblong, separated by

marginal notches from the two other lesser lobes (pl.8, fig.8). The middle lobe of the lower lamella is likewise flat, but narrow, linear, and with a better development of the two other lobes at its base. There is a slight decrease in length on segments 2-7; and on 2; and again on 7, the anterior of the three lobes of the upper lamella is scarcely developed. Setae three, fragile, slender, with minute apical whorls of spinules on the segments.

Color olivaceous brown above, with a variable middle pale line, fenestrate upon the dorsum of the abdomen with paler olivaceous. Below, with a broad pale median area.

Several of my nymphs from Fall creek have colonial Vorticellidae attached promiscuously about the dorsum, or aggregated about the bases of the setae.

Pl.8, fig.1, shows the venation and fig.2 of the same plate shows the form of the appendages of the male imago in this species.

Baetis pygmaea Hagen

This dainty little mayfly, which I described in bulletin 47 (pp. 421-423, pl.15, fig.13 and 14), I bred also from nymphs obtained in Fall creek with those of the preceding species, and I took a few specimens of the imagos in trap lanterns hung about the creek during July 1901.

Callibaetis skokiana Needham

I wish to record here concerning this species that I have made a careful examination of microscopic mounts of the stomach contents of ten well-grown nymphs taken from the Gym pond on the campus of Lake Forest College in Illinois, and have found them containing no recognizable animal remains whatever, but only remains of plant tissues, chiefly the disintegrating fragments of the dead leaves of the higher plants, such as litter from the pond bottom, with a scanty sprinkling of algae—Cyanophyceae and stalked diatoms.

Blasturus cupidus Say

I have found his species common in Six Mile creek at Ithaca, where I bred it in 1897. I have apparently identical nymphs in my collection from Elkhart, Indiana, and Raleigh, North Carolina. The imagos of this genus appear in late spring. As before remarked, Berry has described the nymph in the American

Naturalist vol. 37, pp.27-29, 1903. It will be at once distinguished from all other genera by the form of the gill lamellae,



Fig. 7 Gill lamellae of the nymph of *Blasturus cupidus* Say; e, from the 1st segment; f, from the 4th segment; g, from the 7th segment

a figure of which is herewith given (fig.7). There are well-developed lateral spines present on abdominal segments 8 and 9 only.

Ephemerella

This is one of the genera of *Ephemeridae* that shows great nymphal specialization independently of adult life. The nymphs are obviously very diverse in form and structure; the imagos very much alike, or else their differences are easily overlooked. Eaton pointed out in his Monograph the remarkable differences between the nymph which I have since bred and shown in bulletin 47 to be that of *E. excrucians*, and that of the European *E. ignita*, the only bred species with which he was acquainted. He referred to this nymph as a new unnamed genus allied to *Ephemerella*; but it is the nymph of the typical species. I describe herein the nymphs of two native species closely allied to *E. ignita*. I have compared both nymphs and adults with *E. excrucians*. I have not found differences that would seem to justify the generic separation of the imagos; and notwithstanding the evident differences of the nymphs, I think they may as well, for the present, at least, remain associated together under the one name. The nymphal differences are chiefly in the number and arrangement of the gill lamellae, and these things are perhaps most subject to the influence of environment.

Among the other four North American nymphs described by Eaton are two that will doubtless represent good and distinct genera; and one of these I have been able to identify; for it I erect the new genus *Drunella*. The structural relations between the American nymphs of the *Ephemerella* alliance described by Eaton and those I have since obtained may be set forth by means of the following key:

- a* Antennae inserted in deep angular notches in the front margin of the frons; dorsal hooks of abdomen wanting; nymph from Colorado, imago unknown¹
- aa* Antennae inserted upon the upper surface of the frons; dorsal hooks of abdomen more or less developed in a double row upon the abdomen
 - b* Head armed with high occipital tubercles; hind wings visible at the sides below the fore wings.....*Drunella* gen. nov.
 - bb* Head smooth above; hind wings visible on the dorsum between the bases of the fore wings
 - c* Gill lamellae present on abdominal segments 3-7
 - d* Front femora strongly tuberculate on inner margin; lateral spines of abdominal segments poorly developed, the abdominal margin not serrate. Eaton's no. I from Washington²; imago unknown
 - dd* Front femora smooth on inner margin; lateral spines of abdominal segments strongly developed
 - e* Dorsal hooks of abdomen erect, high, strongly developed
Ephemerella bispina sp. nov.
 - ee* Dorsal hooks of abdomen slightly developed, hardly elevated above the surface. Unknown species from New York (p.45)
 - cc* Gill lamellae present on abdominal segments 4-7
 - d* The operculate anterior lamella of the 4th segment covers succeeding lamellae but imperfectly, these successively protruding their whole apical margins. Eaton's no. IV; imago unknown³
 - dd* The operculate anterior lamella of the 4th abdominal segment covers closely all succeeding lamellae, only their extreme apical margins visible
 - e* Body hardly more than twice as long as wide; *Ephemerella* sp? from Pecos N. Mex.
 - ee* Body more than three times as long as wide
Ephemerella excrucians

Drunella gen. nov.⁴

I have determined the nymph of this genus by means of the venation of the developing wing. Professor Cockerell sent me two nymphs from Pecos New Mexico, one of which, a male

¹Eaton no. III. Monograph, p.132, pl.39, 22 figs.

²Monograph, p.131, pl.38, figs. 1-10.

³Monograph, p.133, pl.40, 17 figs. (Colorado)

⁴To my friend, Professor Theodore Dru Alison Cockerell.

specimen, is in perfect condition for showing the venation. It shows the basal fusion of veins Cu_2 and 1st A that Eaton long since described and figured as characteristic of *Ephemerella grandis* Etn (Monograph, pl.14, fig.24b). This character, together with the rather strong joinings together of the other anal veins basally, readily distinguished this large species from *Ephemerella* proper. The figures of venation I give herewith (pl.10, figs. 1 and 2) are drawn from the nymphal wing, which shows the venation better than does the single female imago I have seen. I have another identical nymph collected at Twin Lakes Colorado, by Mr Chauncey Juday. Since the type of *E. grandis* is from Colorado, it seems very probable that the nymph belongs to this species. In pl.10, figs.3, 4 and 6 I present figures of the male nymph, which differs slightly from the female, figured by Eaton.

Ephemerella bispina sp. nov.

The six specimens of this species that I have seen were sent me in the last lot of material received from the late Mr R. J. Weith. They were collected at Elkhart Indiana, shortly before June 18th—the date on which they reached me at Lake Forest. There were among them single male and female imagos, a male subimago, and three nymphs. The species is apparently near to *E. walkeri* Eaton from Albany river near Hudson's bay—still so insufficiently known—and to *E. ignita* Pol. of Europe.

Imago. Length, 9 mm.; wing, 9 mm.; setae of ♀, 10 mm. (of ♂ wanting); of ♂ subimago, 6.5 mm.

Male imago deep brown, varied with olive green. Antennae brown; a whitish ring around their bases. Thorax rich dark brown above and on all carinae, greenish in the sutures and furrows, excepting the median longitudinal furrow. Beside the median prolongation of the hinder lobe of the mesothorax is a pair of acute spines, each decurved at tip and about as long as the space between them is wide. Wings subhyaline; veins pale brownish, as is also the subcostal space. Legs brown, the femora sprinkled with distinct blackish dots; fore leg dark, becoming gradually lighter toward the tip; middle and hind legs paler and tinged with greenish; claws all brown, the obtuse one of each pair darker than the other.

Abdomen pale brown, except the 10th segment which is yellowish, paler on the sutures and thereby appearing ringed; an in-

distinct middorsal row of minute brown longitudinal dashes. Appendages all brown, the inner ones angulated and thickened in the middle and bent upward thereafter to the tip (this appearing only in lateral view; hence not shown in the figure); forceps (pl.10, fig.10) strongly directed downward, the basal segment distinctly differentiated, the apical segment unusually long and slender.

The female imago is greenish yellow, with pale whitish legs and setae. The basal segments of the antennae are brown and there is a pale brownish tinge to the dorsum of the thorax and the lateral margins of the abdomen. Wings hyaline, veins whitish. The ventral apical lobe of the 9th abdominal segment surpasses the tip of the 10th segment and is obtusely rounded apically.

The male subimago is dark greenish brown, darker on the head, the top of the thorax and the apex of the abdomen; the abdominal sutures, however, are distinctly paler. Legs pale yellowish or greenish, the fore tarsus pale brownish. Wings smoky brown. The two dorsal apines are paler in the ♂ subimago and absent in the ♀.

The nymph. Length, 9 mm; seta, 4.5 mm, additional. Body elongated rather slender, depressed, thinly hairy, widest across the mesothorax. Head short; face oblique. Antennae hardly longer than the head, almost bare. Labrum quadrangular, one fourth wider than long, emarginate in front and hairy on the front border, the hairs being longest on the outer angles. Mandibles short and thick, with the outer canine very broad, 3-toothed at apex, the inner canine of equal length but slenderer; molar surface narrow. Maxillary palpus hardly half as long as the lacinia. Third joint of the labial palpus a conic rudiment.

Thorax flat below, well rounded above; legs short and thinly hairy; claws (pl.10, fig.5) with inferior row of about 10 denticles.

Abdomen depressed, its lateral margins serrate by reason of the flat lateral spines in which the side margins of segments 3-9 terminate. There are two rows of dorsal spines on segments 3-8, erect laterally, flattened, almost cultriform. Gill lamellae present on segments 3-7, double; anterior lamina thickened, covering the delicate posterior one, trapezoidal, obtusely pointed at its inner apical angle, palmately veined; posterior lamina shorter, thinner, its margins cut into a small number of fingerlike filaments. The lamellae regularly overlap, each anterior lamina covering the basal fifth of the one behind it, that of segment 7 shorter. Setae closely parallel, slender, fragile, sparingly pilose. Their two proximal articulations faintly ringed with brown. Color olivaceous, with a broad band of brown extending from the rear of the eye to the base of the lateral caudal seta. There is also a narrow middorsal line of brown on the abdomen.

