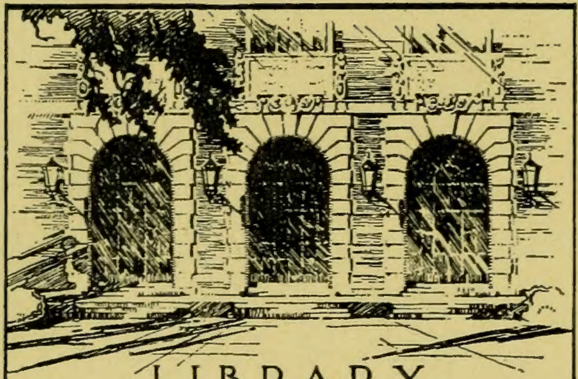

BULLETIN

of the

ILLINOIS NATURAL HISTORY SURVE

LEO R. TEHON, *Acting Chief*

Contents and Index

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1944–1945

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STATE OF ILLINOIS

DWIGHT H. GREEN, *Governor*

DEPARTMENT OF REGISTRATION AND EDUCATION

FRANK G. THOMPSON, *Director*

Urbana, Illinois

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NATURAL HISTORY SURVEY DIVISION
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EMENDATIONS

Page 165, fig. 582. *For* STRAMINEA *read* VESTITA.
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Page 166, column 1, line 5. *For* fig. 582 *read* fig. 583.
Page 166, column 1, line 10 from bottom. *For* fig. 583 *read* fig. 582.
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Page 201, column 1, line 14. *For* Allotype, male *read* Allotype, female.
Page 321, column 1. *For* Mystrophora *read* *Mystrophora.*

Volume 23, Article 1 Urbana, Illinois August 1944

BULLETIN
of the
ILLINOIS NATURAL HISTORY SURVEY
THEODORE H. FRISON, *Chief*

The Caddis Flies, or Trichoptera, of Illinois

HERBERT H. ROSS

Printed by Authority of the
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Volume 23 BULLETIN Article 1

The Caddis Flies, or Trichoptera, of Illinois

HERBERT H. ROSS

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URBANA, ILLINOIS

August 1944

This paper is a contribution from the Section of Insect Survey.

(57806—1500—1-44)

FOREWORD

THE caddis flies, comprising the insect order Trichoptera, are one of the most abundant groups of aquatic insects in Illinois. In both lakes and streams they constitute an important factor in the food economy of our Illinois fishes. For this reason, and because the fauna of the order in the entire Middle West was virtually unstudied, a survey of the caddis flies of Illinois was undertaken in 1931.

In the summer of that year Dr. Cornelius Betten of Cornell University, Ithaca, New York, was employed by the Illinois Natural History Survey to initiate the extensive field work and acquaint the systematic entomological staff of the Survey with the characters used in the classification of caddis flies, and, insofar as possible at that time, with the identity of the various species inhabiting the waters of our state. Since 1931, Dr. Herbert H. Ross, Systematic Entomologist of the Survey, has been responsible for the continuation and completion of the project.

This final report is the culmination of 12 years of field work and study. Most of the field work was carried on in conjunction with other Survey projects, especially those on the Miridae and Cicadellidae, and has followed in general plan and organization our other projects summarized in preceding reports. Caddis flies were collected from all parts of the state and at various seasons, both the adult and immature stages being included in the study. As the work progressed it became apparent that a study of the entire North American fauna was necessary to identify properly the Illinois species, and much of the information so obtained has been invaluable in interpreting material from this state.

We are indebted to several institutions and persons outside the Survey for great help in these studies. In addition to Dr. Betten, who has given constant help and cooperation, we are especially indebted to Dr. Nathan Banks of the Museum of Comparative Zoology, Cambridge, Massachusetts, for making available for detailed study and lectotypic designation the types of Banks and Hagen species in that institution. Persons too numerous to mention have contributed a tremendous amount of information, especially distributional data, in the form of material submitted for identification; although these cooperators are not listed, we wish to draw attention to the significant data their efforts have brought to light.

Several members of our staff in the Insect Survey Section also have contributed greatly to the final manuscript. The full illustrations of adult and larval forms, and also of the cases, are with few exceptions the work of Dr. C. O. Mohr, Associate Entomologist and Artist. Dr. Mohr and Miss Kathryn M. Sommerman, Artist and Entomological Assistant, also added many figures used to illustrate the keys and aid in the diagnosis of genitalic characters. Dr. B. D. Burks, Assistant Entomologist, and Dr. Mohr were responsible for much of the field work, especially the rearing work done at field stations. Finally, the manuscript was read and styled by the Survey Technical Editor, Mr. James S. Ayars.

T. H. Frison, *Chief*
Illinois Natural History Survey

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Connecting Channels of Fox Lake, Illinois

Caddis flies abound in connecting channels and bays of our northern Illinois lakes, which have added many species to our Illinois fauna. Most of the species found in these lakes do not occur in rivers and streams.

The Caddis Flies, or Trichoptera, of Illinois

HERBERT H. ROSS

INTRODUCTION

THE caddis flies, or Trichoptera, are for the most part medium-sized to small insects resembling moths in general appearance. Their larvae are aquatic in habit and caterpillar-like in appearance. The order Trichoptera contains over 750 species, ranking about seventh among the insect orders. For Illinois, we have now recorded 184 species, the largest known list for any state. It must be remembered, however, that Illinois does not have the same wealth of diverse aquatic situations as some other states, the lists of which will be greatly increased with intensive collecting.

In 1931, when this project was started, the only available listing of Illinois species was contained in Dr. Cornelius Betten's then unpublished manuscript of the Trichoptera of New York. In this, Dr. Betten listed not only published records but also the results of his own collecting in the vicinity of Lake Forest, Illinois. This list enumerated 37 species for Illinois. Since that time we have added 146 species to the list, showing how poorly the caddis fly fauna of the entire midwestern and central states was then known.

There is no doubt that additional species will be discovered in the state with continued collecting. For this reason, species known from nearby points have been included in the keys. In addition, as an added precaution to anticipate future discoveries, all genera known to occur in the Great Plains area and eastward have been included in the keys to genera.

Immature stages are known for 120 species treated in this report. There are so many additional species and genera, especially in the western states, for which the immature stages are unknown that the treatment given here will have to be considered as only provisional in certain families for the continent as a whole.

BIOLOGY

The bundle of sticks crawling about in the water, green worms under stones in the stream, swarms of "flies" around the lights along river and lake—these are forms of caddis flies familiar to the general insect collector. They are but a few isolated phenomena, however, in a picture of life histories and interrelationships varied in pattern and interesting in detail.

Life Cycle

In general the life history of caddis flies follows this pattern: The eggs are laid near or in the water, each soon hatching into a worm called a *larva*, which lives in the water and may build a case of sticks, sand grains and other small objects. When full grown, this larva makes a cocoon in which it changes into a transformation stage called a pupa. The adult structures (e.g., wings and genitalia) develop within the pupa. When the adult structures are fully developed within it, the pupa cuts its way out of the cocoon, swims to the surface, crawls out of the water and attaches itself firmly to a stick, stone or other object. The adult then bursts the pupal skin, wriggles and crawls out of it and flies away free. Mating flights follow; a period ensues for maturity of the eggs within the body of the female, which then lays the eggs in the water, beginning the cycle again.

Detailed accounts of various phases of caddis fly life histories have been written by many authors and constitute an extensive literature. This was summarized by Betten in 1934 and again, very extensively and completely, by Balduf in 1939. Consequently, only a brief résumé of the biology is given here. In our Illinois studies, we have stressed the taxonomic aspects; so the following information concerning oviposition is drawn almost entirely from the two sources mentioned above.

Eggs and Oviposition

Caddis flies lay many eggs, the number probably ranging from 300 to 1,000 per female. Considerable information is known regarding the manner and place in which these eggs are deposited, but a tremendous amount remains to be observed.

The adult females of Rhyacophilidae, Philopotamidae, Psychomyiidae, Hydropsychidae and Hydroptilidae enter the water and there lay strings of eggs, fig. 1*B*, on stones or other objects. These strings are usually grouped to form irregular masses, each containing from a few to 800 eggs. The eggs are surrounded by a thin, cement-like matrix.

Females of other caddis fly families usually extrude the eggs and form them into a mass at the end of the abdomen before depositing them. These masses are usually irregular or ovoid, but in some genera are very definite in form, as, for example, the genus *Triaenodes*, in which the eggs are arranged in a flat oval, fig. 1*A*. In all egg masses the matrix surrounding the egg is gelatinous and swells upon absorbing moisture.

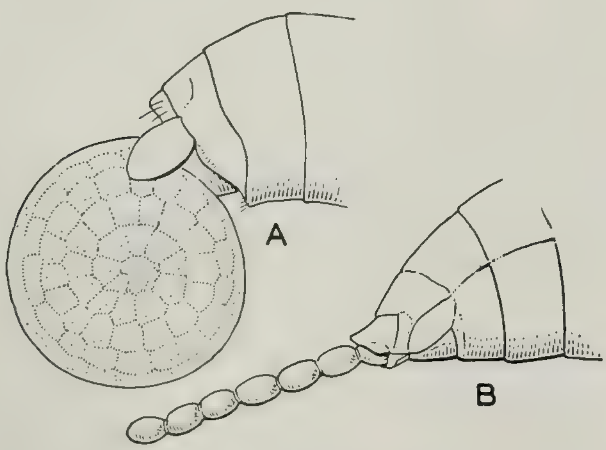


Fig. 1.—Eggs of caddis flies. *A*, *Triaenodes tarda*; *B*, *Cyrnellus marginalis*.

The Leptoceridae, Phryganeidae, Molannidae and Brachycentridae usually attach the egg masses to submerged stones, logs or vegetation. The females of some of these have been observed entering the water or putting the abdomen into it for this purpose. Other families, such as Helicopsychidae, Goeridae, Lepidostomatidae and Sericostomatidae, deposit the egg masses in or near the water, apparently as frequently one way as the other. When not laid in the water, the masses are usually placed near it.

The family Limnephilidae has been the subject of interesting observations and speculations. The egg masses are deposited above the water on plants or stones which protrude above it, on objects along the shore or sometimes on twigs high in trees. In this last case the gelatinous mass may liquefy with rain, and the drops so formed run down the twigs and drop into the water, carrying young larvae with them. Evidence of actual migration to water of young larvae hatched from egg masses far from the water's edge has not been demonstrated. Rain probably plays an important part in this phenomenon.

Larval Habits

Mode of Living.—Possibly the most interesting, and certainly the most startling, aspect of caddis fly biologies is the construction, by many species, of houses in which they live. Not all species have these houses, and many of the houses are of different types. Much has been written regarding possible classifications of these habits, including the formulation of complex systems and explanations. I believe, however, that the following brief synopsis will present most of the pertinent data.

Free-Living Forms.—The larvae of the genus *Rhyacophila* are completely free living, having no case or shelter; they lay a thread trail and have many modifications for free life in flowing water, including widely spaced, strong legs and large, strong anal hooks, fig. 133. For pupation they form a stone case or cocoon.

Also free living are the early instars of many Hydroptilidae (see p. 160).

Net-Spinning Forms.—Larvae of Hydropsychidae, Philopotamidae and Psychomyiidae spin a fixed abode which is fastened to plants or other supports in the water, sometimes in still water but more frequently in running water. Three common types of these structures are found, all of them spun from silk and forming some sort of net; when taken out of water they collapse into a shapeless string. There is always an escape exit at the end of the tube.

1.—Finger nets, fig. 2. These are long, narrow pockets of fine mesh, with the front end anchored upstream, the remainder trailing behind with the current. They are built by the Philopotamidae.

2.—Trumpet nets, fig. 3. In this type the opening of the net is funnel shaped, and the end is fastened in such a way that the water movement distends the net into a trumpet-shaped structure. This type of net is used extensively by the Psychomyiidae.

3.—Hydropsychid net, fig. 4. Peculiar to the family Hydropsychidae is the habit of erecting a net directly in front of a tubelike

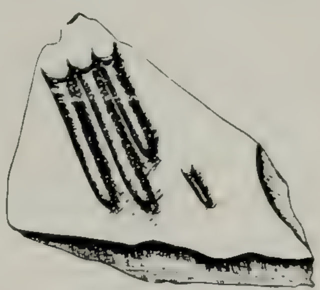


Fig. 2.—Finger nets of *Chimarra aterrima.* (After Noyes.)

retreat concealed in a crevice or camouflaged by bits of wood, leaves or similar material. These nets may be erected between two supports in the open, as in the case of *Potamyia*, or the net may be constructed as one side of an antechamber, as in the case of many species of *Hydropsyche*, fig. 4.

In all these types the caddis fly larva cleans the food and debris off the net, ingesting anything edible swept into it by the current. Normally the larva spends most of its time with its head near the net ready to pounce on any prey. When disturbed, it backs out of the net or retreats with great agility. The flexible body structure enables the larva to move backward rapidly, but it can move forward only slowly.

Tube-Making Forms.—Some psychomyiid larvae, notably of the genus *Phylocentropus*, burrow into sand at the bottom of streams, cementing the walls of the burrow into a fairly rigid structure which may be dug out intact. The mechanics of food gathering in this group are not well understood.

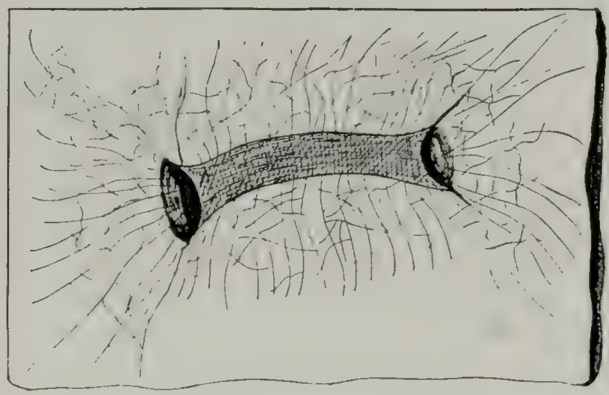


Fig. 3.—Trumpet net of *Polycentropus* sp. (After Noyes.)

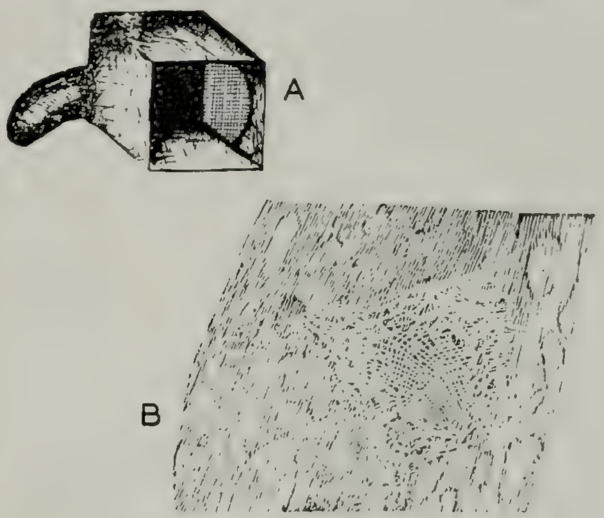


Fig. 4.—Nets of *Hydropsyche.* *A*, diagrammatic figure of house; at the left is the tube in which the larva lives; in front of it is a vestibule having a catching surface with a fine mesh in the side wall; near this net is the opening of the larval tube. (After Wesenberg-Lund.) *B*, net spun over a crevice of a submerged stick which houses the larva. (After Comstock.)

In both the net-spinning and tube-making forms, pupation takes place in the end of the tube or retreat. The larva constructs a cocoon of leaf fragments, stones or whatever other material is available, lining it with silk. The pupa is formed here.

Saddle-Case Makers.—Larvae of the rhyacophilid subfamily Glossosomatinae make a portable case which consists of an oval top made of stones and a ventral strap made of the same material, fig. 136. The larva proceeds with its head and legs projecting down in front of the strap and the anal hooks projecting down at the back of the strap. For pupation, the strap is cut away and the oval dome is cemented to a support, the pupa being formed in the stone cell thus made.

Purse-Case Makers.—Following exactly the same principle as the above are many cases of the Hydroptilidae. In general appearance they resemble a purse, fig. 465. The larva occupies the case with the head and legs projecting out of a slit in the front margin while the anal hooks project out of a slit in the posterior margin. For pupation, however, the case is cemented along one side to a support and the slits are cemented shut to form the pupal chamber. Not all Hydroptilidae have cases of this type, some of them having true cases (see p. 160).

