

# MAYFLIES OF NORTH CAROLINA

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PLATES 5-12

## I. INTRODUCTION

The state of North Carolina, with its several distinct life zones, might well be expected to offer as rich a field to the collector of insects as to the systematic botanist. The results of collecting and rearing representatives of that interesting group of insects, the Ephemera or mayflies, in this state during the years of 1928-30 show that this expectation is fully justified. Twenty-seven genera, two of them new, are represented in the material collected. More than one hundred different species have been taken here, approximately one-third of which have not been previously described. The account of the collecting and rearing of these insects, with certain observations on their habits, occupies the second and third part of this thesis. The fourth part, being purely systematic, is devoted to a presentation of the genera and species found, together with descriptions of the two new genera and the new species.

### *Geographic divisions and life zones.*

The three geographical divisions of the state of North Carolina accord practically with the three main life zones. Thus the coastal plain, extending inland about 125 miles, is in the Lower Austral Zone, except a narrow area south from Wilmington which is in the Gulf Strip. From the inner edge of the sandhills to the foothills of the Blue Ridge is the piedmont region, in the Upper Austral Zone. The remainder of the state, westward from the Blue Ridge to the crest of the Great Smokies, is known as the Appalachian region. Most of this is in the Transition Zone, save for the tops of the higher mountains. Here is found the Canadian Zone, ranging upward from about 4500 ft.

The relatively flat coastal plain or tidewater region is contrasted sharply with the other regions of the state. Deeply indented on its

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seaward side by many bays and sounds, it extends from the banks at the seashore to the sandhills on the eastern borderline of the piedmont. The soil here is mainly a sandy loam, and there are many dark-water streams. Large swamps are numerous, and many good-sized natural lakes, most of them filled with the characteristic black water of the region.

The piedmont varies from relatively low country next to the coastal plain, with an elevation of 200 to 500 ft., to a plateau on the western border, attaining there an elevation of 1200 to 1500 ft. Interrupted chains of weather-worn mountains, the rocks composing them of Pre-Cambrian age, are scattered through the piedmont. Along its eastern and northern borders, the Uharie Mts. appear, often merely as hills somewhat higher than the surrounding country. Isolated areas of higher chains occur in the north and west,—the Sauratown, Brushy and Pilot Mts. The latter chains are often considered foot-hills of the Blue Ridge. The orange to reddish brown clay loam of the piedmont has resulted from slow erosion of the very ancient underlying rocks.

The Appalachian region is a high plateau, bounded on the east by the escarpment of the Blue Ridge, and on the west by the Great Smokies. Many lesser mountain chains running crosswise between these two great ridges divide the plateau into valleys and heights. Included in this region is Mt. Mitchell in the Black Mts., the highest peak east of the Rockies, with an elevation of 6711 ft. Several peaks in the Great Smokies lack but a few feet of attaining the height of Mt. Mitchell. The Great Smoky National Park lies in part within this region, on the Carolina-Tennessee border. The Pisgah, Unaka, Nantahala, and Cherokee National Forests are included within its borders. The orange-red soil found on the lower levels is closely allied to that of the piedmont, in appearance and derivation. A dark acidic humus is found on many of the higher mountains. These mountains, probably of Paleozoic age, are very similar in age and composition to the rocks underlying the piedmont and cropping out as low mountain chains there.

### *Drainage basins*

The drainage basins of the state may be divided into (1) the streams draining into the Atlantic directly, and (2), those whose waters first enter the Gulf of Mexico. The Blue Ridge is the main watershed.

The first group is subdivided into those streams which run to the ocean within the borders of the state, and those which reach it only after

transversing South Carolina and Georgia. The principal rivers of the first division are, from north to south, the Chowan, the Roanoke, the Pamlico or Tar, the Neuse and the Cape Fear. The last three derive their waters from North Carolina alone. In the second division belong the Yadkin, which on crossing the line into South Carolina becomes the PeeDee; the Catawba, which becomes the Wateree, joining the Congaree in South Carolina to form the Santee; and the Rocky, First and Second Broad Rivers, uniting to form the Congaree. All of these rivers have their headwaters in the eastern foothills of the Blue Ridge, and flow southward, cutting gorges as they cross the line of the Uharie Mts.

Only one river arising east of the Blue Ridge fails to flow directly into the Atlantic Ocean. This is the New, which flows northward to join the Ohio. Several large rivers arise on the western slopes of the Blue Ridge and flow westward, receiving tributaries from the lesser mountain chains and from the eastern slope of the Great Smokies. These rivers cut deep gorges through the lofty ridge of the Great Smokies and join the Tennessee or its branches to the west of this great mountain wall. From north to south these are the Nolichucky; the Watauga; the French Broad; the Pigeon; the Little Tennessee, with its large tributaries, the Ocona Lufty, the Tuckasegee, the Cullasaja and the Nantahala; and in the extreme southwest the Hiwassee.

There are no natural lakes of any size in either the piedmont or the Appalachian regions, but many lakes have been formed artificially, particularly in the latter area. The rivers flowing east and south through the piedmont accomplish their main fall before reaching the eastern boundary of the piedmont, so that little real fall occurs at the so-called fall line. Yet in many of these rivers a fair current is in evidence up to within a few miles from the ocean.

#### *When and where collections were made*

During the fall of 1928 and the spring of 1929, collecting was done in the piedmont area only. My headquarters being at Greensboro, trips were made in all directions from this point as a center. The summers of 1929 and 1930 were spent in the Appalachian region. In 1929 my headquarters were at Black Mt., Franklin, and Waynesville. In 1930, the central points for collection were Swannanoa and Penrose. The fall of 1929 and the spring of 1930 were again devoted to collecting in the piedmont, except for a short trip to the eastern coast in April, on which trip some collecting was accomplished in the coastal plain.

In addition to my own collecting in the state, Prof. J. G. Needham has kindly turned over to me many specimens which he collected in the spring of 1929, some from each of the three major divisions of the state. Some specimens were also received from Dr. J. S. Gutsell of the Bureau of Fisheries at Beaufort, taken from the Appalachian region near the town of Sylva.

Collections are at hand from sixteen stations in the coastal plain, thirty-eight stations in the piedmont, and seventy stations in the Appalachian region.

As yet, material from the coastal plain is very limited, and much needs yet to be done in this area before any comprehensive idea can be obtained of its mayfly fauna. The piedmont and Appalachian regions have been worked more thoroughly, yet even here there are many areas in which no adequate collecting has been done. While the present work is far from complete, it is hoped that it may serve to broaden our knowledge of the Ephemera within the boundaries of North Carolina, and lay the foundation for more extensive studies in the future.

### Historical

Previous to this time, reports of mayflies from this state have been very few, and have been related mainly to small areas in the Appalachian region. Eaton, in the *Revisional Monograph*, listed but four species of mayflies that had been reported from North Carolina. These are: *Hexagenia munda* Etn., described from a male imago taken near Morganton, N. C.; *Blasturus cupidus* Say, (listed as variety from N. C.); *Isonychia sicca* Walsh; and *Heptagenia interpunctata* Say. Banks, in 1908, listed from North Carolina a new species of *Leptophlebia*, *Siphonurus mirus* Etn.; and *Heptagenia vicaria* Wlk.; as well as two species listed by Eaton. In 1914, Banks described five species from the Black Mts. of North Carolina. One of these, *Habrophlebia jocosa*, proved to be synonymous with *Habrophlebia vibrans* Needham, while his *Ephemerella vernalis* is stated by McDunnough to be synonymous with *Ephemerella rotunda* Morgan. The three new species are *Leptophlebia assimilis* Bks., *Heptagenia subaequalis* Bks., and *Heptagenia carolina* Bks. In 1924, he described another new species from the same locality, *Pseudocloeon carolina* Bks. McDunnough, 1931, added *Ephemerella dorothea* Needham to the list. As far as I have been able to determine, the foregoing are the only species of mayflies thus far listed as occurring in North Carolina.

## II. METHODS

*Collecting*

In the majority of smaller streams, 'hand-picking' was found to be preferable to other methods of collecting. If a stone is lifted gently from the water and quickly turned over, many mayfly nymphs will remain on it. Species of a few genera, notably *Isonychia* and *Ameletus*, can rarely be taken in this fashion, as they leap back into the water with the quickness of minnows. On the contrary, nymphs of *Rhithrogena* have not been obtained in any numbers by any other means. If a net or dish, or the hand of the collector, be held beneath the stone as it is lifted and turned, any nymphs that let go their hold on the stone and fall off may be caught before they reach the water. Some individuals will have been washed off before the stone can be removed from the water.

Collecting with the hand-screen and rake was most successful in rapid water and in larger streams where the water was quite deep. For this method of collecting, it is well to have a helper, who lifts the stones with the rake while the screen is held in the current below. It can be manipulated by one person if necessary, however. *Rhithrogena* was seldom taken by this method, but specimens of most of the other genera could be thus obtained. *Baetisca* was never taken by hand-picking; all but two of the specimens of this genus caught were taken with the hand-screen. In all streams in which the hand-screen was used, hand-picking was likewise employed in part or all of the same areas.

Wherever pondweeds or other aquatic plants grow, a net is essential for sweeping up the nymphs which normally cling to the stems and leaves. A stick or the handle of the net may be used to brush the plants and cause the nymphs to swim free, after which frequent sweepings of the net through the water catch many of those that were dislodged.

*Isonychia* may often be caught in the hand, for all its activity as a jumper, if a shallow portion of the stream is located in which many nymphs are congregated between and under small stones. A net is useful if the water is not too shallow. Many stones are removed until a small pocket with sand or gravel bottom is formed, in or near which the nymphs collect. They may then be scooped up by the use of both hands.

For collecting burrowing nymphs, some apparatus such as Prof. Needham's sieve net is most useful. This net sifts the mud and silt, retaining all the nymphs. In shallow water, the mud may be scooped

up with a large spoon or other implement of a similar nature, or by hand, and spread out on the bank or the tops of large flat stones. As the water seeps away, the nymphs begin to scramble out, and may be readily located.

### *Transporting nymphs*

In cool weather, nymphs may be placed as caught in glass fruit jars or other containers supplied with a lid. For the homeward journey, the lids must be securely clamped or screwed on to prevent the spilling of the water and the escape of the nymphs. This method is very undesirable, however, for hot weather, for all forms of nymphs that live normally in rapid water, or when the collecting is done in streams many miles from where the nymphs are to be reared. The best success in transporting nymphs has been obtained in this fashion. As the nymphs are taken from the stream, they are placed at once in wire rearing cages of the pillow type, as described in Prof. Needham's *Guide to the Study of Fresh Water Biology*. The cages are kept in the stream until the catch is complete. When ready to return home, the top of the cage is closed, and the cages are placed in a pail one-quarter filled with stream water. If a long journey must be made, or the day is very hot, the water in the pail should be changed every few miles.

### *Rearing the nymphs*

In cool weather, the great majority of nymphs may be successfully reared if placed in shallow water in open dishes, such as petri dishes, or half of an evaporating dish, or porcelain pans. The dishes must then be placed where a draught of air continually blows over the surface of the water, as on a window sill. A well-screened window must be chosen if the nymphs are free in the pans, lest the subimagoes escape on emerging. If the nymphs are to be reared in the wire cages, deeper water must be used, and the container for the cage placed in the window. The nymphs should in any case be provided with a few stones, preferably flattened ones, from their native stream. Select stones well overgrown with diatoms, to provide food for any immature nymphs. Submerged leaves or bur-reed stems may be used for all pond forms. This method has at least one great advantage over the one following. The habits, actions and activities of the nymphs may be studied at leisure, even to selecting individual nymphs for close observation.

Probably the easiest and hence the best way to rear nymphs—but a method which it is not always possible to follow, for lack of equipment—is to have shallow troughs into which untreated stream water flows continually at one end, its height in the trough being regulated by an overflow at the opposite end. Into this trough the cages containing the nymphs may be set immediately on the return from the collecting trip. A trip to the cages once a day thereafter, to remove dead individuals and subimagoes, is all that is necessary.

Leaving the cages in the stream where the nymphs were caught, or transporting them to another stream nearer the headquarters of the collector, may sometimes have to be resorted to. Small boys, curious cows, large spiders, and especially sudden and violent thunder storms, prove disastrous very frequently, however, when such methods are employed. The work of several weeks may be swept away or so badly washed as to kill most of the nymphs, in one such sudden storm.

#### *Rearing the subimagoes*

When a nymph transforms into a subimago, its nymphal skin should be located if possible, removed from the container and placed in a correctly-labelled vial of alcohol. The subimago must now be kept until it becomes an imago. The methods which have proved most successful in my work in North Carolina are as follows. In the first method, pint glass fruit jars are used. A piece of cloth is cut the exact size of the floor of the jar inside, and inserted. Next a twig is placed in the jar for the subimago to climb upon. A leaf or stem of some succulent plant is placed in each jar before the insect is put into it. The top of the jar is covered with loosely woven cloth held in place by an elastic band. Several subimagoes of the same species may be kept in each jar, which is now correctly labelled and set in a cool dark place. If the weather is hot, the leaves should be changed for fresh ones every twenty-four hours. The chief difficulty experienced in rearing the subimagoes is their failure to cast off the subimaginal skin. This seems to result from too little moisture or too much heat, or both. Hence the leaves in the jars. But too much moisture,—enough to dampen the wings of the insects,—is equally fatal.

A second method sometimes employed was to place a small branch with fresh green leaves inside a pillow cage, put the subimagoes in this cage, and after closing it carefully, put the cage in a cool moist place.

### *Preserving the specimens*

All mayflies, whether nymphs, subimagoes or imagoes, are best preserved in 75 to 80 percent alcohol. Four-drachm vials have been found to be the most useful size. If pinned and dried, the winged forms soon lose legs, tails, even wings,—and the genitalia become so shrivelled as to make recognition of the species difficult. The only possible advantage in dry-pinning is that the colors are better preserved thus.

Labels should be inside the vials, preferably written or printed in soft pencil. Data includes place and date of capture or of emergence, and genus and species if known.

As mentioned previously, the last nymphal skin is removed and placed in a separate vial. If the hour of emergence of the nymph is known, add this to the data. When the subimago has transformed, place the imago and the subimaginal skin in the vial with the last nymphal skin, adding to your data hour of final transformation if known. Such a collection, of the imago and its two exuviae, constitutes a so-called 'life-history.' Data on the exact hour of transformation of nymph to subimago, and of subimago to imago, may well be kept as separate records, and the length of the subimaginal stage recorded when the transformation is complete.

## III. ECOLOGICAL

### *Habits of the nymphs*

Aside from certain brief notes regarding the habits and habitats of nymphs which are included in the accounts of the different species, a few general statements as to habits of nymphs may be presented here. Some of these are based on observations made in the field, when the nymphs were in their native habitat; others on closer observations of nymphs kept indoors in the open dishes or in wire cages.

### 1. Subfamily EPHEMERINAE

*Potamanthus*—Nymphs were taken from the sand and fine gravel beneath and in the lee of large stones in midstream, in water not exceeding a foot in depth.

*Ephemera*—Found burrowing in soft black mud along the banks of streams. Usually in mud an inch or two in depth only.

*Hexagenia*—In deeper mud near the shores of a large river. In a large pond from which the imagoes were collected, no nymphs were ever found near shore.

## 2. Subfamily BAETINAE

*Baetisca*—The peculiar swimming habits of this nymph have been described by Walsh (Proc. Ent. Soc. Phil. 1864, pp. 205-6.). In the glass dish in which my specimens were reared indoors, they often moved from one stone to another. Usually each swam about for a time, often bumping the head repeatedly against the sides of the dish, before settling down again on another stone. During the day they were less active than at night. If turned on its back, a nymph had some difficulty in righting itself. They were readily reared in quiet water indoors. It was soon found that tap water did not injure them, if a little was added each day to the creek water in which they were at first kept.

They feign death when lifted from the water. If the rock on which they are resting is taken from the water, some loosen their hold and fall back immediately, others cling tightly to the rock. In the field, none of these nymphs were ever taken by hand-picking, however, except two that were seen swimming across a quiet pool.

For a period of twenty-four to forty-eight hours before the final transformation, the nymphs are quiet or entirely quiescent. When ready to emerge, they may swim about for a time, or may clamber directly up on top of the rock they have been resting upon, until completely above the water line, and at the highest point available.

*Leptophlebia*—These nymphs are so slender that they readily slip through the meshes of a wire pillow cage, even as fine a mesh as sixteen bars to the inch failing to restrain most of them. Many were reared indoors, in glass dishes placed on the window-sill. For others, a lining made of coarse cloth was sewed into an ordinary pillow cage, as high up as the water line. For their final transformation from the nymphal stage, they float free at the surface of the water.

*Blasturus*—Seldom found in absolutely quiet water, but often near borders of ponds or lakes, usually among aquatic plants, where the wash of the water creates a slight stir. Often feign death when taken from the water. Most readily taken with a dipnet.

These nymphs are evidently omnivorous, for in addition to a diet of diatoms and algae they have often been observed feeding on the cast skins of nymphs, of their own or another species. On emerging from its skin, a nymph has often barely moved away before other nymphs are tugging at the cast-off coat. The head and usually the last three or four segments of cast skins are seldom eaten, though this does not hold true for all cases observed. When a nymph dies, its body is eagerly devoured by its fellow nymphs.

For the transformation to the subimago stage, these nymphs often cling to some trash or aquatic plant so that the head and prothorax are out of water. Others transform while floating free at the surface.

*Ephemere*lla—Found in various habitats. See notes under the different species of this genus. May be taken by hand-picking, or by the use of the hand-screen. These nymphs also feed on dead nymphs of their own or other species. They cling so tenaciously to the dead body as often to be lifted out of the water when it is removed. As it is their habit to feign death for some seconds if disturbed, it is not always apparent at first glance which is the dead nymph and which the live one feeding upon it.

Nymphs of this genus swim about the dish frequently, as often with the ventral side uppermost as otherwise, apparently quite at ease in either position. When the stone to which they cling is lifted from the water, they sit perfectly still for some seconds, often blending so well in color with the background of the stone as to be difficult to locate. They swim by means of undulations of the body, meantime holding the legs stiff.

Many species transform into the subimago state while floating free at the surface. Others cling with the fore feet to aquatic plants or rubbish, the head and thorax out of water.

*Oreianthus*—A sluggish stiff-legged nymph, looking like a bit of trash when caught on the hand-screen. It does not move at first, and would be easily overlooked except for its size and its erected tail. Found only in swift and moderately deep water, under the largest stones. No specimens were caught except by the use of the hand-screen. Was not observed when transforming, but the last nymphal skins were found floating on the surface of the water in the cage.

*Isonychia*—Very active swimmers and leapers, mostly found under large rocks in swift water. Usually these are caught most readily by the use of the hand-screen. When in leaf drift or in shallow water when ready to transform, many may be taken by hand-picking. When ready to transform, they leave the deep rapid water for shallower parts of the stream near shore, where an active current flows over small stones. Here they rest among the small stones, or hide, sometimes half out of water, under larger flat stones. They may be caught, as mentioned previously, by trapping them in a small pocket or pool.

For the final transformation, they climb partially or entirely out of water, up on the bank or on the exposed surfaces of stones. Often the cast skins are found several layers deep on one stone.

*Siphonurus*—Active nymphs, which leap like small minnows up and

out of the net and back into the water, if given an opportunity to do so. Found in ponds and along shores of lakes, in the same habitat as *Blas-turus*. They, too, will eat the cast skins of other nymphs, as well as their dead bodies. For the final transformation they climb partly or wholly out of water, on emergent vegetation or on stones.

*Siphloplecton*—Very similar in habits and habitat to *Siphonurus*. Often, like the former, found among aquatic plants or trash near the shore, where there is a slight but constant movement of the water.

*Baetis*—These nymphs are difficult to rear indoors except in cages in running water, as they die in a few hours if placed in quiet water. The smaller species readily escape through the meshes of a wire cage. Some were reared in cages lined as for *Leptophlebia*. For transformation they float free at the surface of the water.

*Callibaetis*—Nymphs of this genus were the only ones found in absolutely stagnant water. Over a hundred were taken from a very small temporary pool, where they had congregated in holes made by the hoofs of a horse, in an inch or two of absolutely quiet water, exposed to the full glare of the sun. Strangely, not one of these completed its life cycle when taken indoors and placed in clean water, seemingly a much more favorable situation.

They fed upon the dead bodies of nymphs of their own species, and upon the bodies of dead tree-frog tadpoles which were numerous in the same small pool. Since the dead bodies were removed soon after taking the nymphs indoors, this would not seem to be the cause of their failure to transform.

*Neocloeon*—In behavior, very like *Callibaetis* and some species of *Baetis*. Usually rests on bottom of the stream, either on or partly under the shadow of leaves or trash. Ocelli ivory-white, appearing luminescent. Transform while floating at the surface of the water. Found only in small spring-fed streams with gentle current.

*Caenis* and *Eurycaenis*—In mud and silt, near the shore, in small ponds and streams.

### 3. Subfamily HEPTAGENINAE

*Heptagenia*—Some species are found in relatively quiet water, but the majority inhabit rapidly-flowing streams. May be taken either by hand-picking or with the hand-screen. They are rather quick to slip off from the rock as it is lifted from the water, and regain their native stream. Nymphs of this genus are hardy, and except in hot weather may be reared readily in open dishes indoors. When ready to transform they float at the surface of the water.

*Ecdyonurus*—Some species quite closely resemble *Heptagenia* in their habits. Others, both in general shape of body and in actions, are more closely allied to *Rhithrogena*. They float at the surface when ready to transform.

*Epeorus*—These nymphs inhabit the swiftest-flowing waters, although they are often found in less rapid currents. They are as prone to rest on the upper as on the under surface of a rock over which a torrent of water is pouring. There they seem to watch every movement of one who would capture them, and at the shadow of an approaching hand dart quickly to the sheltered under surface of the rock. A few will fall back into the water when a stone is lifted free, but many remain perfectly quiet. Some will quickly sidle to the under side of the rock, as quickly sidling the other way if the rock is reversed. The majority sit perfectly still until the fingers of the collector approach, then try to escape. They tend to sit in rows near the edge of the rock, heads usually toward the outside, and many will be overlooked at the first glance. Large flat rocks are preferred by them. None of these nymphs were successfully reared indoors. Nymph skins were found floating on the surface of the water in the cages, or with the forefeet and head out of water as the nymph had clung to the wire of the cage.

*Rhithrogena*—While apparently better equipped than *Epeorus*, by reason of the complete disc formed by the gills, to cling to rocks in very rapid water, these nymphs were seldom found in the swiftest parts of the current. Unlike *Epeorus*, they are more frequently found on small, irregularly shaped smooth stones, and in water several inches only in depth, in a fair but not very rapid current. When the rock is lifted from the water, they may quickly sidle to the under side, or slip into a convenient crevice. Others sit perfectly still until the observer tries to pick them off. Difficulty is experienced in this procedure, as the nymphs adhere so tightly to the rocks as to be removed by the fingers only at the risk of injuring the delicate creatures. A grass blade slipped under the head of the nymph and used as a lever to pry it loose from the rock has been found effective. It may then be lifted up and put into the rearing cage without being touched by the fingers.

Even with such precautions, the death rate among collected nymphs was very high. Dozens died to one that transformed. Many escaped through the meshes of the net. Subimagoes often fell back into the water and drowned themselves almost as soon as they emerged. All told, while many nymphs were seen and collected, they were at no time nor place really numerous, and less success was met with in rearing them than with any one of the other genera concerned except *Callibaetis*.

## Notes on the subimago stage

In the case of several species of mayflies, very accurate account was kept of the exact number of hours spent in the subimago stage. Occasionally the length of this period was known approximately but not exactly. A brief tabulation of the species observed, the number of individuals of each sex in which the length of the subimago stage was recorded, and the number of hours spent in this stage, is presented. Hours given are the shortest and the longest number recorded.