This species differs in the nymphal stage from the nymph next described, chiefly the presence of well-developed dorsal hooks and the absence of black rings on the base of the setae.

Ephemerella unicornis sp. nov.

Along with the six specimens of *E. bispina* came a single male of another apparently very distinct species, distinguished at a glance from all the others by an erect conic tubercle upon the front margin of the middle lobe of the mesothorax. This species is notably smaller, measuring but 5 mm. in length, with the setae of the same length and the wing hardly longer. The hind wing also is marked with a more distinct basal costal angulation than is common in this genus. The spines beside the backward prolongation of the middle lobe of the mesothorax are present also in this species but apparently not so large. Unfortunately the specimen, although perfect, is a subimago, and the mature coloration can not be given; it will probably be brownish since in the subimago it is greenish as in *E. bispina*. The abdominal appendages are well enough developed to show that the end segment of the forceps will be much shorter than in *E. bispina*, while the inner appendages will probably be of the same type as in that species, though probably relatively shorter.

Ephemerella sp?, near *ignita*

This species occurs at Ithaca, but I have thence but a single nymph. There are two nymphs in the U. S. National Museum labeled "From stream on Mr Chamberlain's farm, Richfield Springs, N. Y., May 13, 1837." It is very closely allied to the European *E. ignita*, as figured and described by Eaton (Monograph, pl.40; whole figure copied in Cambridge Natural History, vol.5, p.436, fig.282).

One of the two nymphs from Richfield Springs is apparently grown. It measures in length 8 mm., setae, 3.5 mm. additional. Body rather more elongate than in the typical species; eyes laterally prominent; abdomen (pl.10, fig.7) strongly depressed, the usual submedian double row of dorsal tubercles scarcely indicated. Lateral spines, thin, flat, sharp, on segments 4-9, a mere tooth on 4, increasing in size thereafter to segment 8, broader and less sharp on 9. Gills present on segments 4-7, double, on 4 scarcely

operculate, overlapping the next behind it hardly more than that one overlaps its successor. Setae slender, pale, ringed with dark brown at base, thinly hairy except at base (Plate 10, fig.7).

Ephemerella sp?

Professor T. D. A. Cockerell has sent me from Pecos, N. Mex., a single nymph of so remarkable form (Plate 9, fig.2). I desire to make it known herewith. Its affinities are obviously with *Ephemerella excrucians*, and it differs from all the "allies of *Ephemerella*" figured by Eaton from western North America. Therefore I briefly characterize it here and present a figure made from a photograph of the single known immature specimen.

Body excessively flat and thin, about twice as long as wide, widest across the middle of the abdomen. Head short and much narrower than the prothorax; eyes and ocelli dorsal, remote; antennae short, bare, about as long as the head is wide, composed of only about twelve segments, of which the basal one is as usual longest and thickest.

All lateral margins very hairy. Prothorax half as long as wide, straight on front and sides with rather acute front angles, somewhat widened posteriorly. Legs short; femora flattened, widest before the middle and fringed on both margins.

Abdomen short, about as wide as long, excessively flat, with huge, serrate lateral spines on segments 2-9, increasing in breadth posteriorly, but longest on the middle segments, all strongly curved posteriorly. Segments slightly increasing in length successively to the 8th, 9 much longer, 10 only about one fifth as long as 9, but slightly produced on the dorsal side. Gills covered by an oblong opercular lamella attached at the apex of segment 4. Of the underlying gills I have made no examination, not wishing to injure the unique specimen. Setae 3, closely parallel at base, broken in the specimen. Coloration very obscure, the animal being apparently covered in life by adherent silt, but there is a trace of a brownish ring on the middle of each tibia and another on each tarsus.

Pecos, New Mexico, July or August 1903.

Professor Cockerell sent me from Pecos also a fine pair of imagoes and these may represent the same species as the nymph above described. I should have felt inclined to refer these to *Ephemerella inermis* Eaton but for the conspicuously bifid prolongation of the 9th abdominal sternum in the female;

this Eaton describes as being entire. Otherwise, there is close agreement. The length is 7 mm. in male, 8 mm. in female; setae; 10 mm. in male, 6-7 mm. in female. The segments of the male fore tarsus in order of diminishing length are 2, 3, 4, 5, 1, the first segment being one fifth as long as the second. The legs are wholly pale. The setae of the male are strongly ringed with black except at the extreme tip in the male, wholly pale in the female. The head and thorax and basal segments of antennae are brown. The abdomen in the male is rufous, paler on the middle segments, and suffused with brownish apically above; in the female abdomen there are broadly triangular transverse basal bands of paler on the middle segments. The posterior prolongation of the sternum of the 9th segment in the female abdomen is deeply divided by a wide U-shaped notch. The abdominal appendages of the male are shown in pl.10, fig.9.

Ephemerella excrucians Walsh

In Bulletin 47 I published a description of the nymph of this species (pp.425-426), bred at Saranac Inn. On June 30, 1901, Mr. J. O. Martin gave me a live nymph which he had just collected from the shore of Cayuga lake, and I reared this also. Since that time I have received a large number of specimens from different places in Indiana, notably from Elkhart, sent me by the late Mr R. J. Weith. From some of the latter, selected to show the great variety in depth of color pattern, I have had a new photographic figure made, which I present herewith (pl.9, fig.1). It will serve immediately for comparison with the very different form of nymph found in the species above described. On pl.10, fig.8 are represented the abdominal appendages of the male imago.

? *Caenis allecta*, sp. nov.

This is the commonest species in Fall creek at Ithaca. It swarmed into trap lanterns hung about the creek during July. Its nymph lives in the pools and side channels of that turbulent stream, where the water flows gently among small rock fragments over a bottom thinly strewn with silt. Imagos of our smallest species, *Caenis hilaris* Say, come to the trap lanterns with this one, but in smaller numbers; its nymph I have not found.

Imago. Length, 3.5-4.5 mm.; setae, about 10 mm. additional; expanse of wings, 8 mm.; fore leg of male, 3.5 mm.

General color brown, marked with purplish or slaty gray; head and thorax brown, carinae and margins of ocelli blackish. Wings hyaline, with the usual purplish streak along the radius for two thirds its length. Abdomen pale yellowish brown on base and apex, the middle two thirds washed with gray; some elongate blackish marks on the lateral margins of the 7th to 9th segments; setae white; antennae, femora and forceps yellowish; tibiae and tarsi; except the terminal joint, white. Venation of the wing and the male forceps as shown in the accompanying figures (figs. 8 and 9).

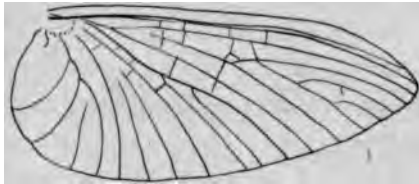


Fig. 8 Venation of wing of ?*Caenis allecta* sp. nov.

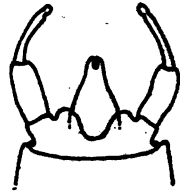


Fig. 9 Ventral view of male abdominal appendages of ?*Caenis allecta* sp. nov., imago.

Nymph. Length, 2.5-4 mm.; setae, 1.5 ♀ to 2 mm.; ♂ mm. additional.

Color greenish brown, obscure on the head, with a transverse broken and obscure line between the paired ocelli, antennae and legs pale, a pair of brown submedian dots on the prothorax; abdominal segments pale basally and on the sutures; gill covers darker beyond the basal third; segments 8-10 darker with a mid-dorsal pale line on 8 and 9. Lateral spines on segments 3-9, flat and thin, best developed on the middle segments, becoming less divergent posteriorly and losing their lateral fringes of spinules. Setae stout at base, rapidly tapering; middle one distinctly longer in female and shorter in male than the laterals, all with scanty apical circlelets of spinules on the segments. Legs scantily and abdomen copiously beset with short hair that is usually covered with adherent silt.

Aside from the not very satisfactory differences of coloration, this nymph differs from that of *C. diminuta* in having the sides of the prothorax parallel; in *diminuta* the prothorax is widened anteriorly, and in having a greater part of the abdomen covered by the opercular lamella; in this species that lamella

covers part of the 8th segment; in *diminuta* it does not wholly cover the 7th segment.

Were it not that these differences of structure of the nymph are so slight I should have thought a separate genus necessary for this new species; for the differences in venation and in the genitalia are certainly as great as usually serve for generic separation. These principal differences may be tabulated as follows:

| Character | <i>Caenis diminuta</i> , <i>hilaris</i> , etc. | <i>C. allecta</i> |
|---------------------------|---|--|
| Anal veins..... | disconnected..... | conjoined basally |
| Vein M ₂ | absent..... | present |
| Crossveins..... | uniserial..... | pluriserial |
| Forceps of male.... | one-jointed..... | three-jointed |
| Basis..... | straight edged..... | bilobed at sides and emarginate in the middle |

Among some mayflies that were kindly collected for me by Mrs Mary Rogers Miller at Thousand Island Park, on the St Lawrence river, are a number of typical specimens of our two previously described species, *C. diminuta* Walker and *C. hilaris* Say, that fit the descriptions exactly. In order to promote accuracy in the determination of the most difficult forms, I have prepared the drawings herewith presented (pl.11, figs.3-6) of the wings and male genitalia of these species. It will be observed by comparing the wings with Eaton's figures that in venational characters ? *C. allecta* agrees better with the European genus *Tricorythus* and the South American genus *Leptophyes*, than with *Caenis*. But there are disagreements also with these, and the ♂ genitalia and nymphs of these are as yet not certainly known.