Case Makers.—All caddis fly larvae except those listed above make portable cases which the larvae drag with them in their daily movements. These cases are usually made of pieces of leaves, bits of twigs, sand grains or stones which are cemented or tied together with silk. Rarely the case is made entirely of silk. Case construction varies a great deal from one group to another, from one species to another within the same genus, and frequently within the same species. In general, cases subject to greatest stream current are the most solidly constructed, whereas those in small ponds where there is scarcely any water movement are the most loosely constructed.

For pupation the case is anchored to a support and a top added to the case; the pupa is formed inside this shelter and no additional cocoon is made.

Feeding Habits.—Most caddis fly larvae are practically omnivorous, eating whatever comes to hand. Such forms as the Hydropsychidae and Limnephilidae eat a preponderance of plankton, sessile diatom growths and other small organisms, but if opportunity affords they will eat insect larvae and often each other. When their populations become crowded, caddis fly larvae are cannibalistic to a high degree.

Certain genera are primarily predaceous, the most notable ones being *Rhyacophila* and *Oecetis*. Examination of stomach contents shows that both of these are voracious eaters; we have found 40 to 60 Chironomidae larvae in single individuals of *Rhyacophila*, the alimentary tract being crowded with these midge larvae from one end to the other. In these two genera the mandibles are long and narrow, apparently fitted for grasping prey of this type. Such mandibles do not occur in phytophagous forms which may be cannibalistic.

The order Trichoptera as a whole, however, may be characterized as one in which the minute aquatic life is assimilated and converted to units of larger size which are in turn usable by a variety of larger organisms.

Respiration.—This function in the Trichoptera is accomplished by cutaneous exchange or by gills. It varies greatly within families and genera. Usually the larvae of greater size have the larger or more abundant gills, and the small larvae have no gills at all. This is by no means a general rule throughout the order. In those species having gills, gill pattern and type is almost uniform throughout the entire period of larval growth, from the youngest to the full-grown stage.

Adult Habits

Caddis flies include many strong fliers, such as *Macronemum*, but they also include other genera that fly only short distances. A few species have brachypterous or apterous females which cannot fly but which run with great agility.

In daytime most of the caddis flies rest in concealed crevices or on foliage in moist, shaded glens bordering streams. At dusk the adults fly quite freely, often skimming back and forth across a body of water just above the surface. These flights are probably mating flights, since males are frequently involved; observations indicate that these flights are not correlated directly with oviposition.

The adults have mouthparts that are adapted for the ingestion of liquid foods and have no hard grinding parts for mastication of hard foods. In some families such as the Phryganeidae the end of the labium forms a large, terminal membranous lobe similar in general appearance to the proboscis of higher Diptera. Records indicate that in spite of having no other means of getting food, adults of many species normally live 1 or 2 months, and probably in all species nearly a month.

Oviposition is discussed in connection with the eggs.

Parasitism

The only record of parasites of caddis flies in North America was reported by Mickel & Milliron (1939). They reared a hymenopterous parasite, *Hemiteles biannulatus* Gravenhorst, from cases of *Limnephilus indivisus* from Itasca Park, Minnesota. In Europe the hymenopterous parasite *Agriotypus* has been reared from caddis fly larvae.

HABITAT PREFERENCE

Over most of Illinois, caddis fly habitats are streams and rivers with medium to slow current, with fairly warm water and frequently with a heavy silt deposit. This statement applies not only to the main water arteries but also to most of the small creeks and branches which feed them. These streams run through the highly developed agricultural area which includes most of the state. Markedly different types of streams are either restricted to small areas such as the Ozark Hills, or very locally distributed, as for example, the spring-fed brooks at Elgin.

In Illinois, natural lakes are restricted to the northeastern corner of the state and are all of glacial origin. Here are found a few typical lake species but they do not form a large proportion of our caddis fly fauna. Artificial lakes are common over most of the state but have few caddis flies.

Typical Large Rivers

The Mississippi, Illinois and Wabash are in some respects typical not only of our large rivers but also of the more sluggish lower portions of smaller ones such as the Fox and Kaskaskia. These have enormous numbers of the net-spinning caddis flies, especially *Potamyia flava*, *Cheumatopsyche campyla* and *Hydropsyche orris*, *bidens* and *simulans*. The case-making species are confined almost entirely to the Leptoceridae, and those taken in abundance include *Oecetis inconspicua* and *avara*, *Athripsodes cancellatus* and *transversus*, and *Leptocella candida*, *exquisita* and *diarina*. Abundant web-spinning forms include *Neureclipsis crepuscularis* and *Cyrnellus marginalis*.

In these situations there are generally few or no very early season species. Most of the species occur in the adult stage throughout the late spring and summer months with continuous generations.

Unusual Large Rivers

Kankakee River.—Of all the rivers in Illinois, the Kankakee, fig. 5, is the most unusual from the standpoint of the caddis fly fauna. Here we have taken 12 species found nowhere else in the state. Several other species are common here but rarities

Fig. 5.—Kankakee River at Wilmington, Illinois. This is one of three rapids on the lower portion of this river, in all of which caddis flies of unusual interest are found.

in other localities. The stream originates in the swamps and lakes of northern and western Indiana, flows through the lower portion of the northeastern eighth of Illinois and empties into the Illinois River a few miles west of Joliet. The water is always colder than in our other rivers, almost always clear and in Illinois passes over three swift rapids. The first rapids are at Momence and are caused by a limestone outcrop over which the river flows; below the outcrop the river gradually slows and in this portion are luxurious beds of eel grass which extend almost the full width of the river bottom. The second rapids are at Kankakee, extending from the foot of a power dam about one-third of a mile downstream; here the river is wider and shallower, and the bottom more gravelly, than at Momence. The third rapids are at Wilmington, also below a power dam, but nearly a mile long; here the bottom has the swiftest portion strewn with boulders and the steepest gradient of all three rapids.

There is a remarkable difference in the taxonomic composition of the caddis flies found in each rapids. Certain species unique to the river are common to all three rapids, but others may be very abundant at one and rare or entirely lacking in the other two. For instance, *Brachycentrus numerosus* and *lateralis* and *Micrasema rusticum* are all very abundant at Momence but have never been taken at Kankakee or Wilmington. *Hydropsyche cuanis* occurs in countless swarms at Wilmington but is a rarity at the other two rapids. *Hydropsyche aerata* is very common at Kankakee but is rare at the other two. *Hydroptila albicornis* is common to all three rapids but is found nowhere else in Illinois. There is no doubt that the physiological attributes of the water are quite different at the three points described, and these differences are likely due to the effect of the power dams and the sewage affluent which goes into the river below each city.

Rock River.—This river, running diagonally across the northwestern eighth of the state, is essentially a clear, swift, cold-water stream with a rock or gravel bottom. In the early 1900's it was an unusually rich stream from the standpoint of large variety and numbers of fish, but affluent from factories, city sewage and silt-laden drainage ditches have altered the stream considerably. The caddis flies found there today, however, show distinctive features in contrast to those of other streams. This is the only river in which *Hydropsyche bifida* occurs in large numbers; it is one of the few streams in which we have taken *Athripsodes mentieus*, *Chimarra obscura* and *Hydropsyche valanis*; and it is the only stream where we have taken the northern *Limnephilus moestus*.

Tributary Streams

Collecting in the smaller rivers and creeks soon shows that as the size of the stream decreases the potentialities for a varied fauna increase. The species mentioned as abundant in the large rivers are found also in these smaller streams but in smaller numbers; conversely, we find here in numbers species which are usually rare in river collections. These include, among the net- and web-spinning groups, *Cheumatopsyche analis*, *oxa* and *aphanta*, *Hydropsyche bronta* and *arinale*, *Nyctiophylax vestitus* and *Polycentropus cinereus*. The case makers are represented by a great variety of the "micros," or Hydroptilidae, such Limnephilidae as *Pycnopsyche* and *Caborius*, and a great variety of Leptoceridae, especially species of *Athripsodes*, *Triaenodes* and *Oecetis*.

Most of these small streams, as stated above, are similar in general characteristics to the large rivers. They are sluggish, silt laden for much of the year and have fairly warm water. Most of the species have continuous generations from late spring to early autumn and few of them are early seasonal forms. The chief exceptions to this are the Limnephilidae mentioned above, which aestivate during the summer and transform only in autumn, and our only common species of Rhyacophilidae, *Rhyacophila lobifera*, which has only one generation, maturing early in spring.

Ozark Hills Streams

In the southern tip of Illinois there is a small range of hills reaching an elevation of about a thousand feet. These are one of the eastern remnants of the Ozark Mountains. In these hills are numerous streams quite different from the usual type found in the northern part of the state. They have rocky beds, and in winter and spring they are swift and clear. Green moss grows in the streams, and they are muddied only temporarily after rain. The banks are wooded with dense stands of trees which form a canopy over the water when the leaves are out. In early spring, beginning in March, these streams abound in a variety of caddis flies; case makers crawl over the rocks, and others crawl in the moss or under the stones.

The taxonomic composition of all these Ozark streams is virtually the same and it is remarkably distinct from all other streams in the state. Species confined to this area include *Rhyacophila fenestra*, *Agapetus illini*, *Dolophilus shawnee* and a number of Hydroptilidae, among them *Ochrotrichia shawnee*, *eliaga*, *anisca* and *unio*, *Hydroptila virgata*, *vala* and *amoena* and *Neotrichia riegeli* and *collata*. Species of *Hydropsyche*, *Cheumatopsyche* and other genera which are common in other streams of the state are a rarity here.

Of unusual interest in this area are four other caddis flies. *Chimarra feria* is very common in these streams but has been taken nowhere else in the state; *C. obscura*, which we find in several other parts of Illinois, has not been taken in our recent collecting in the Ozark Hills but was apparently fairly common in them around 1900, judging by collections made at that time by C. A. Hart. Taken at the same time and place by Hart were several collections of a species of *Athripsodes* believed to be *flavus* (see p. 228); this species has not been taken in the area in our recent survey. The fourth species is *Neophylax autumnus*. These limnephilid larvae make a hard stone case and are exceedingly common in most of the Ozarkian streams. They occur sparingly in other parts of the state.

Early in summer these streams tend to dry up, often going beyond even a pool stage to the point at which no water can be seen along the entire course of the stream. This dry period frequently extends into November and December before water again flows; yet by spring the life in the water is invariably present in great abundance. The manner in which many of the caddis flies survive through this dry period is unknown. Examination of the dry bed has given information on three species which pass through this period in the larval or pupal stage; it is likely that some of the others pass it in the egg stage.

Where the stream bed is shaded and the ground contour provides some subsurface drainage into it, stones and shelflike outcrops may remain damp underneath indefinitely. In these damp situations we found large numbers of *Neophylax autumnus* larvae aestivating; later in the autumn while the stream was still dry these larvae transformed to pupae, and we watched actual emergence of adults from these nearly dry cases. Digging a few inches into the stream bed, we discovered active larvae of *Chimarra feria* and a healthy pupa of *Rhyacophila glaberrima* under stones at a level where stones and sand were moist. In no case did we find signs of active forms along portions of the stream bed which were not shaded.

Unusual Small Streams

Scattered around the state are a number of streams quite different in character and fauna from the usual stream running through most of the agricultural land. Ex-

Fig. 6.—Brook in Botanical Gardens at Elgin, Illinois. This and three parallel sister brooks are fed by seepage and are cold and clear throughout the year. Here live several northern caddis flies found nowhere else in the state.

cept for those in the Ozark Hills, these streams are isolated and local, probably mere relics of habitat types which may have been extensive and numerous before the forests were cleared and the swamps drained in advance of the plow. Some of the caddis fly species occurring in these relic areas are a rarity in this entire Central States area but fairly common in streams of some of the northeastern states. These individual localities have unusual species, many of them not the same as those found in similar Illinois localities. In Indiana and southern Michigan this same type of relic area is found.

Elgin.—Just north of the city of Elgin are the unique Botanical Gardens situated along the low, east bluff of the Fox River. The park is an undisturbed remnant of the original woods of the region and contains a great variety of interesting herbs, shrubs and trees. Out of the sides and base of the bluff run many seepage rivulets which merge to form five small brooks, each from 1 to 3 feet wide and a few inches deep, with a stony bottom and a fairly rapid flow, fig. 6. The water is cold and clear at all times. In all of these streams the caddis flies are extremely numerous, their cases literally paving the bottom of the streams. Here we have taken seven species found nowhere else in the state: *Glossosoma intermedium*, *Dolophilus moestus*, *Rhyacophila vibox*, *Hesperophylax designatus*, *Molanna tryphena*, *Limnephilus rhombicus* and *Drusinus uniformis*. The first four are common, especially the *Glossosoma* and *Hesperophylax*, the cases of which may be found by the thousands in these streams.

Not only are these species peculiar to these streams, but other species found in neighboring streams are practically absent. Other species which occur include chiefly *Lepidostoma liba* and *Diplectrona modesta*, both found only locally elsewhere in Illinois. These conditions mark this Elgin group as the most unusual and interesting of our relic streams.

Somewhat similar in nature are two other spring-fed brooks near the Botanical Gardens. In one we discovered a large colony of *Hydropsyche slossonae* and in the other a colony of *Chimarra aterrima*, both rare and local in the state.

Split Rock Brook at Utica.—This small stream originates, fig. 7, in a spring near the head of a short, wooded ravine and flows along a channel 2 or 3 feet wide through a rich growth of herbs and shrubs. The water is clear and cold and uniform in volume except after hard rains.

This stream has two distinct parts to its course. In the upper, shaded portion we have taken *Diplectrona modesta*, our only Illinois record of *Polycentropus pentus* and great numbers of the case maker *Neophylax autumnus*. It was in this locality that we found individuals of this last species emerging as adults in February and early spring, the only such record for the entire genus (see p. 203).

Fig. 7.—Brook at Split Rock, near Utica, Illinois. Another spring-fed stream which is clear and cold throughout the year. Unusual species found here include *Polycentropus pentus* and *Ochrotrichia riesi* and *spinosa*. (Photo by Donald T. Ries.)

In the lower portion, which flows through a cleared area along the railroad right-of-way, we found *Ochrotrichia riesi* and *spinosa*, to give us the only Illinois records of these species. In this portion of the stream the species mentioned in the preceding paragraph were extremely scarce.

Apple River Canyon State Park.—The Apple River flows out of southern Wisconsin and cuts across the extreme northwestern corner of Illinois. Above and below Apple River Canyon State Park the river is sluggish, silty and nearly devoid of caddis flies except for some of the tolerant species, such as *Oecetis inconspicua*. Through the park, however, it traverses a few miles of rocky land, and has here a rock bottom, faster current, shaded banks and practically clear water, fig. 8. In this stretch we have taken several species rare in the state, such as *Psychomyia flavida, Hydropsyche bronta* and *Neotrichia okopa.*

Of greatest interest at the park is a very swift point in the river where the "leech-egg" cases of the hydroptilid *Leucotrichia pictipes* are found. These are attached at the sides of 30- to 50-pound boulders in the very center of the current. This is the only place in the state where this species has been found, and our only other nearby records are considerably to the north, in Wisconsin and Michigan.

Cave Streams.—There are few caves in the state which discharge a permanent flow of water, and most of these have few or no caddis flies of interest in the resultant stream. There are two, however, which produce cold, permanent streams with interesting species: (1) At Union Spring, near Alto Pass, is a small cave out of which flows a stream about a foot wide; in the few feet from the cave to the bottom of the hill a colony of larvae belonging to *Hydropsychid Genus A* occurs under the stones (see p. 83). (2) Near Quincy is a cave from which flows a small stream in which there is a large colony of *Lepidostoma liba*; while we have found the species in two other small, spring-fed streams in the state, this is the only locality in which the species is numerous.

Seepage Area.—At Matanzas Lake, near Havana, there is a sharp valley cut through the sand ridges by a small stream. At the side of this little valley, right at the base of the hill, we found a seepage area a few feet in diameter and not as deep as the thickness of a caddis fly case. Cases of *Frenesia missa* literally covered this small area, many of the larvae crawling up on the leaves until the case was almost completely out of the water.