SPECIES	INDIVIDUALS	NUMBER OF HOURS
<i>Hexagenia carolina</i> .....	{ 3 females 2 males	22½-27 22-24
<i>Siphonurus quebecensis</i> .....	{ 6 (no sex listed) 8 males	47½-48 47-53
<i>Siphonurus mirus</i> .....	{ 1 female 1 male	36-40 51½-53½
<i>Siphloplecton signatum</i> .....	{ 3 females 1 male	47½-61 44
<i>Blasturus gracilis</i> .....	{ 2 females 3 males	24-41½ 46½-51½
<i>Blasturus grandis</i> .....	{ 4 females 2 males	18½-29 19½-25½
<i>Blasturus austrinus</i> .....	{ 7 females 7 males	20-24½ 19½-22½
<i>Ephemerella cornuta</i> .....	1 male	23½-26
<i>Ephemerella inconstans</i> .....	{ 3 females 4 males	40¼-51½ 26-49½
<i>Baetisca carolina</i> .....	{ 13 females 4 males	21-52 22-23½
<i>Neocloeon alamance</i> .....	1 male	7
<i>Isonychia albomanicata</i> .....	1 female	22-26
<i>Isonychia aurea</i> .....	1 female	31

## IV. SYSTEMATIC

*Genera of mayflies found in North Carolina*

Twenty-seven genera are represented among my material. The following key to the imagoes of these twenty-seven genera is adapted partly from Prof. Needham's key, published in Ward and Whipple's *Fresh Water Biology* (1918-19, pp. 918-921), and partly from Dr. Ulmer's key, published first in *Stettiner Entomologische Zeitung*, 1920. The key to the nymphs is adapted from the *Guide to the Study of Fresh-water Biology*, by Needham and Needham, 1927, pp. 10-14.

The three subfamilies recognized by Prof. Needham are accepted, rather than the suborders and families recognized by Dr. Ulmer. Miss Morgan's interpretation of wing venation is followed, although it is believed that a thorough revision of mayfly wing venation is much to be desired. In the key to the imagoes, venational characters are of the forewing, unless otherwise specified.

The genus *Oreianthus* seems to fall very close to the subfamily Ephemerinae, and is rather difficult to separate from this subfamily on good characters. But the nymph has the characters of the subfamily Baetinae, where it falls close to *Caenis* and *Eurycaenis*. Hence the genus is considered as belonging in the subfamily Baetinae, although this fact is not evident in the key to the imagoes.

Species of the four genera *Heptagenia*, *Ecdyonurus*, *Epeorus* and *Rhithrogena* (subfamily Heptageninae) are not dealt with in this paper, as the group is so large as to make a separate account desirable. Such a separate treatment of this subfamily will be prepared at a later date, to supplement the present account of the other two subfamilies of the order. These four genera are, however, included in the keys and in the general discussions of habits and habitat, as herewith presented.

## KEY TO GENERA OF N. C. MAYFLIES—IMAGOES

1. Cubital and first anal veins strongly divergent at base. Venation never greatly reduced.....2
- Cubital and first anal veins parallel at base (in a few forms with reduced and scanty venation, appearing a little divergent).....5
2. In hind wing, cubital vein forked at somewhat more than halfway to margin; costal angulation of hind wing prominent; median carina on prosternum; fore coxae separated by space equal to length of prosternum....*Oreianthus*
- In hind wing, cubital vein either not forked, or forked near the base of the wing, where a prominent costal angulation is present; no such median carina on prosternum; fore coxae very close together, separated by space less than half the length of the prosternum....Subfamily EPHEMERINAE, 3

3. The third anal vein not forked, but attached to the hind margin of the wing by a series of cross veins; forceps of male 4-jointed..... 4  
 The third anal vein ends in a single fork, and is not attached to the hind margin of the wing, though a few isolated intercalated veinlets lie between; male forceps 3-jointed..... *Potamanthus*
4. Two long tails in male and female; in foreleg of male, tarsus about  $1\frac{1}{2}$  to  $1\frac{1}{2}$  as long as femur; in female, pronotum longer than broad..... *Hexagenia*  
 Three long tails in male and female; in foreleg of male, tarsus about four times as long as femur; pronotum of female shorter than broad..... *Ephemera*
5. 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; venation never greatly reduced; eyes of male simple and remote; hind tarsi with five freely movable segments..... Subfamily REPTAGENINAE, 6  
 Intercalary veins between first and second anal veins never as above; venation various, sometimes greatly reduced; eyes of male enlarged, often approximated on the dorsal side and divided into superior and lateral portions with corneal facets of different sizes; hind tarsi usually with but four freely movable segments..... Subfamily BAETINAE, 9
6. First tarsal segment of the hind leg shorter than the second..... *Heptagenia*  
 First tarsal segment of hind leg as long as or longer than the second..... 7
7. In the fore tarsus of the male, the first segment is as long as or longer than the others; claws of fore leg of male similar, blunt; dissimilar on the other legs and in the female; first segment of fore tarsus of female about as long as the second..... *Epeorus*  
 In the fore tarsus of the male, the first segment is shorter than several of the following segments; claws of all legs dissimilar, in both sexes; first segment of fore tarsus of female shorter than the second..... 8
8. First segment of fore tarsus in male shorter than the fifth; 10th sternite of male usually concave in the middle of the hind margin; in foreleg of female, fifth segment of tarsus about twice as long as first..... *Rhithrogena*  
 First segment of fore tarsus in male longer than the fifth; 10th sternite of male slightly convex in the middle of the hind margin; in foreleg of female, fifth segment of tarsus less than  $1\frac{1}{2}$  times as long as the first.... *Ecdyonurus*
9. 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*  
 Anal veins strongly divergent distally, usually both the second and the third ending in the inner margin; branches of the radial vein in the hind wing more symmetrical..... 10
10. The posterior division of the median vein with a normal posterior fork; hind wings, when present, usually but little longer than broad and with a copious venation..... 11  
 Posterior fork of the median vein apparently simple,  $M_4$  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..... 22
11. The intercalaries between the first and second anal veins variable, but usually more or less independent, and not directly dependent upon the first anal; three well-developed tails (except in most species of *Blasturus*, in our fauna)..... 12

- 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 tails, the median one being rudimentary or wanting; hind tarsi five-segmented, the basal joint more or less united with the tibia.....19
12. Hind wings present.....13  
Hing wings absent.....17
13. Bisector of the cubital fork independent; between it and  $Cu_2$  no intercalaries; vein  $Cu_2$  in the hind wing rarely preserved; tails generally much longer than the body; penultimate segment of the male forceps shorter than the antepenultimate.....14  
Bisector of the cubital fork tending to be attached to the posterior branch of  $Cu_2$ ; between this bisector and  $Cu_2$  are generally some short intercalaries; tails about as long as body; penultimate segment of the male forceps longer than the antepenultimate.....*Ephemerella*
14. Hind wing obtuse oval, costal region narrow, long; costal margin weak and irregularly arched, interrupted in the middle by a shallow indentation; no costal angulation.....15  
Hind wing with an angular lobe projecting forward from the middle of the costal margin; costal region broad and usually greatly shortened, rarely long; few cross veins in hind wing.....16
15. Median tail as long as or longer than the lateral ones; third anal vein of hind wing wanting.....*Leptophlebia*  
Median tail much shorter than the lateral ones (except in *B. gracilis*); third anal vein of hind wing present, and often followed by one or two additional intercalaries.....*Blasturus*
16. Vein Sc of hind wing reaching almost to the apex, therefore long; basal segment of genital appendages hardly as long as the two terminal segments together.....*Habrophlebia*  
Vein Sc of hind wing ending right behind the costal projection, being therefore greatly shortened; basal segment of genital appendages much longer than the two terminal segments together.....*Habrophlebiodes*
17. Vein  $Cu_2$  and cubital bisector of forewing as long as  $Cu_1$ , both therefore running up to the base; cross veins of wings arranged singly; no intercalary region with more than one cross vein, only radial region with 2 or at most 3 cross veins; genital appendages 1-segmented.....18  
Vein  $Cu_2$  and cubital bisector much shorter than  $Cu_1$  in forewing, not extending up to the base; cross veins of wings not arranged singly, but much more numerous, almost all intercalary spaces with several to many cross veins; genital appendages two to three segmented.....*Tricorythus*
18. Prosternum very narrow, two to three times longer than broad, the fore coxae therefore closely approximated; second antennal segment not lengthened.....*Caenis*  
Prosternum very broad, twice as broad as long, the fore coxae therefore widely separated; second antennal segment three times as long as the first.....*Eurycaenis*
19. Hind tarsus shorter than or at most as long as tibia; fore tarsus of male varying in length.....20

- Hind tarsus longer than tibia; fore tarsus of male at least twice as long as tibia.....21
20. Claws of all tarsi dissimilar.....*Ameletus*  
Claws of fore tarsi similar, blunt; claws of second and third tarsi similar, pointed.....*Isonychia*
21. Claws of all tarsi similar, narrow, hooked.....*Siphonurus*  
Claws of all tarsi dissimilar.....*Siphloplecton*
22. Hind wings absent.....23  
Hind wings present.....24
23. Short free intercalaries arranged singly on outer margin of wing.....*Neocloeon*  
Intercalary veins arranged in pairs.....*Pseudocloeon*
24. Fore wings with numerous costal cross veins before the bulla; hind wings with a moderate number of cross veins, at least in the costal region.....*Callibaetis*  
Fore wing without costal cross veins before the bulla; hind wings without cross veins, or with but 1-3 of them.....25
25. Marginal intercalary veinlets single.....*Centroptilum*  
Marginal intercalary veinlets in pairs.....26
26. Hind wings oblong, usually with a short costal angulation; with 2 or at the most 3 longitudinal veins.....*Baetis*  
Hind wings very small and narrow, without costal angulation; only 2 simple longitudinal veins.....*Acentrella*

## KEY TO GENERA OF N. C. MAYFLIES—NYMPHS

1. Mandible with a tusk projecting forward and visible from above the head  
Subfamily EPHEMERINAE, 2  
Mandible with no tusk that is visible from above.....4
2. Fore tibia longer than hind ones.....*Potamanthus*  
Fore tibia shorter than hind ones.....3
3. Elevated frontal process on head rounded.....*Hexagenia*  
Elevated frontal process on head bifid.....*Ephemera*
4. Head strongly depressed; eyes dorsal.....Subfamily HEPTAGENINAE, 5  
Head not strongly depressed; eyes lateral.....Subfamily BAETINAE, 8
5. Tails two.....*Epeorus*  
Tails three.....6
6. Gills of last pair, tapered filaments.....*Heptagenia*  
Gills of last pair, flat plates.....7
7. Gills of first and last pairs directed laterally.....*Ecdyonurus*  
Gills of first and last pairs convergent ventrally.....*Rhithrogena*
8. Gills completely concealed beneath an enormously enlarged thoracic shield  
*Baetisca*  
Gills exposed; thoracic dorsum normal.....9
9. Outer tails fringed on both sides.....10  
Outer tails fringed only on the inner side.....18
10. Gills on abdominal segments 1-7, double.....11  
Gills absent from one or more of segments 1-7; one pair usually more or less elytroid, covering those behind it.....14
11. Gills filamentous.....12  
Gills lamelliform, at least on the middle segments.....*Blasturus*
12. Each a pair of simple filaments.....13  
Each a pair of clusters of slender filaments.....*Habrophlebia*

13. Labrum rather deeply cleft on the front margin; second and third segments of labial palp about equal in length, the latter conical distally  
*Habrophlebiodes*  
 Labrum very little indented on the front margin; third segment of labial palp considerably longer than the second, (often three times as long)  
*Leptophlebia*
14. Gills present on the seventh abdominal segment, often elytroid on the third or fourth segment; usually a pair of tubercles on the apical margin of each abdominal segment beside the mid-dorsal line.....*Ephemerella*  
 Gills absent from the seventh abdominal segment; elytroid on the second segment; no such paired dorsal tubercles.....15
15. Elytroid gill quadrangular.....16  
 Elytroid gill triangular.....*Tricorythus*
16. Elytroid gills usually grown together along median line; a median dorsal keel on abdomen, with or without one median dorsal spine on segments 1-3 and 6-9.....*Oreianthus*  
 Elytroid gills not grown together along median line; no median dorsal keel nor spines.....17
17. Three prominent ocellar tubercles on head.....*Eurycaenis*  
 No such ocellar tubercles.....*Caenis*
18. Posterolateral angles of the hinder abdominal segments prolonged into thin, flat, sharp lateral spines.....19  
 Posterolateral angles of the hinder abdominal segments hardly more than acute—not prolonged into thin lateral spines.....22
19. Fore legs conspicuously fringed with long hairs; gill tufts present upon the bases of maxillae and front coxae.....*Isonychia*  
 Fore legs without conspicuous fringes; no maxillary or coxal gills.....20
20. Fore claw short, broad and bifid at tip; other claws pointed, about twice the length of the fore claw.....*Siphloplecton*  
 All claws pointed, none bifid at tip.....21
21. Gill lamellae all single.....*Ameletus*  
 Gill lamellae double on the basal abdominal segments.....*Siphonurus*
22. Gill lamellae double, at least on some of the basal abdominal segments  
*Callibaetis*  
 Gill lamellae single.....23
23. Tails two.....24  
 Tails three (in all known eastern forms).....25
24. Second pair of wing buds present.....*Acentrella*  
 Second pair of wing buds absent.....*Pseudocloeon*
25. Middle tail as long as outer ones; distal joint of labial palp much dilated at tip, its summit truncate.....26  
 Middle tail shorter than outer ones; distal joint of labial palp not noticeably dilated at tip, its summit rounded or conical.....*Baetis*
26. Gills symmetrical; tracheae of gill lamellae with normal pinnate branching  
*Centroptilum*  
 Gills asymmetrical, the inner margin extended into a lobe-like process; tracheae of gill lamellae pinnately branched, but all branches unilateral on the inner side.....*Neocloeon*

## Subfamily EPHEMERINAE

This subfamily is represented in my North Carolina material by three genera only; *Hexagenia*, *Ephemera* and *Potamanthus*.

GENUS *HEXAGENIA* Walsh 1863

Three new species of this genus were taken, one from each of the three geographic divisions of the state. Since descriptions of these species appeared in the September 1931 Annals of the American Entomological Society, along with four other new species of this genus, a brief summary only of each is given here.

***Hexagenia elegans* Traver**

From the coastal plain region. Imagoes captured by Miss L. E. Brett from the Chowan River near Winton, in Hertford Co., N. C., during the second week of August, 1930.

This is a very small and dainty species, the males measuring 12-17 mm., the females 14-19 mm. The hind wings of the male are bordered with purplish brown; both wings have prominent purplish black spots. The abdomen of the male is marked prominently with purplish red. Genitalia very slender, of the *carolina* type. Body of female creamy white, the abdomen marked dorsally with dark grey.

***Hexagenia carolina* Traver**

From the piedmont area, and a rather similar species from the Appalachian region at Franklin. In the piedmont, taken at Hamburg Lake, near Greensboro, in June 1930. Nymph skins were collected from the surface of the water, and nymphs which appear to be similar were later found in the South Toe River near Micaville, in the mountain region of the state.

This is a large species, predominantly yellowish white, the male marked with greyed rose to lavender. There is no dark outer border on the hind wing, and no prominent dark spots in either wing. Genitalia of the *carolina* type. The head of the female is sulphur yellow, also the metanotum. Abdomen marked much as in male, with median brownish grey stripe and lateral extensions of the same. Sternites 8-10 sulphur yellow. Males measure 20-24 mm., females 25-35 mm.

**Hexagenia rosacea** Traver

A single male, taken at Penrose in the mountains, probably from the French Broad River. Superficially quite similar to *H. carolina*, but differs from that species by the greater amount of color on the anterior abdominal segments, the shorter second tarsal joint, the larger compound eye, and by the appearance of the genitalia. Whitish, marked prominently with deep rose red. Genitalia of the *carolina* type. Size 20 mm.

**Hexagenia** sp?

Besides the three species above mentioned, nymphs, of a third and apparently undescribed species were taken from the Tuckaseegee River by Dr. J. S. Gutsell. Since only two immature subimagoes were among this material, it was not considered advisable to describe it as a new species, until more material becomes available. The nymph of this species is described as Nymph No. 6, in the before-mentioned paper on the genus *Hexagenia*. In this paper, likewise, are presented keys to the imagoes and nymphs of several species of the genus *Hexagenia*.

GENUS EPHEMERA Linn. 1746; restricted, Leach 1815

**Ephemera blanda**, n. sp.

## MEASUREMENTS

	BODY	TAILS	FOREWING	FORELEG
Female nymph (4 specimens).....	18-20	4½-7		
Male imago (2 specimens).....	13-14	25-27	12-12½	12½-13
Female imago (2 specimens).....	16-17	19	16-17	6-6½

Nymph brown dorsally, cream colored ventrally. Marked prominently with purplish-black lines. Gills purple. Wings of imago lacking the usual pattern of dark blotches; the normal location of these blotches, as in *E. varia*, represented by very small clouded areas only. Abdomen marked with blackish longitudinal pencillings.

*Nymph*

*Head*—Dark red-brown. A light cream-colored area laterad of each lateral ocellus. Epicranial suture narrowly white. Prongs forming each side of median frontal process blackish brown. Notch in frontal process straight on each side, rounded in center; see Pl. 12, Fig. 22.

Antennal sclerite, basal joint and distal half of second joint of antenna dark brown. Remainder of antenna light yellowish brown. Mouth-parts as in Figs. 1 and 24.

*Thorax*—Dark red-brown dorsally, median line narrowly white. Cream colored ventrally. Anterior and posterior margins of pronotum narrowly black. A wide curving black band on each side of median line, not reaching the anterior margin. Mesonotum cream-white at anterior lateral angles, above wing-roots, a narrow band on each side of median line, and on mesonotal spine. Wing-cases very dark brown except for cream colored inner margin. A few small black blotches due to markings of enclosed wings.

*Legs*—Tibia and tarsus of foreleg dark brown, femur cream colored. Black spot at distal ends of femur and tibia. Other legs cream colored, margined narrowly with orange. Hairs tawny. Claw of third leg shown on Pl. 12, Fig. 33.

*Abdomen*—Yellowish to orange brown dorsally, tergites 7-10 darker. Tergites 2-6 with a pair of curving purplish-black marks on each side of median line, also a shorter mark at center of tergite nearer the pleural fold on each side. Tergites 7 and 8 similarly marked, with the addition of another narrower dark line nearer the median line on each side, in the anterior half of the tergite only. On 9, the two central narrow marks as in 7 and 8, but the wider outer marks are joined to form one bar on each side. Tergite 10 dark brown, no black markings. Ventrally cream colored, the last three or four sternites sometimes flushed with pale yellow. Sternites 3-9 with a black mark on each side of the median line. On 3, this is a mere dot, on 6-9 a narrow line. Pleural folds cream colored on some specimens, amber on others.

*Gills*—Central portion and fringes dark purplish-grey. Rudimentary first pair of same color.

*Tails*—Light brown, joinings purplish. In distal half, several joinings will be light brown, then follow a group of three or more that are purplish, then another group of light brown. Fringed with purplish grey hairs.

#### *Male imago*

*Head*—Yellowish brown, darker on occiput and median portion of vertex. Compound eyes slate-grey, upper portion lighter than lower. Ocelli pearl-grey, ringed widely with black at base. Basal joints of antenna cream colored, black distally. Antennal filament grey.

*Thorax*—Pronotum yellow in median area, except on anterior border.

Margined and bordered with cream. A brown area lies within the cream margin. A black longitudinal stripe is present on each side, between the yellow median portion and the outer brown area. Mesonotum brown, sides in anterior portion margined with cream, the whole bordered with darker brown. Median line narrowly pale. Pleura cream colored with brown markings. Ventrally cream-yellow, except for dusky posterior portion of prosternum, and brown antero-lateral portions of mesosternum.

*Legs*—Trochanter and femur of foreleg, and distal half of tibia, yellowish brown. Basal half of tibia cream-yellow. Tarsus grey-brown, darker basally. Distal end of femur and both ends of tibia widely black. Joinings of tarsus narrowly blackish grey. Other legs cream-white, claws greyish.

*Wings*—No large dark blotches. Costal margin of forewing tinged with purplish brown. Cross veins in this area narrowly bordered with dark brown. Other cross veins of forewing, in areas which are centers of large blotches in wings of *E. varia*, bordered more widely with purplish brown. Wing thus appears clear except for four small brown clouded areas near the central disc and a somewhat larger one nearer the base. Longitudinal veins of forewing, and main cross veins, brown. Veins of costal area of hind wing yellowish, all others silvery white. Outer margin faintly and narrowly yellow.

*Abdomen*—Cream-white, segments 8-10 washed with yellow. Posterior margins of tergites grey, widest on 4-7. Tergites 1 and 2 with irregularly rectangular purplish grey patches, one on each side, halfway between median line and pleural fold. Curving purplish black pencilings arranged longitudinally on remaining tergites in this fashion. One on each side of median line, wider near anterior margin; laterad of each of these a second narrower line, fainter in color on tergites 3-6. On tergites 6-9, a short bar on each side is interposed between the median line and the darker longitudinal bar. This is faint on 6, distinct and extending almost to the posterior margin on 7 and 8. On 9, it extends only to the center of the tergites. On 7 and 8 the three bars on each side tend to run together posteriorly. On 9, the two outer bars are united into one dark streak. Besides these longitudinal markings, tergites 3-6 have three other blackish spots on each side. Two black dashes are present on the pleural fold, one near each lateral angle, and a third somewhat rounded spot nearer the center of the tergite and inward from the pleural fold. Pleural fold on 7-9 bordered with black, and a narrower black mark at the anterior angle of the fold on tergite 2.

Ventrally, purplish-black longitudinal pencillings are present, one on each side of the median line, on sternites 2-8. On sternite 1, two small dots, one on each side of the median line at the center. Sternite 9 has the median line purplish black except at the anterior and posterior margins, likewise two bars in the posterior half, in the same relative position as the dark pencillings on the other sternites. In addition, round brown dots occur, one on each side of the anterior end of the median dark line.

*Tails*—Olive brown, joinings dark brown. In places, only alternate joinings are thus darker than the segments of the tails.

*Genitalia*—Forceps base brown, forceps limbs grey. Quite similar to *E. simulans*, but the second joint of the forceps relatively longer and less curved than in that species. Third joint likewise somewhat longer proportionately. See Pl. 12, Fig. 15.

#### *Female imago*

*Head* and dorsal aspect of thorax much lighter brown than in male. Mesonotum cream except the anterior portion and the lateral borders. Thoracic pleura entirely cream, sternites white.

Foreleg silvery white tinged with yellow, blackish markings as in male. Other legs silvery, claws faint grey-lavender. Costal border of forewing lacking the brown wash characteristic of the male; the stigmatic area opaque white. Cross veins margined as in male, but more faintly. Only four indistinct purplish spots in central disc of wing, none toward base.

*Abdomen* cream-white. Tergite 1 entirely white; tergite 2 as in male. Tergites 3-9 marked somewhat as in male, with a double row of blackish pencillings on each side of the median line, forming thus four almost continuous black longitudinal streaks. On 8 and 9 appear faint marks nearer the median line, one on each side in the anterior half of each tergite. Ventrally very similar to male.

*Tails* very light tan. Near the base the first four joinings are brown, followed by a wide purplish black joining. For a distance the brown and purplish black joinings alternate. Distally the latter predominate.

Holotype—Male imago—French Broad River at Penrose, N. C., July 19, 1930. No. 1082.1 in Cornell University collection.

Allotype—Female imago—Cullasaja River south of Franklin, N. C., July 3, 1929. No. 1082.2 in C. U. collection.

Paratypes—Female subimago—Reared from nymph taken at South Toe River, near Micaville, N. C., July 6, 1930.

Male subimago, male imago and female imago—North Fork of Swannanoa River near Swannanoa, N. C., June 30, 1930. No. 1082.3-5 in C. U. collection.