Leptophlebia praepedita Etn. ?

This species, hitherto known only from New Hampshire and not yet reported from New York State, is common about Lake Forest, Illinois, where I have found it in three quite diverse situations: 1) in the Skokie (north branch of Chicago river), a sluggish creek flowing through open meadows and marshes;

2) McCormick ravine, where a puny stream, overhung with witch-hazel and dogwood, flows between deep banks through a hardwood forest; and 3) in a glacial pothole, grown full of buttonbush (*Cephalanthus*) on the top of a moraine. In all these situations the water is fairly permanent, disappearing only in seasons of extreme drouth.

The species appears to be diurnal in its habits. Males may be found in abundance sitting on top of the leaves of shrubs beside the water, or flitting over them in the bright sunshine, quickly gathering in companies and dancing up and down, and as quickly dispersing and settling again. They fly at low elevation, and are easily taken in large numbers in a net, and are as easily swept when at rest from the witch-hazel leaves.

I found the species first in the Skokie May 8, 1901. There were then a very few subimagos on the wing, and a bed of mixed ranunculus and polygonum in the water was fairly swarming with the nymphs. I took a large number home and placed them in a bowl of water, where they began transforming the next day. The subimago stage lasts about 24 hours.

When Eaton described the species he had some doubts as to whether it should go in *Leptophlebia*; but the characters of the nymph are in essential agreement with those of the typical species of *Leptophlebia*, and thus confirm the reference of the species to that genus. In pl.11, fig.1, is represented the venation, and in fig.2 the ♂ abdominal appendages are shown.

The nymph. Length of body, 6.5 mm.; antennae 2 mm. and setae 6 mm. additional. Body slender, scarcely depressed, widest across the mesothorax, smooth. Face nearly vertical, ocelli in front, eyes rather small situated just before the hind angles of the head; antennae pale, basal segments rather stout, the following ones rather tapering to slender and very fragile tips. Mouth parts very similar to those of *Choroterpes*, shown on pl.5, the maxillae more oblique on the end of the combined lacinia-galea, and lacking the pectinated spine tipping the former; the palpi, however, are three-jointed beyond the basal palpiger, and the palpi of the labium are two-jointed; thus the conditions of segmentation in these appendages are reversed in the two forms; this segmentation, however, is often very indistinct, and more or less evidence of division of the last segment when there appear to be but two are generally discoverable in all the palpi.

Legs rather short, nearly bare; femora scarcely flattened, but somewhat concave on the side applied to the body; pale brownish, paler at the sutures. Wing cases reaching posteriorly as far as the apex of the 3d abdominal segment.

Abdomen very slightly depressed, regularly tapering posteriorly, its segments very slightly increasing in length to the 9th, the 10th a little shorter on the dorsum, where produced backward in a rounded lobe, one half shorter at the sides; short lateral spines on segments 8 and 9, larger on 9, the lateral angles of the preceding segments obtuse.

Gills present on segments 1-7, double, similar, or slightly longer on the middle segments, divided in nine tenths of their length into two long, slender, simple tapering filaments, pigmented with purplish along the tracheae. Setae 3, equal, nearly bare at base and sparingly whorled with spinules beyond, gradually tapering to long slender tips.

General color olivaceous, paler below, with a very narrow median pale line on head and prothorax, a median row of pale spots on the abdomen of the female becoming larger posteriorly, and a pair of spots either side on segments 3-9, becoming confluent with the median one on 9; male darker and more uniformly brown.

May 8, 27, 30, 31; June 13, 14, 18.

Heptageninae

I deem it necessary to state that I have scarcely entered into the study of this interesting and difficult complex of interrelated forms, having dealt at first hand only with those species in whose life histories I have become interested. The foregoing keys for this group of genera are based largely on characters culled from Eaton's Monograph, and these are but a few of the many characters therein given, and the value of these few as absolute distinctions of closely allied genera I have not personally tested. This group should furnish a most inviting field for some special student, especially here in North America, where it is so abundantly represented.

In this group the independent specialization of the nymphs is extreme. Their life is relatively long, and the conditions under

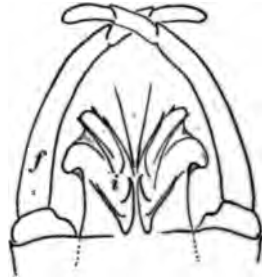


Fig. 10 Ventral view of male abdominal appendages of *Ecdyurus maculipennis* Walsh, imago; f, forceps; i, inner appendages

which they dwell are very diverse. The conditions of adult life are, however, much the same in all; and we find the adults much more alike. The beginner will certainly find them much more

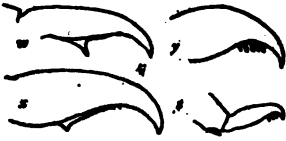


Fig. 11 Tarsal claws of nymphs of Heptageninae; w, of *Heptagenia interpunctata* Say; x, of *Rhithrogena elegantula* Etn. ?; y, of *Iron* sp. ? from Coy Glen, Ithaca; z, of *Ecdyurus maculipennis* Walsh; hind claws in each case; middle ones would be similar; front ones sometimes different

difficult to distinguish, and would do well to study nymphs and adults together. The critical diagnosis of the species will doubtless rest on the highly individualized genital armature of the male. A suggestion of the strength and definiteness of the characters presented by these parts may be had from reference to the

accompanying figure of the male forceps and inner appendages of *Ecdyurus maculipennis* (fig. 10). These project strongly from the ventral side of the apex of the abdomen, and are easily separated therefrom in fresh or

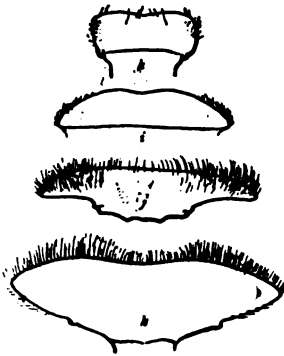


Fig. 12 Labra of nymphs of Heptageninae; h, of *Iron* sp. ? from Coy Glen, Ithaca; i, of *Rhithrogena elegantula* Etn. ?; j, of *Ecdyurus maculipennis* Walsh; k, of *Heptagenia interpunctata* Say



Fig. 13 Mandibles of nymphs of Heptageninae; c, of *Rhithrogena elegantula* Etn. ?; d, of *Iron* sp. ? from Coy Glen, Ithaca; e, of *Ecdyurus maculipennis* Walsh; f, of *Heptagenia interpunctata* Say

alcoholic specimens by a longitudinal snip with a pair of fine scissors. They may then be permanently mounted on a slide as microscopic preparations so as to give a square ventral view. It is from preparations so made that all the figures of the male appendages in this paper have been drawn.

The nymphs in this subfamily are recognizable at a glance by their dorsally placed eyes, with the lateral flaring margins of the sides of the head projecting beneath them. They are all strongly depressed also, and have lateral pectinations to the tarsal claws (fig.11), aiding them doubtless in clinging to their supporting surfaces washed by currents of streams or waves of shores. Further than this, however, there is very great diversity among them, and *Ecdyurus*, *Iron* and *Rhithrogena* furnish a most interesting illustration of a special adaptation to life in torrents. In *Ecdyurus* (pl.10, fig.3) the gill lamellae

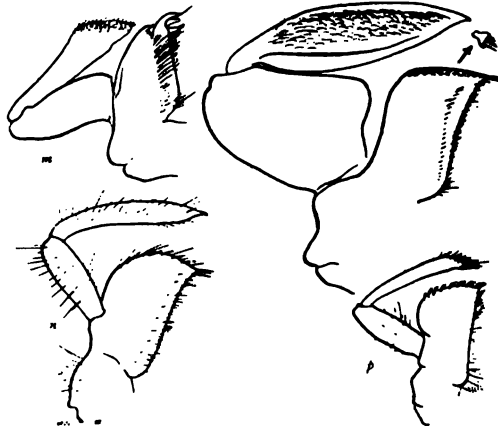


Fig. 14 Maxillae of nymphs of Heptageniinae; m. of *Iron* sp? from Coy Glen, Ithaca; n. of *Heptagenia interpunctata* Say; o. of *Rhithrogena elegantula* Etn. ?; p. of *Ecdyurus maculipennis* Walsh

are all divergent and the gill filaments are beneath their bases. In *Iron* (pl.10, figs.6 and 7) and in *Rhithrogena* (pl.10, fig.4 and 5) the abdomen is more limpet-shaped, and the gill lamellae form a closely overlapping series whose outer border fits the supporting surface to which the nymph clings as closely as do also the flaring lateral and front margins of the head; but this is not all, the gills have migrated outward and now lie upon the bases of the lamellae, exposed on the outside to the stream of water which now dashes over, but does not flow beneath the lamellae. Furthermore, by the enlargement and approximation beneath the thorax of the foremost lamellae and by the depression and inward curvature beneath the tip of the abdomen of the hindmost of them, there is formed beneath the abdomen a disk for

adhesion to the surfaces of the stones, fairly well developed in *Iron*, very perfect in *Rhithrogena*. So complete is its border that when applied to the surface of a stone, any elevation of the abdomen would create a partial vacuum beneath it. It doubtless serves in a different way the same purpose as the row of smaller discs possessed by the larva of the net-winged midge (*Blepharocera*), found in the same situations; and among anatomical shifts for a living is one of the most remarkable known to me.