In the summer of 1941 this little spring apparently dried up, for no cases were found in it in October, the month in which pupation occurs. A few scattered individuals were found in the adjacent stream, and these likely represent a small reservoir of population for the rehabilitation of the seepage areas after drought conditions.

Other Peculiar Streams.—There are several other streams which have caddis

Fig. 8.—Apple River in Apple River Canyon State Park, Illinois. Outside the park this stream is sluggish, muddy and has little aquatic life. The rapids inside the park, however, afford a varied caddis fly fauna, including our only record of *Leucotrichia pictipes.* (Photo by Donald T. Ries.)

flies unusual for Illinois but which differ only slightly in general characteristics from average streams in the vicinity. Prominent among these is Quiver Creek, a fairly clear, cold, rapid stream flowing through the sand region just north of Havana, where we have taken a variety of interesting species, the collection here including our only record of *Lype diversa*; also the Salt Fork and Middle Fork rivers, near Oakwood and Danville, fairly large streams with many riffles, rocky rapids and less silt than usual in Illinois, streams in which rare species such as *Helicopsyche borealis*, *Hydropsyche frisoni* and *cheilonis*, and many Hydroptilidae occur.

Fig. 9.—Lake Michigan, at Zion, Illinois. Collecting within wading distance of shore nets only scattered caddis fly records. Presumably more of the species live at a depth beyond the grinding action of the undertow. Several species of Leptoceridae and *Hydropsyche recurvata* have been taken in Illinois only in or along Lake Michigan.

Lake Michigan

Our information concerning Lake Michigan, fig. 9, is based chiefly on light collections along the shore. We have made shore collections along the entire Illinois beach but have been unable to take more than scattered larvae in most places.

Several species of the case-making genus *Athripsodes* have been taken at lights along the shore of the lake; these include *dilutus*, *erullus* and *resurgens*, the last two constituting our only Illinois records of the species. The larvae of these probably occur on stones in the lake beyond the wading line.

Unique to our state fauna was a colony of *Hydropsyche recurvata*, found at the south edge of Evanston. The larvae were fairly common on the larger stones in 3 to 4 feet of water. This species is northern in distribution and usually lives in rivers. Apparently in this situation the wave action and coldness of water were a sufficient substitute for its usual conditions.

Smaller Glacial Lakes

In a few counties in the northeastern corner of Illinois are a large number of glacial lakes, fig. 10, similar in general character to the northern lakes of Wisconsin, Michigan and Minnesota. They vary in depth, the shallower ones having extensive marsh areas; their size varies from a few to several hundred acres. The water is clear, and the bottom is clean stones, a mass of reed and sedge roots, or a bed of peaty organic matter. Large beds of aquatic plants abound in the little bays or the short, sluggish connecting waterways; the predominant plants are *Elodea*, *Ceratophyllum*, *Utricularia* and *Potamogeton*.

These lakes have a caddis fly fauna quite different from that of the river systems. Conspicuous to a high degree are the Leptoceridae, whose cases may be found under almost every stone and on every weed. The Hydroptilidae, Molannidae and Psychomyiidae are the only other families represented in numbers; the Limnephilidae and Phryganeidae are almost entirely confined to marsh situations.

The commoner Leptoceridae include *Oecetis inconspicua*, *cinerascens*, *immobilis* and *osteni*, *Triaenodes tarda* and *injusta*, *Leptocella albida* and *exquisita*, *Leptocerus americanus*, *Athripsodes dilutus* and *tarsipunctatus* and *Mystacides longicornis* and *sepulchralis*. Some of these, such as *Oecetis osteni*, *Mystacides longicornis* and *Leptocella albida*, are confined to lakes; most of the others may be found in rivers, artificial ponds or canals. The combination of all these together, however, along with the absence of Hydropsychidae and other stream dwellers, is a phenomenon unique to these lakes.

The curious case of *Molanna uniophila* (see p. 206) occurs on sand bars in these lakes; the minute cases of *Orthotrichia* and *Oxyethira* abound on the stones and plant stems; and the transparent, small, green cases of *Leptocerus americanus* cluster in the tips of the *Ceratophyllum*.

Dead River Marsh

At Zion, just north of Waukegan, there is a large marsh area through the center of which runs the Dead River, fig. 11, so named because Lake Michigan, by backing up into it, prevents its flow except at times of heavy rain. This ribbon-like river is therefore more like a marshy lake than a stream; its banks are crowded with extensive beds of cyperaceous growth and its channel is choked with mats of *Ceratophyllum* and *Polygonum*.

Living in this mass of plant stems is one of the most extraordinary communities of caddis flies in Illinois. Large, case-building Phryganeidae are common, including *Phryganea cinerea* and *sayi*, *Banksiola selina*, *Fabria inornata* and *Agrypnia vestita*; the

Fig. 10.—Grass Lake near Fox Lake, Illinois. Certain of the lake species, in particular the Leptoceridae, are found in the lake proper rather than in the connecting channels.

Fig. 11.—Dead River, in Dunes Park near Zion, Illinois. This river is more marsh than stream. It is the only situation in the state in which large numbers of both individuals and species of the large Phryganeidae have been found.

leptocerid *Triaenodes aba* is common; *Polycentropus interruptus* is also common. Except for *Phryganea sayi*, these are known only from similar nearby situations. Restricted in Illinois to this locality are *Fabria inornata*, *Triaenodes baris* and *Polycentropus remotus*.

A somewhat similar marsh area is located along the edges of the Des Plaines River near Rosecrans, just a few miles south of the Wisconsin line. In this area we have taken *Triaenodes aba* in considerable numbers, but only a few of the other species common in the Dead River.

DISTRIBUTION

In the preceding pages an analysis is given of the manner in which the various species of Illinois caddis flies are distributed in relation to habitats within the state. To understand the faunal characteristics, however, this should be correlated with the geographic distribution of the species in relation to the entire continent.

We have found that the geographic distribution of caddis fly species within Illinois may give an erroneous impression of their continental distribution. For instance, the fact that *Cheumatopsyche lasia* occurs principally in the central and northern parts of Illinois might indicate that the species is primarily northern; such is not the case, most of the records for the species being southwest of Illinois, and a few northwest, with no records yet known from northeast of Illinois, fig. 12. Similarly our Illinois records of *Phylocentropus placidus* are from the extreme southern portion of the state, whereas the main range of the species is to the northeast.

These circumstances have led to a study of the continental range of as many species as possible. The results are of considerable interest because of the scarcity of caddis fly records in past literature and because of the demonstration that many caddis flies have an extensive range. Since many species are known from few records, the following remarks apply to the better known. It is difficult to determine accurately the center of distribution of any caddis fly species on the bases of existing records, because in many areas in North America collecting for this order has been very inadequate. The present analysis attempts to give a picture gleaned from available records.

The Illinois species may be divided roughly into two general categories. The first

Fig. 12.—Range map of *Cheumatopsyche lasia.*

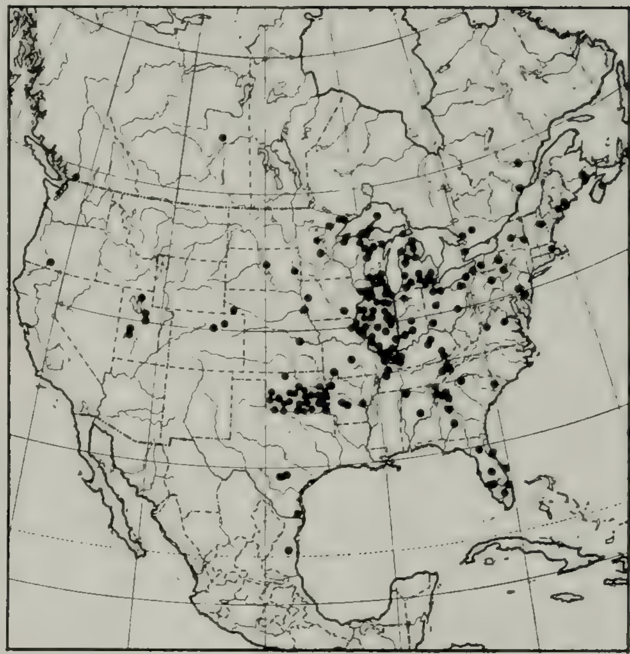


Fig. 13.—Range map of *Oecetis inconspicua,* the commonest North American caddis fly.

includes those whose range centers roughly in or near Illinois; the second those touching Illinois on the outskirts of their range.

Ranges Centered in Illinois

Widespread Species.—Some of the common Illinois species of caddis flies have a range which occupies almost the entire continent. Examples include *Oecetis inconspicua,* fig. 13, and *avara, Cheumatopsyche campyla* and *analis* and *Hydroptila hamata.* The first four of these are exceedingly common in the central and eastern states and occur in scattered collections westward to the Pacific Coast.

Central States Species.—Conspicuous examples of this set are some of the caddis flies inhabiting the large rivers typical of this part of the country. *Hydropsyche simulans* and *orris* are two such species; they have overlapping ranges, fig. 14, and the

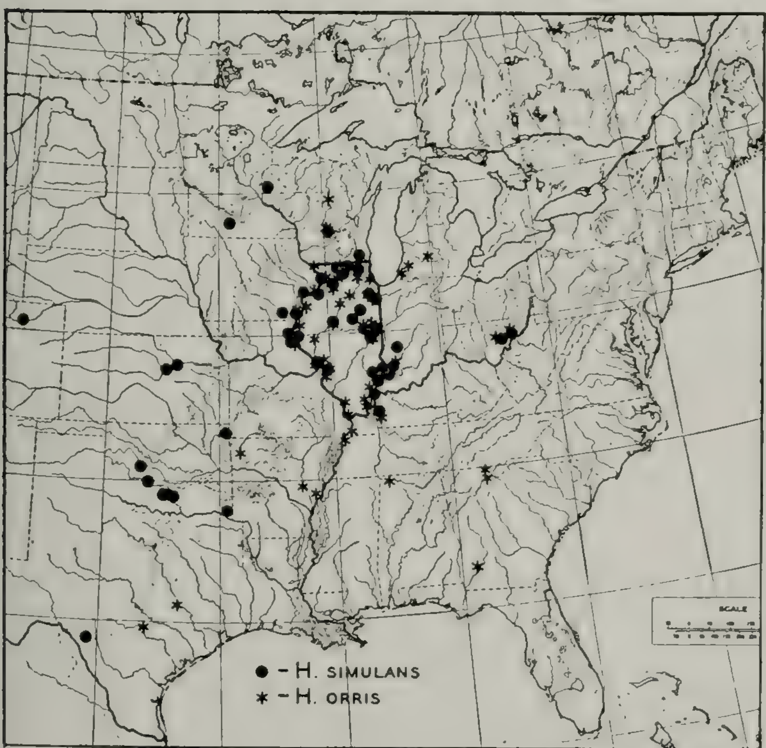


Fig. 14.—Range map of *Hydropsyche simulans* and *orris.*

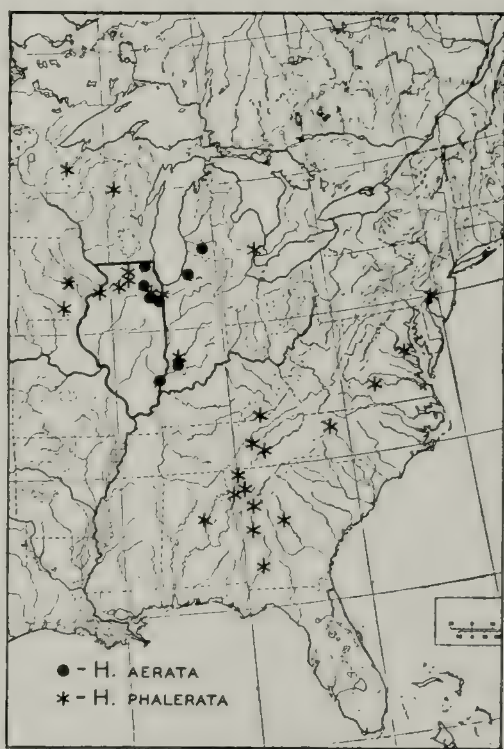


Fig. 15.—Range map of *Hydropsyche aerata* and *phalerata.*

area of overlap coincides very closely with the Corn Belt. Another type of range in this class is illustrated by *Hydropsyche aerata*, which appears to have a very restricted range, fig. 15. Among the Hydroptilidae are several species which, on the basis of present records, appear to be restricted to the Corn Belt and its immediate vicinity; these include *Hydroptila angusta, grandiosa* and *ajax* and *Neotrichia falca*.

Ranges Projecting Into Illinois

Northern-Northeastern Species. — Of the caddis flies having a range that just touches Illinois, or nearly touches this state, the most numerous are northern and northeastern species. Examples include representatives of many families: *Hydropsyche slossonae* and *recurvata*, fig. 16, *Chimarra aterrima*, fig. 17, *Oecetis osteni*, *Limnephilus moestus*, *rhombicus* and *argenteus*, and many others. These include both lake and stream species. Each of these species has a slightly different range, some extending south just into Illinois, others deeper into the state and still others not reaching it at all. A number of these species, such as *Mystacides longicornis* and *Neureclipsis bimaculatus*, are Holarctic and many more will undoubtedly prove to range extensively northwestward through the northern coniferous forest. This group, as would be expected, embraces a large number of species which have been found in Illinois in isolated and local colonies and an additional number which have been taken in southern Wisconsin and Michigan but not yet in Illinois.

Northeastern-Ozark Species.—One of the most surprising discoveries in this investigation was the unexpected number of species common to both the northeastern states and the Ozark series of mountains, including various areas in Oklahoma and, to some extent, the "cross-timbers" which extend diagonally across Texas. Most of the species exhibiting this type of range occur in Illinois, especially along its northern, eastern and southern margins. Present collections indicate that the Illinois Ozarks are one of the few existing connecting links between the northeastern and southwestern parts of the range. This is well shown in the case of *Chimarra obscura*, fig. 18.

Some species, such as *Cheumatopsyche sordida*, have a range of the same type but highly discontinuous, so that the Ozark records are at a great distance from any others known at present.

Ozark Species.—A few caddis flies occur only in the Ozarks, extending throughout their course from Illinois to Oklahoma and into the neighboring hills and ranges. Examples include *Agapetus illini, Dolophilus*

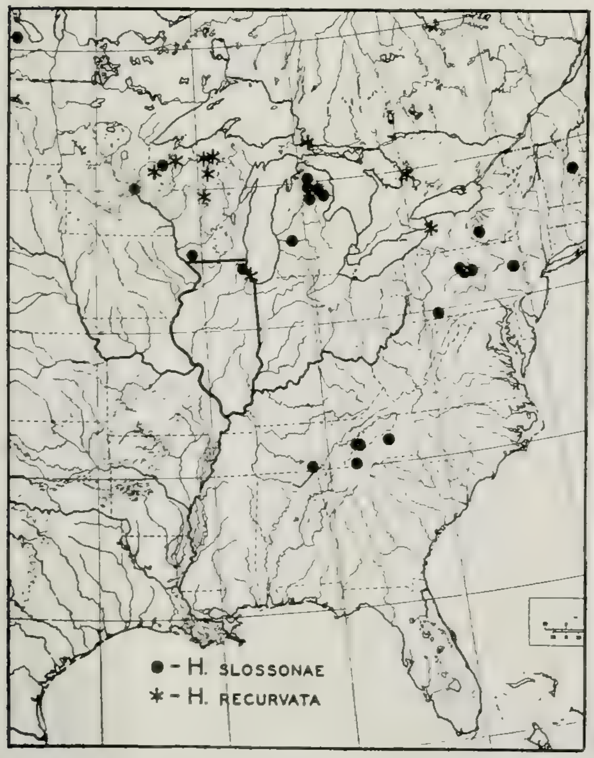


Fig. 16.—Range map of *Hydropsyche slossonae* and *recurvata*.