*Distribution*—Rather general throughout the Appalachian region. Nymphs of this species were found burrowing in soft mud and ooze close to the banks of several different streams. On July 1 and 5, 1930, several were collected from the Rocky Broad River at Lecky Gap, not far from the town of Black Mt. Others taken were as follows. Davidson River, July 18, 1930; South Toe River near Micaville, July 6, 1930; North Fork of the Swannanoa River near Swannanoa, July 1, 1930; and immature nymphs at Little River near the town of Cedar Mt., July 12, 1930. Prof. Needham collected nearly mature nymphs, slightly larger than any from the above localities, at Horse Pasture River, on April 8, 1929. While these nymphs appear similar, there is a possibility that they are not *E. blanda*.

Adults of the new species *E. blanda* were usually taken only in the evenings at the lights of the automobile, when it was parked near the banks of a stream. Most of these were subimagoes, which were kept until they attained the imago stage. Dates and localities are as follows. Cullasaja River south of Franklin, July 3, 1929 (female taken while ovipositing); North Fork of Swannanoa River, June 30, 1930; South Toe River near Micaville, July 6, 1930; Toxaway River at Lake Toxaway, July 16, 1930; and at Penrose on the French Broad River, July 19, 1930.

Only one specimen was reared, a female subimago from a nymph taken at the South Toe River. This reared individual establishes the correct connection between nymphs and adults. It should be noted that the nymph slough does not show the black pencillings. This fact was observed also in the case of several nymphs which died just before completing their transformation to the subimago stage.

Considering the localities from which the nymphs and adults were taken,—rather small streams, well shaded by thick growths of trees on either bank, the water usually but a few feet in depth except for an occasional deeper hole,—it appears that *E. blanda* is rather similar in its habits to the species *E. guttulata*, an account of which is given by Dr. Kennedy. Its habitat is thus quite different from *E. simulans*, which is more commonly found in lakes or larger rivers.

GENUS *POTAMANTHUS* Pictet 1843-5; restricted, Eaton 1871

A few immature nymphs of this genus were taken in sandy riffles partly beneath or in the lee of large flat stones in the current of Laurel River, not far from Hot Springs, on June 29, 1930. When the sand was scooped up and held in the hand or placed on the tops of flat rocks above water level, the nymphs soon began to scramble out, and were thus easily located. Only three were found in the course of an hour's collecting. The water was quite shallow and warm where they were found.

As the nymphs were immature, they were placed at once in vials of alcohol. No other nymphs of this genus were found, and as none were reared, the species cannot at present be determined. A brief account of the characters of these nymphs is given, however, as they seem to differ from those of the species figured by Prof. Needham in his paper on Burrowing Mayflies.

*Potamanthus* sp? No. 1 (Immature nymphs)

Length of body of largest nymph,  $9\frac{1}{2}$  mm.; tails 6 mm. General color of body light straw yellow marked dorsally with chestnut brown. Irregular zigzag brown markings on head and dorsum of thorax. Mouthparts, as shown on Pl. 7, Figs. 22, 23 and 25. Legs barred with brown. See Pl. 7, Fig. 21. Dorsal pattern of abdomen varying somewhat on the different tergites, but rather typical on tergite 4, as shown on Pl. 7, Fig. 24. Gills cream colored, marked along main trachea with wide greyish lavender band. Fringes of same color. Tails cream colored, fringed with grey hairs. Ventrally without conspicuous markings of any sort.

A female subimago of the genus *Potamanthus* was taken at the lights of the automobile on June 30, 1930, from the North Fork of the Swannanoa River. On July 19, 1930, another female subimago was captured in similar fashion from the French Broad River at Penrose. The former died as a subimago, the latter successfully transformed to the imago stage. These females seem to be of the same species.

As yet, the females of the genus *Potamanthus* have not been sufficiently studied to make their identification positive, when no males of the same species are at hand. Of the five species recognized by Mr. Argo, and briefly discussed in his paper, none seem to correspond to the females from North Carolina. The infuscated cross veins of the fore wings of the N. C. species definitely prevent its inclusion in the species

*P. rufous*, *P. diaphanus*, or *P. myops*. The wing expanse—each fore wing measuring 13–14 mm.,—prevents its being placed with *P. verticis* or *P. flaveola* (these species, according to Dr. McDunnough, are synonymous). Dr. Banks, in his account of *P. medius*, makes no mention of the veins of the wings, but does speak of “a broad median reddish stripe on prothorax and vertex of head, and less distinctly on mesothorax.” As no such reddish stripe is present in the North Carolina form, it cannot be *P. medius*. The type specimen of *P. inequalis* cannot be located; Mr. Argo has considered it to be synonymous with *P. diaphanus*.

As all the previously described species of this genus would seem thus to be ruled out, the North Carolina form is probably a new species. It is briefly described here, but for lack of adequate material and the absence of males of the same species, is designated by number only.

### Potamanthus sp? No. 2

#### MEASUREMENTS

	BODY	TAILS	FOREWING	FORELEG
Female subimago.....	15	16	14	6½
Female imago.....	12	18	13	6½

#### Female imago

Body pale yellowish white.

*Head* and median area of mesonotum ivory white. Compound eyes black, distance between these equal to about 2½ eye diameters. Ocelli light pearl-grey, ringed basally with purplish-black.

*Thorax*—Pleura very faintly flesh-tinted, main sclerites very narrowly bordered with black. Posterior margin and spine of mesonotum likewise narrowly black-bordered.

*Legs*—Femur of foreleg faintly yellowish. Basal joints of tarsus washed with pale grey, the joinings narrowly brown. Other legs silvery white, tarsal joinings similar but even narrower.

*Wings*—Cross veins in central disc of both fore and hind wings, and more faintly those toward apex of forewing, margined narrowly with greyed lavender. Stigmatic area of forewing slightly opaque, remainder of both wings transparent. Longitudinal veins and unmargined cross veins silvery.

*Abdomen*—Eggs impart an orange to flesh-colored cast to the abdomen. Segments 9 and 10 washed with very pale yellow, more opaque than anterior segments. No distinct markings of any sort.

*Tails*—Silvery white, no different color at joinings.

*Female subimago*

Differs from the above only in these features. Entire body more definitely washed with pale yellow. Fore legs light straw yellow, claws reddish brown; joinings of tarsus reddish brown. Other legs paler yellow. Tails pale yellowish, very slightly darker at joinings. Fringed with yellow hairs.

## Subfamily BAETINAE

My collections from North Carolina include two new genera in this subfamily, namely *Oreianthus* and *Neocloeon*. Other genera represented are; *Baetisca*, *Leptophlebia*, *Habrophlebia*, *Habrophlebiodes*, *Blasturus*, *Ephemerella*, *Caenis*, *Eurycaenis*, *Tricorythus*, *Siphonurus*, *Siphloplecton*, *Isonychia*, *Ameletus*, *Baetis*, *Pseudocloeon*, *Centroptilum*, *Acentrella* and *Callibaetis*.

## GENUS OREIANTHUS Traver 1931

An account of this genus, and of the single species, *Oreianthus purpureus*, at that time known in the genus, appeared in the Canadian Entomologist 63, in May 1931. The genus is particularly interesting in that the nymph is very close to *Caenis*, and is apparently the same genus, though a different species, as that described by Joly from the Garonne River, France, in 1871; while the imago falls, by reason of its wing venation, close to the subfamily Ephemerinae. The general appearance of the imago, other than the venation, is as close to certain members of the subfamily Baetinae as to the Ephemerinae, and I think it is more closely allied to the former than to the latter group.

On Pl. 5 the distinctive features of this genus, both nymph and adult, are presented. It should also be mentioned that since the appearance of the account of the genus, another species of the genus, nymph only, has been sent to the Cornell University collection by Prof. P. W. Fattig, of Emory University, Ga. This nymph will be described in a later paper. *Oreianthus purpureus* is also represented among Prof. Fattig's material, and a new record for its occurrence in North Carolina is a specimen taken by Dr. J. S. Gutsell, of the Bureau of Fisheries at Beaufort, N. C., in the Tuckaseegee River, on Oct. 22, 1930. The female imago of *O. purpureus* measures 16 mm., male imago not known.

I should like also to call attention to the fact that through an error, a wrong type number was assigned to the species *O. purpureus*. The correct type number for this species is 1002, in the Cornell University collection.

## GENUS NEOCLOEON Traver 1931

The description of this genus, and of the single species *Neocloeon alamance*, will appear in a forthcoming issue of the Journal of the N. Y. Entomological Society. On Pl. 6 are presented the main characteristics of this genus, both nymph and imago. It is close to *Cloeon*, *Pseudocloeon*, and the several other genera allied to these two. The nymph possesses three tails; the labial palp is dilated at the tip, as in *Centroptilum*; the gills are single, the inner margin prolonged into a lobe so that the shape of each gill is asymmetrical; the tracheae branch pinnately, but all branches are unilateral on the inner side. The imago lacks the second pair of wings; intercalaries of the fore wing are single; the genitalia are rather close to some species of *Centroptilum*. The male imago of *N. alamance* measures 5-6 mm.; the female, 5½-7 mm.

## GENUS BAETISCA Walsh 1862

**Baetisca carolina** Traver

This species was described in the Journal of the N. Y. Entomological Society 39, March, 1931. The nymph differs from that of *B. obesa* Say in the absence of dorsal spines on the mesonotal shield, and in the greater length of the maxillary palp. The dark areas of the wings of the subimago are more extensive than in *B. obesa*. Hind wing almost entirely, and fore wing basally, flushed with bright orange. Easily distinguished from *B. rubescens* Prov., in which the wings are flushed with reddish, by its much larger size. Male imago measures 8½-10 mm.; female imago, 8-10½ mm.

This species is represented in my collection only from the piedmont area, where it was taken in two different stations in the vicinity of Greensboro. Later, Dr. J. S. Gutsell obtained a nymph of this species from the Tuckaseegee River in the western part of the state.

## GENUS LEPTOPHLEBIA Westwood 1840; restricted, Etn. 1881

**Leptophlebia moerens** McD.

Mature nymphs of this species were found in a small stream in the outskirts of Greensboro, on April 13, 1930. Many more were taken at the same stream three days later, several of these transforming the same day. The remainder transformed between this date and April 27. Examination of the genitalia of the male imagoes shows this species to be *L. moerens*.

**Leptophlebia guttata** McD.

Male imagoes of this species were picked out of a spider's web over a small tributary of one branch of the Pigeon River between Waynesville and Hazelwood, and others caught in their noonday 'dance' above the same stream, on July 18, 1929. A nymph taken from this stream two days later died without transforming. It has the long maxillary palp and other structural features of the species *L. guttata*, to which species the imago males also belong. The labial palp of this nymph is shown on Pl. 7, Fig. 14. The molar surfaces of the mandibles are unusually well developed; see Pl. 7, Fig. 20. Another nymph of this species was taken near Swannanoa on June 15, 1930.

**Leptophlebia debilis** (?) Wlk.

An immature nymph, taken in Big Alamance Creek on Oct. 19, 1929, is referred to this species, on the basis of its mottled abdominal tergites, the structure of the gills, the dark bands on the legs and the mouthparts. No imagoes of this species were secured.

**Leptophlebia swannanoa**, sp. nov.

Nymphs of this species were first found in considerable numbers in the North Fork of the Swannanoa River, near Black Mt., on June 14, 1929. They were not yet fully mature. In 1930, mature nymphs were taken from this stream on June 12, and again on June 14, and reared to the imago stage. Several of these transformed on June 15. The species proves to be a new one, allied to the "mollis-adoptiva" group. Gills of the nymph most resemble those of *L. adoptiva*, while the mouthparts are more like those of *L. mollis*, but with the canines of the mandibles much more highly developed. The genitalia of the male imago differs somewhat from *L. mollis*, but bear a general similarity to this species.

Nymphs of *L. swannanoa* were taken at a number of other streams in the Appalachian region during the summers of 1929 and 1930. These localities are as follows. The Ocona Lufty River near Cherokee, July 2, 1929; the Cullasaja River thirteen miles south of Franklin, July 3, 1929; a small tributary of the Pigeon River near Hazelwood, July 15, 1929; Davidson River in the Pisgah National Forest, near the town of Pisgah Forest, June 20, 1930; a tributary of the French Broad River at Selica, July 13, 1930; and a small tributary of the Davidson River, July 19, 1930. Imagoes were obtained only by rearing nymphs from the North Fork of the Swannanoa River.

It is interesting to note that *L. assimilis* Bks. was taken from the North Fork of the Swannanoa River in the month of May. However, Dr. Banks' statement that his species is "very close to *L. praepedita*" would seem to indicate that the new *L. swannanoa* cannot be synonymous with *L. assimilis* Bks.

## MEASUREMENTS

	BODY	TAILS	FOREWING	FORELEG
Male nymph (9 specimens).....	4½-5	2-2½		
Female nymph (11 specimens).....	4½-5½	2-4		
Male subimago (1 specimen).....	4½	4	5½	2
Male imago (1 specimen).....	5	6½	5½	5
Female imago (2 specimens).....	5	4	5½	1¼-2½

Nymph distinguished readily by the great overdevelopment of the canine area of the mandibles. Gills with tracheoles. Male imago with abdominal segments 2-7 white, unmarked except for dark stigmatic dashes. Genitalia very similar to *L. mollis*.

*Nymph*

General color reddish brown.

*Head*—Light reddish brown. Middle ocellus much smaller than lateral ones. A large white spot laterad of each lateral ocellus, a small white spot anterior to median ocellus. Head square, the large mandibles with their greatly developed canines being very prominent. See Pl. 7, Figs. 2 and 12 for mouthparts. Four pectinate hairs below crown of maxilla. Median line of clypeus white. Antenna dark brown at base, remainder light brown. Maxillary palp barred with dark brown.

*Thorax*—Reddish brown, slightly darker than head. Median line of pronotum narrowly, and lateral margins widely whitish. Median line of mesonotum white, also three indistinct spots; one laterad and anterior of the mesonotal spine on each side, the third on the mesonotal spine. Pleura white between the sclerites. Very light brown ventrally.

*Legs*—Light brown barred rather indistinctly with darker brown. A wide bar on the distal half of the femur, a narrower band at proximal end of the tibia, and a darker wide band on the basal half of each tarsus. Claws with teeth along inner margin.

*Abdomen*—Dark reddish brown dorsally, light brown ventrally. Tergites darker near pleural fold on each side, and indistinctly mottled with grey-brown on each side of median line, which is faintly lighter.

A dark grey bar on each side of each sternite, near the pleural fold; on sternite 1, this forms rather a large spot. A rather short postero-lateral spine on 9, none on segment 8.

*Gills*—With tracheoles, branched about one-third from the base. See Pl. 7, Fig. 6a, for appearance of gill.

*Tails* light brown.

#### *Male imago*

Very similar to *L. mollis*. Distinguished from this species by the black stigmatic dashes on the abdomen and the lack of an opaque cloud in the stigmatic area of the forewing.

*Head*—Brown. Antennae light tan. Ocelli grey. Upper part of compound eye orange-brown; lower part bluish black.

*Thorax*—Dark reddish brown. Darker area at posterior border of pronotum, on each side of the median line, and at postero-lateral angles. Mesonotum bordered narrowly with darker brown. Center of mesonotum somewhat lighter brown.

*Legs*—Silvery white, except coxa, trochanter and femur of foreleg, which are slightly washed with yellow.

*Wings*—Transparent, slightly iridescent. All veins silvery white. No opaque area in stigmatic area of forewing, as in *L. mollis*.

*Abdomen*—Tergite 1 dark brown, with saddle-shaped yellow marking in anterior half, not reaching to pleural fold on each side. Sternite 1 yellowish brown except next to pleural folds, where it is dusky brown. Segments 2-6 translucent silvery white, with only a faint dark mark in the pleural fold at the stigmatic area. Segment 7 opaque, yellowish white; posterior margin of 7th tergite yellowish brown. Segments 8-10 dark reddish brown, darker along pleural folds.

*Tails*—Silvery white.

*Genitalia*—Of the "mollis-adoptiva" type, quite similar to *L. mollis*. See Pl. 7, Figs. 3 and 13, for side and ventral views.

#### *Female imago*

*Head*—Yellowish. Ocelli grey, ringed basally with black. Compound eyes black.

*Thorax*—Pronotum yellowish in anterior center, light greyish brown elsewhere. Darker oblique bar from postero-lateral angle forward and inward, reaching anterior margin on each side of the median line. Mesonotum light reddish brown except for a yellowish streak forward from the wing roots. Metanotum and pleurites somewhat darker red-

brown. Prosternum yellowish, with grey patch on each side from inner base of leg almost to median line. Center of anterior half of mesosternum yellowish; posterior half rather dark brown.

*Wings* as in male.

*Legs* entirely silvery white.

*Abdomen*—Reddish brown, somewhat lighter ventrally. Segments 8-10, and sternite 1, greyish brown. Pleural fold white. A dusky line parallel and adjacent to this white border on each tergite. Tergites 2-7 with indistinct lighter pattern; from anterior border on each side of median line a backward-directed mark reaching about to the center; median line itself lighter. An irregular lighter patch on each side, halfway from median line to pleural fold on the anterior border, extending backwards three-fourths of the tergite. Large yellowish patch on 9, occupying most of each side of the tergite from the anterior border. Smaller patch in same position from posterior border, the two light areas separated by a grey band. Sternites dusky on each side next to pleural fold, and a darker area in center of posterior margin of 7. See Pl. 7, Fig. 11, for shape of posterior margin of 9th sternite.

*Tails* as in male.

#### *Male subimago*

Darker than male imago, the abdomen greyish brown in portion which is silvery white in imago. Legs faintly yellowish, tarsi faintly greyed. Tails silver-grey, joinings faintly and narrowly brown.

*Holotype*—Male imago—Reared from nymph. North Fork of Swannanoa River, N. C., June 15, 1930. No. 1083.1 in Cornell University collection.

*Allotype*—Female imago—Same data. No. 1083.2 in C. U. collection.

*Paratypes*—Female imago and male subimago—Same data. No. 1083.3-4 in C. U. collection.

#### *Leptophlebia* sp? No. 1.

Several immature nymphs which are unlike any of the eastern species thus far described were taken near Swannanoa on June 15, 1930. Others, apparently similar, were collected from Pinedale, near Greensboro, on April 24, 1930. Dr. J. S. Gutsell took nymphs that appear to be the same from Scott's Creek on April 8, 1930. A brief description of one of the nymphs from Swannanoa follows.

Uniformly brown. Body 6 mm.; tails  $3\frac{1}{2}$  mm. additional.

*Head*—Small light spot anterior to median ocellus, a larger one between the lateral ocelli. Vertex marked with black. Maxilla as on Pl. 7, Fig. 10. Labium and maxillary palp similar to *L. mollis*. Three pectinate hairs below crown of maxilla, as contrasted with five in *L. mollis* and four in *L. adoptiva*. Mandibles show no unusual features.

*Thorax*—Pronotum margined posteriorly and laterally with white. Legs not banded, but femur slightly darker in its distal third. Claws with spines.

*Abdomen*—Gills with tracheoles. Branched about three-sevenths from the main trachea. Fifth gill as on Pl. 7, Fig. 6. Postero-lateral spines present on segments 8 and 9, longer on 9.

*Tails*—Pale, faintly brown at joinings.

#### OBSERVATIONS ON THE MANDIBLES OF LEPTOPHLEBIA

Certain species of the genus *Leptophlebia* exhibit unique developments of the canine area of the mandibles. A tendency toward an enlargement of this region is noticeable in *L. adoptiva* (see Pl. 7, Fig. 16). In *L. mollis* this tendency has been carried much further (see Fig. 17). In *L. swannanoa* it seems to have reached its height (see Fig. 12, same plate). At first glance it might seem that the tusked mandible of the western *L. packii* Needham was the ultimate expression of this tendency. But in this species, it is the outer canine only which has become enlarged and elongated, the inner canine and lacinia remaining unmodified. Since *L. packii* falls into the 'moerens-guttata' group, and the three species first mentioned are of the 'mollis-adoptiva' group, it seems probable that the modifications of the former are the result of an independent line of development.

#### GENUS HABROPHLEBIODES Ulmer 1920

##### *Habrophlebiodes americana* Bks.

In the piedmont area, this species was found at one station only,—the Cascades, on a small stream tributary to the Dan River, near Danbury, N. C. This is in the Sauratown Mts. Nymphs taken here on May 12, 1929, were successfully reared to imagoes, which transformed on May 24.

In the mountain area of the state, imagoes were taken from a spider's web over a tributary of Wayah Creek, near Franklin, on July 2, 1929. Near Penrose, on July 8, 1930, two imagoes were taken in flight over a small spring-fed stream.

The nymph of *Habrophlebiodes* is strikingly similar to that of a *Leptophlebia*. The structure of the gills is like that of a *Leptophlebia* of the 'adoptiva-mollis' group. Mouthparts are in the main of the *Leptophlebia-Blasturus* type. Certain slight differences may be noted. The labrum is more deeply cleft on the fore margin than in *Leptophlebia*. Large hairs or spines are present below the crown of the maxilla, pectinate and set in circular bases as in *Leptophlebia* and *Blasturus*. They differ slightly from most of those of the above genera in extending upward from the base and then turning sharply outward at right angles to their previous course. The labial palp resembles *Habrophlebia* more than *Leptophlebia*, the third joint being short and somewhat conical. The second and third joints together are about as long as the first. A row of teeth is present on the inner margin of each claw. Abdominal segments 8 and 9 bear postero-lateral spines, that on 9 being somewhat the longer. Tergites 7 to 9 are margined posteriorly with relatively long spines. Mrs. Morrison has described this species as *Leptophlebia betteni*, and figured the gills and mouthparts, in the *Canadian Entomologist* 61:139-146.

Although the nymph is thus so similar to *Leptophlebia*, the peculiar hind wing of the imago and the ovipositor of the female probably justify its position in a separate genus.

#### GENUS HABROPHLEBIA Etn. 1881

Along with *Habrophlebiodes*, a few nymphs of *Habrophlebia* were taken on May 12, 1929, at the Cascades, in the Sauratown Mts. near Danbury. One of these, a male, transformed to the subimaginal stage on May 14, but died before becoming an imago. Examination of the genitalia of this specimen shows that it differs considerably from *Habrophlebia vibrans* Needham, the only other species of this genus thus far described from eastern North America. A new species, *H. pusilla*, is therefore proposed for this North Carolina form. It is to be noted that the species described by Banks from near Black Mt., N. C., as *H. jocosa*, has been determined by McDunnough as identical with *H. vibrans*.

#### *Habrophlebia pusilla*, sp. nov.

##### *Nymph*

Described from nymph slough.

Length of body, 6 mm.; outer tails,  $4\frac{3}{4}$  mm.; middle tail, 6 mm.

General color, light brown. No definite markings on body, other than a rather indistinct darker mid-ventral line on sternites 4-7.

*Mouthparts*—Very similar to those of *H. fusca*, as figured by Eaton in the *Revisional Monograph*, Pl. 36. Maxillary palp three-jointed, the distal joint shortest. Four to five large pectinate hairs below the crown of the maxilla, instead of seven as shown in *H. fusca*. Four spines or hairs at upper portion of inner margin, the second of these pectinate. Third joint of labial palp slightly shorter than the second. The second and third together are about equal to the first. Mandibles with three outer and three inner canines. Upper portion of lacinia comb-like. See Pl. 7, Figs. 4, 5, 7, 15 and 26.

*Legs*—Tibia and tarsus of each leg yellowish brown.; femur brown. No dark bands. Joinings narrowly darker. Tarsus of foreleg very slightly, and tarsi of other legs considerably, shorter than their respective tibiae. Claws with a row of teeth along inner margin, and near the distal and extending up on the side. Thirteen teeth on claw of foreleg.

*Abdomen*—Posterior margins of tergites set with short teeth or spines. Postero-lateral spines on tergites 8 and 9, that on 9 being somewhat the longer.

*Gills*—Each main trachea divides into two branches, each of which is soon subdivided into three parts, except gills of segments 1 and 7, in which one branch has but two subdivisions. First and fourth gills as in Pl. 7, Figs. 18 and 19.

*Tails*—Middle tail longer than outer ones. Light brown in color. Short hairs at each joining. In addition, in basal region each joining is margined with short blunt teeth or spines. Joints become progressively longer from base toward tip.