The three figures of mouth parts of nymphs of the four genera hereinafter described (figs. 12, 13 and 14) show very considerable structural differences. It is because of the remarkable definiteness of such minute parts as the canines of the mandible that I have been able to determine with certainty some of the elements of the food of nymphs of *Chironetes albomanicatus*, its food being all reduced to very minute fragments.

Heptagenia interpunctata Say

This is the commonest species in Fall creek at Ithaca, with *E. maculipennis* a close second. Both species swarm into trap lanterns set about the creek during July—mostly subimagos just risen from the water. During the daytime imagos are easily found sitting on the vegetation along the sides of the gorge. *H. interpunctata* is also a common species on the shore of Lake Michigan near my home in Lake Forest, being very abundant along shore in the latter part of August, associated with *H. flavipennis* Walsh, and a few scattering specimens may be taken as late as September.

The rather well marked color pattern of the wing of this species is shown in the photograph reproduced in Plate 4, fig. 4.

The nymphs of this species are found in all the streams about Ithaca in rapid water under large stones. They are distinguishable at a glance from those of all other species by the black markings of the under side, shown in pl. 6, fig. 3.

The nymph. (Pl. 6, fig. 3). Length of full grown female nymph, 9.5 mm.; antenna, 2 mm., and setae, 11 mm. additional.

Body strongly depressed, widest across the head, but with the sides behind the head parallel to the middle of the abdomen, thence tapering rather rapidly to the base of the setae.

Head flat, almost orbicularly rounded, limuloid, the infero-lateral margins thin, flat, flaring, fringed with decurved hairs. Eyes distinctly dorsal, the lateral margins of the head projecting beneath them. Antennae minute, hardly longer than the head, the basal segments brown and the remainder pale.

Mouth parts as shown in figs. 12h, 13f and 14n.

Prothorax with its declined and flaring lateral margins decurrent upon the sides of the mesothorax; legs short; femora much flattened, and with well-developed posterior fringes of hair; similar fringes on middle and hind tibiae, but scarcely developed of fore tibiae.

Abdomen rather short, strongly depressed, and much tapering beyond the 7th segment; lateral spines on segments 2-9, on 3-5 minute, on 6-9 strong, straight and sharp, longest on 7 and 8, the tip of that on 8 reaching the level of the middle of the 9th segment. Segments of the abdomen diminishing slightly in length to the 7th, the 8th and 9th, then successively a little longer; 10th produced in a rounded posterior lobe.

Gills represented on segments 1-7, on 1-6 double, consisting of an anterior protecting lamina and a posterior basal one, margined with respiratory filaments, whose tips are visible at the inner margin of the lamina. Gill lamella on 1 oblong, somewhat oblique, with a small lobe beside the basal attachment on the side next the median line of the body; on 2-6 similar, becoming somewhat more elongate and less oblique; posterior lamina with its outer two fifths cut into a border of 1-2 branched respiratory filaments. On segment 7 there is a simple linear lanceolate filament (representing the anterior lamina only) whose tip reaches the level of the apex of the 9th abdominal segment.

Setae long, slender and very hairy for more than half their length, the hairs distinctly shorter externally; tips pale, whitish, ringed with darker and nearly destitute of hair.

Coloration olivaceous or greenish brown, darker on head on sides of prothorax and on dorsum of abdominal segments 6 and 10. On the head there is a pale spot before the middle ocellus, another one between each lateral ocellus and the eye, and an oblique pale streak extends from the eye to the margin below it. A pale, narrow middorsal line extends from the rear of the head to the metathorax. The legs are pale, with two broad light-brown bands on each of the femora. On each of the exposed abdominal segments is a transverse pale basal area which includes on each segment, except the 6th, a pair of brownish dots; these dots are elongated into longitudinal dashes on segments 8 and 9. Abdomen beneath conspicuously barred with brown (pl.9, fig.3), one angulated bar on each segment, the bars interrupted in the

middle on both basal and apical segments, but best defined apically.

Bred at Ithaca 18th July, 1901.

Heptagenia sp. no. 8

The nymph of this species was not bred. Like the two preceding it is strongly marked and easily recognized. It occurs in the larger streams, clinging to rocks in the swiftest currents.

The nymph. (Pl. 6, fig. 4.) Length, 10 mm.; antenna, 3 mm., and setae 13 mm. additional.

Body rather elongate, scarcely wider across the head than across the mesothorax. Head strongly depressed, evenly rounded in front, with flaring infero-lateral margins, dilated at the sides and distinctly visible outside the eyes. Antennae slender, pale. Prothorax slightly narrowed posteriorly, its margins flaring, dilated. Legs moderate, pale; femora with indistinct median and apical darker bands, and with a scanty development of the usual posterior fringes of hair. Wings reaching the level of the base of the 4th abdominal segment.

Abdomen regularly tapering posteriorly. Segments 8-10 slightly diminishing in length, 10 a little produced on the dorsal side, and produced in a sharp triangular spine on each lateral margin; lateral spines developed only on segments 7-9, best developed on 8.

Gills represented on segments 1-7, on 1-6 double, consisting of an anterior protecting lamella and a posterior respiratory lamella whose border is cut into a long fringe of branching gill filaments; upper lamella obliquely oval, produced at the tip into an acute spine-like point, becoming broader distally (obovate) on 4 and 5, and narrower again on 6. On segment 7 there is a simple linear hairy filament, obtuse at the apex and hardly reaching the level of the base of the lateral spine on the 8th segment.

Setae 3, long and hairy, the hairs becoming whorled and finally obsolete toward the tip.

The distinctive features of the color pattern are shown in the photographs reproduced in pl. 9, fig. 4. These are a broad pale middorsal band divided with brown on the posterior abdominal segments, lateral pale dashes at the sides of the abdominal segments, and a brown longitudinal dash either side of segments 8 and 9 below.

***Ecdyurus maculipennis* Walsh**

As remarked under the account of the *Heptagenia interpunctata*, this species was found commonly in Fall creek, at Ithaca. Its larvae were more commonly found at the edges of the stream; those of that species oftener in the current, but both often occurred together. This is a dainty little species with narrow wings, conspicuously marked with black on the crossveins (pl.4, fig.3). My bred specimens bear the dates July 9th, 13th and 14th, 1901.

The nymph. (Pl.7, fig.3.) Length, 7 mm.; antennae, 2 mm., and setae, 5 mm. additional.

Body strongly depressed, elongate triangular in outline, widest across the dilated, depressed and squarish frons, and rather regularly tapering posteriorly; head rather flat above; paired ocelli larger and more approximate above in the male than in the female; antennae slender and short. Mouth parts as shown in figs.12j, 13e and 14p.

Legs short, femora flattened, with a thin external fringe of hairs; tibiae slender and somewhat tapering; wing cases reaching the level of the apex of the 3d abdominal segment; abdomen rather short and slender, slowly tapering to the apex, middle segments longest, segments 8 and 9 slightly shorter, 10 again longer on the dorsal side, but shorter at the sides and below; lateral spines present on segments 5-9, longest on 6 and 7, straight and sharp; setae divaricate, the median one in the mature nymph more slender; the apical rings of brown on the segments of the setae are alternately broader and narrower, and the apical whorls of setae are excessively short.

General color pattern olive brown, mottled with pale greenish, darker on head and prothorax, divided by a median narrow pale line, and varied upon the sides with pale hieroglyphics; abdomen with pale and indistinct fenestrate markings along the sides. In the male there are broad dorsal blotches on the dorsum of segments 4 and 5; in the female, on segments 7, 8 and 9.

Iron sp?

This species has not been bred. It is found in Coy Glen—a spring-fed stream near Ithaca, possessing a rich and peculiar fauna. Among our forms hitherto made known this species is peculiar in the possession of but two caudal setae in the nymphal stage. I have a number of nymphs collected years ago, from which, unfortunately, the date label has become detached.

The nymph. (Pl.7, figs.6 and 7.) Length, apparently full grown, 9 mm.; antenna, 1.5 mm., and setae, 9 mm. additional.

Body elongate, strongly depressed, widest across the front of the head and the mesothorax, these being of about equal width; head widest across the front well before the eyes, and strongly narrowed posteriorly to the obtuse hind angles; infero-lateral margins of the head thin and flaring as usual, and closely fringed with hairs; antennae short, slender, pale. Mouth parts as shown in figs.12h, 13d and 14m.

Dorsum of the prothorax a little produced laterally, and angulate obtusely in the middle of the sides. Legs moderate, tibiae and femora all with well developed external fringes of hair; femora very moderately flattened and dilated, the fore femora most so; tarsal claw pectinate, there being two to four minute teeth at its anterior border before the apex (fig.11y). The wing cases reach the base of the 4th abdominal segment.

Abdomen regularly tapering posteriorly, its segments increasing in length to the middle. Two lateral spines each side of segments 2-6 and one on segment 7, all stout, triangular, and directed outward.

Gills represented on segments 1-7; on 1 a very large, broadly and obtusely triangular flap of membrane shaped like the gill scoop of a crawfish, attached by the middle of one of the sides, its front end extending forward and lying against the base of the hind leg, its hind end overlapping the succeeding gill lamella. On segments 2-7 the lamellae are ovoid, dorsally carinate, obtusely pointed membranous plates, each with regularly arcuate front margin overlapping the hind margin of the one on the preceding segment, and each bearing at its base a tuft of 7-15 short, finger-like gill filaments. The lamellae diminish in breadth posteriorly, and become less divaricate in pairs, and the tips of the 7th pair are curved beneath the abdomen.

Setae 2, rather short and stout, the median seta being represented by a minute triangular rudiment. The tips of the developing male forceps project beyond the apex to the 10th segment.