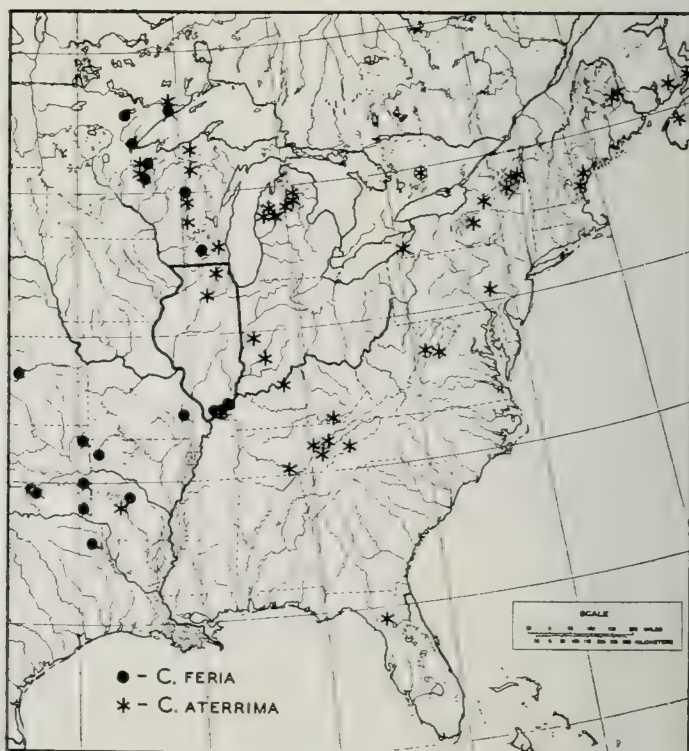


Fig. 17.—Range map of *Chimarra aterrima* and *feria*.

Fig. 18.—Range map of *Chimarra obscura.*

shawnee and *Ochrotrichia anisca.* These species and others of similar faunistic habits occur in the Ozark Hills of southern Illinois.

Southwestern Species.—Another group of Illinois caddis flies is southern or southwestern in general distribution. This includes such forms as *Cheumatopsyche lasia*, fig. 12, and *Chimarra feria*, fig. 17. The range of each centers around Oklahoma, with extensions eastward to Illinois and as far northward as Montana or Minnesota. It is interesting to note that the former extends throughout the northern portion of Illinois; the latter has been found in Illinois only in the Ozark Hills of the southern part of the state.

Certain other southern or southwestern species have a range extending into southern Mexico. This is true especially of many Hydroptilidae, of which *Mayatrichia ayama* ranges from southern Mexico to New York, following closely the pattern of *Chimarra obscura* in fig. 18.

Southeastern Species.—A few members of the Illinois fauna have been collected in other states only to the south and east. This group includes *Hydropsyche incommoda*, *Cheumatopsyche burksi* and *Hydropsychid Genus A*, extending from Illinois to Georgia or Florida. A small number of species not yet taken in Illinois are known to range from Georgia to Indiana; these include *Macronemum transversum* and *Hydropsyche depravata*, which have essentially the same range as the three just mentioned. *Hydropsyche phalerata* has a range which centers in the southeast but differs from the above examples by extending considerably north of Illinois, fig. 15.

Summary

A review of the above data shows that in North America the caddis flies form several fairly distinct geographic groups. One of these, embracing the states of the Corn Belt, centers roughly in Illinois. Throughout the northern and northeastern states is one large group of species; to the southwest, extending through the Ozarks into Mexico, is a second large group; and to the southeast is a third smaller group. All three of these contain fairly distinctive species that range into Illinois, which is approximately at the meeting point of these "avenues" of distribution. This axial position has been demonstrated with several other groups of insects studied for the state, including the Miridae, Orthoptera and Plecoptera, although in each the details are different.

COLLECTING AND PRESERVING

Caddis flies have such diverse habits and habitat preferences that several kinds of collecting are necessary to get representative samples from a given area. In most cases these same methods are equally effective with other aquatic groups, including stoneflies, mayflies and midges. The adults are aerial and the larvae aquatic; further, it is more the rule than the exception that at any one place the adults in the air and the larvae in the stream belong to different sets of species. Collecting for one phase must not be stressed to the exclusion of the other.

With one exception, caddis flies, both immature stages and adults, should be collected in liquid, preferably 80 per cent grain alcohol. The exception is adults of the genus *Leptocella*, readily distinguished in the field by a long, narrow shape, extremely long antennae and white ground color (see p. 213). In this genus it is necessary for specific diagnosis to use color patterns formed by the delicate wing hairs, which rub off with remarkable ease. Specimens of this genus should be killed in a cyanide or other dry bottle, a few at a time, and carefully handled to avoid rubbing in transit and in pinning.

Adult Collecting

Adults of most caddis flies come to lights readily on warm nights having neither wind nor a bright moon. Collecting at lights is thus a profitable source of material. In towns, illuminated store windows and signs attract many of these insects and provide convenient collecting points.

Vapor Glow-Tubes.—Adult Trichoptera are attracted very strongly to blue light and hence are to be found most abundantly around blue "neon" lights, or glow-tubes. Fortunately for the entomologist many of these blue lights can be found in towns and these will serve as good concentration points for caddis flies. At points where such lights are not available we have had very good success with a portable mercury glow-tube which emits a strong blue light and is very attractive to Trichoptera and many other insects. This is described in detail by Burks, Ross & Frison (1938).

Automobile Headlights.—Another type of night collecting we have found effective at points away from towns is as follows. Drive an automobile to a spot overlooking a stream or lake and turn on the bright lights. Into a shallow pan, such as a pie pan, pour enough alcohol to cover the bottom with from one-eighth to one-fourth inch of liquid. Hold the pan directly under a headlight. If aquatic insects are on the wing, they will come to the light and eventually drop into the liquid, which traps them. With a small piece of wet cardboard, scrape the entire insect contents of the pan into a small bottle of alcohol, which should then be labeled, location, name of collector and place being given.

If few insects fly to the car lights, it is convenient to dispense with the pan. In this case the caddis flies may be picked off the light easily by dipping an index finger in alcohol, "scooping up" the insect rapidly but gently on the wet surface and then dipping it in the bottle. An aspirator, or sucker, also can be used with success.

Sweeping.—For daylight collecting, sweeping often proves effective. Resting places differ widely with the species, but most caddis flies prefer shaded, humid places. For these, sweep vegetation overhanging the water, whether it is herbage nearly trailing in the water or boughs which hang above it. I have noticed that many times the flies seem to prefer (for resting places) coniferous trees near the stream, and heavy beating of these is usually profitable. Sometimes the flies are numerous in bark crevices of large tree trunks along stream banks; here they are extremely difficult to detect, for they mimic bark to a remarkable degree when their wings are folded. Be sure to have your net ready when you examine a tree trunk, because the flies dodge and fly with surprising speed when alarmed.

Bridges.—One of the favorite resting places of adult Trichoptera is the shaded, damp, underside of a concrete bridge. When other collecting fails it is sometimes possible to pick up from a few to many caddis flies resting under a highway bridge. Here again the flies are wary, and must be approached with caution and a ready net.

Along the Water's Edge.—Frequently the adults may be captured on stones, sticks and vegetation in the water. This is true especially of the Rhyacophilidae. A method which sometimes gives good results is to press floating vegetation, such as water cress, until it is slightly submerged. Any adults resting in this foliage will swim to the surface in a moment or two.

Collecting Larvae and Pupae

All Nearctic caddis flies are aquatic in the developmental stages. For this reason almost any water habitat has possibilities for the collection of larvae and pupae. These should be preserved in liquid, preferably 80 per cent grain alcohol, as with the adults. If vials are filled with larvae, the liquid should be changed a few hours after collection.

The easiest way to start a search for these immature stages is to turn over stones and logs in riffles and rapids; if present, larvae and cases may be found without difficulty in these situations. Handfuls of drift, weeds from the stream or river bottom, and debris may be laid on the bank, and the caddis fly larvae may be picked out as they begin to move, at which time they are easily detected.

Cocoons of caddis flies may generally be identified because they are securely fastened to some object. These should be removed very carefully, in order to avoid breaking the silk membranes more than necessary.

Where conveniently situated they may be cut away from both sides with the sharp ends of a pair of forceps.

Rearing Methods

Association by Pupal Dissection.—In almost all caddis fly groups the larval sclerites are packed into the posterior end of the pupal chamber after the pupa is formed. Later in the pupal life the adult structures take definite form within the pupal skin, and, just before actual escape of the pupa, the complete adult may be teased out of the pupal skin. Such pre-adult specimens show all adult characters except those of wing venation, which does not develop until the wings have expanded and dried by natural emergence. Of greatest importance is the fact that the genitalia of both sexes become completely formed, hardened and colored before emergence of the adult.

If, then, a cocoon or case is collected which has a mature pupa in it, the larval sclerites and fully formed genitalia are associated, and it is possible thus to link the adult and larval forms of the species. This type of association was fully explained by Vorhies (1909) in his report on the Wisconsin caddis flies. It was described again by M. Milne (1938). We have used this method for many years as a means of linking the various developmental stages. It is frequently necessary to collect in the same locality several times before certain species can be associated, but we have found it more satisfactory than cage rearing because of extreme cannibalism developed by caged larvae.

Cage Rearing.—A few caddis fly groups have pupal cases with a slit at one end, instead of the conventional mesh used by most groups. In these species the larval sclerites are kicked out of the case by the respiratory movements of the pupa. This is true throughout the family Leptoceridae and to a limited extent in the genus *Parapsyche*. For these species we used cages for rearing numbers of specimens. The type of cage used was square and suspended by side flanges from a raft constructed to form square openings, as described and used for stonefly rearing by Frison (1935, p. 303). The caddis fly adults were so fast in their movements, however, that a layer of muslin had to be tied over the cage and the lid placed over this; such an arrangement allowed the operator to take off the lid, see what adults had emerged and grasp them with fingers or forceps through the muslin.

Preservation

As mentioned before, for study purposes it is most practical to preserve all stages of caddis flies in liquid, preferably 80 per cent grain alcohol. This allows study of different structures from various angles, since the material is flexible. Furthermore, the muscle tissue of caddis flies does not become coagulated as in some other insect groups and can be cleared readily in caustic soda or potash solution.

One genus, *Leptocella*, must be collected dry, as mentioned on p. 213. Specimens of this genus should be killed a few at a time in a strong cyanide bottle and handled and pinned with great care to avoid rubbing the delicate hair which makes up the pattern.

For display purposes or for color study, it is sometimes necessary to pin material of other genera. The pin should be inserted with care to avoid piercing the scutellum and middle line. These areas may be diagnostic for family or genus.

Clearing Technique

Accurate identification for almost every caddis fly species must be based on characters of the genitalia, not only in the males but also in the females of those groups in which specific characters are known for this sex. It is usually necessary to clear the genitalia to see the diagnostic characters, and for this operation we have found the following procedure entirely satisfactory.

Remove the apical half or third of the abdomen from the specimen and place this portion in cold 10 to 15 per cent caustic potash or caustic soda solution. Allow it to soak 6 to 12 hours, depending on its size and color; then remove it to a dish of distilled water. If the specimen softens up in a minute or two, gently squeeze, prod and press until the dissolved mass of viscera has been worked out of the shell. If the specimen does not soften, resoak it in hot 5 per cent caustic solution for 5 or 10 minutes; then squeeze out the viscera. The following procedure is recommended for hot treatment: Put the caustic solution in a vial, which should be placed in a beaker of water; a little twisted wire should be placed in the beaker so that the vial will not actually touch the bottom; heat the beaker until the water boils; the caustic solution will not boil. This water bath treatment guards against overclearing of the specimen. After the viscera are more or less extracted, transfer the specimen through at least three baths of distilled water, leaving it at least 1 hour in each, and then place it in a dish of alcohol to which a few drops of 1 per cent acetic acid solution have been added. Remove the preparation to neutral alcohol. It is now ready to study.

For liquid preservation, the cleared genital capsule and the specimen to which it belongs can be placed together in a small shell vial 74 by 4 mm.; this vial can then be filled and stopped with a cotton plug and inverted in a ring-neck, 3-dram vial. Hard red rubber stoppers are desirable for these vials; to insert stopper, wet it with alcohol, place a long pin alongside it and insert both together into the neck of the vial as far as desired; then hold stopper in place and pull out pin. This technique allows air to escape from the vial as the stopper is inserted and prevents air pressure from being built up inside the vial below the stopper.

For pinned specimens the genital capsule, if not too large, may be placed in a minute shell vial with a small amount of glycerine in the bottom. The vial can be corked and mounted under the specimen by simply running the specimen's pin through the cork. The genitalia can be removed from this container with a pin which has a minute hook at the end. For further details, see article about this procedure by DeLong & Davidson (1937).

For study under a compound microscope, these cleared genitalia may be placed in pure glycerine. Very convenient for such study is a slide with a ground-out place or well in which the glycerine may be placed. Minute angles may be made from fine wire or pins and these used in the glycerine to keep the preparation in place while it is being studied or drawn. The glycerine keeps the preparation perfectly flexible and it also has a fine refraction, even when a cover slip is not used. Glycerine and alcohol are readily miscible so that preparations may be transferred from one to the other without harm.

For the family Hydroptilidae it is desirable to clear the entire specimen without detaching the abdomen. The procedure is the same as above except that in this case it is necessary to tear a slit in the base of the abdomen through which the dissolved viscera may be expelled. This technique destroys a clear view of the wing venation, but this is seldom decipherable even in an uncleared specimen and does not appear essential now for either family or generic diagnosis. On the other hand, characters of the ocelli, legs, thoracic structure and genitalia, which are all essential for identification, are not plainly visible without clearing.

CLASSIFICATION

Adults of the order Trichoptera are distinguished by the following combination of characters: head with long antennae; mouthparts with vestigial mandibles, well-developed maxillary and labial palpi, their parent sclerites more or less fused to form a flabby, proboscis-like structure; thorax with tergites and pleurae normally divided; two pairs of wings present (abortive in the females of several genera), covered with setae which may be hairlike or modified into

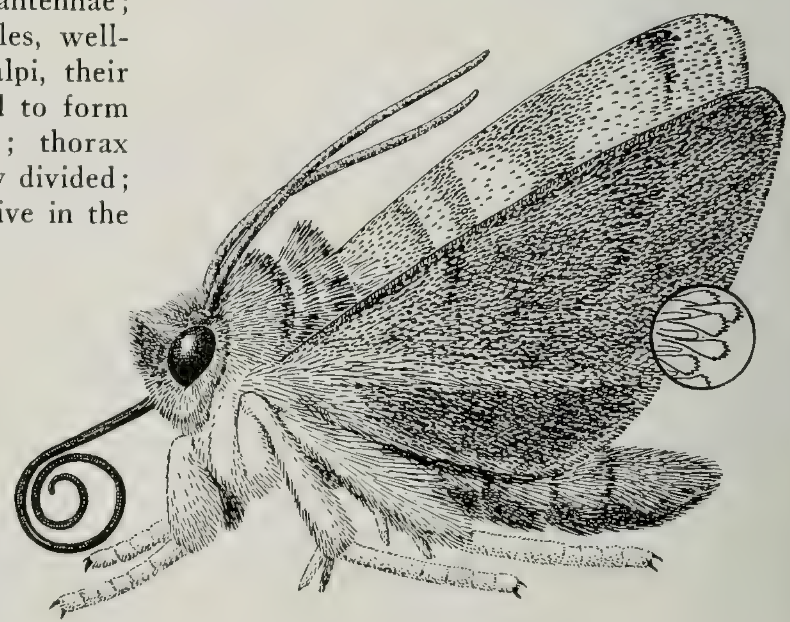


Fig. 19.—Lepidoptera. A typical moth showing the scales on wings and body and the sucking tube, which is coiled up under the head when not in use. Species in which the tube is poorly developed or entirely lacking always have the wings with a very dense and uniform covering of scales.

scales, with simple venation and only the hypothetical number of crossveins.

The Trichoptera belong to the holometabolous group of orders. The reduced crossveins will distinguish them from the Neuroptera, Megaloptera, Mecoptera and their allies; the two pairs of wings will distinguish them from the Diptera; and the narrow ventral portion of the meso-episternum will distinguish them from the Hymenoptera.

Members of this order are most closely related to the Lepidoptera, many forms of the two groups being quite similar in general morphology and wing venation. Almost all Lepidoptera differ from Trichoptera by having a coiled sucking tube which may be very long, fig. 19, or quite short. All those Lepidoptera occurring in this region which have no sucking tube or only a short one have the wings entirely covered with closely packed scales, as in fig. 19. The Trichoptera of this continent do not have a coiled sucking tube; most of them have no scales on the wings, but a few species either have patches of scales which do not cover the entire wing or have scales which are scattered and interspersed with hair.