#### *Male subimago*

*General color* dark brownish. (Specimen was boiled for a few seconds in KOH, which changed its color to reddish brown. Markings were recorded before the specimen was boiled, but measurements taken afterwards.)

*Length of body*, 4 mm.; tails, 4 mm.; foreleg  $2\frac{3}{4}$  mm.; forewing  $4\frac{3}{4}$  mm.

*Antennae* brown at base, filament greyish.

*Legs*—Fore femur and distal end of tibia reddish brown; remainder of foreleg very light brown. Other legs greyish white, joinings very light brown.

*Wings*—See Pl. 3, Fig. 8, for hind wing. Wings light grey, no trace of amber near the base.

*Abdomen*—Large white patches near centers of tergites 3–6. On tergites 7 and 8, whitish lines parallel to and near the pleural folds. Sternites lighter brown than the tergites, without definite markings.

*Tails*—Greyish white.

*Genitalia*—Ventral view as in Pl. 7, Fig. 1. Side view, Fig. 9. Penes seemingly narrower than in *H. vibrans*. The appendages from these are much longer than in *H. vibrans*, reaching backward almost to the posterior margin of the 9th sternite. In ventral view these somewhat resemble the beaks of stork-like birds.

Holotype—Male subimago—Reared from nymph, May 14, 1929.

Taken at the Cascades near Danbury, on a tributary of the Dan River. No. 1084.1 in C. U. collection.

### GENUS BLASTURUS Eaton 1881

#### *Provisional Key to Male Imagoes of Blasturus*

1. Wings with definite brown cloud occupying the apical third of the forewing  
*B. nebulosus*  
Fore wings without any such brown cloud in the apical third..... 2
2. Stigmatic area of forewing clouded with brown.....*B. cupidus*  
Forewing without dark cloud in stigmatic area..... 3
3. Middle tail equal to outer tails in length. Abdominal segments 3–6 translucent white. Forceps limbs four-jointed, the third joint inflated distally.  
Small species, 5–7 mm. in length.....*B. gracilis*  
Middle tail distinctly shorter and weaker than outer ones. Abdominal segments not as above. Forceps limbs three-jointed, rarely a partial fourth joint. Larger species, over 8 mm. in length..... 4
4. Large species, 11½ to 14 mm. in length. Penes of the "scarf" type, appendages reaching to the sinus between the limbs of the penes.....*B. grandis*  
Smaller species, 9 to 11½ mm. in length. Penes of the "hooded" type, appendages not reaching to the sinus between the limbs of the penes  
*B. austrinus*

#### *Provisional Key to Blasturus Nymphs*

1. Legs distinctly banded..... 2  
Legs not banded, or with indistinct bands..... 4
2. Medium to large species, 9–16 mm. in length. Six to seven large pectinate hairs just below the crown of the maxilla..... 3  
Smaller species, 7 to 9 mm. in length. Four large pectinate hairs just below crown of maxilla.....*B. intermedius*
3. Medium-sized species, 10–12 mm. in length. Pronotum with black markings  
*B. austrinus*  
Large species, 11½ to 16 mm. in length. Pronotum without black markings  
*B. grandis*

4. First pair of gills with no lateral tracheal branches extending out from the two main divisions. No white marks on venter of abdomen. Small species, 5 to 7½ mm. in length. . . . . 5  
 First pair of gills with lateral tracheal branches arising from each of the two main divisions. Venter of abdomen with four white marks near the median line. . . . . 6
5. Lower gill of third pair with the lateral lobes at the tip of the gill plate unequal. Spinous extension of the 8th abdominal segment slightly shorter than that of the 9th segment. Extension of median trachea of upper gill of third pair equal to or exceeding the gill plate in length. . . . . *B. sp. No. 2*  
 Lower gill of third pair with the lateral lobes at the tip of the gill plate approximately equal. Spinous extensions of 8th and 9th segments about equal in length. Extension of median trachea of upper gill of third pair shorter than the gill plate proper. . . . . *B. gracilis*
6. Uppermost gill of third pair with the median extension of the main trachea as long as or longer than the gill plate proper. Lateral lobes at tip of lower gill of third pair unequal in length. . . . . *B. nebulosus*  
 Uppermost gill of third pair with the median extension of the main trachea shorter than the gill plate proper. Lateral lobes at tip of lower gill of third pair may be equal or unequal. . . . . 7
7. Lateral lobes at tip of lower gill of third pair unequal in length. 5 to 6 large pectinate hairs below the crown of the maxilla. . . . . 8  
 Lateral lobes at tip of lower gill of third pair equal or approximately equal in length. 6 to 7 large pectinate hairs below crown of maxilla. . . . . 9
8. Fore claw with about 20 teeth on inner margin, 8 in upper row. Spinous extension of 8th abdominal segment approximately equal to that of the 9th  
*B. collinus*  
 Fore claw with 16 to 17 teeth on inner margin, 5 in upper row. Spinous extension of 8th segment shorter than that of the 9th. . . . . *B. sp? No. 1*
9. Spinous extensions of 8th and 9th abdominal segments about equal in length, both being long, slender and sharp-pointed. The 9th extends beyond the center of tergite 10. Fore claw with 8 teeth in upper row, 20 to 21 on inner margin. . . . . *B. austrinus*  
 Spinous extension of 8th segment shorter than that of the 9th. The latter rather blunt, not reaching to the center of tergite 10. Fore claw with 3 to 4 teeth in upper row, about 14 on inner margin. . . . . *B. cupidus*

#### *Distribution in the state*

Many nymphs of this species were found, in all three of the major geographical divisions of the state. They were most numerous, however, in the piedmont area. From nymphs collected in the piedmont, many adults were reared, and three new species established for this section of the state. Two species of nymphs collected from tributaries of the Cape Fear River in the coastal plain region proved also to be new. Prof. Needham collected several subimagos in Lenoir Co., in the coastal plain, two species of nymphs and a few adults from near High-

lands, in the Appalachian region. The three species from the piedmont, one from the mountains and one from coastal plain are named and described herewith, while the other two, for lack of adequate material, are designated by numbers only, and their chief characteristics indicated. Neither *B. cupidus* Say nor *B. nebulosus* Wlk. are represented in the collections from any part of the state. It is quite possible that the new *B. austrinus* is the species placed by Eaton under *B. cupidus* and designated as the 'variety from North Carolina.' The description of the western species *B. gravestellus* Etn. does not seem to apply to any of the North Carolina material.

### Generic characters

*Blasturus* has been separated from *Leptophlebia* heretofore, as regards the imago stage, by the shorter middle tail of the former. In the new species *B. gracilis*, however, the middle tail *nearly or quite equals the lateral ones* in length. The gills of the nymph are of the *Blasturus* type. In the American species of *Leptophlebia*, the genitalia differ quite markedly from those of the known species of *Blasturus*. In the European *L. marginata* and *L. vespertina*, however, the genitalia are strikingly similar to some species of *Blasturus*, particularly of *B. gracilis*. A comparative and rather detailed study of the genera *Blasturus* and *Leptophlebia* would seem to be advisable. It is suggested that wing characters may prove useful in this respect, both as to venational differences and as to relative shape and size. Both fore and hind wings are wider in proportion to length than in *Leptophlebia*, the anal angle of the fore wing better developed. Cross veins in the costal cell before the bulla are very faint and indistinct, those in the apical third of this space are well developed and often anastomose. The hind wing of *Blasturus* has many more cross veins and marginal intercalaries than in *Leptophlebia*, the entire lower half of the wing being better developed.

Nymphs of *Blasturus* differ from those of *Leptophlebia* principally in the structure of the gills, the second to sixth pairs of which in *Blasturus* are lobed at the tips, while all seven pairs in *Leptophlebia* are more slender, simple and not lobed at the tips.

The claws of *Blasturus* have, in addition to the row of teeth along the inner margin, an extra upper row of teeth along one side, which teeth are not present in any *Leptophlebia* examined. Mouthparts of *Leptophlebia* vary greatly in the different species, while those of all the known species of *Blasturus* are so constant as to be of little or no use in classification.

*Specific characters*

Both as to nymphs and imagoes, the genus *Blasturus* is a difficult one to separate into its component species. Structural differences are minor and difficult to recognize until some time is spent in studying the group as a whole. Color differences exist, but are likewise minor and relative, and are an unsatisfactory basis for the separation of species. The combination of several minor and relative characters for each species is the best the writer is able to offer at the present time.

*Nymphs*

The number of teeth along the inner margin and in the upper row on the claws varies in different species, and within certain limits may be useful in distinguishing one from another. Gills of the first, third and seventh pairs have been studied, and those of the third pair figured, as a possible aid in identification. Large pectinate spines just below the upper margin of the galea-lacinia, each set in a circular base, have been found to vary in number in different species. While the other very numerous and much smaller spines on the crown of the maxilla are likewise pectinate, they are not set definitely in such prominent basal structures. Color patterns of head, thorax and abdomen, while more or less uniform throughout the genus, occasionally differ enough to mark off a definite species. Differences in color of mature nymphs as to the sexes must not be overlooked, as these may differ from the immature forms. At least two species may usually be separated by the distinct bars of darker color on the legs.

*Imagoes*

Imago males may be separated by differences in the genitalia, color differences of legs, body and tails, and sometimes by wing markings. Female imagoes show slight differences in the structure of the cleft plate which forms the apex of the ninth sternite. The male genitalia differ (1) in number and relative length of forceps joints; (2) in appearance of tip and outer margin of penes; and (3) in length and appearance of the elongated processes of the penes. As to length, in some species the tips of these processes, when fully extended as when mounted on a slide, do not reach as far as the sinus between the two parts of the penes. In other species, they reach to or beyond this sinus. One type of the penes processes forms a "hood" over the tips of the penes; a second type turns back and upward upon itself, giving the effect of a cape, or a scarf thrown over the shoulder. In one species, a definite indentation or sinus

is present on the outer margin of each portion of the penes; this is associated with the "scarf" type of processes, which are likewise as long as or longer than the sinus. In one species the forceps, which are usually three-jointed, are regularly four-jointed, and occasional specimens in other species show this same condition. Other variations will be noted in accounts of the species.

*From the Appalachian region*

Prof. J. G. Needham collected several *Blasturus numphs* and a few adults from Mirror Lake and Harbison's Pond, near Highlands, N. C. Two species are represented in this material, both of them apparently new. One is described here as *B. collinus* n. sp.; the other, represented by nymphs alone, is designated as *B. sp?* No. 1. No other representatives of this genus were taken from the Appalachian region of the state.

***Blasturus collinus*, sp. nov.**

MEASUREMENTS

	BODY	OUTER TAILS	INNER TAILS	FORELEG	FORE- WING
Male nymph (5 specimens).....	8½-9½	8	11		
Female nymph (6 specimens).....	9-10½	9-10	10		
Male subimago.....	9½	Broken	Broken	5½	9
Female imago.....	10	17	Broken	Broken	9½

A medium-sized species, reddish brown in color in all stages.

*Nymph*

*Head*—Black between ocelli. Vertex mottled with black. Lighter brown laterad of lateral ocelli and forward from median ocellus, also on inner margin of compound eyes. Remainder of head dark brown. Five to six large pectinate hairs below the crown of the maxilla.

*Thorax*—Six white marks on pronotum. One on each side on anterior margin, halfway to lateral border. One on each side of median line, slightly back of anterior margin. A larger crescentic mark on each side near the lateral margin and somewhat parallel to it. Two indistinct small light areas above each wing root, on mesonotum.

*Legs*—Light red-brown, slightly darker at joinings. Not banded. Fore claw with about 20 teeth on inner margin, and 8 in the upper row.

*Abdomen*—Groundwork of tergites red-brown, with grey-brown W-shaped markings and lateral extensions from these. A yellowish mark

on each side of median line at anterior margin of each tergite. See Pl. 8, Fig. 18b. Ventrally, lighter red-brown. Each sternite with four white marks in the characteristic position, and on each side a dark bar parallel to and near the pleural fold. Female nymphs darker than males, both dorsally and ventrally. Spinous extensions of segments 8 and 9 approximately equal in length.

*Gills*—For gills of third pair, see Pl. 8, Fig. 9.

*Tails*—Reddish brown, slightly darker at joinings. Alternate joinings wider.

#### *Male subimago*

*Body*—Dark reddish brown, lighter ventrally.

*Head*—Blackish on vertex.

*Thorax*—Very dark brown dorsally. Pronotum narrowly bordered posteriorly with light brown. A longitudinal stripe of light brown on each side of mesonotum. Pleurites somewhat lighter than dorsal aspect. Ventrally dark red-brown.

*Legs*—Light red-brown, joinings slightly darker. Tarsi of second and third pairs greyish brown.

*Wings*—The submarginal cuticle was removed from one of the wings. No stigmatic cloud nor other dark area is present on the wing of the imago thus exposed. Veins in the stigmatic area show considerable anastomosis. Longitudinal veins, and cross veins on upper half of fore wing, light brown. All others faintly greyish to hyaline.

*Abdomen*—Very dark brown dorsally, somewhat lighter ventrally. Each tergite with a yellow mark from the anterior margin on each side of the median line, reaching to about the middle of the sclerite. Each is also narrowly bordered posteriorly with yellow. Ventrally, the ganglionic areas are yellowish brown. A dark spot on each side of median line at center of sternite 1. A narrow indistinct dark bar on each side of each sternite near pleural fold. Each sternite shows faint white markings near the median line, as in the nymph.

*Tails*—Dark red-brown, blackish at joinings. Alternate joinings wider.

*Genitalia*—See Pl. 8, Fig. 6.

#### *Female imago*

Light reddish brown, somewhat darker on dorsal and ventral aspects of thorax, and the markings of the abdominal tergites. Sternites of abdomen yellowish red. Sternites unmarked, except that the ganglionic area is faintly outlined on each. Wings as in male, except that the stigmatic

area is faintly opaque, and the veins of the fore wing and the upper half of the hind wing are yellowish brown. Tails yellowish white, joinings light red-brown. Alternate joinings wider. See Pl. 8, Fig. 1b., for appearance of apical margin of 9th sternite.

Holotype—Male subimago—Taken at Mirror Lake, near Highlands, N. C., on April 7, 1929, by Prof. Needham. No. 1078.1 in Cornell collection.

Allotype—Female imago—From Harbison's Pond, near Highlands, April 5, 1929. Same collector. No. 1078.2 in C. U. collection.

Paratypes—Five nymphs—Same data as for female imago. No. 1078.3-7 in C. U. collection.

### *Blasturus* sp? No. 1

Nymphs greyish brown; very close to *B. cupidus* in general color but differing from this species in the number of large pectinated hairs on the maxilla, the number of teeth on the fore claw, and somewhat in the structure of the gills.

*Size*—Male nymphs,—body 8-9½ mm. Female nymphs, body 9-10 mm. In all the specimens the tails were broken.

*Head*—Whitish areas near ocelli quite prominent, especially the streak extending forward from the median ocellus. A few black reticulations on vertex of head.

*Thorax*—Light areas on pro-and mesonota, as in *B. collinus*. In addition, a few small black marks on the pronotum.

*Legs*—Femora light reddish brown, tibiae and tarsi yellow-brown. Faintly darker at joinings.

*Abdomen*—Light marks, one on each side of median line at anterior margin, on tergites 4-8, often rather indistinct. Tergites 1-3, and 9, usually without markings. Tergite 10 lighter in color, and with median and two lateral darker streaks. Ventrally, four lighter spots near center of each sternite and the dusky bar near the pleural fold present, but rather indistinct.

*Tails*—Light brown, darker at joinings. Alternate joinings wider.

### *From the piedmont region*

Specimens taken from the piedmont fall into three new species. A large form, *B. grandis*; a somewhat smaller *B. austrinus*; and the very small *B. gracilis* are recognized in this material and described as new species.

*Blasturus grandis*, sp. nov.

## MEASUREMENTS

	BODY	OUTER TAILS	INNER TAILS	FORE-WING	FORE-LEG
Male nymph (9 specimens).....	11½-14	11-14	11-14		
Female nymph (7 specimens).....	11½-16	13-18	13-19		
Male imago (9 specimens).....	11-13	20-28	10-14	10-12½	8½-11
Female imago (6 specimens).....	12-15	14-18	11-14	11-13½	5½-7

This is a large species, the abdomen of the male imago being predominantly yellowish with grey markings dorsally and no distinct ventral markings. Genitalia with rather deep incisure on outer margin on each side of the penes. Considerable variation in both size and color.

*Nymph*

*Head* reddish brown. Vertex and occiput mottled with black. Space between ocelli black. Yellowish white spots laterad of lateral ocelli, yellowish streak, extending to margin of labrum, forward from median ocellus. Six to seven large pectinate hairs just below crown of maxilla.

*Thorax*—Four white spots on each side of prothorax. See Pl. 8, Fig. 3a. Several small white spots anterior to each wing root, on mesonotum. *Legs* prominently barred with brown (in a few specimens, barring rather indistinct.) Femur with broad bar one-third from distal end; tibia brown at basal end and in center; tarsus with wide basal and narrow distal band. About 20 teeth along inner margin of fore claw; 9-10 teeth in upper row.

*Abdomen*—Dorsally dark brown in mature female, yellowish brown in male. A white crescentic spot on each side of median line of each tergite near center. Two (sometimes three) white marks, separated by a darker bar, on each side near pleural fold. Median dorsal line dark. In male, a triangular yellowish mark projects forward from the posterior border on each side, between median line and pleural fold. In this sex also, tergites 9 and 10 are predominantly yellow. Ventrally, male yellow, female dark red-brown. Rather indistinct whitish marks on each sternite; four grouped near center, one on each side near pleural fold.

*Gills*—of third pair as on Pl. 8, Fig. 13.

*Tails* of female dark red-brown, of male yellow-brown. Joinings of each dark brown, alternate joinings near the base being wider.

A species somewhat smaller than *B. grandis*, and darker in color, but not as dark as *B. cupidus*. Faint brownish stain in stigmatic area of fore wing of male imago. Considerable variation in color, in all stages. Light-colored males very similar to *B. grandis*. Darker forms show two dark bars on each sternite, one on each side of the medial line, projecting backwards from the anterior margin, as in *B. cupidus*. This species may be the "variety from North Carolina" placed by Eaton under *B. cupidus*.

### Nymph

A light reddish-brown form, abdomen marked dorsally with yellow. *Head*—As in *B. grandis*. Six to seven large pectinate hairs below the crown of the maxilla.

*Thorax*—Pro- and mesonota marked with black, leaving light areas. See Pl. 8, Fig. 3c, for appearance of pronotum.

*Legs*—Yellow to light reddish brown. In fully-mature nymphs the tarsi are often dusky, and tibiae slightly darker than the femora. In some specimens, fairly distinct bars on the legs, as is typically the condition in *B. grandis*. More frequently the legs are entirely unbanded, or show very faint dusky marks as the location of the bands. Joints darker. Small triangular brown mark often present at distal end of femur; basal end of tibia likewise brown. 20 to 21 teeth on inner margin of fore claw; about 8 in upper row.

*Abdomen*—Dorsally, females with reddish brown background on each tergite, marked with yellow. Males, yellow to light red background, marked with brownish grey. For color pattern, see Pl. 8, Fig. 18a. Ventrally, four white marks on each sternite near median line. Larger pair just back of anterior margin, one on each side of center, directed slightly outward. Smaller pair nearer median line at center of sternite, parallel to this line and to each other. In males, a slender crescentic white mark may be present near the pleural fold. On each sternite a blackish bar parallel to and near the pleural fold. The white crescentic mark, when present, lies outside of this dark bar. In young nymphs, the dark bars are evident, but not the white marks.

*Tails*—Yellow in immature stages. In mature male nymph, outer ones dark red-brown. In female, all three are light red-brown. Joinings in every case dark reddish brown, wider alternately.

### Male imago

#### a. Light form

*Head*—Vertex light brown, darker on posterior margin. Basal joints

of antenna orange, filament grey. Upper portion of compound eye light orange.

*Thorax*—Pronotum dark brown, narrowly bordered with whitish on posterior margin, widely bordered on each lateral margin. Median line black, narrowly bordered with white. Meso- and metanota dark red-brown, margined narrowly with cream-white. Pleurites of meso- and metathorax dark brown, lighter between sclerites. Prothoracic pleurum light grey, with indistinct brown bar. Sternum dark red-brown except central portion of posterior sclerites of mesosternum, which are light brown.

*Legs*—Femur and tibia of fore leg light orange-yellow. Tarsus greyed yellow, coxa and dorsal aspect of femoro-tibial joint brown. Other joinings light brown. Other legs yellow, joinings light brown.

*Wings*—Translucent. Longitudinal veins of forewing and cross veins except in anal region, yellow-brown. All others greyish. Apical portion of stigmatic area of forewing somewhat opaque, but lacking a brown cloud. Tendency for cross veins in this area to be strongly anastomosed.

*Abdomen*—Very similar to *B. grandis*, except that the sternites are usually light brownish yellow, the basal half of 1 and 9 dark brown. Tergites narrowly bordered with yellowish white posteriorly. Differs from *B. grandis* principally in the presence of indistinct bars on each sternite, one on each side of median line, at anterior border. Ganglionic area usually greyish orange. A dark spot on each side of median line at center of sternite 1. A prominent greyish-brown bar, parallel to and near the pleural fold on each side, is constantly present. Posterior margin of each sternite greyish white.

*Genitalia*—Of the "hooded" type. No incisure on outer margin of penes, as in *B. grandis*. The appendages of the penes are shorter relatively than in *B. grandis*, not reaching to the sinus between the two limbs of the penes. See Pl. 8, Fig. 21. Genitalia light yellow in color.

*Tails*—Light brown, the joinings blackish brown. Alternate joinings wider.

*b. Variations from the above description*

Some males have the sternites of the abdomen much lighter in color, greyish white with faint yellow tinge. In some, the posterior margins of the sternites are dark grey, at least in the central part.

Darker forms often occur, in which the antennae are dark brown, and all (or the basal two-thirds) of the femur, and the tibia, of the foreleg are

to wing roots on mesonotum, another crescentic mark one-third from posterior spine. Median dorsal line narrowly yellowish white.

*Legs*—In young nymph, yellowish white. In mature nymph, very light reddish brown dorsally, yellow ventrally. Darker at joinings. On some, very indistinct darker bar on femur. Claw of first leg with 18 teeth on inner margin, 5 in upper row.

*Abdomen*—Light reddish brown dorsally, except 10 and posterior half of 9, which are yellow. Some mature male nymphs are yellowish red dorsally. On each tergite, four white spots. One on each side of median line at anterior border, and a larger one in or just posterior to each anterior lateral angle. Anterior margin of each sternite, and a very small triangular mark at ganglionic area of each, dark brown.

*Gills* greyish white, tracheae purple-black. First gill lacking lateral branches from main tracheae. See Pl. 8, Fig. 10, for third pair of gills.

*Tails* yellowish white, joinings reddish brown. Alternate joinings slightly wider.

#### *Male imago*

*Head*—Orange. Upper part of compound eyes orange; small basal portion black. Ocelli amber, black-ringed at base. Basal segments of antennae yellow; filament grey.

*Thorax*—Pronotum yellowish white, with large brown spot occupying most of dorsal area on each side of the wide median yellowish portion, and an oblique brown band across lateral margin. Mesonotum and metanotum reddish brown. A triangular creamy white patch at anterior margin of mesonotal scutellum. Pleura yellow with brown patches. Sternites brown. White ring around base of each leg.

*Legs*—Forelegs as long as or slightly longer than body. Coxa and trochanter light brown. Femur and sometimes tibia light yellow or yellowish brown. Tibia and tarsus white, except brown basal end of tibia. Second and third legs yellowish white. Claws margined with purplish brown.

*Wings*—Longitudinal and main cross veins in all but anal region of forewing light brown. Other veins white or very faintly yellow. Cross veins in costal space between humeral vein and bulla very indistinct. In apical portion, cross veins readily visible; some slight tendency toward anastomosis. Apical portion of cells C and Sc with faint whitish cloud. Hind wing rather small.

*Abdomen*—Segments 1, 9 and 10, and tergite 8, reddish brown. Segment 2 and tergite 7 olive brown, except a white border on each margin.