This remarkable nymph dwells in the swiftest parts of the stream, and its whole organization exhibits the most wonderful adaptation to life in such a place; the extra grappling armature appended to its claws and especially its flattened form with *thin edges all the way around* closely applicable to the supporting surface, and admirably adapted to divert the flow of the water. Probably the oval enclosure of the gill lamellae of the ventral side of the abdomen acts as a sort of sucker, and holds the animal

securely to the rock surface. The net winged midge *Blepharocera* is the commonest associate of this species in Coy Glen.

This is another genus that has not hitherto been known eastward of the Rocky mountains.

Rhithrogena elegantula Etn ?

For the sake of illustrating a still more perfect development of the ventral abdominal disk framed with gill lamellae, as well as illustrating the variety of form in this group, I insert here a figure and a brief description of a nymph from Twin Lakes, Colorado, sent me for study by Mr Chauncey Juday, collected in the summer of 1902:

The nymph. (Pl.7, figs.4 and 5.) Length of full grown female nymph, 10 mm.; male, 9 mm.; antennae and setae broken. Body short, stout, flat, narrowly elliptical behind the dilated head; head widest across the eyes, semicircular in outline, its thin lateral margins naked; behind the widest portion the sides converge with very great abruptness to the hind margin; antennae short and stout and bare, the joinings of the segments becoming oblique apically. Mouth parts as shown on figs.12i, 13c and 14o.

Prothorax three to four times as wide as long, produced at the sides in an obtuse projecting angle; legs rather short and nearly bare, the femora moderately curved and flattened with a fringe of rather stiff, very short bristles on the curving superior carina; each of the claws with a basal lateral tooth (fig.11x).

Abdomen short and ovate; gill plates on segments 1-7 membranous, white, obtuse, closely superposed at their broadly overlapping edges, bearing copious tufts of long, simple gill filaments at their bases above. The anterior ends of the lamellae of the 1st segment meet beneath the metathorax, and the incurved tips of those of the 7th segment meet beneath the slightly upcurved tip of the abdomen. Setae in male 2, with a rudimentary middle one, in female 3 well-developed, bare, the median paler than the others; extreme bases of setae brown, like the general integument of the body.

EPIHEMERINAE

Since the publication of bulletin 47 I have made no new breedings in this subfamily, but my friend Mr W. E. Howard of Ottawa, Ill., has reared and studied our *Polymitarceys albus* Say and has prepared at my request the following

account of that interesting species, which differs in some respects from the well-known *Polymitarceys virgo* Oliv.:

Polymitarceys albus Say

BY W. E. HOWARD

This description was undertaken at the request of Prof. Needham, who identified the imago for me. Without his kind assistance in this respect, as well as in many others, it would not have been prepared.

Nymphs of *P. albus* are abundant in both the Illinois and Fox rivers at Ottawa. These rivers flow at this place over bottoms of solid sandstone, with bars of loose sand accumulated in the eddies. The streams are swift in the main currents, and the nymphs of this species are to be found under flat stones at the edge of swift water when about ready to transform. It was from two such situations that most of my collections were made, from which I succeeded in breeding a single specimen. I have seen the subimagos emerge and arise from the surface of the water in great numbers, but always just far enough out from the shore, so that the nymph skins were immediately swept into the current, where they disappeared before they could be procured. The difficulty in collecting the skins from the natural breeding places is further heightened by the emergence occurring during the evening twilight.

According to my observation, not only this species but all others observed invariably emerge from the nymph skin at the surface of the water and leave the skin afloat. This makes the collecting of the sloughs a much more difficult task than in the case of stoneflies and dragonflies.

My collections indicate that this is a midsummer species in northern Illinois. My bred specimen is dated June 22. None of the imagos in my collections shows an earlier date than this, but I have nymphs which are evidently near to transforming which were collected the first week of June. Imagos and subimagos of the collections are scattered all through July, but August 5th shows them most abundant. At about this date they were observed in swarms. By the end of August they are much less numerous, and I have no collections which are as late as September.

The subimago stage lasts 24 hours, and when the final emergence takes place the subimago alights on some object near the edge of the stream, where it transforms in less than a minute. The skin of the subimago remains attached to the bases of the setae of the imago and in this manner is carried out over the stream by the flying insect, where it is finally released after some minutes.

The adult of this species is briefly described in Eaton's Monograph, p.47. The habitat given there is Passaic river, Belleville, N. J. (Williamson); Winnipeg river (Say); Red river of the north and New York (Hagen). This seems to indicate a rather wide distribution for *P. albus* in the eastern and northern United States, but during the summer of 1903 I made collections from several of the boulder and limestone streams tributary to the Wabash in Indiana without obtaining a single specimen.

The nymph. Length, 14-16 mm.; antennae, 3.5-4 mm., and setae, 7-8 mm. Body depressed, widest across prothorax where the thin lateral margins project; eyes prominent and lateral; three somewhat crescent-shaped ocelli arranged in the form of a broad-based triangle; antennae many-jointed, bearing a whorl of minute bristles at the apical ends of the joints, the first two joints much stouter and the joints 4-8 decidedly shorter than the others, projecting beyond the mandibular tusks by a little less than half the length of the latter; mandibular tusks about 2.5 mm. long, stout at base, narrowing rather abruptly near the middle, the slender distal half tapering gradually to the acute, slightly out-curved tip; the basal half of tusk is thickly set with stout, acute spines, being less numerous on the slender distal portion, and entirely disappearing at about one third the distance from the tip; a few long hairs are borne on the outer side near the base; mandible stout, bearing two prominent tridentate fangs on its anterior surface nearly parallel with the distal half of the tusk, the middle tooth of each the longest; the endopodite arising from the base of the inner fang is inclined toward the molar surface, and bears a brush of long hairs on its inner side near the tip; the labrum is about half as long as broad, slightly emarginate in front, and thickly covered with fine hairs; maxillae somewhat slender, the outer basal portion fringed with stiff hairs; the maxillary palpi three-jointed besides the short pedicel, the second joint the shortest, the third joint about as long as the first and second together; outer side of third joint bearing a few long hairs, the stoutest ones being near the distal extremity, the

inner side covered with finer ones; the first joint fringed with short, stiff hairs on outer side only; the galea truncate at the tip, which is densely fringed with fine hairs, inner margin with fewer stout hairs, and the inner distal angle bearing a few stout spines; the labium with three-jointed palpi, the large ovate galeae with their tips projecting a little beyond the tips of the small lanceolate laciniae, both galeae and laciniae pilose.

Thorax depressed, widest across prothorax where the pronotum is continued laterally into a wide, thin margin, each margin ending anteriorly with a prominent acute process. The wing pads reach to about the base of the third abdominal segment. The legs are rather long, the foreleg being the longest; the fore femora stand almost at right angles to the long axis of the body, the middle femora at about 45° , and the hind femora closely appressed and nearly parallel with the body; the fore femur bears three or four rows of short spines on its anterior side, and a few stout hairs on its posterior side near the distal extremity; the fore tibia is long, and its inner side, as well as that of the tarsus, bears a fringe of long hairs; the former bears at its inner apical extremity a long, pointed process closely appressed against the inner side of the base of the tarsus; the inner sides of the fore tibia and tarsus both bear a number of small, sharp spines, being the most prominent on the tarsus and the apical process of the tibia.

Abdomen long and gradually tapering from about the third segment, tenth segment about as long as wide. Gills present on segments 1-7, each gill inserted on a lateral prominence bearing a minute tooth just in front of the gill base, the lateral prominence located just in front of the lateral, hinder angle of the segment, directed outward at an angle of about 45° to the long axis of the body; the first pair of gills small, single and spatulate, with minute fringes, are curved upward against the body and are nearly concealed beneath the edges of the wing pads; the other gills are double and shaped somewhat like a tuning-fork, the two branches linear acuminate, about equal in length, the outer branch bearing a rounded prominence at its basal end at the outer side; the respiratory filaments long, linear, about one third the length the gill lamina.

Setae about half the length of the body, plumose throughout the greater part of their length, and then tail-pointed, the median seta not so stout at the base as the others.

Colors of the body chiefly brown, amber on legs and thin margins of the body, an amber stripe along the dorsal median line of the abdomen; a brown band on each femur near the distal extremity, and a small brown blotch near the base of each.

EXPLANATIONS TO THE PLATES

PLATE 1

The bull-frog, *Rana catesbeiana* Shaw. Photo by Dr. J. L. Hancock

PLATE 2

Hemerobian wings

- 1 Wings of *Hemerobius tutatrix* Fitch.
- 2 Wings of *Spadobius occidentalis* Fitch.

PLATE 3

Hemerobian wings

- 1 Wings of *Micromus insipidus* Hagen.
- 2 Wings of *Micromus jonas* sp. nov.
- 3 Wings of *Palmobius amicus* Fitch.

PLATE 4

Mayflies

- 1 Wings of subimago of *Baetisca obesa* Say, showing color pattern: 1, 2, 3, anal veins.
- 2 Lateral view of nymph of *Baetisca obesa* Say
- 3 Wings of imago of *Ecdyurus maculipennis* Walsh
- 4 Wings of imago of *Heptagenia interpunctata* Say

PLATE 5

Chirotenetes

- 1 Female imago of *Chirotenetes albomanicatus* sp. nov.
- 2 Wings of subimago of same
- 3 Lateral view of nymph of same
- 4 Dorsal view of nymph of same

PLATE 6

Chirotenetes

- 1 End of male abdomen of *Chirotenetes albomanicatus* sp.* nov. viewed from below; f, forceps; m, rudimentary median caudal seta
- 2 Labrum of nymph of same species
- 3 Labium of nymph of same
- 4 Mandible of nymph of same
- 5 Maxilla of nymph of same, with suboval gill tuft attached
- 6 Base of antenna of nymph of same
- 7 Fore leg of same, with coxal gill tuft attached
- 8 Hind leg of same
- 9 Claw of hind tarsus of same
- 10 Gill lamella of the fourth abdominal segment with gill tuft attached to its base on the under side

PLATE 7

Mayfly nymphs (photographed from alcoholic specimens)

- 1 Nymph of *Ameletus ludens* sp. nov.
- 2 Nymph of *Choroterpes basalis* Banks
- 3 Nymph of *Ecdyurus maculipennis* Walsh

*White fore tarsi accidentally cut away in cutting out the back-ground.