The Trichoptera larvae have a distinct head capsule, full complement of mouthparts, single-segmented antennae which are often difficult to see, a pair of distinct, single-facet eyes, sclerotized pronotum (mesonotum and metanotum sometimes sclerotized also), three pairs of distinctly segmented legs, all provided with claws, and a pair of anal hooks. Tracheal gills of various sizes and shapes are sometimes present. The end of the abdomen never has a long mesal process as in some Megaloptera and Coleoptera.

Family Groupings

The Trichoptera are represented in North America by 17 families. This division departs in certain respects from the traditional plan of dividing the order but has been necessary because of the following circumstances.

1. In attempting to formulate a key to the larvae it was noticed that some subfamilies of the Sericostomatidae appeared more closely related to other families than to each other. A tentative key was made up in which the various groups of this nature were treated as separate families.

2. One difficulty with past keys was the uncertainty of diagnosing a female specimen to family, especially when the specimen was slightly teneral and the venation difficult to determine. A search for other characters which would circumvent the use of wing venation in the key brought to light differences in thoracic sclerites, tarsal claws and arrangement of spines and spurs on the middle legs. Using these in the family key, it was possible to key out both males and females together, and the resultant grouping agreed almost perfectly with the independent grouping suggested by the larvae.

3. The pupae offered only little evidence on the question, but what there was decidedly favored the new family segregations.

It appears, therefore, that the old family Sericostomatidae represented a heterogeneous assemblage of diverse groups such as the Helicopsychidae, Goeridae and Brachycentridae; these had been considered as one family solely on the basis of a secondary sexual similarity, namely, the three-segmented and curved or modified maxillary palpi of the males. Certain other groups, such as the Beraeidae, have been treated as separate families; and the opinion of Betten and others that the Odontoceridae and Calamoceratidae are distinct is substantiated by characters of all stages. There are many points to be cleared up in the placement to family of several genera from western states. In addition, many immature stages need to be discovered. These points, however, do not preclude an analysis of the present material.

The Rhyacophilidae, in particular the genus *Rhyacophila*, appear to be the most generalized family in the order. The simple wing venation, fig. 21, well developed ocelli, unmodified mouthparts and other characters of the adults, together with the simple type of larvae with either no case or a simple one, seem to represent basic characters from which developed other specializations of the order.

Three families, Philopotamidae, Psychomyiidae and Hydropsychidae, are a natural group differentiated by the annuliform maxillary palpi of the adults and the net-building habits of the larvae. Of these families the Philopotamidae appear the most primitive, having diverged relatively little in adult structure from the Rhyacophilidae. The sclerotized larval mesonotum and metanotum, and larval gills mark the Hydro-

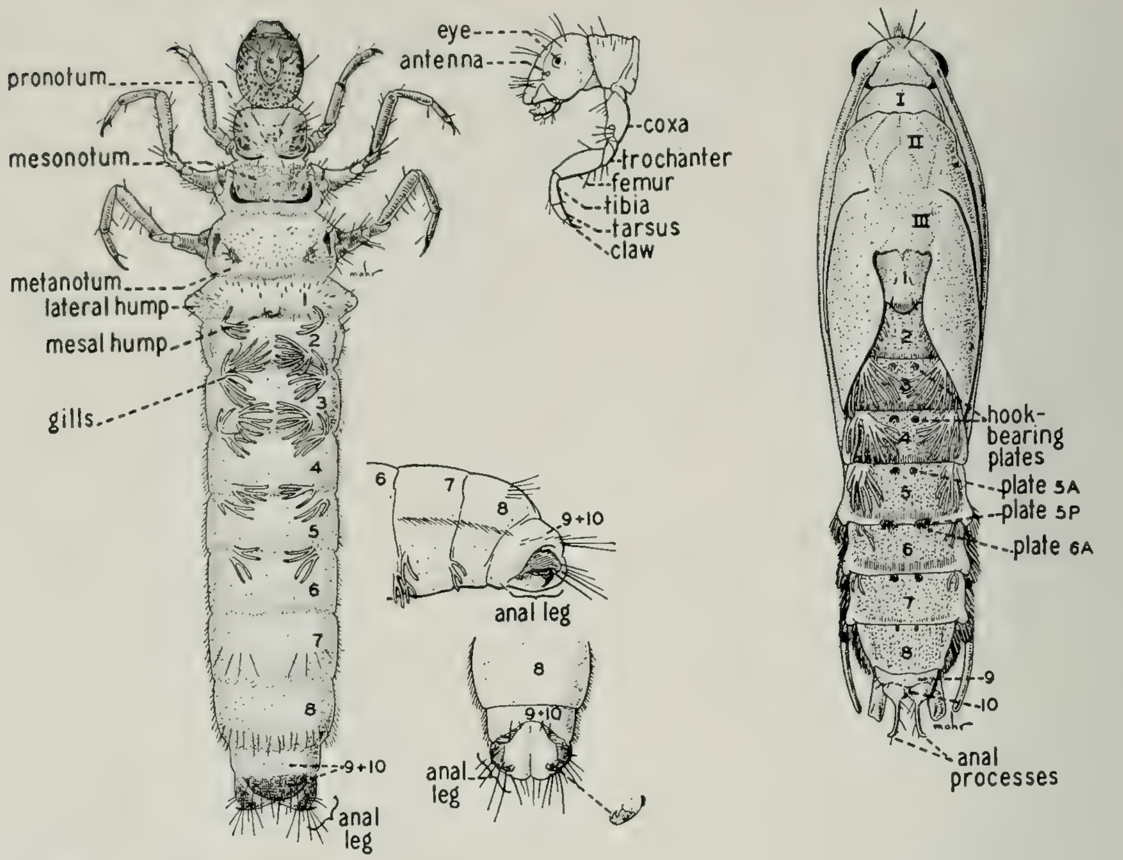


Fig. 20.—*Limnephilus submonilifer* larva and pupa, illustrating terminology of parts.

psychidae as the most specialized members of this group.

The Hydroptilidae comprise an isolated group combining certain primitive adult characters with a great variety of larval and biological specialization. The larvae are peculiar among the entire order, apparently, in having a sort of hypermetamorphosis in which the young larvae are active and free living, later building cases. The more primitive of these cases are simple adaptations of the saddle cases of some Rhyacophilidae, but the more specialized are similar in construction to the true cases of the Leptoceridae and other families.

The remainder of the families form the large complex of true case-makers, including the large families Leptoceridae and Limnephilidae. This group presents a real problem in determining the phylogenetic arrangement of the families. It may be divided into two or three series on the basis of certain characters as outlined below, but whether or not these segregations are artificial or natural will rest on further evidence and investigation:

A. Ocellate series (ocelli well developed).
1. Phryganeidae—probably the most primitive member of the case-making group.
2. Limnephilidae—this family may not be closely related to the Phryganeidae but is certainly one of the more generalized members of the case makers.

B. Nonocellate series (ocelli absent).

Many families of this group have been regarded as very primitive. It is certain, however, that having no ocelli they could not have given rise to groups that have, such as the Phryganeidae. The Molannidae are probably the most primitive members of this series. It seems impractical, however, to attempt a phylogenetic analysis of the series at the present time. Also included in it are the Odontoceridae, Calamoceratidae, Goeridae, Lepidostomatidae, Leptoceridae, Beraeidae, Helicopsychidae, Sericostomatidae and Brachycentridae.

Generic and Specific Characters

For the diagnosis of genera and species an effort has been made to use such characters as could be seen easily on specimens preserved in liquid and, insofar as possible, on preadults dissected from pupae. This has led to the substitution of head, thoracic and leg characters for wing venation in many places in the keys. In certain families, such as the Hydroptilidae, these new characters have proved to be the first satisfactory basis for generic separation, at least in key form.

In almost all groups the adults have been separated to species on the basis of genitalic characters. In a few genera, such as *Macronemum* and *Leptocella*, genitalia have not given complete diagnosis, and color and proportions have been used.

There is a large amount of information in the literature regarding the immature stages of Trichoptera. Much of this is referred to in various places throughout the text of this report. Additional articles of considerable interest and value are the following: Denning (1937), Elkins (1936), Milne & Milne (1938, 1939), Margery Milne (1939) and Ulmer (1902, 1906*b*).

Terminology

The terms used commonly in the keys for wing venation and structural parts are illustrated in figs. 20 and 21 which include terms used for larvae, pupae and adults.

Material Studied

This report is based on extensive collecting over many years, during which a large amount of material has accumulated. We estimate that approximately 750,000 specimens were actually collected and checked over. Most of the specimens proved to be females or larvae which could be identified only to genus. About 150,000 specimens have been identified to species, and these constitute the basis for most of this report.

Disposition of Material

Unless otherwise noted, Illinois material recorded here is in the collection of the Illi-

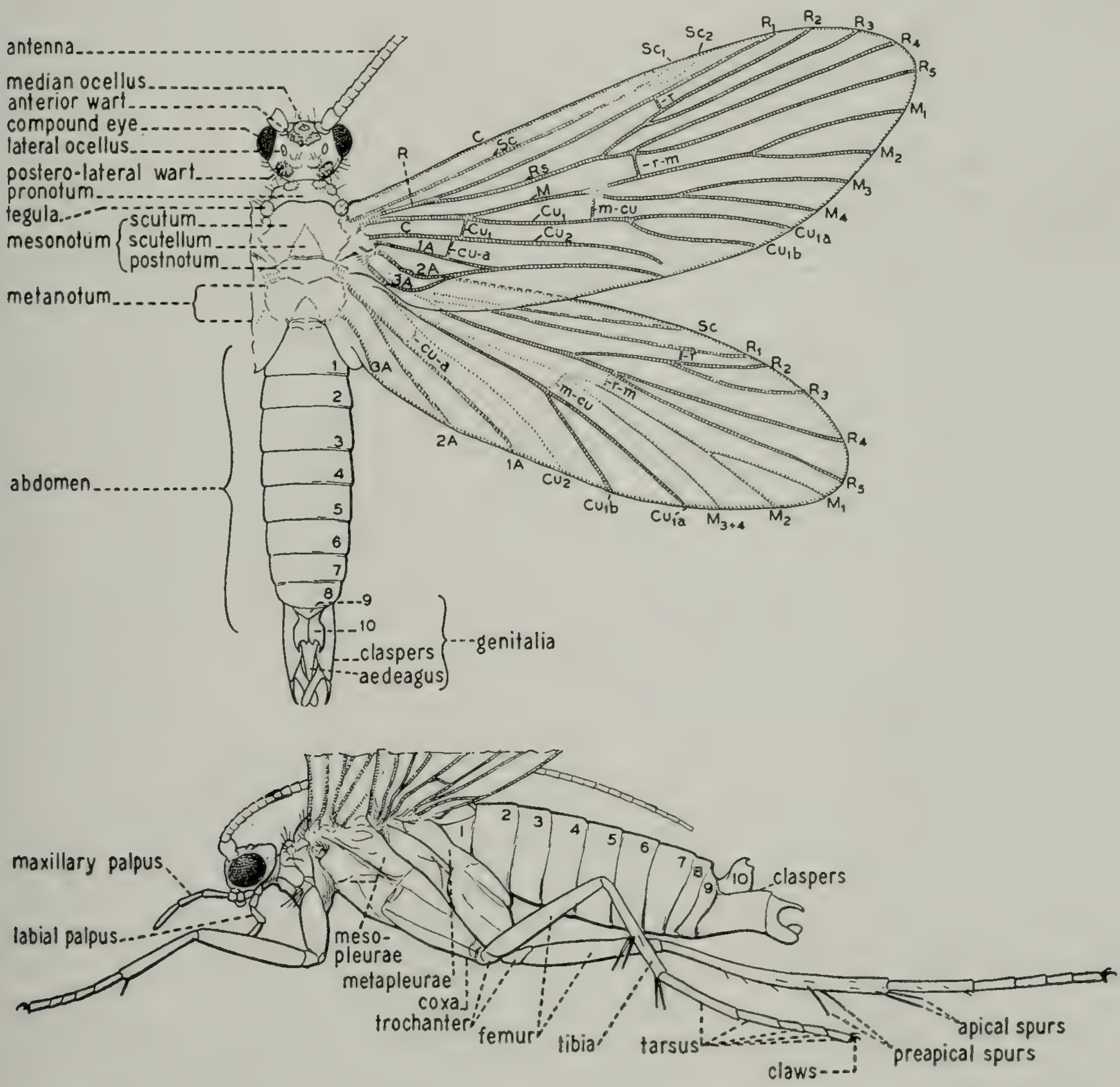


Fig. 21.—*Rhyacophila lobifera* adult male, illustrating terminology of parts.

nois Natural History Survey at Urbana. Some material is cited which belongs to other institutions, and this is usually indicated by letters following the record; these letters are as follows:

BC—Betten Collection, Ithaca, New York.

UM—University of Minnesota, St. Paul, Minnesota.

FM—Chicago Natural History Museum, Chicago, Illinois (formerly Field Museum).

MCZ—Museum of Comparative Zoology, Cambridge, Massachusetts.

Records Outside Illinois

Many records for states other than Illinois which are cited in this report are the first for these states. Those not taken from the literature are from Illinois Natural History Survey files, which are accessible for procuring additional locality and seasonal data.

KEY TO FAMILIES

Larvae

1. Pro-, meso- and metanotum each with a single, sclerotized shield embracing the entire notum, fig. 557 2
   Either meso- or metanotum or both without sclerites or with sclerotized shield subdivided into separated plates, figs. 36, 37 3
2. Abdomen with many conspicuous branched gills, fig. 281; larva living in a nest, fig. 4 . . . . **Hydropsychidae**, p. 76
   Abdomen without gills; larva living in a definite case, fig. 465 . . . . **Hydroptilidae**, p. 117
3. Anal legs projecting beyond, and free from, membranous lobes of tenth segment, fig. 22; note especially fig. 23 4
   Anal legs appearing as lateral sclerites of membranous lobes of tenth segment, fig. 20 6
4. Sclerotized shield present on dorsum of ninth abdominal segment, fig. 22 . . . . **Rhyacophilidae**, p. 30
   Dorsum of ninth abdominal segment entirely membranous 5
5. Labrum with anterior and lateral portions expanded into a wide, membranous area, fig. 24 . . . . **Philopotamidae**, p. 44
   Labrum shorter, entirely sclerotized, fig. 25 . . . . **Psychomyiidae**, p. 51
6. Claws of hind legs very small, those of middle and front legs large, fig. 26 . . . . **Molannidae**, p. 205
   Claws of hind legs as long as those of middle legs, fig. 27 7
7. Antennae long, at least eight times as long as wide, and arising at base of mandibles, fig. 28 . . . . **Leptoceridae**, p. 209
   Antennae much shorter, fig. 709, not more than three or four times as long as wide, often very inconspicuous, and arising at various points, figs. 29, 30 8
8. Mesonotum submembranous except for a pair of parenthesis-like, sclerotized bars as in fig. 764 . . . . **Leptoceridae**, p. 209
   Mesonotum without such bars 9
9. Meso- and metanotum entirely membranous or with only minute sclerites, figs. 561–566 . . . . **Phryganeidae**, p. 161
   Mesonotum and usually metanotum with some conspicuous sclerotized plates 10
10. Labrum with a row of about 20 stout setae across middle, fig. 31 . . . . **Calamoceratidae**, p. 209
    Labrum without such a row of setae, usually with 6–8 long setae, not in a row, and other scattered small setae, fig. 32 11
11. Anal hooks with a long comb of teeth, fig. 33; larva living in a case shaped exactly like a snail shell, fig. 906 . . . . **Helicopsychidae**, p. 266
    Anal hooks with accessory teeth, but these not forming a comb, fig. 34; case not at all snail-like 12
12. Metanotum with a wide, straplike anterior sclerite, a pair of oblong lateral sclerites and a posterior thin sclerite, as in fig. 36, the posterior sclerite frequently difficult to distinguish . . . . **Odontoceridae**, p. 209
    Metanotum not with this grouping of sclerites, usually with only 1 or 2 round, small and more or less indefinite sclerites, fig. 37 13
13. Anal hooks formed of 2 or 3 long teeth situated one over another, fig. 35 . . . . **Sericostomatidae**, p. 266
    Anal hooks formed of a single large tooth with 1 or more small teeth on its dorsal edge, fig. 34 14
14. Pronotum with a deep furrow running almost the full width of the sclerite, figs. 892, 896, 897, the posterior margin of the furrow forming a sharp and slightly overhanging carina . . . . **Brachycentridae**, p. 260
    Pronotum either without any trace of a