Anterior two-thirds of tergite 3, and anterior half of tergites 4-6, silvery white. Posterior margins of these tergites narrowly white; remainder of each olive-brown. An oblique black dash in center of pleural fold on each side of tergites 1-6; black bar parallel to pleural fold on entire length of segments 7-9. The above applies to light-colored specimens. Darker forms have tergites 3-6 similar to 2 above, and 7 somewhat darker. Three small white spots clustered together next to the pleural fold are present on some specimens, on tergites 1-7.

Sternites 2-7 on light specimens, and 2-5 on darker forms, translucent white. Remaining sternites very light reddish brown. Posterior margin of 9 white.

*Genitalia*—Forceps white, penes and forceps base yellowish. Forceps 4-jointed; fourth joint very small, third swollen at distal end. Processes of penes not as long as angle between limbs of penes; the spine at the distal end very short and inconspicuous. See Pl. 8, Fig. 14.

*Tails*—Middle tail only slightly more slender than outer ones, and equalling or approximately equalling them in length. Greyish white, joinings narrowly red.

#### *Female imago*

Slightly smaller than male. Head, thorax and abdomen light red, the thorax and abdominal tergites being slightly darker than the other parts of the body. Femora very light red, tibiae and tarsi yellowish. All veins except along the costal margin of the forewing white or very faintly yellowish. In other respects similar to male.

Holotype—Male imago—Reared from nymph, Hamburg Lake near Greensboro, N. C., April 28, 1930. No. 1077.1 in C. U. collection.

Allotype—Female imago—Same data. April 22, 1930. No. 1077.2 in C. U. collection.

Paratypes—5 male imagoes. 5 female imagoes—Same data. April 22-28, 1929; April 28, 1930. No. 1077.3-12 in C. U. collection.

The slender and graceful nymphs of this small species were collected mainly from Hamburg Lake, 11 miles north of Greensboro. A few were taken likewise from a tributary of Big Alamance Creek at Tom's Place. In the former locality they were most numerous among a growth of *Potamogeton* on the northeast shore of the pond. Nearly mature nymphs were taken here on April 5, 1929. A female transformed on April 10, and many others from April 22 to 26. In 1930, mature nymphs

were collected on April 17. The first of these transformed on April 20, others from April 28 to May 4.

Occasionally a nymph transformed as early as 10:30 a.m., but most of those observed came out between 2 and 5 p.m. In a period of relatively cool weather, two males each spent  $46\frac{1}{2}$  to  $47\frac{1}{2}$  hours in the subimago stage, while a third required 50 to  $51\frac{1}{4}$  hours to complete its transformation. One female transformed in exactly 24 hours, another in  $41\frac{1}{2}$  hours, the latter in warm weather. With the exception of the one female transforming in 24 hours, the periods spent as subimagoes by individuals of this species are much longer than for the other two species from the piedmont. See notes following descriptions of these.

#### *From the coastal plain region*

Of the species collected from the coastal plain region, one is represented by nymphs alone, and is designated as *B. sp?* No. 2. Two subimagoes and one female imago taken by Prof. Needham from Lenoir Co. on April 11, 1929, are so similar to *B. gracilis* as to be considered of that species, at least until more adequate material is at hand.

From nymphs of a third species, one male subimago was reared. This is apparently a new species, and is known as *B. intermedius*.

#### ***Blasturus intermedius*, sp. nov.**

*Size*—Male nymph—body 8–9 mm; outer tails 9–12, inner tail 8 mm. Female nymph, body  $7\frac{1}{2}$ –8 mm; tails broken. Male subimago, body 8 mm; outer tail 10, inner  $8\frac{1}{2}$ ; foreleg  $5\frac{1}{4}$ ; forewing  $7\frac{1}{2}$  mm.

#### *Nymph*

Body red-brown.

*Head* brown. White spot laterad of each lateral ocellus. White streak forward from median ocellus to margin of clypeus. Two white spots on median line of clypeus, one such spot on labrum. Four large pectinate hairs just below crown of maxilla.

*Thorax*—Prothorax as on Pl. 8, Fig. 3b. No definite light markings on meso- or metathorax. Legs definitely barred with dark brown. Bar on femur one-third from distal end. Tibia dark at basal end, bar across center. Tarsus barred at each end. Claw of foreleg with 16 teeth on inner margin, 8 in upper row.

*Abdomen*—Wide dark mark along median line of each tergite. On 7–9, tending to divide toward posterior margin into two forks. White

spots on each side of median line large, quite prominent. No evident markings on sternites.

*Gills* of third pair as on Pl. 8, Fig. 7. First pair with few or no lateral branches.

*Tails* straw colored to light brown, joinings red-brown. Alternate joinings wider in basal half.

#### *Male subimago*

*Head*—yellowish brown. Eyes and antennae as in other species of the genus.

*Thorax*—Pronotum brown, margined with yellow. Mesonotal shield dark red-brown, with three longitudinal white lines; mesonotal spine and area anterior to it, white. Metatotum like pronotum. Ventrally, center of prosternum, anterior and central sclerites of posterior portion of mesosternum dark brown. Remainder yellowish brown.

*Legs*—Orange-brown. Dark brown marks on trochanter and femoro-tibial joints. Tarsi somewhat dusky brown, joinings darker.

*Wings*—Dusky brownish grey.

*Abdomen*—Tergites yellowish brown. Each with black streak on median line; black mark on each side near pleural fold; an oblique black mark in pleural fold, except on 8–10. 1 and 2 likewise with transverse semicircular dark line near center. Posterior margin of each dusky. Sternites lighter yellow-brown; very indistinct grey lines in anterior half of each, bordering median line.

*Genitalia* as on Pl. 8, Fig. 19.

*Tails*—Light brown, joinings dark brown. Alternate joinings wider.

*Holotype*—Male subimago—Reared from nymph. Tributary of Cape Fear River, near Buies Creek, N. C., April 1, 1930. No. 1080.1 in C. U. collection.

*Paratypes*—Five nymphs—Same data. No. 1080.2–6 in C. U. collection.

#### *Blasturus* sp? No. 2.

Another small species, differing from *B. gracilis* in color, structure of gills, number of teeth on fore claw, and number of large pectinate hairs on maxilla. Body dark greyish brown.

#### *Nymph*

*Size*—Male nymphs, body 5–6 mm; female nymphs, body 5½–6 mm. Tails of all specimens broken.

*Head*—Vertex light brown, sutures white; no dark marks. Dark brown area around each antenna. White areas on sides of each lateral ocellus and anterior to median ocellus. Six large pectinate hairs below crown of maxilla.

*Thorax*—Median dorsal line white. Pronotum mottled with white, the principal markings being as follows. Large crescentic mark half-way to lateral border on each side; small mark near anterior margin, on each side of median line; oblong blotch just posterior to center of each side of sclerite; crescent at center of posterior margin; anterior lateral angles white. Mesonotum with indistinct longitudinal white bar parallel to median line, on each side.

*Legs*—Light yellowish grey. No distinct dark bands, but some specimens show faint darker regions in center of femur. Joinings narrowly brown. Claw of foreleg with about 16 teeth on inner margin, 4 in upper row.

*Abdomen*—Dorsally greyish brown, with indistinct white marks on each tergite. One on each side of median line at anterior margin; pleural borders of 3-8 white, except posterior lateral angles. Tenth tergite largely yellowish white. 8 and 9 whitish at center of posterior margin, on median line. Ventrally, a darker line on each side of each sternite, parallel to pleural fold. No other markings.

*Gills*—Third pair as on Pl. 8, Fig. 15. Faintly tinged with brown; tracheae black. Gills of first pair lacking lateral branches from the two main divisions of the trachea.

*Tails*—Yellowish white, narrowly reddish brown at joinings.

These nymphs were collected from two small tributaries of the Cape Fear River near the little town of Buies Creek on April 1, 1930. No adults were reared.

#### GENUS TRICORYTHUS Etn. 1868

##### *Tricorythus* sp?

A few nymphs of this genus were taken in the piedmont area, in a small stream near Spero, on March 24, 1929. None were reared, nor were any others of this genus found, in any area of the state.

#### GENUS CAENIS Stephens 1835

##### *Caenis diminuta* Wlk.

Nymphs of this species were found in the mud and trash along the shore of Hamburg Lake,—a small artificial pond north of Greensboro,

N. C. Imagoes were reared from these nymphs, emerging on April 10-25, 1929, and on April 27, 1930. This species was taken at no other station.

### Caenis sp?

A single nymph of another species was collected from Big Alamance Creek at Tom's Place, on April 13, 1930. It differs from the nymph of *C. diminuta* in 1) being much more slender of body; 2) bandings of legs less prominent; 3) prothorax more definitely widened at the anterior border.

No other *Caenis* nymphs nor adults were collected.

### GENUS EURYCAENIS Bengtsson 1917

#### *Eurycaenis nitida*, sp. nov.

The interesting three-horned nymphs of this species were taken at several stations in the Appalachian region. A single female imago was reared from these nymphs.

This species may possibly be synonymous with *E. pallida* Ide, of which only the male imago is known. However, the female imago is somewhat larger than the measurements given for *E. pallida*, and does not agree in color with the description of the male of that species. It seems best, therefore, to consider it a new species. The nymph differs from the description of *E. lacustris* (Needham), in N. Y. State Coll. For. Tech. Pub. No. 9, 1918, in its larger size, its darker color, different color pattern, the presence of conspicuous tubercles on the lateral margins of the prothorax, the narrower head, the absence of a dark band on tibia and tarsus, and the unbanded tails. A description of female imago and nymph follows.

#### MEASUREMENTS

	BODY	TAILS	FOREWING	FORELEG
Female nymph (5 specimens).....	7-7 $\frac{1}{4}$	3-3 $\frac{1}{4}$		
Female imago (1 specimen).....	4 $\frac{1}{2}$	3	5	2

Female imago with dark reddish brown mesonotum. Abdominal segments 1-6 purplish, posterior segments yellowish. Sternite 1 very wide; 2-6 very narrow, 7 and 8 wider, but not as wide as 1. Tergites 1-6 very narrow, 7-9 wide. Pleural filaments purple. Femora light

olive brown, tarsi whitish. Wings purplish in proximal half of costal border. Tails white, unbanded, hairy in distal half.

Nymph possessing a tubercle on each lateral margin of the prothorax. Color in general dark reddish brown, lighter ventrally; tergite 9 greyish white; legs and tails yellowish white.

#### *Female imago*

*Head*—Light yellowish brown, except median carina and portion of vertex anterior to lateral ocelli, which are purplish black. Compound eyes black. Ocelli large; black basally, pearl-grey at vertex. Antenna whitish.

*Thorax*—Prothorax dark purplish brown, somewhat lighter on lateral margins. Mesonotum very wide and long; dark reddish brown, a lighter strip on each side of the median line. Sutures purplish black. Metanotum purplish, pleura light brown except between second and third leg, where the color is dark reddish brown. Ventrally light brown shaded with purple, the sutures purplish black. Areas around median coxae yellowish brown. Anterior portion of mesosternum most heavily shaded with purple.

*Legs*—Foreleg short; second and third legs relatively long, each being about 3 mm. in length, and extending to or beyond the tip of the abdomen. Femora of last two pairs about as long as tibia and tarsus combined; fore femur longer than combined tibia and tarsus. Femora, and tibia of foreleg, light olive brown margined with dark brown. Tibiae of second and third legs yellowish. Tarsi whitish.

*Wings*—Greyish white. Veins in proximal half of costal border purplish. Main longitudinal veins purplish grey in their basal portions, fading into greyish white distally. Wing as on Pl. 12, Fig. 5.

*Abdomen*—Tergites 1-6 very short; 7-9 longer. Tergites 1-3 purplish black, 4-6 purplish grey in central portion; the lateral borders of each are greyish white, with posterior margins lavender. The peculiar long filamentous pleural processes are purplish. Tergites 7-9 greyish yellow, the posterior borders and median line greyed lavender. Tergite 10 yellowish brown, purplish on median line and posterior border. Ventrally, sternite 1 very long, sternites 2-6 very short; 1-6 purplish, finely mottled with very tiny light dots; posterior borders darker purple. Two larger light spots posterior to center of sternite 1, rather indistinct. Lateral margins shading into greyish lavender. Tergites 7-9 yellowish, 8 shaded with brown. Apical margin of 9th sternite extending out to a blunt point at the center. See Pl. 12, Fig. 23.

*Tails*—Greyish white, faintly washed with lavender at the base. In distal half, set with numerous whitish hairs.

### *Nymph*

*Head*—Narrower than any portion of the body except the last three abdominal segments. Clypeus, genae and area around compound eyes yellowish brown. Vertex blackish brown. Occiput dark red-brown, median line yellow. The three ocellar tubercles light brown. Compound eyes black margined with amber. Antenna yellow to yellowish brown. Mouthparts as on Pl. 12, Figs. 2, 7, 8, 10, 25 and 27.

*Thorax*—Pronotum dark reddish brown, shaded with purple laterally. A triangular portion at center of posterior margin lighter brown; black area in center at median line and on each side. A prominent tubercle on each lateral margin, anterior to the center. Anterior margin somewhat incised. Sclerite much narrower at anterior than at posterior margin, so that the prothoracic pleura extend out from beneath the pronotal border as rounded prominences. Mesonotum dark reddish brown, the median line and region on each side of this on the dorsum marked irregularly with black. Blackish marks anterior to wing roots. Pleura reddish brown, a purple-black spot posterior to foreleg and anterior to middle leg. Ventrally, light reddish brown with wash of purple.

*Legs*—Foreleg relatively short,  $1\frac{1}{4}$  to  $1\frac{1}{2}$  mm. in length. Second and third legs long, each measuring about 4 mm.; the third very slightly exceeding the second in length. Yellow, the tibiae and tarsi lighter than the femora. Claws amber.

*Abdomen*—Dorsally reddish brown, tergite 9 yellowish distally, yellowish brown basally. Elytroid gills very dark red-brown; the long hairs of the other gills which protrude from beneath these covers are greyed purple. Spinous lateral projections and area next to pleural fold purplish brown. Posterior margins of tergites 8 and 9 narrowly yellow. Tergite 10 very dark brown except for crescentic yellow mark at center of anterior margin and a yellow posterior border.

Ventrally, reddish brown except distal half of sternite 9, which is yellow. Sternite very long and tapering. On 2-8, a dark brown transverse mark from pleural fold almost to median line on each side, parallel to but toward center from the anterior margin.

*Tails*—Yellow basally, shading into amber brown in distal portion. Margined with yellowish white hairs.

Holotype—Female imago—Reared. Rocky Broad River, N. C., July 2, 1930. No. 1089.1 in C. U. collection.

Paratypes—Four female nymphs—Rocky Broad River, N. C., July 2, 1930; Bald Creek, N. C., July 6, 1930; Little River, near town of Cedar Mt., N. C., July 12, 1930; Tributary of Davidson River, N. C., July 9, 1930. No. 1089.2-5 in C. U. collection.

Besides the localities listed under the paratypes, these nymphs were found at Toxaway River, near the big falls below the town of Lake Toxaway, on July 16, 1930. These latter nymphs were immature, and are therefore not included among the paratypes.

Nymphs of this species appear to differ somewhat from those of *E. lacustris*, in their habitat. Prof. Needham says of the latter species, "This seems to be in America an inhabitant only of lakes, though its European counterpart above mentioned (*E. harrisella*) is not." As my specimens of *E. nitida* were taken from small rivers and mountain streams, they would seem to be closer to *E. harrisella* (Curtis) in their manner of life than to *E. lacustris*. The nymph of *E. pallida*, the only other species of this genus, is not known.

#### GENUS EPHEMERELLA Walsh 1862

##### *Key to Species of Ephemerella Nymphs found in North Carolina*

Note: That portion of the key which deals with the *bicolor-lutulenta* group is taken from Dr. McDunnough's recently published key on that group of the genus Ephemerella.

1. Gills present on segments 3-7; not operculate.....2  
Gills present on 4-7; operculate or semi-operculate on segment 4.....16
2. Femur I with serrations or spiny outgrowths on anterior margin; frontal horns present, but may be inconspicuous.....3  
Femur I without such serrations or spines; frontal horns lacking.....9
3. Frontal horns long and conspicuous, extending beyond anterior edge of frontal shelf.....4  
Frontal horns short and often inconspicuous, not reaching anterior edge of frontal shelf.....6
4. Projection on distal end of fore tibia (tibial spine) short and blunt, not turning outward. Frontal horn strongly incurved, almost semilunar  
*cornutella*
- Tibial spine long (reaching at least to middle of tarsus) and sharp at tip. Frontal horns less strongly curved.....5
5. Tibial spine extending well beyond middle of tarsus; its distal third curving sharply outward. Spine below median ocellus sharp.....*longicornis*  
Tibial spine not extending beyond middle of tarsus, curving out gradually from base. Spine below median ocellus rather blunt.....*cornuta*

6. Occipital tubercles present.....7  
 Occipital tubercles absent.....8
7. Tubercles present on thorax.....*tuberculata*  
 Tubercles not present on thorax.....*conestee*
8. Dorsal spines present; nymph much flattened, hairy.....*wayah*  
 Dorsal spines absent; nymph only slightly flattened, not conspicuously hairy;  
 prothorax broad, yellowish white.....*lata*
9. Occipital tubercles present.....sp? No. 2  
 Occipital tubercles absent.....10
10. Dorsal spines present and conspicuous.....11  
 Dorsal spines absent or inconspicuous.....13
11. Nymph large (7-11 mm.); margins and sometimes upper surface of fore femur  
 thickly set with short tubercles.....*rotunda*  
 Nymph small (not exceeding 5½ mm.); no such tubercles on fore femur.....12
12. Body semi-depressed. Lateral extension of 9th abdominal segment extending  
 beyond end of 10th segment. Ventrally a row of dark lines on each side  
*serrata*  
 Body cylindric, compressed. Lateral extension of 9th abdominal segment  
 not reaching to end of 10th. Ventrally, four dark marks on each sternite,  
 as well as a row of dark lines on each side.....*serratoides*
13. Maxillary palp absent.....*deficiens*  
 Maxillary palp present.....14
14. Postero-lateral angles of abdominal segments blunt to rounded.....*dorothea*  
 Postero-lateral angles of abdominal segments sharp spinous processes.....15
15. Slender small nymphs, 5-7 mm. in length. No indication of dorsal spines  
*catawba*  
 Stout larger nymphs, 7½-10 mm. in length. Faint traces of dorsal spines, very  
 inconspicuous.....*inconstans*
16. Gill on segment 4 semi-operculate, only partially covering remaining gills  
 sp? No. 1  
 Gill on segment 4 fully operculate, covering remaining gills.....17
17. Width between dorsal tubercles on abdominal tergites 5-7 much less than the  
 width of the respective tergites on the median line; large species, occipital  
 tubercles strongly developed.....*temporalis*  
 Width between dorsal tubercles on abdominal tergites 5-7 more or less equal  
 to the length of the respective tergite on the median line; occipital tubercles  
 lacking in male, much reduced in female.....*minimella*

#### NOTES ON THE GROUPING OF THE EASTERN SPECIES OF EPHEMERELLA

On the basis of similarity of male genitalia or of structural characters of the nymphs, or of a combination of these characters, the eastern species of the genus *Ephemerella* seem to fall into natural groups within the genus.

##### *I. Bicolor-lutulenta group*

Nymphs of this group possess gills on segments 4-7 only; gill on segment 4 elytrid, covering gills on 5-7. Dorsal spines present on abdo-

ment, and prominent; lateral margins of abdomen much flattened, and widely prolonged into spinous processes; tubercles usually present on occiput. Maxillary palp lacking; no spines on front margin of fore femur. The great similarity of the male genitalia of the species in this group serves to confirm the above grouping, based on nymphal characters.

The nine species included in this group have been adequately dealt with by Dr. McDunnough, in his recent paper on this group (Canad. Ent. 63: 30-42, and 61-68, 1931.). These nine species are; *E. prudentalis* McD.; *E. temporalis* McD.; *E. funeralis* McD.; *E. lutulenta* Clemens; *E. coxalis* McD.; *E. minimella* McD.; *E. bicolor* Clemens; *E. aestiva* McD.; and *E. verisimilis* McD.

## II. *Invaria* group

On the basis of the male genitalia, this group falls into two subdivisions. In the first subdivision, the distal portion of the second joint of the forceps is enlarged. To this division belong the species *E. invaria* Etn.; *E. norda* McD.; *E. rotunda* Morgan; *E. dorothea* Needham; *E. subvaria* McD.; and *E. fratercula* McD. (*E. vernalis* Bks. is said to be synonymous with *E. rotunda* Morgan; it falls in this subdivision.)

To the second subdivision belong those species in which the second joint of the forceps is not enlarged distally. *E. excrucians* Walsh (the species recognized by Dr. McDunnough under this name, and *E. semiflava* McD., are members of this subdivision. (Dr. McDunnough thinks these species may be synonymous.)

The nymph of *E. fratercula* is as yet unknown. The known nymphs are rather cylindrical of form; possess gills on segments 3-7, neither operculate nor semi-operculate; lateral margins of abdomen somewhat depressed and produced into spines; dorsal abdominal spines present in some, but absent in others; head and thorax without tubercles. They are generalized forms.

## III. *Fuscata* group

Nymphs of this group possess frontal horns, well developed in some and barely noticeable in others; and spines on the front margin of the fore femur. The nymphs of the eastern species seem to fall into three subdivisions within this group.

In the first subdivision, the body is more compressed than depressed, though a tendency toward depression is apparent. No tubercles are

present on head or thorax, and no dorsal abdominal spines. Here belong *E. cornuta* Morgan; *E. depressa* Ide; *E. cornutella* McD.; *E. lata* Morgan; and the new species *E. longicornis*. (*E. inflata*, which would fall here, is said to be synonymous with *E. lata*.)

Nymphs of the second subdivision are moderately depressed in body form; possess tubercles on vertex, occiput and usually on the thorax; and have dorsal abdominal spines. To this subdivision belong *E. tuberculata* Morgan and the new species *E. conestee*.

Nymphs of the third subdivision are much depressed in body form; dorsal abdominal spines are present, but minute and inconspicuous; all femora much flattened; antennae set in notches on each side of the broad frontal shelf; occipital tubercles very minute or absent; abdomen hairy ventrally; no tubercles on thorax. To this subdivision belong the two eastern species *E. fuscata* McD. and the new species *E. wayah*. The nymph of the western species *E. doddsii* Needham shows the same modifications carried to a greater development. (*E. bispina* Needham, which would fall here, may be synonymous with *E. fuscata*.)

The male genitalia of this group, while not as closely alike as are those of the *bicolor-lutulenta* group, nevertheless show a general resemblance one to another.

#### IV. *Simplex* group

Nymphs of this group agree in having the gills present on segments 4-7 only, the gill on 4 being semi-operculate and partially covering the gills posterior to it; and in having the lateral margins of the abdominal segments depressed and much prolonged into wide flat spines. Two subdivisions are evident, however.

Nymphs of the first subdivision have rather cylindrical bodies; femora slender, compressed and without spines; dorsal spines present but small; prominent thoracic tubercles and short inconspicuous occipital tubercles. *Ephemerella attenuata* McD. belongs here.

To the second subdivision belong nymphs having bodies depressed or partially depressed; femora less slender and less compressed, the fore femur enlarged at the center, but without spines on the front margin; no thoracic tubercles; occipital tubercles, if present, very minute; no dorsal abdominal spines. To this division belong *E. simplex* McD. and the new nymph from N. Carolina, *Ephemerella* sp? No. 1.

The nymph of *E. molita* McD., which species Dr. McDunnough places in this group on the basis of the male genitalia, has not been described.

V. *Serrata* group

On the basis of the male genitalia, Dr. McDunnough places the four species *E. serrata* Morgan, *E. sordida* McD., *E. frisoni* McD., and *E. serratoides* McD., in this group.