- 4 Ventral view of nymph of *Rhithrogena elegantula* Etn.?
- 5 Dorsal view of the same
- 6 Ventral view of *Iron* sp? from Coy Glen near Ithaca
- 7 Dorsal view of the same

PLATE 8

Choroterpes and Ameletus

- 1 Wings of imago of *Choroterpes basalis* Banks
- 2 Abdominal appendages of the male imago of same, from below
- 3 Labium of nymph of the same
- 4 Maxilla of nymph of the same
- 5 Labrum of nymph of the same
- 6 Mandible of the nymph of the same
- 7 Gill filament of the first abdominal segment of the same
- 8 Gill lamellae of the fourth abdominal segment of the same
- 9 Venation of the wings of *Ameletus ludens* sp. nov.

PLATE 9

Mayfly nymphs (photographed from alcoholic specimens)

- 1 Three nymphs of *Ephemerella excrucians* Walsh, showing differences in depth of coloration; the left front foot of the left hand specimen has been lost and is regenerating
- 2 Nymph an unknown *Ephemerella* from Pecos New Mex.
- 3 Dorsal and ventral views of nymphs of *Heptagenia interpunctata* Say
- 4 Dorsal and ventral views of nymphs of *Heptagenia* sp? no. 3, from Ithaca N. Y.

PLATE 10

Drunella and Ephemerella

- 1 Venation of fore wing of nymph of *Drunella grandis* Etn.?
- 2 Venation of hind wing of same
- 3 Face of the nymph of same (male)
- 4 Claw of hind tarsus of same
- 5 Claw of hind tarsus of *Ephemerella bispina* sp. nov.
- 6 Lateral view of nymph of *Drunella grandis* Etn?, legs removed
- 7 Dorsal view of abdomen of nymph of *Ephemerella* sp? from Richfield Springs N. Y.
- 8 Male abdominal appendages of *Ephemerella excrucians* Walsh
- 9 Male abdominal appendages of *Ephemerella* sp? from Pecos N. Mex.
- 10 Male abdominal appendages of *Ephemerella bispina* sp. nov.

PLATE 11

Leptophlebia and Caenis

- 1 Venation of wings of *Leptophlebia praepedita* Etn.
- 2 Abdominal appendages of male of same, drawn from mounted slide, the ventral processes of the inner appendages somewhat turned aside by pressure of the coverglass
- 3 Venation of the wing of *Caenis hilaris* Say
- 4 Venation of the Wing of *Caenis diminuta* Walker

- 5 End of male abdomen of same from below
- 6 End of male abdomen of *Caenis hilaris* Say, from below.
3 and 4 to same scale; 5 and 6 to same scale

PLATE 12

Nymph of *Polymitarcys albus* Say.

DRAWINGS BY W. E. HOWARD

- 1 Dorsal view of the nymph
- 2 Mandible
- 3 Maxilla
- 4 The right fore leg
- 5 Labium
- 6 Antenna
- 7 A gill from the fourth abdominal segment
- 8 Labrum

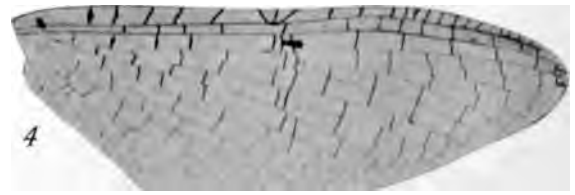
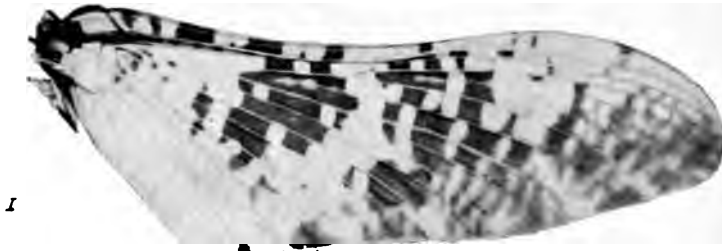
PLATE 13

- 1 Apex of abdomen of *Hydroptila consimilis* from beneath
- 2 Apex of abdomen of *Hydroptila consimilis* from above
- 3 Apex of abdomen of *Hydroptila consimilis* from side
- 4 Another view of penis of *Hydroptila consimilis*
- 5 Apex of abdomen of *Hydroptila delineatus* from beneath
- 6 Apex of abdomen of *Hydroptila delineatus* from side
- 7 Apex of abdomen of *Hydroptila delineatus* latero dorsal aspect
- 8 Apex of abdomen of *Hydroptila spatulata* from beneath
- 9 Dorsal of plate of *Hydroptila spatulata* from above (not quite satisfactory)
- 10 Apex of abdomen of *Hydroptila spatulata* from side
- 11 Apex of abdomen of *Hydroptila hamata* from beneath
- 12 Apex of abdomen of *Hydroptila hamata* from above
- 13 Apex of abdomen of *Hydroptila hamata* from side

PLATE 14

- 14 Apex of abdomen of *Ithytrichia clavata* from beneath (not satisfactory)
- 15 Apex of abdomen of *Ithytrichia clavata* from side
- 16 Apex of abdomen of *Ithytrichia confusa* from above
- 17 Apex of abdomen of *Ithytrichia confusa* latero ventral aspect
- 18 Apex of abdomen of *Orthotrichia brachiata* from beneath
- 19 Apex of abdomen of *Orthotrichia brachiata* from side (not satisfactory)
- 20 Apex of abdomen of *Oxyethira coerrens* from beneath
- 21 Apex of abdomen of *Oxyethira coerrens* from above
- 22 Apex of abdomen of *Oxyethira coerrens* from side
- 23 Apex of abdomen of *Oxyethira viminalis* from beneath
- 24 Apex of abdomen of *Neotrichia collata* from beneath
- 25 Penis of *Neotrichia collata*
- 26 Apex of penis of *Neotrichia collata*, another view
- 27 Fore wing of *Neotrichia collata*
- 28 Hind wing of *Neotrichia collata*