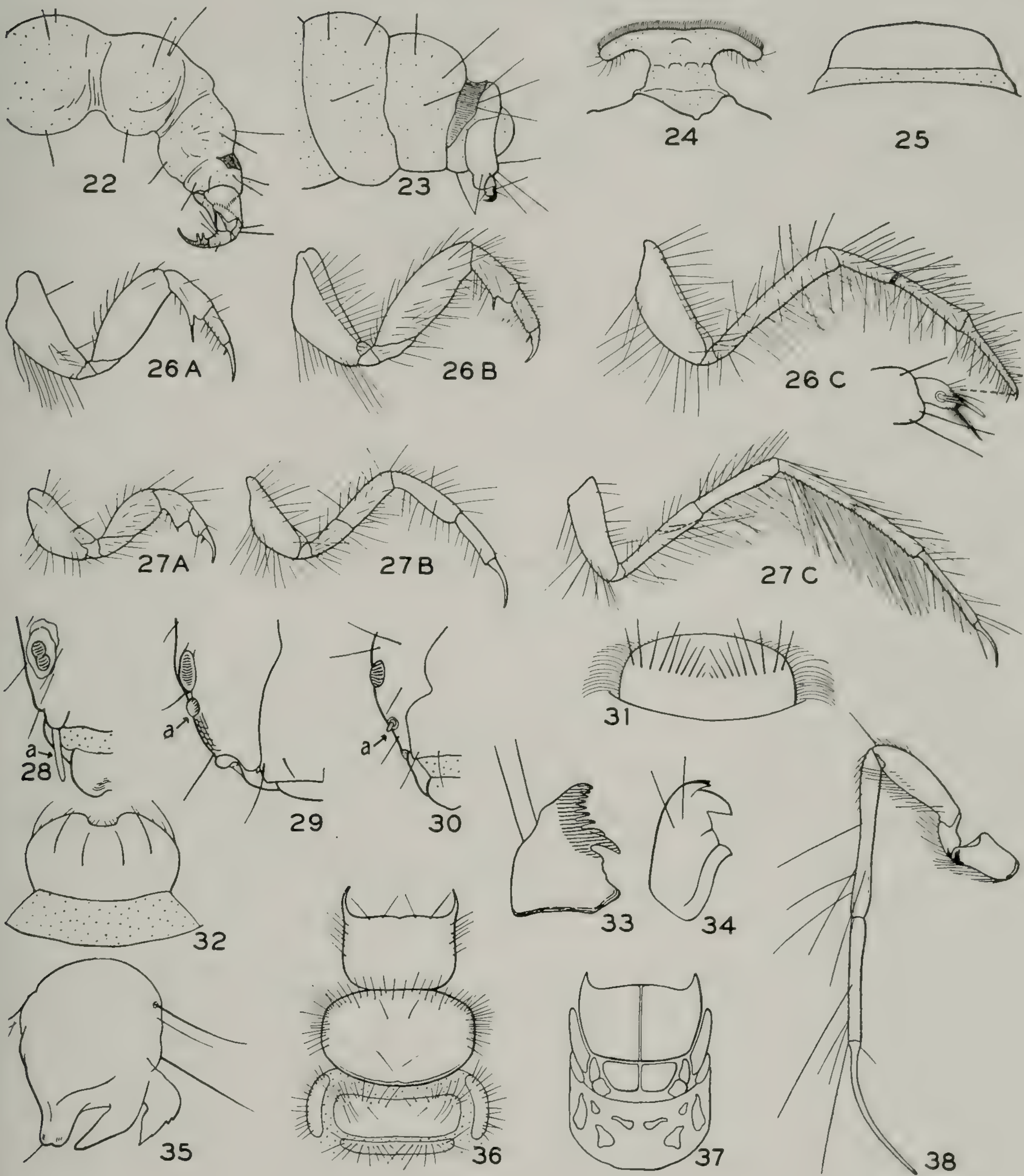


Fig. 22.—*Rhyacophila lobifera* larva, apex of abdomen.

Fig. 23.—*Agapetus illini* larva, apex of abdomen.

Fig. 24.—*Chimarra feria* larva, labrum.

Fig. 25.—*Polycentropus interruptus* larva, labrum.

Fig. 26.—*Molanna uniophila* larva, legs. *A*, front leg; *B*, middle leg; *C*, hind leg.

Fig. 27.—*Triaenodes tarda* larva, legs. *A*, front leg; *B*, middle leg; *C*, hind leg.

Fig. 28.—*Leptocerus americanus* larva, antenna (*a*).

Fig. 29.—*Lepidostoma liba* larva, antenna (*a*).

Fig. 30.—*Limnephilus submonilifer* larva, antenna (*a*).

Fig. 31.—*Ganonema americanum* larva, labrum.

Fig. 32.—*Limnephilus submonilifer* larva, labrum.

Fig. 33.—*Helicopsyche borealis* larva, anal hooks.

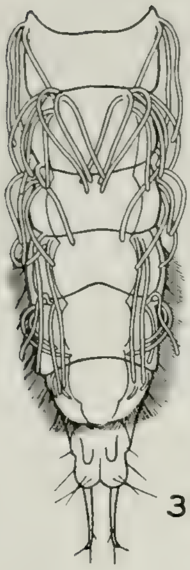
Fig. 34.—*Brachycentrus numerosus* larva, anal hooks.

Fig. 35.—*Sericostoma* sp. larva, anal hooks. (After Ulmer.)

Fig. 36.—*Psilotreta* sp. larva, thorax.

Fig. 37.—*Goera* sp. larva, thorax. (After Ulmer.)

Fig. 38.—*Beraea* sp. larva, hind leg. (After Ulmer.)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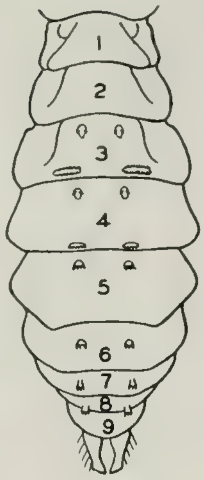
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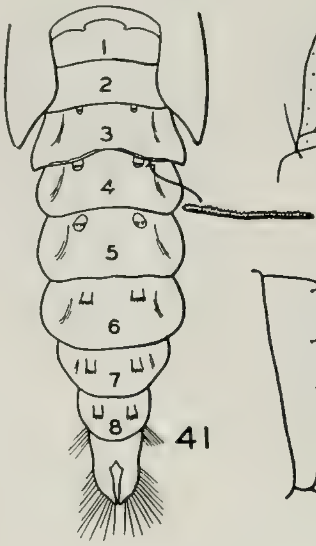
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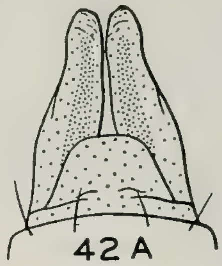
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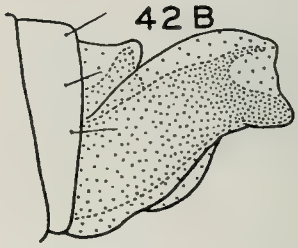
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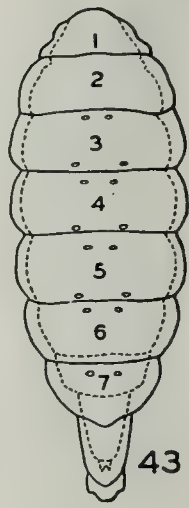
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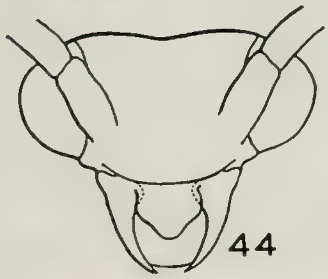
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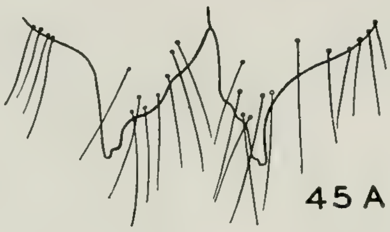
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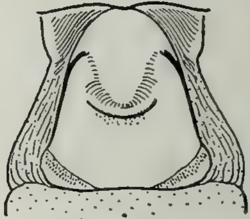
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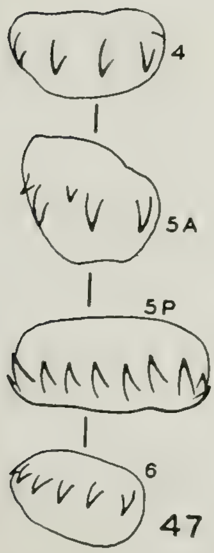
Fig. 39.—*Limnephilus submonilifer* pupa, venter of abdomen.
Fig. 40.—*Hydropsyche orris* pupa, abdomen.
Fig. 41.—*Macronemum zebratum* pupa, abdomen.
Fig. 42.—*Rhyacophila lobifera* pupa, abdomen, ♂, *A*, dorsal aspect; *B*, lateral aspect.

Fig. 43.—*Rhyacophila lobifera* pupa, abdomen, ♀.
Fig. 44.—*Ochrotrichia anisca* pupa, head.
Fig. 45.—*Beraea* sp. pupa, apical processes. (After Ulmer.) *A*, dorsal aspect; *B*, lateral aspect.
Fig. 46.—*Molanna uniophila* pupa, first abdominal tergite.

transverse furrow or with a gently concave depression across the sclerite 15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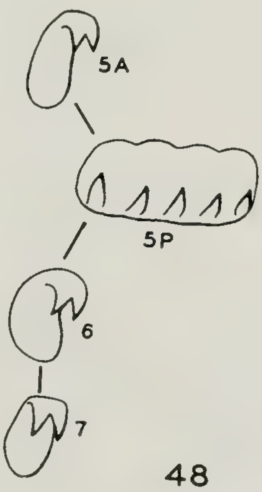
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Fig. 47.—*Molanna uniophila* pupa, hook plates.
Fig. 48.—*Oecetis inconspicua* pupa, hook plates.

15. Hind tarsal claws extremely long and narrow, as long as tibia, as in fig. 38 . . . . . . **Beraeidae,** p. 208
Hind tarsal claws much shorter, as in fig. 27 16

16. Mesonotum divided into 2 pairs of plates, fig. 37 . . . . . . **Goeridae,** p. 256
Mesonotum not divided into plates, but forming a single, rectangular sclerite with only a mesal fracture line, fig. 20 17

17. Antennae situated very close to eye, fig. 29; first abdominal tergite without a hump . . . . . . **Lepidostomatidae,** p. 258
Antennae situated either midway between eye and margin of head or closer to margin of head than to eye, fig. 30; first abdominal tergite with a hump, fig. 20 . . . . . . **Limnephilidae,** p. 176

Pupae

1. Apex of abdomen membranous, without definite lobes except ventral

membranous ones which contain developing genitalic parts, figs. 42, 43 2
Apex of abdomen with definite, projecting, platelike processes, figs. 570, 571, or finger-like or triangular processes in addition to lobes containing developing parts of genitalia, figs. 20, 49–54.................... 4

2. Mandibles without teeth or serrations, fig. 44..........**Hydroptilidae**, p. 117
Mandibles with either serrations, fig. 97, or distinct teeth, fig. 158....... 3

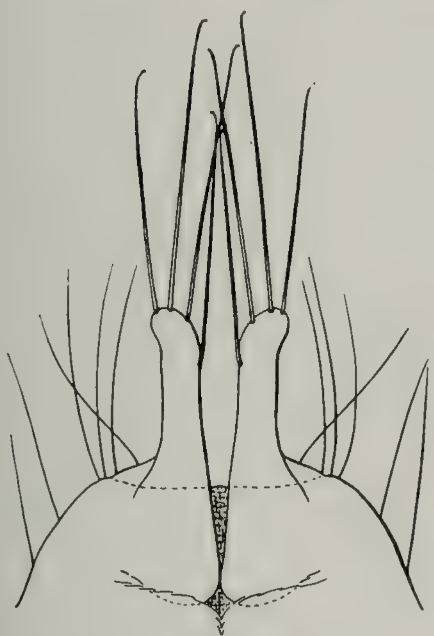
3. Mandibles with teeth grouped near apex, figs. 158–161.............................**Philopotamidae**, p. 44
Mandibles with teeth near middle, or mandibles only serrate, figs. 97–100 ....**Rhyacophilidae**, p. 30

4. Fifth tergite with only anterior pair of hook-bearing plates, third or fourth tergites with both anterior and posterior pairs, figs. 40, 41.... ....**Hydropsychidae**, p. 76
Fifth tergite with both anterior and posterior hook-bearing plates, third and fourth tergites at most with anterior pair, fig. 20.............. 5

5. Seventh abdominal tergite without a pair of sclerotized plates.......... 6
Seventh abdominal tergite with a pair of sclerotized hook-bearing plates, fig. 20......................... 9

6. Apical processes of abdomen short, appearing triangular from dorsal view, sharply curved ventrad from lateral view, fig. 45...**Beraeidae**, p. 208
Apical processes of abdomen either much longer, fig. 49, or not curved ventrad........................ 7

7. First abdominal tergite with a short, arcuate ledge near middle of segment, fig. 46; sclerotized plates of



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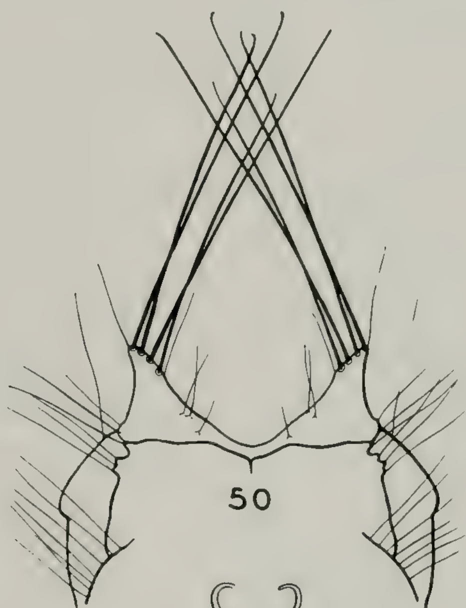

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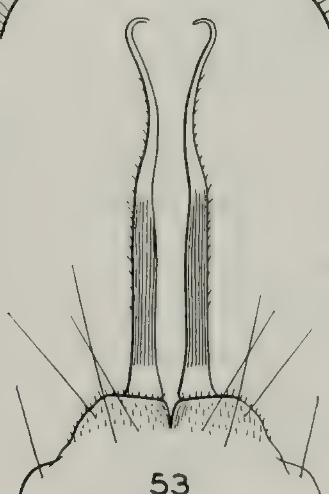

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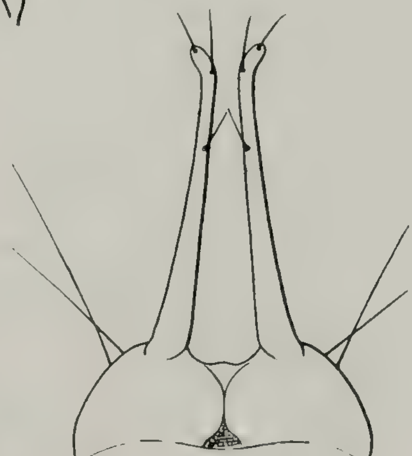

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Fig. 49.—*Helicopsyche borealis* pupa, apical processes, dorsal aspect.

Fig. 50.—*Lepidostoma liba* pupa, apical processes, dorsal aspect.

Fig. 51.—*Psilotreta* sp. pupa, apical processes, dorsal aspect.

Fig. 52.—*Sericostoma* sp. pupa, apical processes, lateral aspect. (After Ulmer.)

Fig. 53.—*Goera* sp. pupa, apical processes, dorsal aspect. (After Ulmer.)