Nymphs of *E. serrata* and *E. serratoides* agree in having partially depressed body form; gills present on segments 3-7, neither operculate nor semi-operculate; lateral margins of abdominal segments depressed and much prolonged into wide flat spines: dorsal abdominal spines present. *Ephemerella serratoides* is described (McDunnough, Canad. Ent. 63: p. 83) as lacking both occipital and thoracic tubercles, while *E. serrata* has tubercles on the thorax. The nymphs of *E. sordida* and *E. frisoni* seem not to have been described. (Dr. McDunnough includes *E. deficiens* Morgan in this group, also.)

VI. *Species which do not seem to fall into the above groups*a. *E. septentrionalis* McD.

Nymph more closely allied to those of the *invaria* group than to any others, but strikingly different from any others known in the possession of very long legs and an extremely attenuated body. Nymph lacks dorsal spines on the abdomen; has very inconspicuous occipital tubercles; no thoracic tubercles; legs very long and slender; lateral margins of abdomen depressed and slightly prolonged into spinous processes. The genitalia also are unlike those of the other groups thus far considered. (Dr. McDunnough considers this species as a "slight modification or development" of the *invaria* group, along with the two other species *E. needhami* McD. and *aurivillii* Bngtssn.)

b. *E. deficiens* Morgan.

While Dr. McDunnough places this species in the *serrata* group, as already noted, I am not yet convinced that it belongs there. In body form of nymph and in genitalia of the male imago, it seems to me to be close to *E. tibialis* McD., a western form. It differs in the nymphal stage from all other known nymphs except those of the *bicolor* group, in the complete absence of the maxillary palp. The nymph lacks dorsal spines; has neither occipital nor thoracic tubercles; gills present on 3-7; lateral margin of abdomen somewhat depressed; spinous processes much as in the *invaria* group; and tails with prominent spines at the joinings.

c. *E. consimilis* Walsh.

Nymphs unknown; determination of the imago and its relation to other members of this genus uncertain, since the only type specimen has been destroyed.

d. *E. needhami* McD.

*E. excrucians* Needham (nec Walsh)

The male genitalia of this species, as figured by Prof. Needham (N. Y. State Mus. Bull. 86: Pl. 10, fig. 8) seem somewhat different from those of any other known species of *Ephemerella*, but are probably nearest *E. septentrionalis*. The nymph figured with the description of this species belongs quite certainly to a different species, one of the *bicolor* group. It is therefore advisable to consider the nymph of the above species unknown.

As I have not had the opportunity to examine the specimen of *E. excrucians* in the Cambridge museum which Dr. Banks has selected as the lectotype of this species (see McDunnough, *Canad. Ent.* 57: 171), I am here accepting Dr. McDunnough's determination.

e. *E. bispina* Needham

This species may be a member of the *fuscata* group.

#### THE GENUS EPHEMERELLA IN NORTH CAROLINA

This genus was better represented in all three of the geographical divisions of the state than was any other except *Heptagenia*. Of the material collected, five species are new, and are herein described. Eleven others have been positively identified and two others tentatively. There remain unidentified several species of the *bicolor-lutulenta* group, two of which have been reared but are represented by insufficient material, the others being represented by nymphs alone. Besides these, two species of nymphs are described but not named, as they have not been reared, and may prove to be nymphs of already described species known only in the imago stages.

Dr. McDunnough was kind enough to examine some of the specimens, concerning the identification of which I was in some doubt. His help was especially useful in the difficult *bicolor-lutulenta* group, on which he has recently published an excellent paper (*Can. Ent.* 63: 30-42, 61-68).

*Coastal plain region*

The *bicolor-lutulenta* group is represented in this area by several nymphs and imagoes collected by Prof. Needham in April 1929, and a few nymphs of my own collecting, in April of the following year. One species was reared, but could not surely be identified, as only females were obtained.

***Ephemerella minimella* McD.?**

Dr. McDunnough thinks that the specimens collected by Prof. Needham from Burncoat Swamp may be of the above species.

*Piedmont region****Ephemerella dorothea* Needham**

Collected from the following places. Big Alamance Creek at Tom's Place, April 4, 1929, from which imagoes emerged April 25 to May 1; Caraway Creek near Sophia, April 20, 1929, imagoes emerging April 22–May 13; lake near Liberty, March 24, 1929; tributary of the Dan River at Cascades, May 12, 1929, imagoes emerging May 13; tributary of the Reedy Fork River near Guilford Battleground, April 20, 1930; and from a small creek near Tabernacle Church south of Greensboro, May 1, 1930.

The yellowish-white subimagoes of this species generally emerged between 7 and 8 p.m. When reared indoors in open dishes, they flew at once upward toward the ceiling light, and could be easily collected. While no exact records were kept of the subimaginal stage of this species, several of my notes indicate that more than 24 hours was spent in this stage.

***Ephemerella deficiens* Morgan**

From nymphs collected in Big Alamance Creek on May 17, 1929, a male and female imago emerged on May 22.

***Ephemerella temporalis* McD.**

The large sluggish nymphs of this lake-inhabiting species were first taken at the lake near Liberty on April 23, 1929. The first of these, a male, transformed April 28. Dr. McDunnough verified my identification of this species.

*Bicolor-lutulenta* group is represented in the piedmont also, by two unidentified species, both of which were reared, but very little material of each was taken. One of these Dr. McDunnough thinks, on the basis of what little material I sent him, may be *E. verisimilis* McD. It was collected in the Uharie River, Apl. 3, 1929.

*Ephemerella inconstans*, sp. nov.

MEASUREMENTS

	BODY	TAILS	FOREWING	FORELEG
Male nymph (8 specimens).....	8-10	4½-6		
Female nymph (11 specimens).....	7½-11	4-7		
Male imago (13 specimens).....	8-9½	9½-13	8-9	7-9
Female imago (8 specimens).....	6-10½	9-12	8-10½	3-5

A member of the 'invaria' group, the second joint of the forceps enlarged distally. Quite close to *E. rotunda*, but even in light specimens, more definitely marked with brown than that species, the legs and tails somewhat darker. Differs from *E. subvaria* in the lighter venation of the wings and the dark marks bordering the pleural folds. Abdomen of male appears to be ringed with purplish brown, due to the whitish posterior margin of each segment. Pleural fold margined on each side by a purplish-brown streak. Ventrally, a short dark bar and a dark spot on each side of each sternite, near the center. Posterior segments yellowish brown. Tails and legs variable in color. Penes with fewer spines than in *E. rotunda*.

Apparently two varieties, a large and a small one,—which do not seem to exhibit good structural differences other than size. See notes following description. Considerable variation in color, of both nymphs and imagoes.

Nymph very much like *E. rotunda* in general appearance. Differs from that species in that the dorsal tubercles are very minute, the spinous lateral extensions of the abdomen are more rounded on the outer margin and not incurved at the tip, and in having more serrations on the inner margin of the claw. Whole body finely mottled with tiny dots.

*Male imago*

*Head*—Light brown. Upper portion of compound eyes light orange. Antennae pale in light forms, light brown in dark forms.

*Thorax*—Pronotum light brown, often a dorsal median light streak. Posterior lateral angles light yellowish. Mesonotum yellowish to light brown; spine brown, margined with dark red-brown. Pleura light brown, sutures cream colored. Ventrally brown, darkest at center of mesosternum. In dark forms, dark reddish brown in this portion.

*Legs*—In light forms, yellowish white, coxa and trochanter light brown. Purplish streaks in distal portion of femur, light brown at base of tibia. In dark forms, femur and tibia of foreleg light brown, tarsi lighter. Other legs yellowish to light yellowish brown.

*Wings*—Longitudinal veins in basal half of costal border yellowish. Other veins of forewing very light yellowish brown. Stigmatic area opaque whitish.

*Abdomen*—Tergites 2-4 light purplish-brown; narrow median whitish line, posterior borders and posterior lateral angles greyish white. Tergite 1 brown on anterior and lateral margins, the central portion greyish lavender. 5-7 much like 2-4, but the brownish area much reduced and the light portion increased in size. On some, a brown longitudinal line between the central patch and the pleural fold. 8-10 washed with yellowish brown; median light brown line; center of each side with brownish patch. On each tergite, a purplish-brown line borders the pleural fold, and one or more short dark dashes are present near the stigma.

Ventrally, sternites 1-5 greyish, washed with lavender; a dark brown line on each paralleling the pleural fold. 6-10 yellowish brown, streak by pleural fold less evident. Anterior border of sternite 1 narrowly brown, lateral area widely of same color. All sternites narrowly white on the posterior margins. Ganglionic area of each sternite whitish. Two dark dots near center of sternite 1, one on each side of median line. Similar dots on succeeding sternites except 9; likewise on each of these a dark dash on each side, laterad and anterior to the dark dot.

Light forms similar in pattern but lighter in color, the posterior margins of the segments wider. However the dark bars near the pleural fold and the stigmatic spots near it on each tergite are sometimes more prominent than in dark forms. Edge of pleural fold whitish, in some specimens.

*Tails*—In dark forms, light brown in basal third, shading to light tan distally. Each joining ringed with purplish brown. In light forms, greyish to light tan throughout length; joinings as in dark forms.

*Genitalia*—Second joint of forceps enlarged distally. Penes quite similar to *E. rotunda*, but with fewer spines. Some variation in number

and location of spines, but generally a group of three on each side, and one on each side near the basal portion. Two specimens have also a single short spine on each side of the center on the distal margin. See Pl. 9, Figs. 4 and 23.

#### *Female imago*

Differs from the male as indicated.

*Head* light yellow in light forms, light brown in others. Ocelli ringed at base with purplish-black. Antennae purplish in basal two-thirds, white distally.

*Thorax*—Pronotum yellowish to light brown, a lavender streak in center of posterior margin and one on each side of center, on anterior margin. Mesonotum yellow, spine and metanotum shaded with purplish brown. Pleura yellow. Ventrally light yellowish brown, a darker brown spot at center of mesosternum.

*Legs*—Yellowish to light yellowish brown.

*Wings*—Longitudinal veins light yellow.

*Abdomen*—Greyish yellow, segments 6-10 yellowish brown, these marked ventrally with darker brown. Eggs impart reddish to purplish brown tinge. Pleural fold greyish; not bordered with dark streaks in light forms, but in dark forms similar to male. Faint dark dots as in male, in dark forms, often absent in light ones. Posterior margin of 9th sternite as on Pl. 9, Fig. 25b.

*Tails*—Light tan, joinings very faintly darker in some light forms. Dark forms similar to light males.

#### *Nymph*

General shape similar to *E. rotunda*, but somewhat less robust. Varying in color from light yellowish brown to dark mahogany brown. Body finely mottled with numerous tiny yellowish dots.

*Head*—Basal half of first joint, all of second, and first three or four succeeding joints, dark brown; remainder whitish. Yellowish transverse band between and laterad of lateral ocelli; yellowish marks cephalad of the median ocellus, and along the inner margin of each compound eye.

*Thorax*—Pronotum yellow at each lateral angle and on median line. Triangular blotch on posterior margin at each side of center (not always present), and another on anterior margin between median line and lateral margin. Other smaller light spots irregularly placed. Mesonotum with white median line, on many specimens. Large yellow dots

irregularly placed, anterior to wing roots. Ventrally, yellowish with numerous small brown dots.

*Legs*—Brown to dark brown, barred with yellow. Femur yellowish at each end and near center. Tibia yellowish at distal end, also a large patch near basal end. Tarsus yellowish except for dark brown bar one-third from basal end. Third claw as on Pl. 9, Fig. 26.

*Abdomen*—Median yellowish dorsal streak on most specimens. Flattened lateral margin beneath gills, on 3–7, yellowish white. Very dark brown streak on these segments, at inner edge of the yellow margin. Whitish spot at location of each minute dorsal spine. Lateral spinous projections more rounded on outer margin than in *E. rotunda* (see Pl. 9, Fig. 24), the end spines not incurved. Black streak across center of each process. Margins serrate. Ventrally, an indication of a yellowish median line, also a dark line on each side nearer the margin. Some nymphs have also a whitish mark at the anterior margin on each side, halfway to the pleural fold, and two dark lines and dots on each sternite as in the imago. In most nymphs, the posterior abdominal segments are darker than the anterior ones, especially on the ventral surface.

*Tails*—Yellowish to very light tan, slightly darker at base and with several dark brown bars in the distal two-thirds. Almost bare basally and at tip, moderately long hairs in intervening space.

*Holotype*—Male imago—Reared. Hamburg Lake, N. C., March 15, 1930. No. 1093. 1 in C. U. collection.

*Allotype*—Female imago—Reared. Hamburg Lake, March 15, 1930. No. 1093. 2 in C. U. collection.

*Paratypes*—9 male imagoes, 7 female imagoes, 2 male subimagoes, 1 female subimago—All reared. Big Alamance Creek, N. C., at Tom's Place, March 24–27, and April 11, 1930; Inlet of Scales Lake, N. C., March 27, 1930; Trib. Reedy Fork River, N. C., March 21, 1930. No. 1093. 3–21 in C. U. collection.

This was the most abundant early spring species of *Ephemerella* in the piedmont area. Nymphs were collected, and many imagoes reared, from a number of streams in the vicinity of Greensboro during the spring of 1929 and again in 1930. Locations and dates of collections are as follows. Big Alamance Creek, about fourteen miles south of Greensboro, and a tributary of this stream, on March 10, 1929, and on many succeeding dates, both in 1929 and 1930; the outlet of Hamburg Lake,

about ten miles north of Greensboro, April 5, 1929, and succeeding dates; Middle Belew's Creek near the station of Belew Creek, March 31, 1929; Big Alamance Creek at Tom's Place, April 13, 1929; and several later dates; a tributary of the Uharie River near Farmer, April 2, 1929; the inlet to a private lake on the Scales estate near Greensboro, March 25, 1930; a small tributary of Reedy Fork River near Guilford Battleground, on April 17, 1930.

A large nymph, quite similar to that of *E. inconstans*, but seeming to differ slightly from it, was taken from Polecat Creek south of Greensboro on April 5, 1930.

### *Ephemerella catawba*, sp. nov.

#### MEASUREMENTS

	BODY	TAILS	FOREWING	FORELEG
Male nymph (2 specimens).....	5½-7	3½		
Female nymph (17 specimens).....	5-7	3½-5		
Male imago (2 specimens).....	6¼-7	9-10	7	6-6¼

A member of the *invaria* group. Seemingly distinguished from other species of this group by the lack of spines on the penes. Tails white, joinings purple. Thorax of male red-brown, abdomen olive-brown dorsally. Nymph slender, smooth, in life olive-green to brown in color. A 'moss-dweller.' Apparently has two color phases.

#### *Male imago*

*Head*—Light brown. Compound eyes light orange in upper portion.

*Thorax*—Reddish brown. Pronotum margined laterally with light yellow. Mesonotum marked and blotched with yellow. Sclerites of pleura brown, intersegmental spaces yellow. Metanotum and mesonotal spine darker brown. Antecoxal pieces of foreleg white, prosternum light yellowish brown. Mesosternum light brown in anterior portion, remainder dark reddish brown. Metasternum shaded with purple at anterior margin.

*Legs*—Foreleg light reddish brown, claw and last two tarsal segments greyish. Other legs yellowish white, claws and tarsi washed with light brown.

*Wings*—Hyaline. Forewing brown at base. Veins colorless except the three big veins on the costal border, which are tinged with yellow. Stigmatic area opaque, cross veins anastomosed.

*Abdomen*—Dorsally, olive brown with purplish brown markings on tergites 1-6. Tergites 7-9 light chestnut brown, 7 marked on each side of median line with purplish brown. Posterior margins of each darker brown, anterior margins yellowish. Tergites 1-6 shaded in central portion with darker markings of purplish brown. Median line faintly greyish white. Sternites 1-6 greyish white, washed with lavender; sternite 1 marked with chestnut brown on anterior margin and along lateral borders. Pleural fold greyish white. An indistinct darker dot on each side of median line near the center, also fainter oblique dashes at the anterior margin. Ganglionic area of each, grey-white.

*Genitalia*—See Pl. 9, Fig. 3. A very weak spine is present on one side of the penes of one specimen; the other lacks spines completely. This character should distinguish the species from others of the same group.

*Tails*—Smoky white at base, becoming silver white for most of their length. Joinings purple.

### *Nymph*

Slender, smooth. In life olive-green to brown, changing to reddish-brown in alcohol. Apparently two color phases, one with large white patches on abdominal tergites 4-7.

*Head*—Yellowish white patches around each compound eye, laterad of each lateral ocellus and cephalad of the median ocellus. Vertex and occiput often mottled. Antenna brown, in some specimens darker at base. Mouthparts very similar to others of the *invaria* group.

*Thorax*—Pro- and mesonotum often considerably mottled with yellow and brown markings. Pleura yellow; sternites light red-brown.

*Legs*—Yellowish brown with darker brown markings. Femur with longitudinal brown band near center, another on each margin. Numerous rather long orange-brown spines on upper surface, mainly toward distal end and along hind margin. Tibia dark brown basally, lighter brown in distal half. Tarsus dark brown except a yellow basal band. Claw slender. See Pl. 9, Fig. 11c.

*Abdomen*—No dorsal spines. Postero-lateral margins considerably flattened and expanded, the outer margins serrate; postero-lateral angle prolonged into a sharp spine. Dark reddish brown. The flattened lateral margin yellow in light forms; in dark specimens, red-brown except for yellow spine. One color phase has whitish patches on tergites 4-7, bordering the gills. Posterior margin of each narrowly darker. Ventrally lighter red-brown, usually without markings.

However, one specimen exhibits a few laterally placed whitish blotches on the central sternites.

*Gills*—Purplish grey, an oval lighter area in center of each.

*Tails*—Yellowish to reddish brown, crossed by several narrow bands of yellow. In basal half, spines at joinings; distally fringed with short hairs.

Holotype—Male imago—Reared. Catawba River at Andrews Geyser, N. C., June 21, 1929. No. 1094. 1 in C. U. collection.

Paratypes—Male imago—Reared. Tributary of the Dan River at Cascades, N. C., May 10, 1930.

Nymphs—12 from Ocona Lufty River, June 22, 1930; 6 from Cascades, May 3, 1930. No. 1094. 2-14 in C. U. collection.

The slim olive-brown nymphs of this species were quite numerous crawling about in the moss on rocks in the stream at Cascades, near Danbury, on May 12, 1929. None of these were reared. However, from other nymphs collected on May 3, 1930, one male imago transformed.

[To be continued]

## EXPLANATION OF PLATES

### PLATE 5

#### OREIANTHUS PURPUREUS

- Fig. 1. Mature nymph, dorsal aspect.
- Fig. 2. Left mandible of nymph.
- Fig. 3. First leg of nymph.
- Fig. 4. Second leg of nymph.
- Fig. 5. Third leg of nymph.
- Fig. 6. Genitalia of male subimago, dissected out from mature nymph.
- Fig. 7. Hypopharynx of nymph.
- Fig. 8. Labium of nymph.
- Fig. 9. Labrum of nymph.
- Fig. 10. Right mandible of nymph.
- Fig. 11. Wings of female imago.
- Fig. 12. First leg of female imago.
- Fig. 13. Second leg of female imago.
- Fig. 14. Third leg of female imago.
- Fig. 15. Maxilla of nymph.

## PLATE 6

## NEOCLOEON ALAMANCE

- Fig. 1. Nymph, not yet fully mature. Dorsal aspect.  
 Fig. 2. Right mandible of nymph.  
 Fig. 3. Labrum of nymph.  
 Fig. 4. Hypopharynx of nymph.  
 Fig. 5. Right maxilla of nymph.  
 Fig. 6. Detailed sketch of canines, right mandible of nymph.  
 Fig. 7. Plates of 10th sternite of female imago, with apical margin of 9th sternite.  
 Fig. 8. Head of male imago, lateral aspect.  
 Fig. 9. Labium of nymph.  
 Fig. 10. Genitalia of male imago, dorsal aspect. Basal joint of forceps stippled lightly; chitinized structures stippled more heavily; openings of vasa deferentia unstippled.  
 Fig. 11. Left mandible of nymph.  
 Fig. 12. Detailed sketch of canines, left mandible of nymph.  
 Figs. 13-17. Gills of left side of body of nymph. In order, taken from segments 1, 2, 4, 5, 7.  
 Fig. 18. Left wing of male imago.

## PLATE 7

- Fig. 1. Genitalia of male subimago, *Habrophlebia pusilla*.  
 Fig. 2. Maxilla of nymph, *Leptophlebia swannanoa*.  
 Fig. 3. Genitalia of male imago, *Leptophlebia swannanoa*.  
 Fig. 4. Canines and lacinia of left mandible of nymph, *Habrophlebia pusilla*.  
 Fig. 5. Left mandible of nymph, *Habrophlebia pusilla*.  
 Fig. 6. Fifth gill of *Leptophlebia* nymphs: a. *L. swannanoa*. b. *L. sp?* No. 1.  
 Fig. 7. Outer apical angle of maxilla of nymph, *Habrophlebia pusilla*. See Fig. 26.  
 Fig. 8. Hind wing of male subimago, *Habrophlebia pusilla*.  
 Fig. 9. Genitalia of male subimago, *Habrophlebia pusilla*.  
 Fig. 10. Maxilla of nymph, *Leptophlebia sp?* No. 1.  
 Fig. 11. Apical margin of 9th sternite of female imago, *Leptophlebia swannanoa*.  
 Fig. 12. Left and right mandibles of nymph, *Leptophlebia swannanoa*.  
 Fig. 13. Genitalia of male imago, *Leptophlebia swannanoa*. Lateral aspect.  
 Fig. 14. Labial palp of nymph, *Leptophlebia guttata*.  
 Fig. 15. Labium of nymph, *Habrophlebia pusilla*.  
 Fig. 16. Right mandible of nymph, *Leptophlebia adoptiva*.  
 Fig. 17. Right mandible of nymph, *Leptophlebia mollis*.  
 Fig. 18. First gill of nymph, *Habrophlebia pusilla*.  
 Fig. 19. Fourth gill of nymph, *Habrophlebia pusilla*.  
 Fig. 20. Upper portion of mandible of nymph, *Leptophlebia guttata*.  
 Fig. 21. Second leg of nymph, *Potamanthus sp?* No. 1.  
 Fig. 22. Maxilla of nymph, *Potamanthus sp?* No. 1.  
 Fig. 23. Right mandible of nymph, *Potamanthus sp?* No. 1.  
 Fig. 24. Color pattern of fourth tergite of nymph, *Potamanthus sp?* No. 1.  
 Fig. 25. Labrum of nymph, *Potamanthus sp?* No. 1.  
 Fig. 26. Maxilla of nymph, *Habrophlebia pusilla*.

## PLATE 8

## GENUS BLASTURUS

Fig. 1. Apical margins of 9th sternites of female imagoes:

a. *B. gracilis*.

b. *B. collinus*.

c. *B. grandis*.

d. *B. austrinus*.

Fig. 2. Color patterns of fifth abdominal segment of nymph, *B. grandis*.

a. Fifth tergite.

b. Fifth sternite.

Fig. 3. Color patterns of pronotum of nymphs:

a. *B. grandis*.

b. *B. intermedius*.

c. *B. austrinus*.

Fig. 4. Details of penes of male imago, *B. grandis*. See Fig. 11.

Fig. 5. Color patterns of fifth tergites of male imagoes:

a. *B. grandis*.

b. *B. cupidus*.

c. *B. gracilis*.

d. *B. austrinus*.

e. *B. nebulosus*.

Fig. 6. Genitalia of male subimago, *B. collinus*.

Fig. 7. Third pair of gills of nymph, *B. intermedius*.

The two-lobed gill is the under one of the pair in this and other figures of gills.

Fig. 8. Genitalia of male imago, *B. cupidus*.

Fig. 9. Third pair of gills of nymph, *B. collinus*.

Fig. 10. Third pair of gills of nymph, *B. gracilis*.

Fig. 11. Genitalia of male imago, *B. grandis*.

Fig. 12. Third pair of gills of nymph, *B. austrinus*.

Fig. 13. Third pair of gills of nymph, *B. grandis*.

Fig. 14. Genitalia of male imago, *B. gracilis*.

Fig. 15. Third pair of gills of nymph, *B. sp?* No. 2.

Fig. 16. Color pattern of fifth tergites of nymphs:

a. *B. gracilis*.

b. *B. intermedius*.