Plate 4



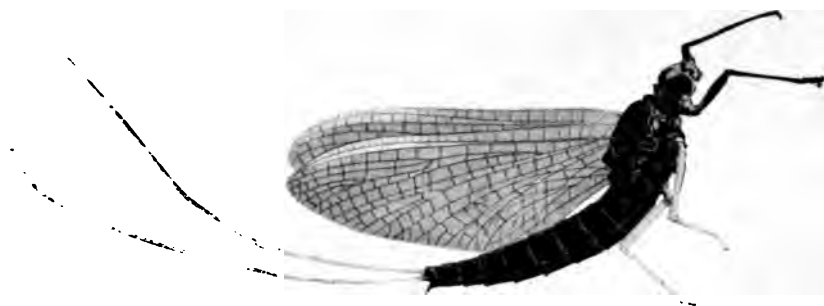
May fly structures

1952

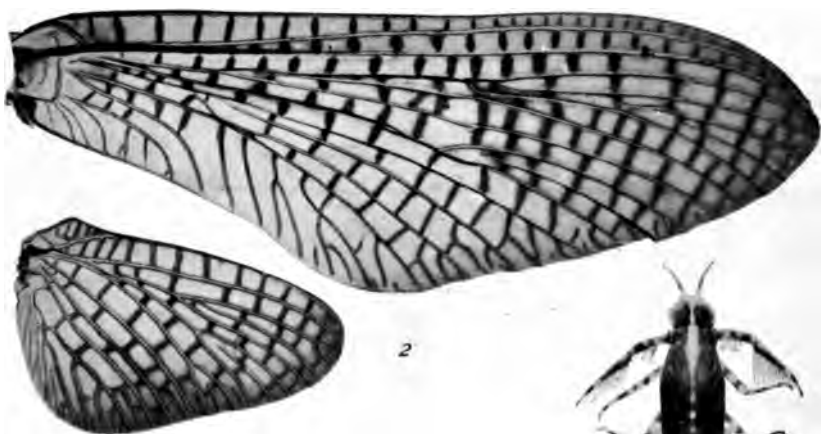
1952



Plate 5



1



2



3



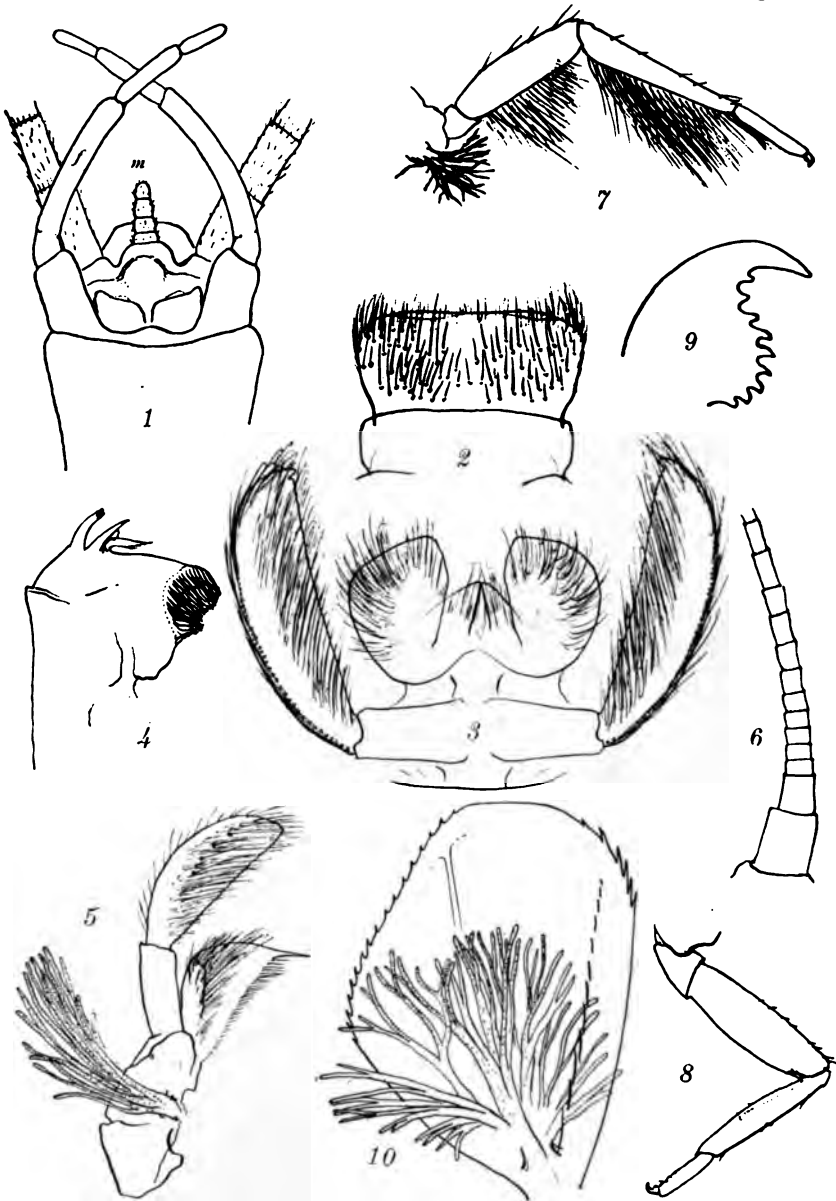
4

Chironetes
The white-gloved howdy

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TILDEN FOUNDATIONS



Plate 6

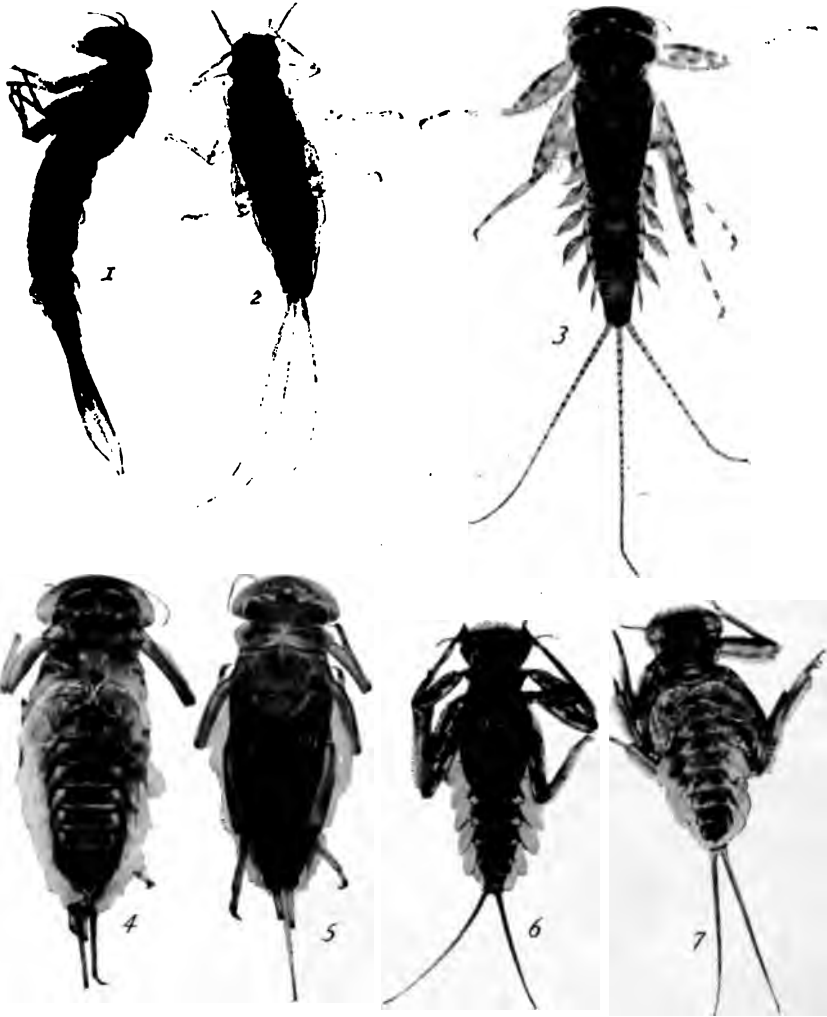


Chirotenetes

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TILDEN FOUNDATION

Plate 7

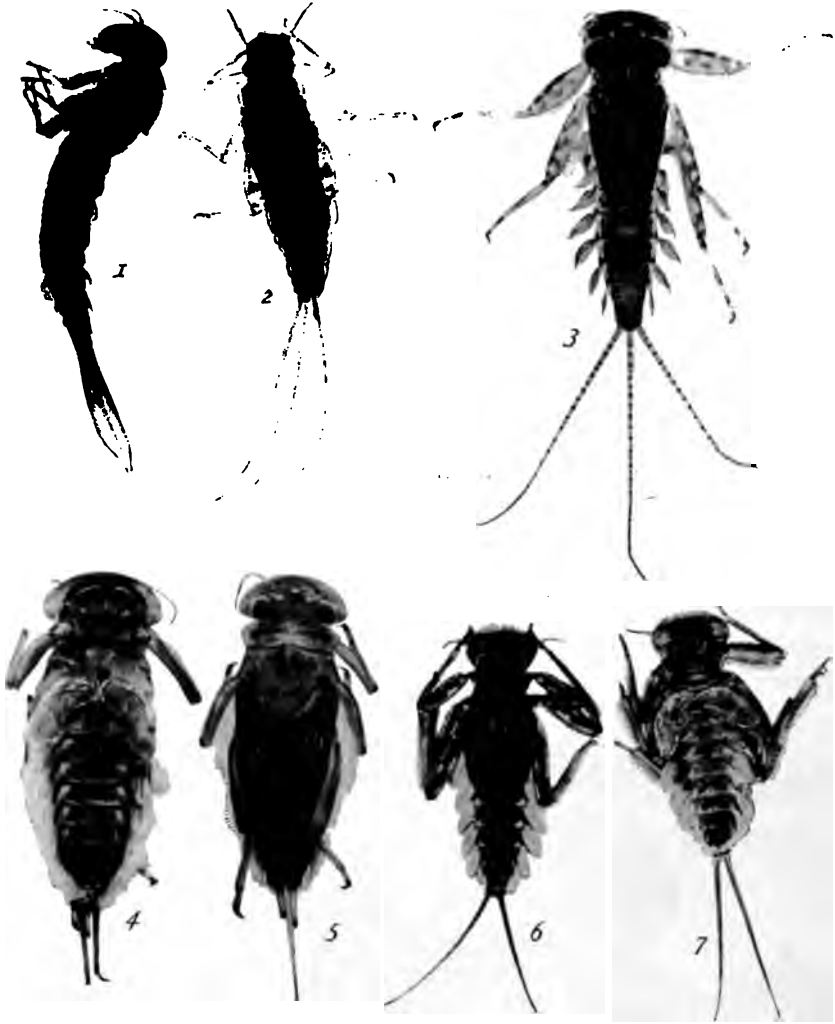


May fly nymphs

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Plate 7