Fig. 54.—*Limnephilus submonilifer* pupa, apical processes, dorsal aspect.

fifth and sixth segments wide, with 4 to 8 hooks, fig. 47 .... **Molannidae,** p. 205

First abdominal tergite without a ledge except at apex, fig. 20; sclerotized plates of fifth and sixth segments narrow, some or all with only 2 or 3 hooks, fig. 48 8

8. Apical processes of abdomen narrow and finger-like, and with apical black hairs as long as the process, fig. 49. .... **Helicopsychidae,** p. 266

Apical processes of abdomen either not finger-like, or without long, apical hairs, figs. 721–726 .... **Leptoceridae,** p. 209

9. Abdomen without a fringe of hair; apical processes as in figs. 205–207 .... **Psychomyiidae,** p. 51

Abdomen with a lateral fringe of hair, fig. 39 10

10. Abdomen with a pair of almost linear, transverse lines of hooks (plate 5*P*) between fifth and sixth tergites, figs. 888, 889 ..... **Brachycentridae,** p. 260

Abdomen with these areas of hooks not as thin, at least as broad as in fig. 618 11

11. Apical processes of abdomen short and stubby, appearing platelike from dorsal view, figs. 570, 571 .... **Phryganeidae,** p. 161

Apical processes of abdomen finger-like, at least as long as in fig. 50, often styliform, fig. 49 12

12. Apical processes of abdomen short, widely separated and bearing black spines many times as long as the processes, fig. 50 .... **Lepidostomatidae,** p. 258

Apical processes either close together or much longer, figs. 51–54 13

13. Mandibles produced at apex into a narrow, whiplike style, fig. 55 .... **Odontoceridae,** p. 209

Mandibles pointed but not produced into a style, figs. 56, 57 14

14. Dorsum of abdomen with transverse patches of dense, fine hair, these patches forming bands on some segments, fig. 58 .... **Calamoceratidae,** p. 209

Dorsum of abdomen without patches of hair, with only isolated setae, fig. 20 15

15. Apical processes with slender, terminal appendage, fig. 52 .... **Sericostomatidae,** p. 266

Apical processes without appendage .. 16

16. Antennae twice length of body, looped several times around apical processes .... **Leptoceridae,** p. 209

Antennae much shorter, not looped around apical processes 17

17. Apical processes extremely slender at apex, threadlike and sinuate, fig. 53 .... **Goeridae,** p. 256

Apical processes not greatly narrowed at apex, with apical hairs and not sinuate, fig. 54 . . **Limnephilidae,** p. 176

Adults

1. Mesoscutellum with posterior portion forming a triangular, flat area with steep sides, figs. 438–446; mesoscutum without warts; front tibiae never with more than 1 spur. Small, hairy individuals not over 6 mm. long .... **Hydroptilidae,** p. 117

Either mesoscutellum evenly convex, without a triangular posterior portion set off by sharp sides, figs. 80, 83, or mesoscutum with warts, figs.

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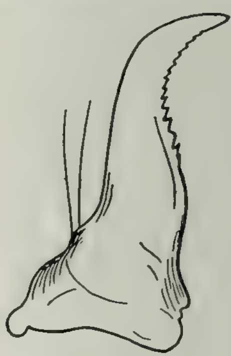

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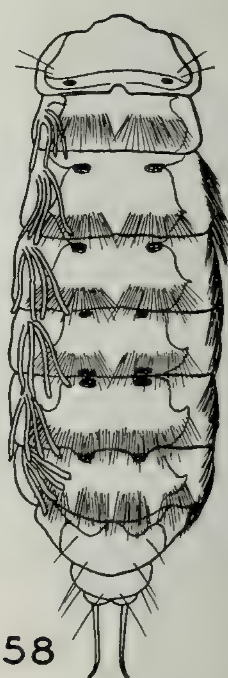

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Fig. 55.—*Psilotreta* sp. pupa, mandible.

Fig. 56.—*Sericostoma* sp. pupa, mandible. (After Ulmer.)

Fig. 57.—*Goera* sp. pupa, mandible. (After Ulmer.)

Fig. 58.—*Calamoceratidae* sp. pupa, dorsum of abdomen.

81–90. Includes a size range of 5 to 40 mm. 2

2. Ocelli present, fig. 21 3
Ocelli absent 8

3. Maxillary palpi 3-segmented, fig. 65. . . . . ♂ **Limnephilidae,** p. 176
Maxillary palpi 4- or 5-segmented 4

4. Maxillary palpi 4-segmented, fig. 64. . . . . ♂ **Phryganeidae,** p. 161
Maxillary palpi 5-segmented, fig. 63. . 5

5. Maxillary palpi with fifth segment two or three times as long as fourth, fig. 61. . . . . **Philopotamidae,** p. 44
Maxillary palpi with fifth segment not

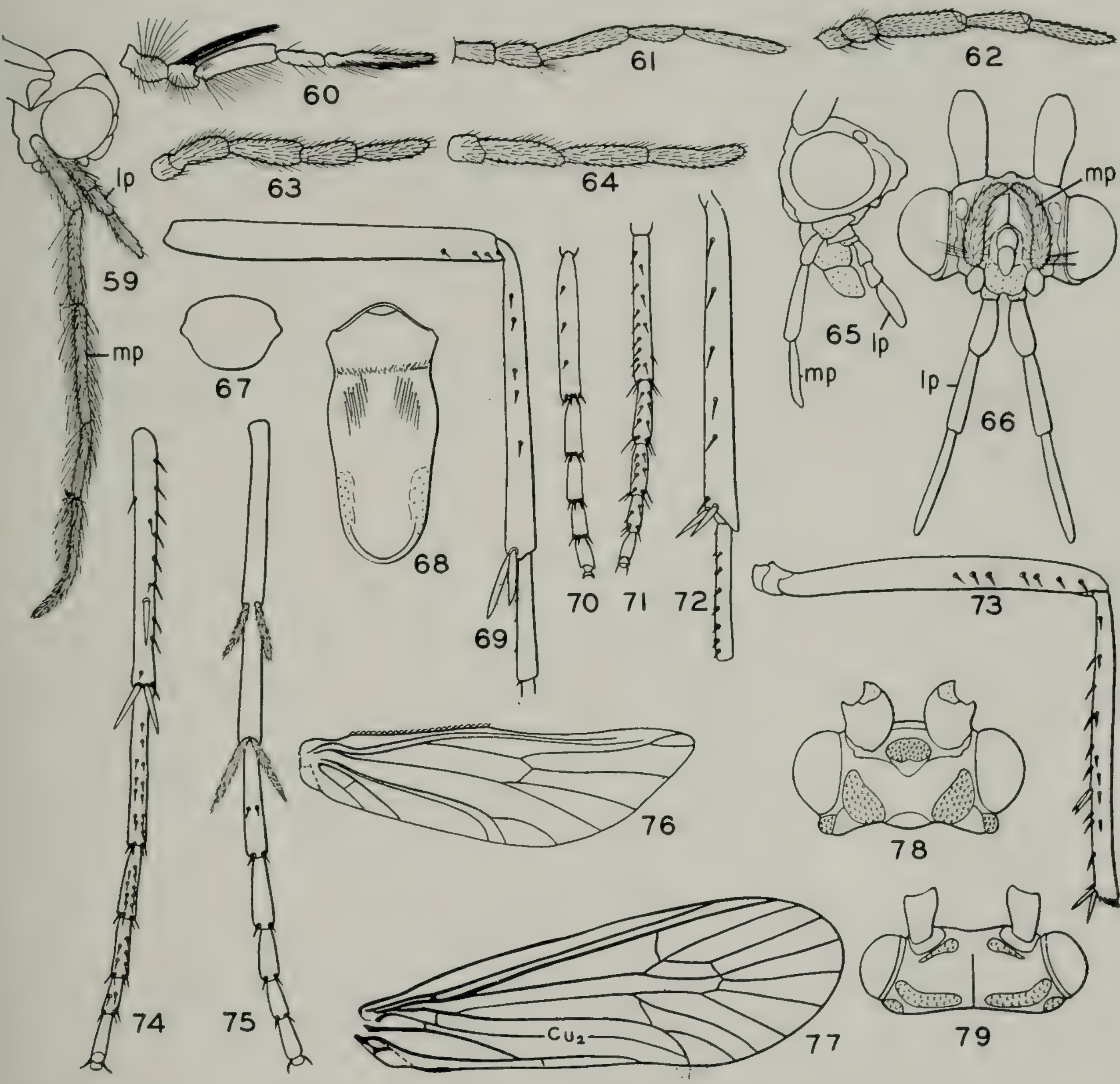


Fig. 59.—*Triaenodes tarda* ♂, head; *lp*, labial palpus; *mp*, maxillary palpus.

Fig. 60.—*Psilotreta* sp. ♂, maxillary palpus.

Fig. 61.—*Dolophilus shawnee* ♂, maxillary palpus.

Fig. 62.—*Rhyacophila lobifera* ♂, maxillary palpus.

Fig. 63.—*Banksiola selina* ♀, maxillary palpus.

Fig. 64.—*Banksiola selina* ♂, maxillary palpus.

Fig. 65.—*Limnephilus submonilifer* ♂, head; *lp*, labial palpus; *mp*, maxillary palpus.

Fig. 66.—*Lepidostoma liba* ♂, head; *lp*, labial palpus; *mp*, maxillary palpus.

Fig. 67.—*Rhyacophila lobifera*, labrum.

Fig. 68.—*Phryganea cinerea*, labrum.

Fig. 69.—*Beraea gorteba*, middle leg.

Fig. 70.—*Beraea gorteba*, middle tarsi.

Fig. 71.—*Sericostoma crassicornis*, middle tarsi.

Fig. 72.—*Sericostoma crassicornis*, middle tibia.

Fig. 73.—*Molanna uniophila*, middle leg.

Fig. 74.—*Brachycentrus numerosus*, middle tibia and tarsi.

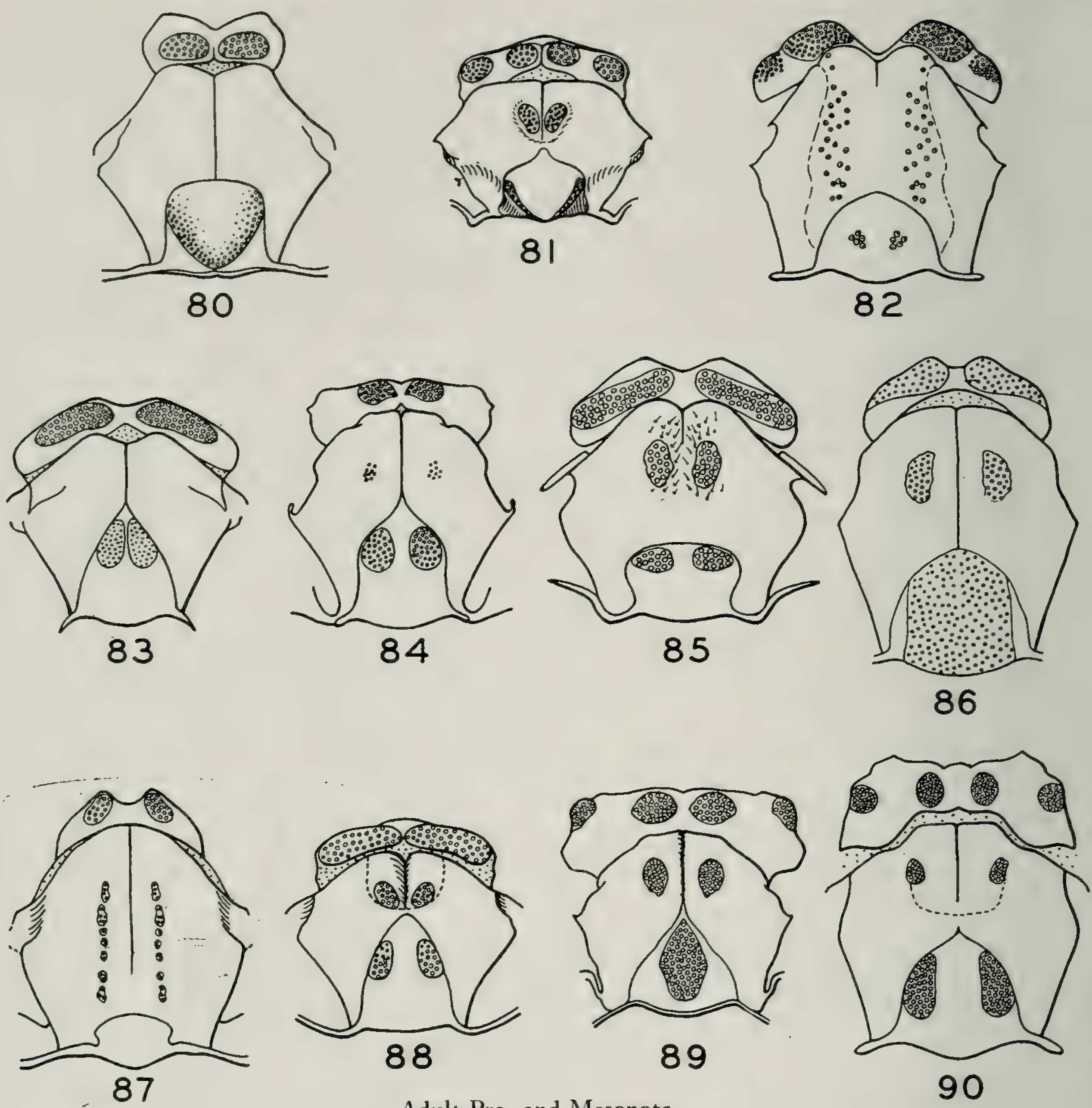
Fig. 75.—*Theliopsyche corona*, middle tibia and tarsi.

Fig. 76.—*Helicopsyche borealis*, hind wing.

Fig. 77.—*Sericostoma crassicornis*, front wing.

Fig. 78.—*Sericostoma crassicornis*, head.

Fig. 79.—*Brachycentrus numerosus*, head.