Fig. 17. Genitalia of male imago, *B. nebulosus*, a) Details of penes; b) genitalia as a whole.

Fig. 18. Color patterns of fifth tergites of nymphs:

a. *B. austrinus*.

b. *B. collinus*.

c. *B. sp?* No. 1.

d. *B. sp?* No. 2.

Fig. 19. Genitalia of male subimago, *B. intermedius*.

Fig. 20. Color pattern of fifth tergites of nymphs:

- a. *B. cupidus*.
- b. *B. nebulosus*.

Fig. 21. Genitalia of male imago, *B. austrinus*.

- a. Details of penes.
- b. Genitalia as a whole.

## PLATE 9

### GENUS EPHEMERELLA

Fig. 1. Genitalia of male imago, *E. lata*.

Fig. 2. Left mandible of nymph, *E. wayah*.

Fig. 3. Genitalia of male imago, *E. catawba*.

Fig. 4. Penes of male imago, enlarged.—*E. inconstans*. Note variation from form shown in Fig. 23.

Fig. 5. Genitalia of male subimago, *E. conestee*.

Fig. 6. Crown of maxilla, much enlarged; nymph, *E. wayah*.

Fig. 7. Right mandible of nymph, *E. wayah*.

Fig. 8. Head of nymph, *E. conestee*.

Fig. 9. Upper portion of right mandible, of nymph, much enlarged—*E. wayah*.

Fig. 10. Foreleg of nymph, *E. longicornis*.

Fig. 11. Third claws of nymphs:

- a. *E. sp?* No. 1.
- b. *E. sp?* No. 2.
- c. *E. catawba*.

Fig. 12. Labium of nymph, *E. wayah*.

Fig. 13. Maxilla of nymph, *E. wayah*.

Fig. 14. Head of nymph, *E. longicornis*.

Fig. 15. Claw of foreleg, much enlarged—nymph, *E. longicornis*.

Fig. 16. Claw of third leg of nymph, *E. conestee*.

Fig. 17. Foreleg of nymph, *E. conestee*.

Fig. 18. Foreleg of nymph, *E. wayah*.

Fig. 19. Claw of foreleg of nymph, *E. wayah*.

Fig. 20. Head of nymph, *E. wayah*.

Fig. 21. Maxilla of nymph, *E. sp?* No. 1.

Fig. 22. Genitalia of male imago, *E. longicornis*.

Fig. 23. Genitalia of male imago, *E. inconstans*. Compare with Fig. 4.

Fig. 24. Lateral abdominal spines of nymph, *E. inconstans*. Segments 2-9 shown, and part of 10.

Fig. 25. Outlines of distal portions of 9th sternites of female imagoes:

- a. *E. wayah*.
- b. *E. inconstans*.
- c. *E. conestee*.
- d. *E. longicornis*.

Fig. 26. Claw of third leg of nymph, enlarged,—*E. inconstans*.

Fig. 27. Genitalia of male imago, *E. tuberculata*.

## PLATE 10

GENUS *ISONYCHIA*

Figs. 1-4. Apical margins of 9th sternites of female imagoes

Fig. 1. *I. notata*.

Fig. 2. *I. pacoleta*.

Fig. 3. *I. albomanicata*.

Fig. 4. *I. sicca*, var. *manca*.

Fig. 5. Third gill of nymph, *I. notata*.

Fig. 6. Genitalia of male imago, *I. similis*.

Fig. 7. 9th sternite of female imago, *I. annulata*.

Fig. 8. Third gill of nymph, *I. annulata*.

Figs. 9-12. Apical margins of 9th sternites of females.

Fig. 9. *I. similis*.

Fig. 10. *I. georgiae*.

Fig. 11. *I. serrata*.

Fig. 12. *I. aurea*.

Fig. 13. Tibial spines, tarsi and claws of forelegs of nymphs:

a. *I. pacoleta*.

b. *I. albomanicata*.

c. *I. serrata*.

d. *I. aurea*.

Fig. 14. Genitalia of male imago, *I. pacoleta*.

Fig. 15. Tibial spines, etc., of nymphs:

a. *I. similis*.

b. *I. notata*.

c. *I. georgiae*.

d. *I. manca*.

e. *I. annulata*.

Fig. 16. Details of penes of male imago, *I. similis*.

Fig. 17. Details of penes of male imago, *I. obscura*.

Fig. 18. Claws of forelegs of nymphs, much enlarged:

a. *I. aurea*.

b. *I. similis*.

c. *I. pacoleta*.

d. *I. albomanicata*.

Fig. 19. Genitalia of male imago, *I. serrata*.

Fig. 20. Claws of forelegs of nymphs:

a. *I. serrata*.

b. *I. manca*.

c. *I. georgiae*.

d. *I. annulata*.

e. *I. notata*.

Fig. 21. Details of penes of male imago, *I. annulata*.

Fig. 22. Details of penes of male imago, *I. serrata*.

Fig. 23. Genitalia of male imago, *I. annulata*.

Fig. 24. Genitalia of male imago, *I. obscura*.

Fig. 25. Genitalia of male imago, *I. sicca*, var. *manca*.

## PLATE 11

- Fig. 1. Genitalia of male imago, *Siphonurus marginatus*.  
 Fig. 2. Details of penes of male imago, *Siphloplecton speciosum*. See Fig. 19.  
 Fig. 3. Portion of foreleg of nymph, *Isonychia notata*. F, femur; Tb, tibia; Tar., tarsus.  
 Fig. 4. Portions of forelegs of nymphs of *Isonychia*, showing femoral flange and spines on base of tibia.  
 a. *I. aurea*.  
 b. *I. pacoleta*.  
 c. *I. serrata*.  
 d. *I. manca*.  
 e. *I. similis*.  
 f. *I. annulata*.  
 g. *I. georgiae*.  
 h. *I. albomanicata*.  
 Fig. 5. Details of penes of male imago, *Siphloplecton signatum*. See Fig. 13.  
 Fig. 6. Details of penes of male imago, *Siphonurus marginatus*. See Fig. 1.  
 Fig. 7. Third gill of nymph, *Isonychia albomanicata*.  
 Fig. 8. Third gill of nymph, *Isonychia similis*.  
 Fig. 9. Genitalia of male imago, *Siphonurus decorus*.  
 Fig. 10. Third gill of nymph, *Isonychia manca*.  
 Fig. 11. Third gill of nymph, *Isonychia georgiae*.  
 Fig. 12. Third gill of nymph, *Isonychia aurea*.  
 Fig. 13. Genitalia of male imago, *Siphloplecton signatum*.  
 Fig. 14. Third gill of nymph, *Isonychia serrata*.  
 Fig. 15-16. Details of penes of male imago, *Siphonurus decorus*, showing slight variations. See Fig. 9.  
 Fig. 17. Third gill of nymph, *Isonychia pacoleta*.  
 Fig. 18. Details of penes of male imago, *Siphonurus decorus*. Lateral aspect.  
 Fig. 19. Genitalia of male imago, *Siphloplecton speciosum*.

## PLATE 12

- Fig. 1. Maxilla of nymph, *Ephemera blanda*.  
 Fig. 2. Maxilla of nymph, *Eurycaenis nitida*.  
 Fig. 3. Genitalia of male imago, *Baetis australis*.  
 Fig. 4. Hind wing of male imago, *Baetis australis*.  
 Fig. 5. Wing of female imago, *Eurycaenis nitida*.  
 Fig. 6. Maxilla of nymph, *Ameletus lineatus*.  
 Fig. 7. Left mandible of nymph, *Eurycaenis nitida*.  
 Fig. 8. Hypopharynx of nymph, *Eurycaenis nitida*.  
 Fig. 9. Genitalia of male imago, *Baetis* sp? No. 1.  
 Fig. 10. Right mandible of nymph, *Eurycaenis nitida*.  
 Fig. 11. Hind wing of female imago, *Acentrella ampla*.  
 Fig. 12. Maxilla of nymph, *Ameletus* sp? No. 2.  
 Fig. 13. Upper portion of right mandible of nymph, *Pseudocloeon carolina*.  
 Fig. 14. Labial palp of nymph, *Pseudocloeon dubium*.  
 Fig. 15. Genitalia of male imago, *Ephemera blanda*.

PLATE 14

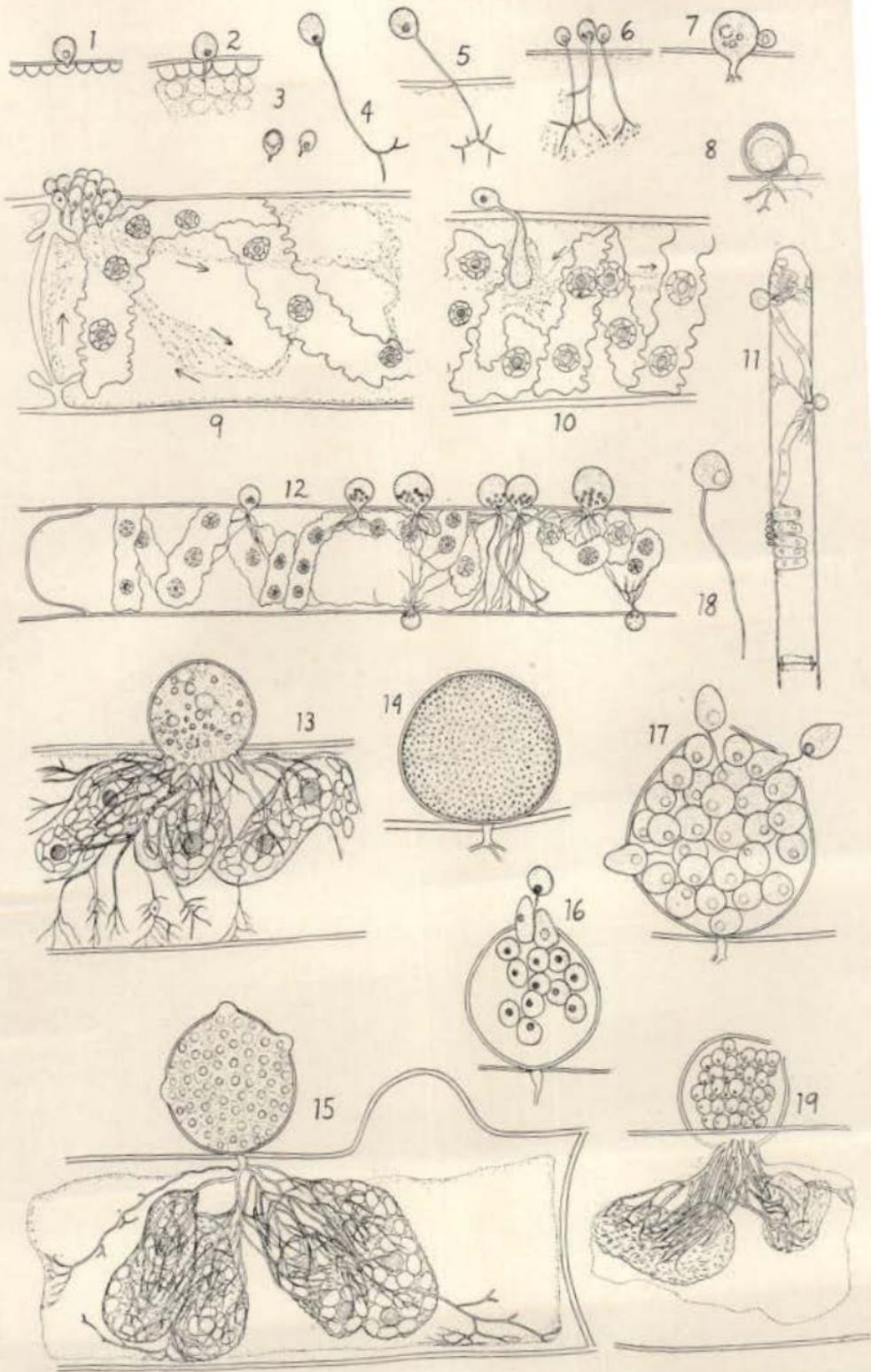


PLATE 15

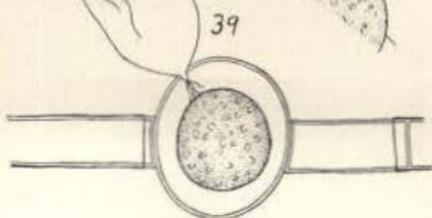
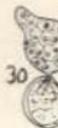
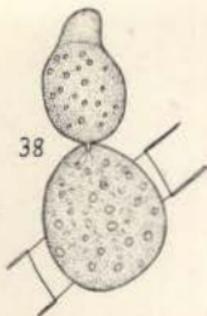
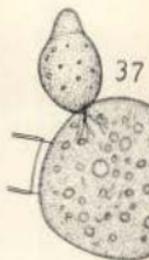
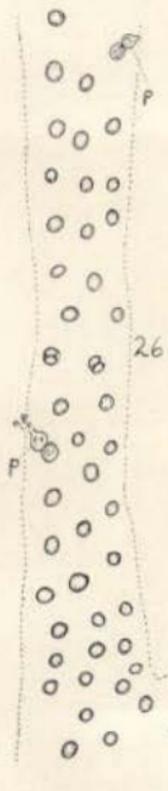
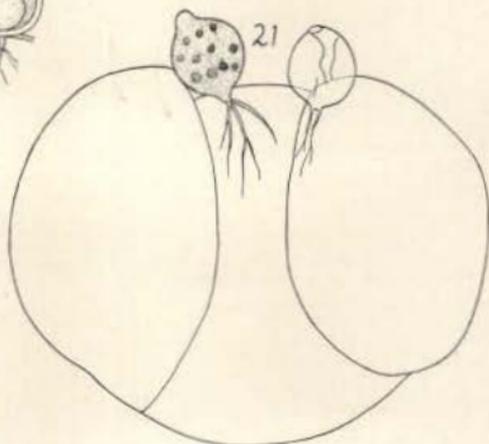
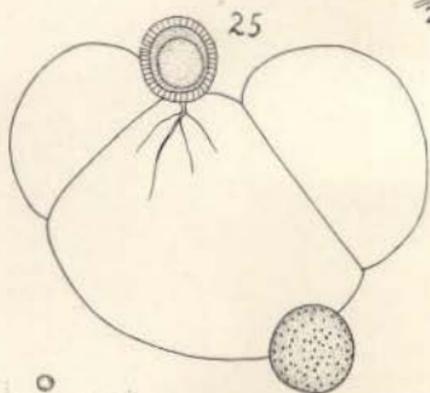
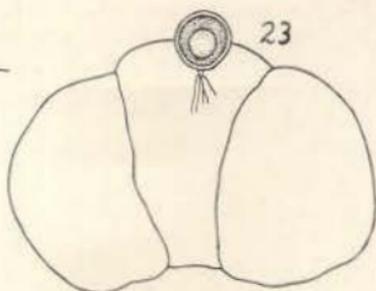
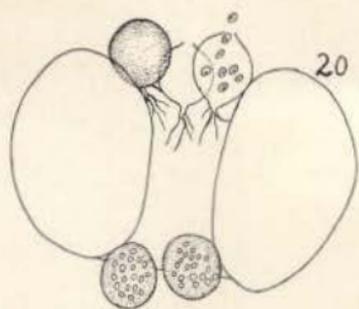


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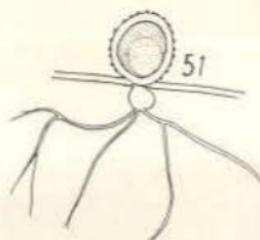
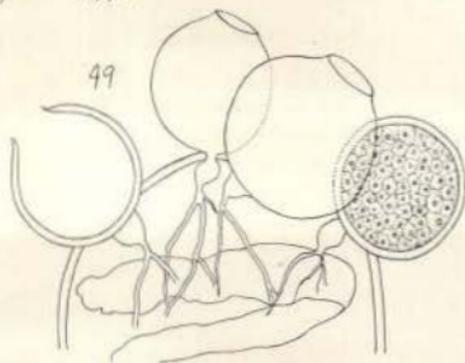
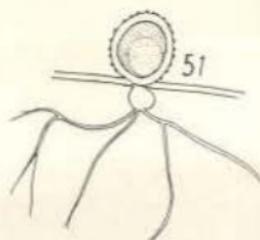
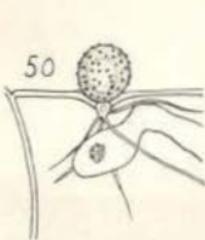
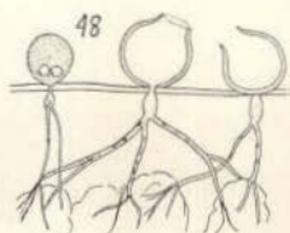
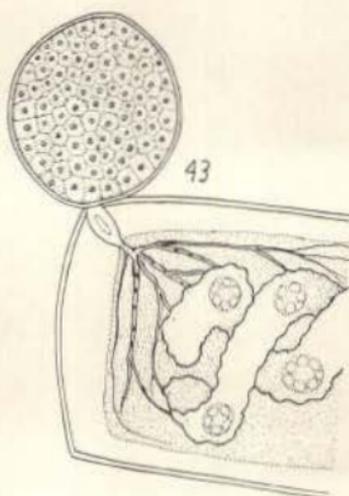
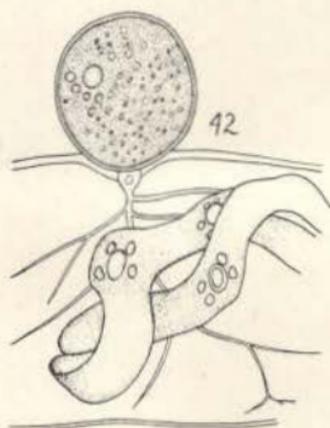
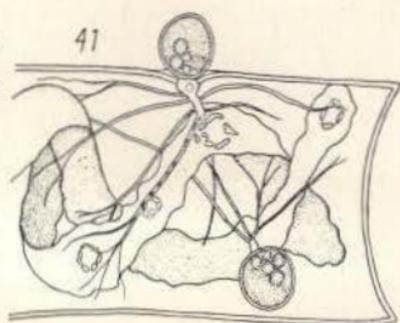
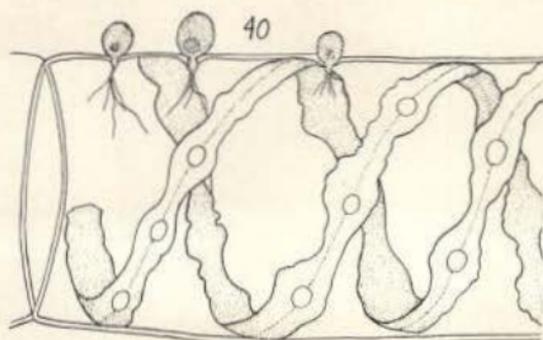
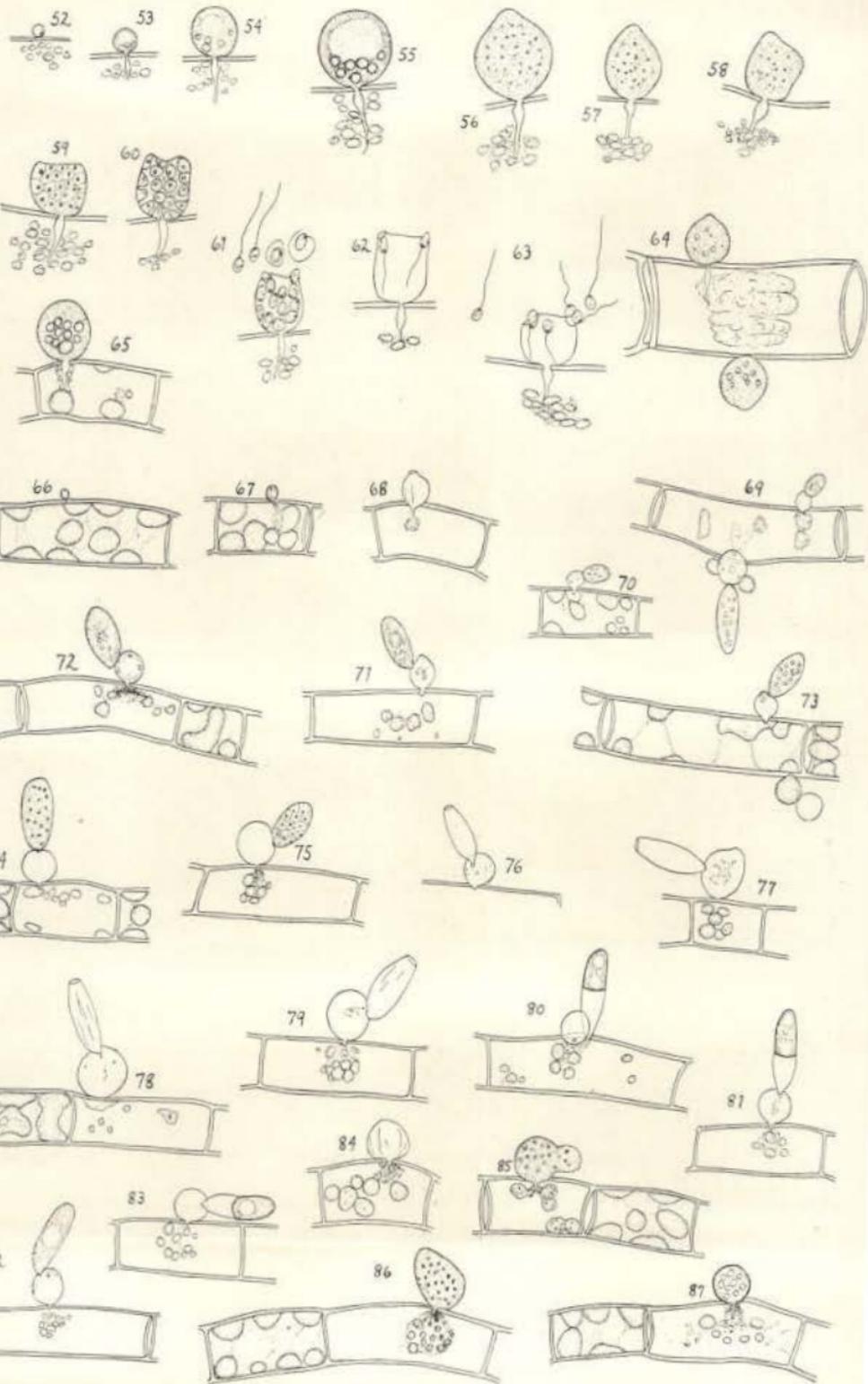


PLATE 17



- Fig. 16. Second and third gills of nymph, *Siphloplecton* sp? No. 1.
- Fig. 17. Upper portion of right mandible of nymph, *Pseudocloeon dubium*.
- Fig. 18. Apical margin of 9th sternite of female imago, *Siphonurus decorus*.
- Fig. 19. Apical margin of 9th sternite of female imago, and paired plates of 10th sternite.—*Baetis australis*.
- Fig. 20. Apical margin of 9th sternite, and plates of 10th, of female imago, *Acentrella ampla*.
- Fig. 21. Genitalia of male imago, *Acentrella ampla*.
- Fig. 22. Frontal process of head of nymph, *Ephemera blanda*.
- Fig. 23. Apical margin of 9th sternite of female imago, *Eurycaenis nitida*.
- Fig. 24. Labrum of nymph, *Ephemera blanda*.
- Fig. 25. Labrum of nymph, *Eurycaenis nitida*.
- Fig. 26. Apical margin of 9th sternite of female imago, *Ameletus lineatus*.
- Fig. 27. Labium of nymph, *Eurycaenis nitida*.
- Fig. 28. Labial palp of nymph, *Pseudocloeon* sp?
- Fig. 29-31. Apical margins of 9th sternites of female imagoes
- Fig. 29. *Siphloplecton basalis*.
- Fig. 30. *Siphloplecton speciosum*.
- Fig. 31. *Siphloplecton signatum*.
- Fig. 32. Maxillary palp of nymph, *Pseudocloeon* sp?
- Fig. 33. Claw and distal portion of third leg of nymph, *Ephemera blanda*.