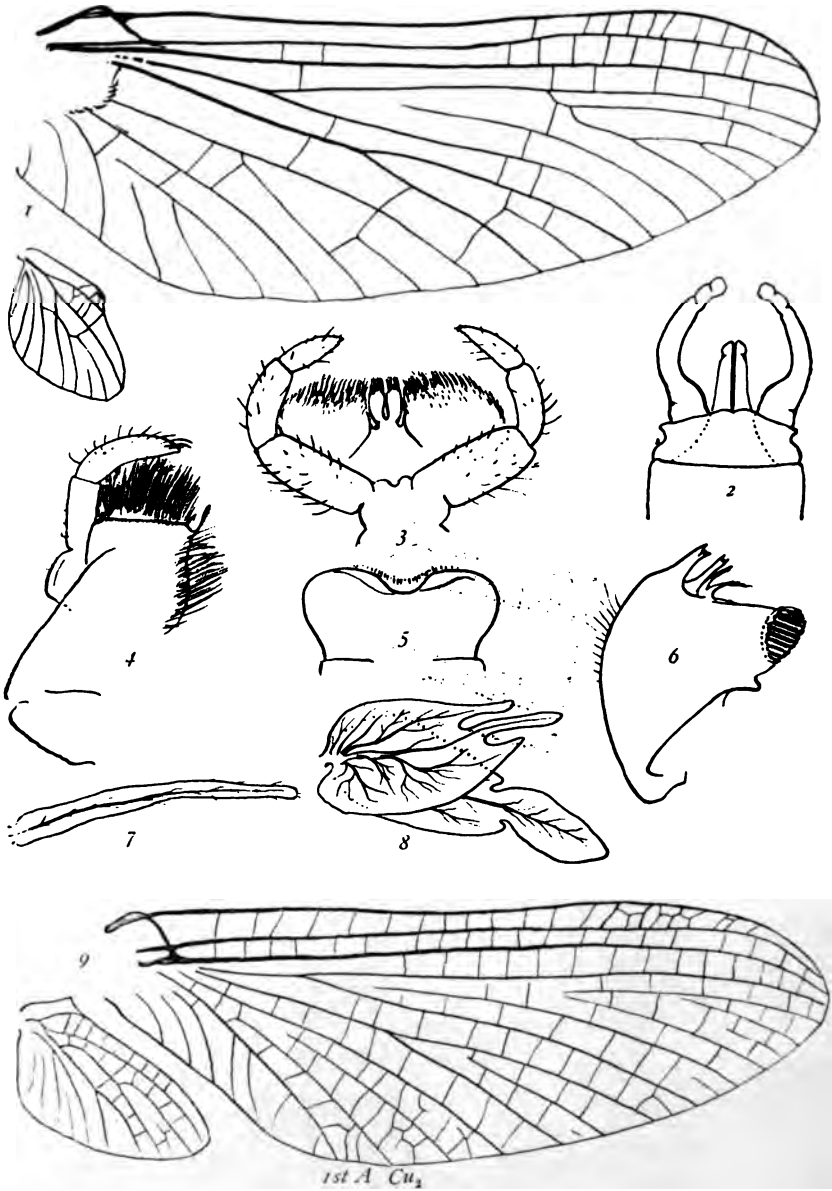


May fly nymphs

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Plate 8



Choroterpes and Ameletus

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Plate 9

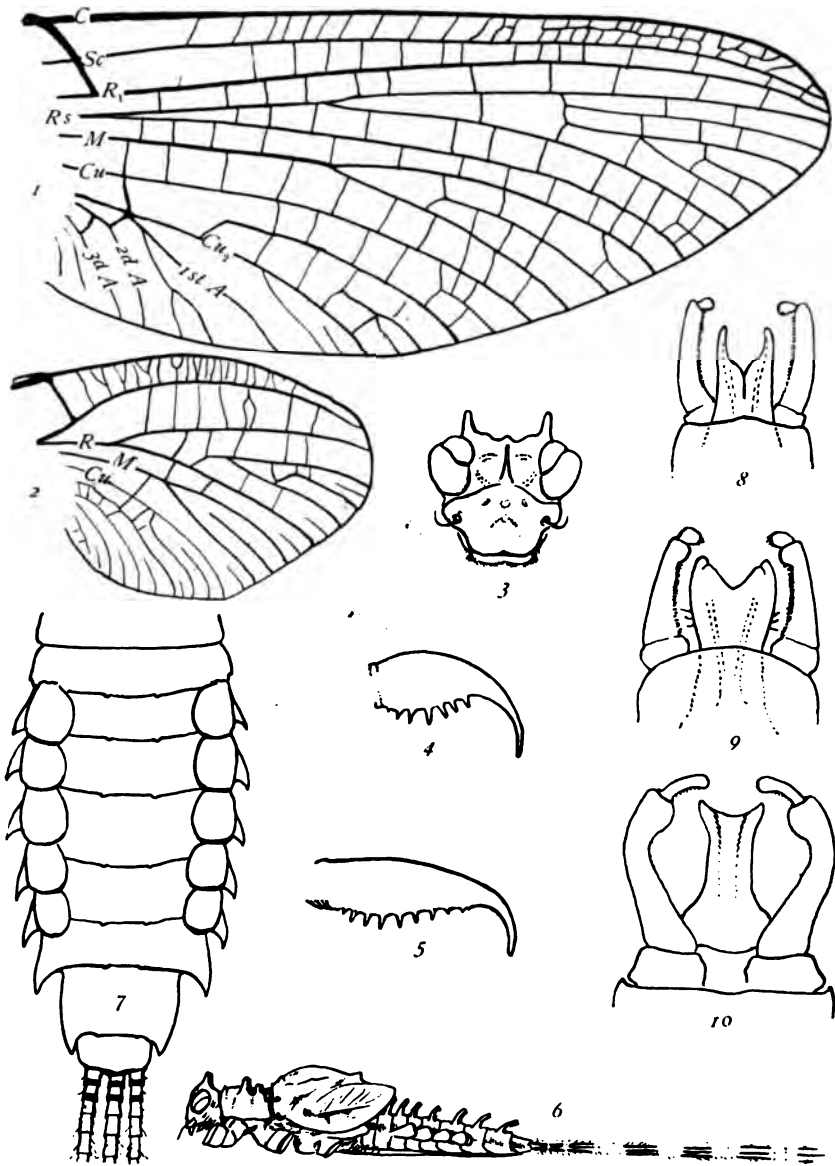


May fly nymphs

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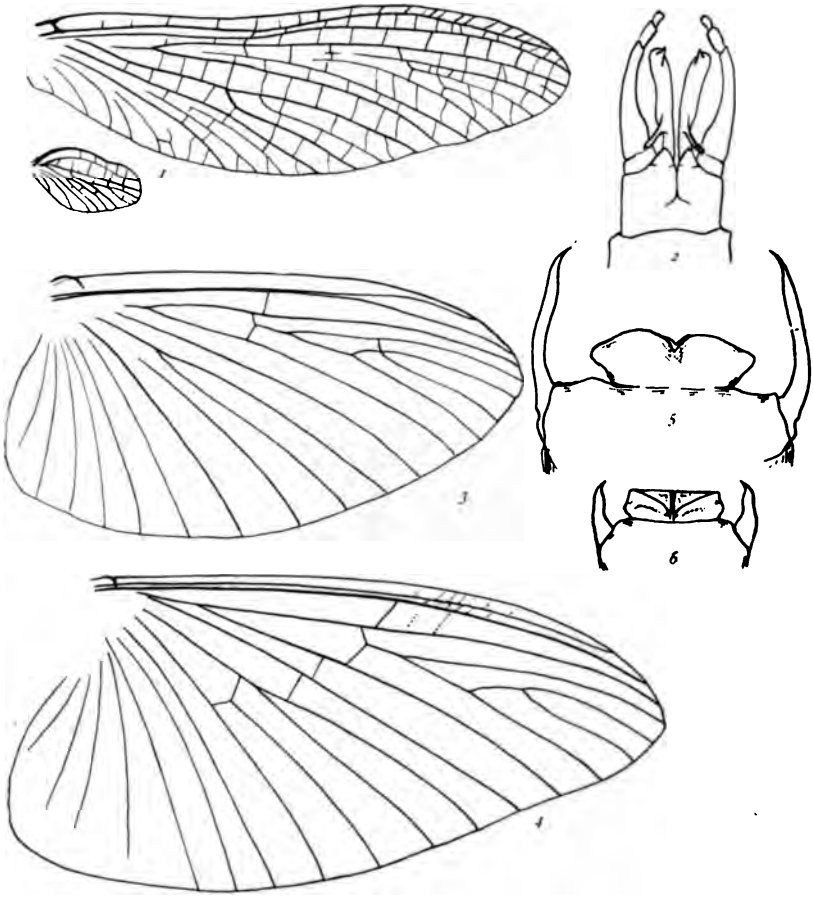
Plate 10



Drunella and *Ephemerella*



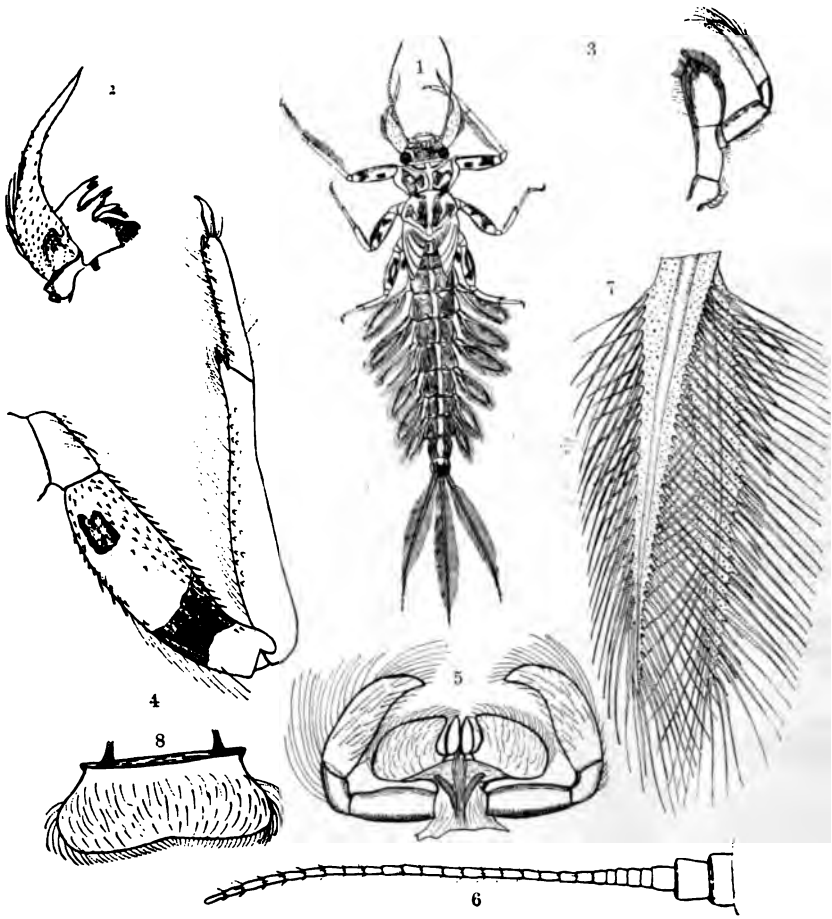
Plate 11



Leptophlebia and Caenis

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Plate 12



Polymitareys albus