PLATE 5

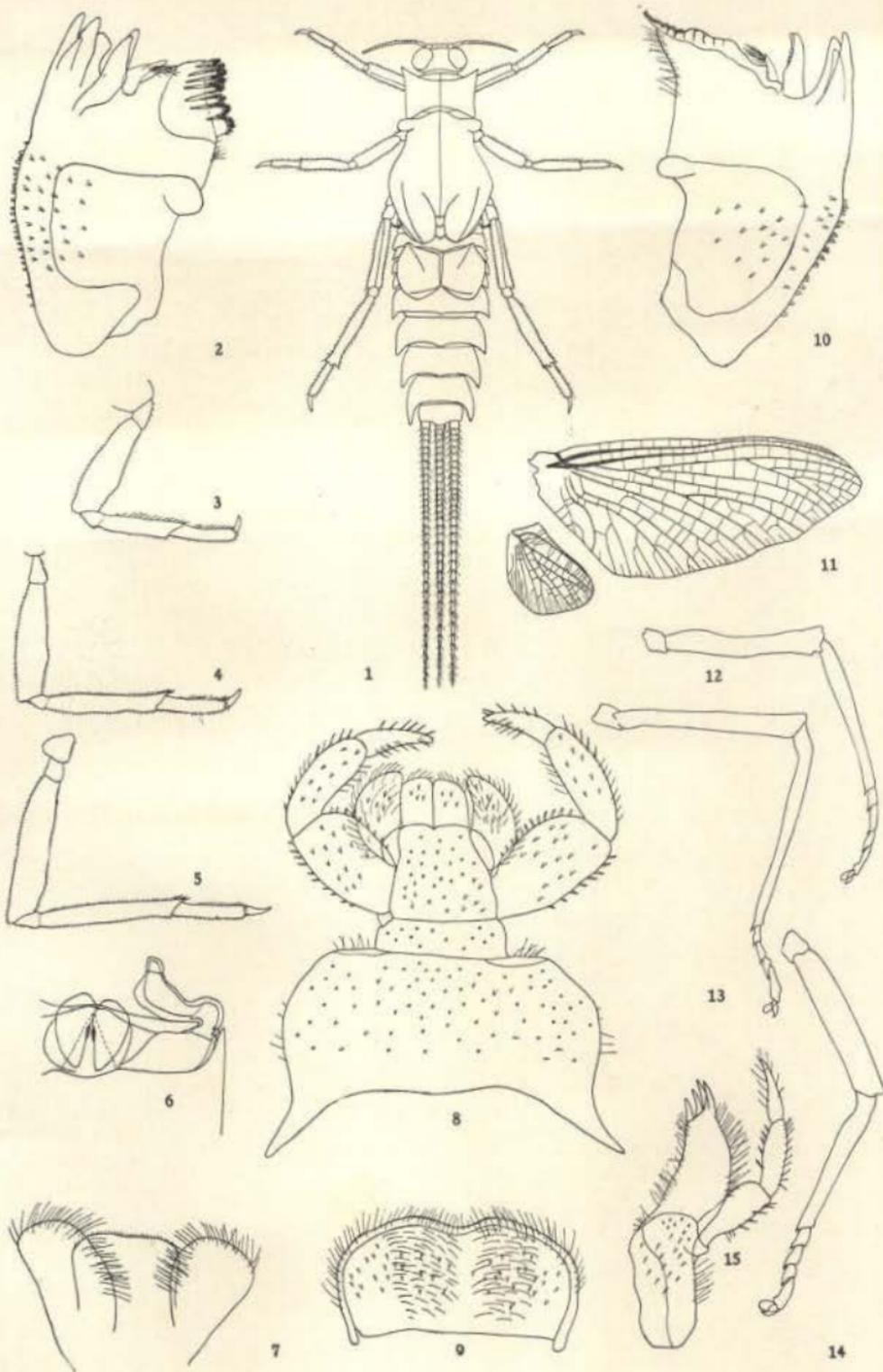
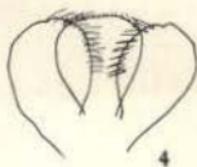
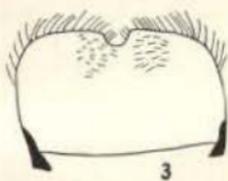
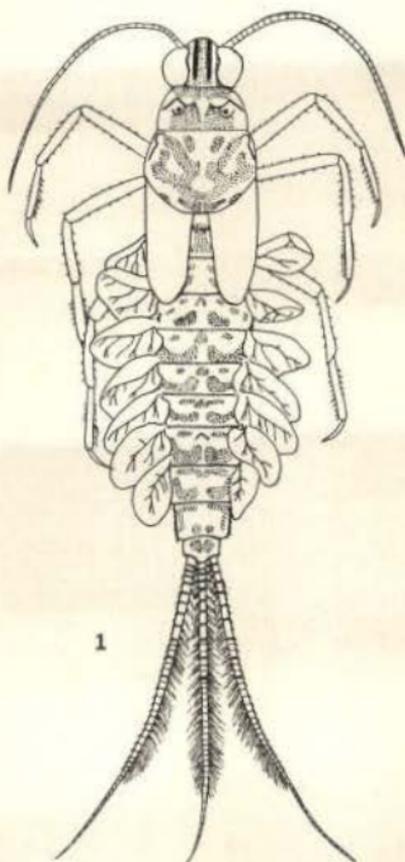


PLATE 6

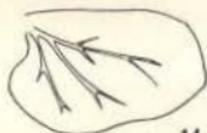


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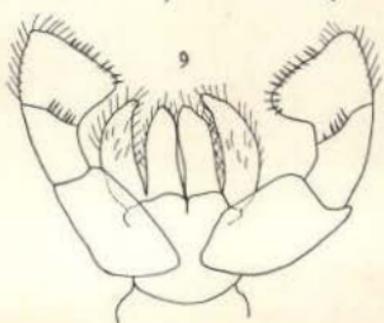
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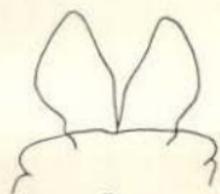
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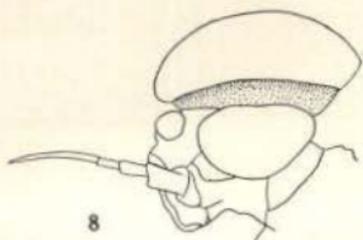
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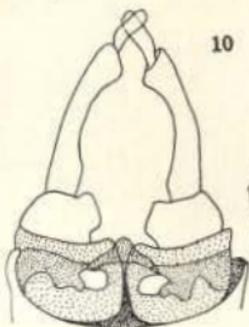
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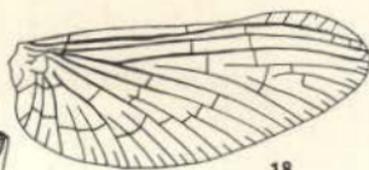
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PLATE 7

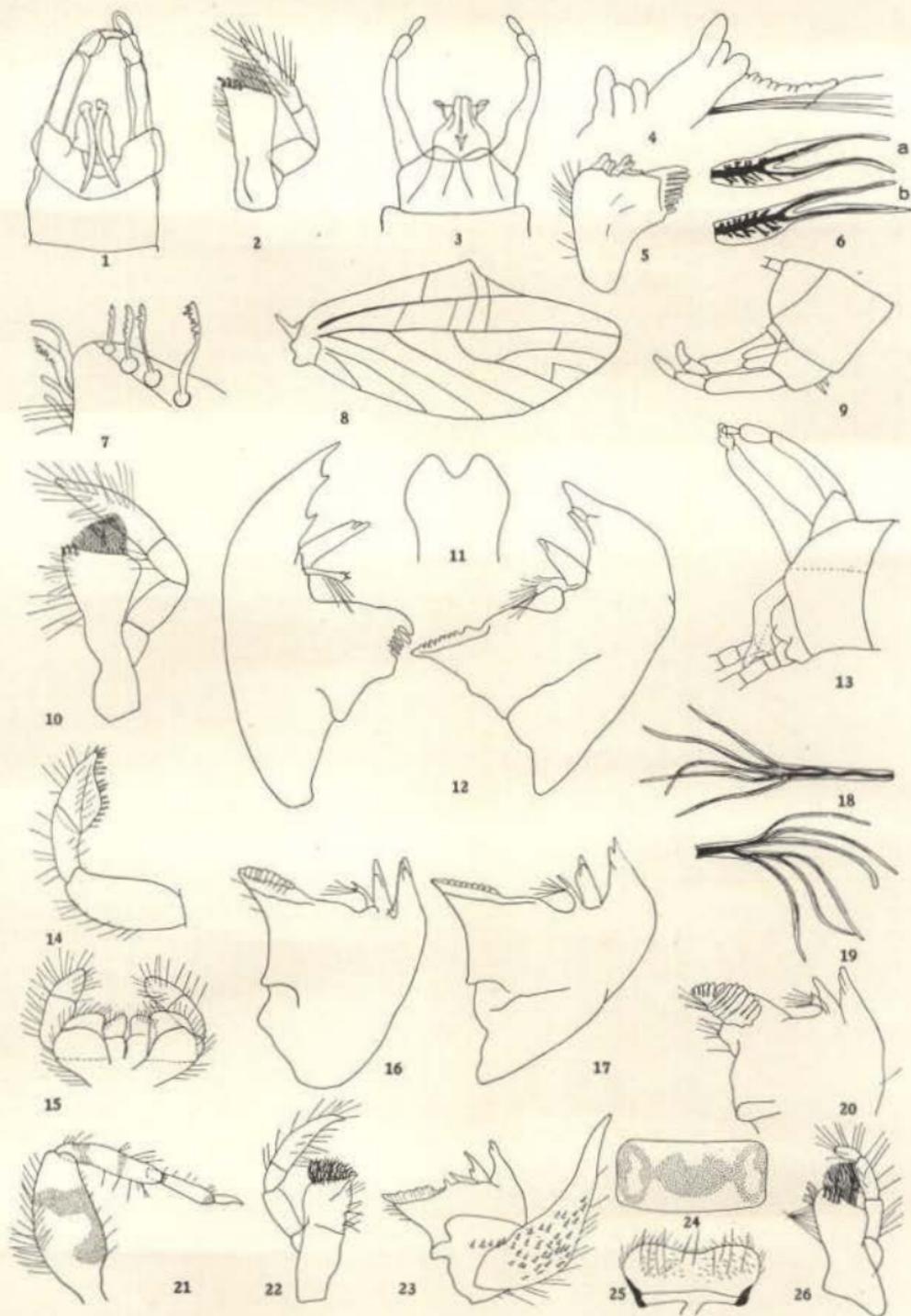


PLATE 8

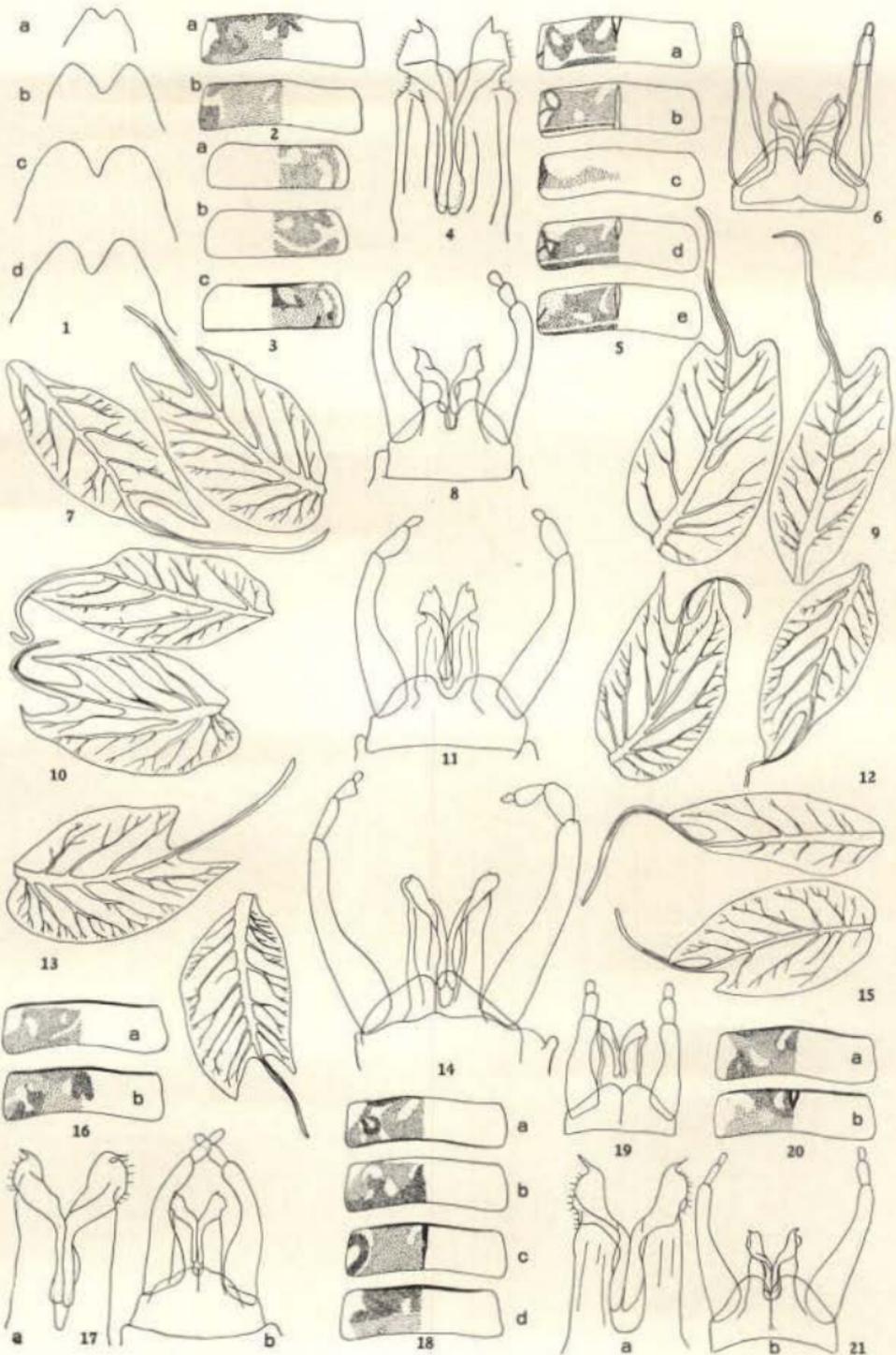


PLATE 9

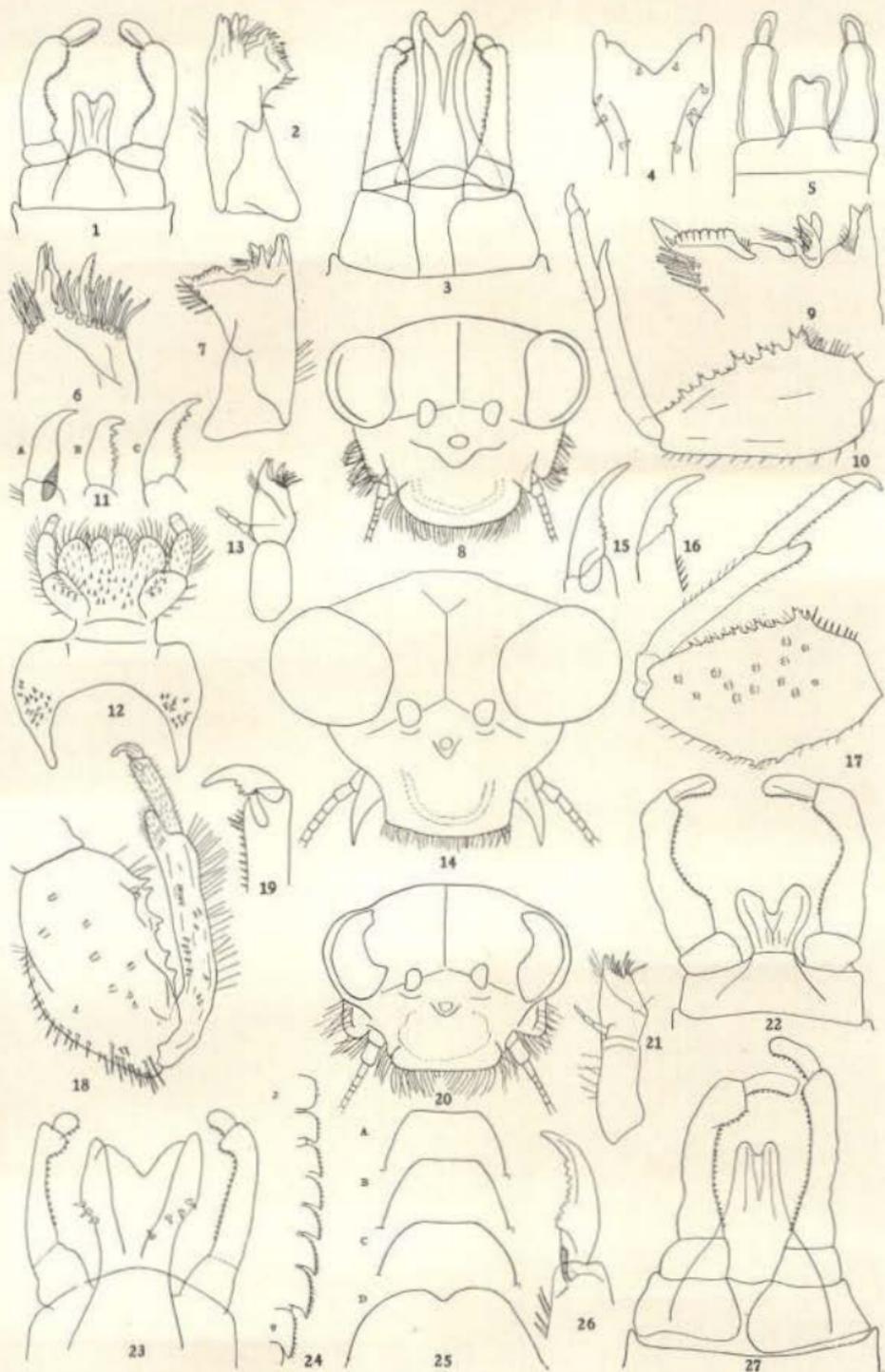


PLATE 10

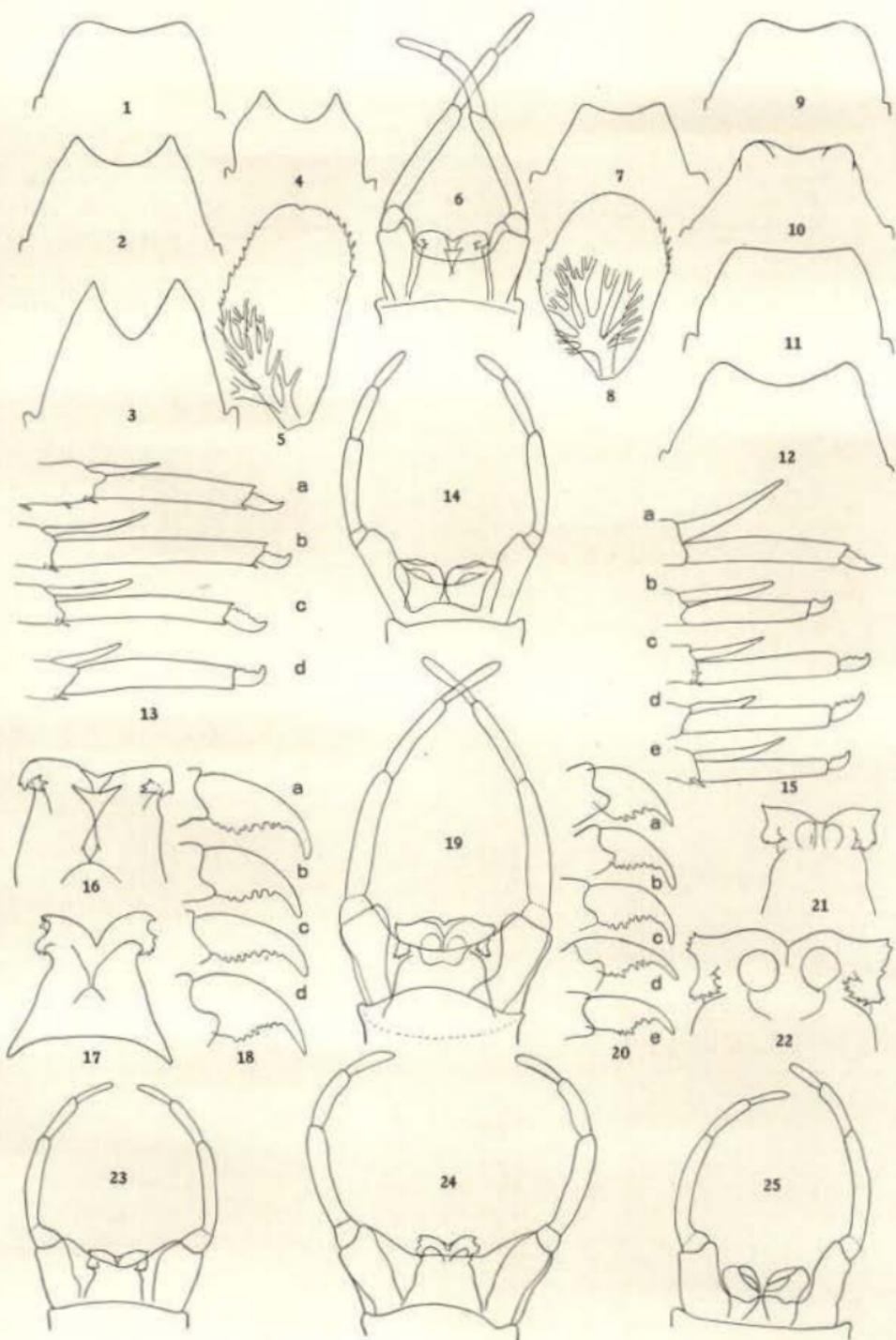
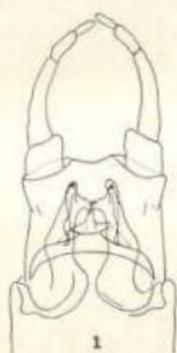
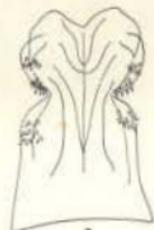


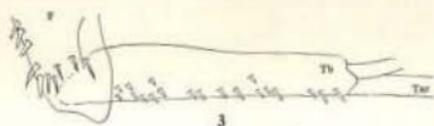
PLATE 11



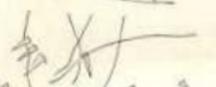
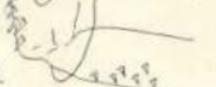
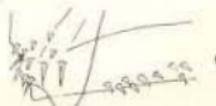
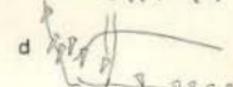
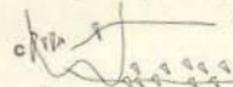
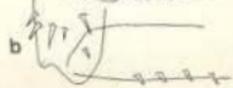
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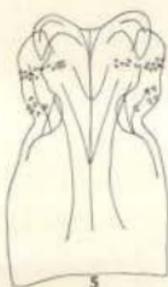


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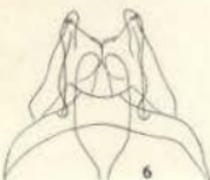
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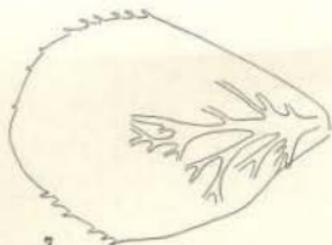
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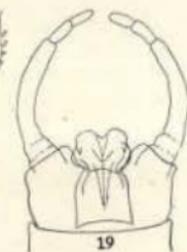
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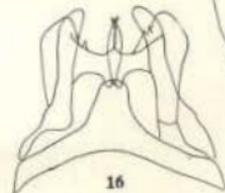
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PLATE 12