Adult Pro- and Mesonota

Fig. 80.—*Hydropsyche simulans.*
Fig. 81.—*Psychomyia flavida.*
Fig. 82.—*Athripsodes tarsi-punctatus.*
Fig. 83.—*Beraea gorteba.*
Fig. 84.—*Brachycentrus numerosus.*
Fig. 85.—*Helicopsyche borealis.*
Fig. 86.—*Psilotreta frontalis.*
Fig. 87.—*Ganonema americanum.*
Fig. 88.—*Sericostoma crassicornis.*
Fig. 89.—*Goera calcarata.*
Fig. 90.—*Theliopsyche* sp.

more than one and one-third times as long as fourth, fig. 62 6

6. Maxillary palpi with second segment short, subequal to first, fig. 62; labrum evenly rounded and fairly wide, fig. 67 .... **Rhyacophilidae**, p. 30

Maxillary palpi with second segment much longer than first, figs. 63–65; labrum with a wide basal portion set off by a crease from a long, tonguelike apex, fig. 68 7

7. Anterior tibiae with 2 or more spurs; middle tibiae with 4 spurs .... **Phryganeidae**, p. 161

Anterior tibiae with at most 1 spur; middle tibiae with 2 or 3 spurs .... **Limnephilidae**, p. 176

8. Maxillary palpi with 5 or more segments, figs. 59, 60 9

Maxillary palpi with less than 5 segments, figs. 64–66 12

9. Terminal segment of maxillary palpi much longer than preceding and with close, suture-like, cross striae, which are not possessed by the other segments, figs. 214, 321 10

Terminal segment of maxillary palpi without such striae and similar in general structure to fourth segment, figs. 59, 63, usually of same length, or some segments with long hair brushes, fig. 60.................... 12

10. Anterior tibiae with a preapical spur as in fig. 21....................
................**Psychomyiidae**, p. 51
Anterior tibiae without a preapical spur.......................... 11

11. Hind wings with R almost or entirely normal in its course, with 4 or all 5 branches distinct and the stem distinct from Sc, fig. 334; anal area at least as large as in fig. 333; mesoscutum without warts, fig. 80........
..............**Hydropsychidae**, p. 76
Hind wings with R much reduced, the stem either absent or fused with Sc and only 3 or 4 branches present, figs. 212, 213; anal area reduced to a small area as in fig. 212; mesoscutum with a pair of small warts, fig. 81...
................**Psychomyiidae**, p. 51

12. Middle tibiae without preapical spurs and with a row of black spines, fig. 69.............................. 13
Middle tibiae with preapical spurs, with or without a row of spines, figs. 73–75.......................... 17

13. Pronotum consisting of a lateral pair of erect, platelike warts separated by a wide, mesal, excavated collar which is usually hidden by the produced, angulate margin of the mesonotum, fig. 82; mesonotum with short scutellum and with scutal warts represented by a long, irregular line of setate spots; antennae always very long and slender, fig. 863............**Leptoceridae**, p. 209
Pronotum with warts much closer together, not platelike, and usually prominent, fig. 83; mesonotum with scutal warts either small, fig. 85, or absent, fig. 83; antennae as stout as or not longer than those in fig. 702 14

14. Hind wings each with anterior margin cut away beyond middle, fig. 76, with a row of hamuli along straight basal portion of margin ....
.............**Helicopsychidae**, p. 266
Hind wings each with anterior margin straight or evenly rounded, fig. 874 15

15. Middle and hind tarsi with a crown of 4 black spines at apex of each segment and only a few preapical spines arranged in a single row on the basitarsus, fig. 70; apical spurs of middle tibiae nearly half length of basitarsus, fig. 69..........**Beraeidae**, p. 208
Middle and hind tarsi with apical spines more separated and not forming a crown, and with numerous preapical spines on all segments, arranged in a double row on the basitarsus, fig. 71; apical spurs of middle tibiae not more than one-third length of basitarsus, fig. 72........ 16

16. Mesoscutum with a deep, antero-mesal fissure with scutal warts near meson, fig. 88; head with posterior warts diagonal and tear-shaped, fig. 78; front wings with a long crossvein between R_1 and R_2 and with Cu_2 joining apex of Cu_{1b} directly, fig. 77
............**Sericostomatidae**, p. 266
Mesoscutum with only a shallow antero-mesal crease, with scutal warts some distance from meson, fig. 84; head with posterior warts linear and transverse, fig. 79; front wings without a crossvein between R_1 and R_2 and with Cu_2 connected to apex of Cu_{1b} with a crossvein, fig. 890.....
.............**Brachycentridae**, p. 260

17. Middle femora each with a row of 6–10 black spines on antero-ventral face, fig. 73............**Molannidae**, p. 205
Middle femora each with none to 2 black spines on antero-ventral face 18

18. Mesonotum with small, rectangular scutellum, and with scutal warts represented by a linear area of small, setate spots extending the full length of the scutum, fig. 87.............
.............**Calamoceratidae**, p. 209
Mesonotum with longer and pointed scutellum, and with scutal warts oval or lanceolate and short, fig. 84 19

19. Mesoscutellum with a single large oval or round wart which extends the full length of the scutellum, fig. 89, and may occupy almost the entire scutellum, fig. 86................... 20
Mesoscutellum with 2 warts which are smaller and confined to the anterior half of the scutellum, figs. 84, 90... 21

20. Mesoscutellum round and distinctly domelike, the wart appearing to occupy most of the sclerite; scutum with mesal line only faintly indicated, fig. 86; tibial spurs not hairy; maxillary palpi of males 5-segmented
...............**Odontoceridae**, p. 209
Mesoscutellum triangular, only slightly convex, the wart elongate and occupying only the mesal portion of the sclerite; scutum with distinct mesal depression, fig. 89; tibial spurs hairy; maxillary palpi of males 3-segmented.........**Goeridae**, p. 256

21. Middle tibiae with an irregular row, middle tarsi with a long double row of spines, preapical spurs of tibiae bare, shorter and situated about

two-thirds distance from base of tibiae, fig. 74. . . . . **Brachycentridae,** p. 260

Middle tibiae without spines, their tarsi with only a scattered few in addition to apical ones, preapical spurs of tibiae hairy, longer and situated at middle of tibiae, fig. 75. . . . . **Lepidostomatidae,** p. 258

RHYACOPHILIDAE

The adults, both sexes, of the Rhyacophilidae have five-segmented maxillary palpi. Two distinct groups are included in the Illinois representatives of this family; the subfamily Rhyacophilinae has free-living, predaceous larvae and the subfamily Glossosomatinae has saddle-case making larvae. This remarkable difference in habits of the larvae has no apparent outstanding counterpart in the adults. The southwestern genus *Atopsyche* has been placed in the subfamily Hydrobiosinae, but until the larvae of this genus are discovered its true position is enigmatic.

KEY TO GENERA

Larvae

1. Anal larvapods with long, large hooks, figs. 22, 91. Free living without cases. . . . . **Rhyacophila,** p. 32

   Anal larvapods with very small, retractile hooks, fig. 23. Living in saddle-shaped cases constructed of small stones. 2

2. Pronotum notched only at extreme antero-lateral angle, at which point the legs are attached, fig. 92. . . . . **Glossosoma,** p. 39

   Pronotum narrow from anterior margin to middle, the legs attached at this central point, fig. 93. 3

3. Dorsal plate of last segment with 4 long, apical setae; pronotum with only a few scattered setae; anal hook divided into many teeth, fig. 96. . . . . **Protoptila,** p. 41

   Dorsal plate of last segment with 6 long, apical setae, fig. 94; pronotum with a line of setae near posterior margin, and with a brush of setae along each anterior corner, fig. 93; anal hook with only 1 large and 1 small tooth, fig. 95. . . . . **Agapetus,** p. 39

Pupae

1. Mandibles with inner margin minutely serrate, and with apical inner tooth

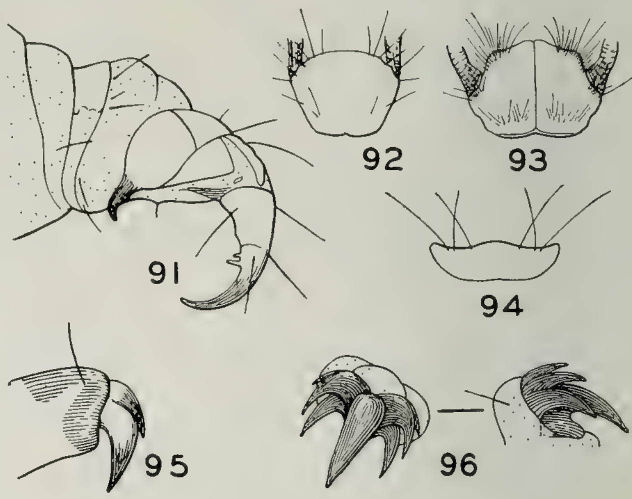


Fig. 91.—*Rhyacophila lobifera* larva, anal hook.

Fig. 92.—*Agapetus illini* larva, pronotum.

Fig. 93.—*Glossosoma intermedium* larva, pronotum.

Fig. 94.—*Agapetus illini* larva, plate of tenth tergite.

Fig. 95.—*Agapetus illini* larva, anal hooks.

Fig. 96.—*Protoptila lega* larva, anal hooks.

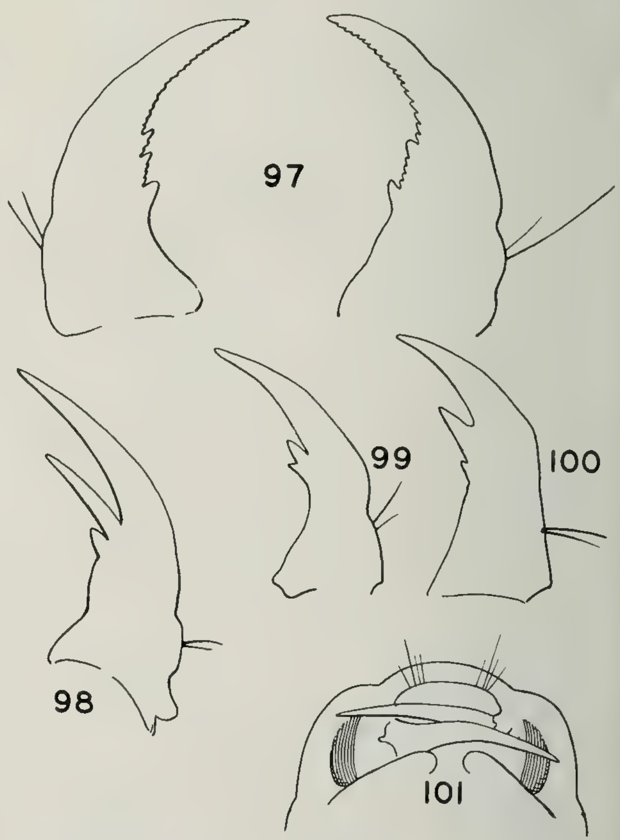


Fig. 97.—*Rhyacophila lobifera* pupa, mandibles.

Fig. 98.—*Protoptila lega* pupa, left mandible.

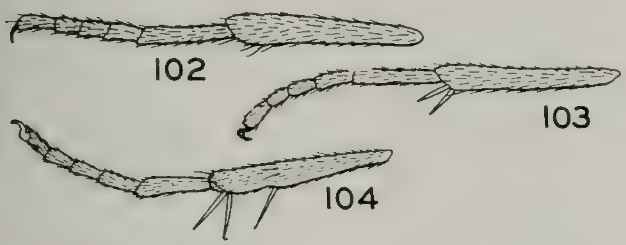
Fig. 99.—*Agapetus illini* pupa, left mandible.

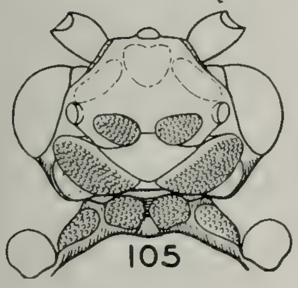
Fig. 100.—*Glossosoma intermedium* pupa, left mandible.

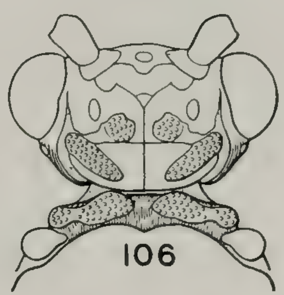
Fig. 101.—*Protoptila lega* pupa, head, ventral aspect.

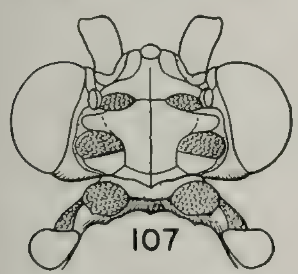
no larger than basal one; each mandible with 2 or 3 inner teeth, fig. 97 .... **Rhyacophila,** p. 32

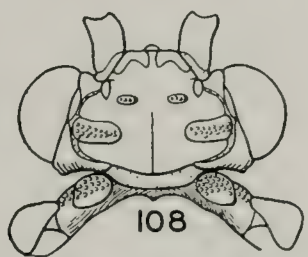
Mandibles with inner margin not serrate, and with apical inner tooth larger than basal one; each mandible with 2 inner teeth.............. 2











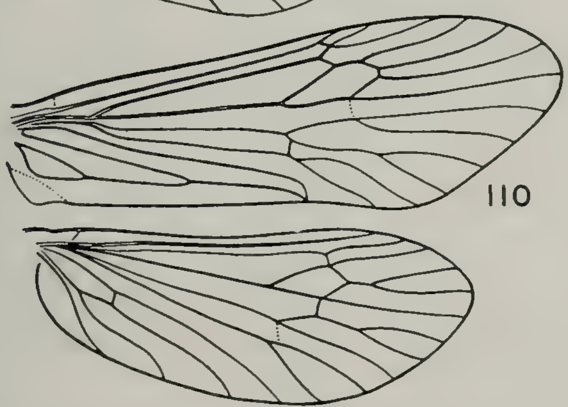


Fig. 102.—*Protoptila maculata*, front tibia.
Fig. 103.—*Agapetus illini*, front tibia.
Fig. 104.—*Rhyacophila vibox*, front tibia.
Fig. 105.—*Palaeagapetus celsus*, head and pronotum.
Fig. 106.—*Rhyacophila vibox*, head and pronotum.
Fig. 107.—*Agapetus illini*, head and pronotum.
Fig. 108.—*Glossosoma intermedium*, head and pronotum.
Fig. 109.—*Agapetus illini*, hind wing.
Fig. 110.—*Glossosoma intermedium*, wings.

2. Apical inner tooth of mandibles half as long as apical blade and subparallel with it, fig. 98; mandibles in repose over-reaching side of head, fig. 101; size small, less than 4 mm. .... **Protoptila,** p. 41
   Apical inner tooth of mandibles much shorter, fig. 100; mandibles in repose not reaching side of head; size larger, over 5 mm................ 3
3. Apical inner tooth of mandibles only slightly larger than basal one, fig. 99; apical segments of abdomen only slightly curled ventrad............ .... **Agapetus,** p. 39
   Apical inner tooth of mandibles many times larger than basal one, fig. 100; apical segments of abdomen curled ventrad and slightly forward...... .... **Glossosoma,** p. 39

Adults

1. Front tibiae with apical spurs absent or hairlike, fig. 102.... **Protoptila,** p. 41
   Front tibiae with both apical spurs prominent and sclerotized, fig. 103 2
2. Front tibiae with a preapical spur, fig. 104............... **Rhyacophila,** p. 32
   Front tibiae never with preapical spur, fig. 103......................... 3
3. Pronotum with mesal pair of warts nearly touching; posterior warts on head large, arcuate, tapered to a curved, narrowed point, the two nearly meeting on meson, fig. 105.. .... **Palaeagapetus,** p. 38
   Pronotum with mesal pair of warts well separated by a concave area; posterior warts of head oval or round and widely separated on meson, fig. 108......................... 4
4. Head with 1 or both pairs of dorsal warts connected by sutures running across epicranial stem, fig. 107; hind wings with radial sector apparently 2-branched, fig. 109.... **Agapetus,** p. 39
   Head with neither pair of dorsal warts connected by sutures, fig. 108; hind wings with radial sector 4-branched, fig. 110........... **Glossosoma,** p. 39

RHYACOPHILINAE

The larva is free living, in all the Illinois species without external gills; it constructs a dome-shaped cocoon of pebbles for pupation. The pupa is formed within an ellipsoid, translucent pupal chamber anchored at each end within the cocoon. The adults have short antennae, very simple and similar front and hind wings and five-segmented maxillary palpi in both sexes.

Rhyacophila Pictet

Rhyacophila Pictet (1834, p. 181). Genotype, here designated: *Rhyacophila vulgaris* Pictet.

In Illinois we have taken five species of this genus. Four of them occur in streams which are temporary but which are rapid and clear when running; the fifth occurs in a set of small, clear, spring-fed brooklets at Elgin. Over 70 species of *Rhyacophila* inhabit North America, most of them restricted to the rapid, clear streams of mountainous terrain or northern country.

Westwood (1840, p. 51) lists *vulgata* Pictet as the genotype. This is undoubtedly an emendation of *vulgaris* Pictet, since Pictet did not list a species by the name of *vulgata* in his description of *Rhyacophila*.

KEY TO SPECIES

Larvae

1. Second segment of anal larvapods with a long, bladelike, dorso-lateral spur, fig. 111 . . . . **fuscula**, p. 36
   Second segment of larvapods without a distinct spur, fig. 112 2
2. Second segment of maxillary palpus much longer than first, fig. 115 3
   Second segment of maxillary palpus not longer than first, fig. 114 . . . . **glaberrima**, p. 35
3. Front and middle legs almost the same size and shape, fig. 116; baso-ventral sclerotized rod of anal prolegs produced into a short, sharp, curved hook, fig. 91 . . . . **lobifera**, p. 35
   Front femora much stouter than middle femora, giving the two legs different shapes, fig. 117; baso-ventral sclerotized rod of anal prolegs not hooked, fig. 112 4
4. Head wide and short, fig. 118; anal hooks without teeth on inner margin, fig. 113 . . . . **ledra**, p. 37; **fenestra**, p. 36
   Head narrower and longer, fig. 119; anal hooks with at least one small inner tooth, fig. 112 . . . . **vibox**, p. 36

Adults

1. Apex of abdomen with long claspers (males) 2
   Apex of abdomen cylindrical (females) 8
2. Apical segment of clasper deeply incised to form a long dorsal point, fig. 120 . . . . **lobifera**, p. 35
   Apical segment of clasper either only

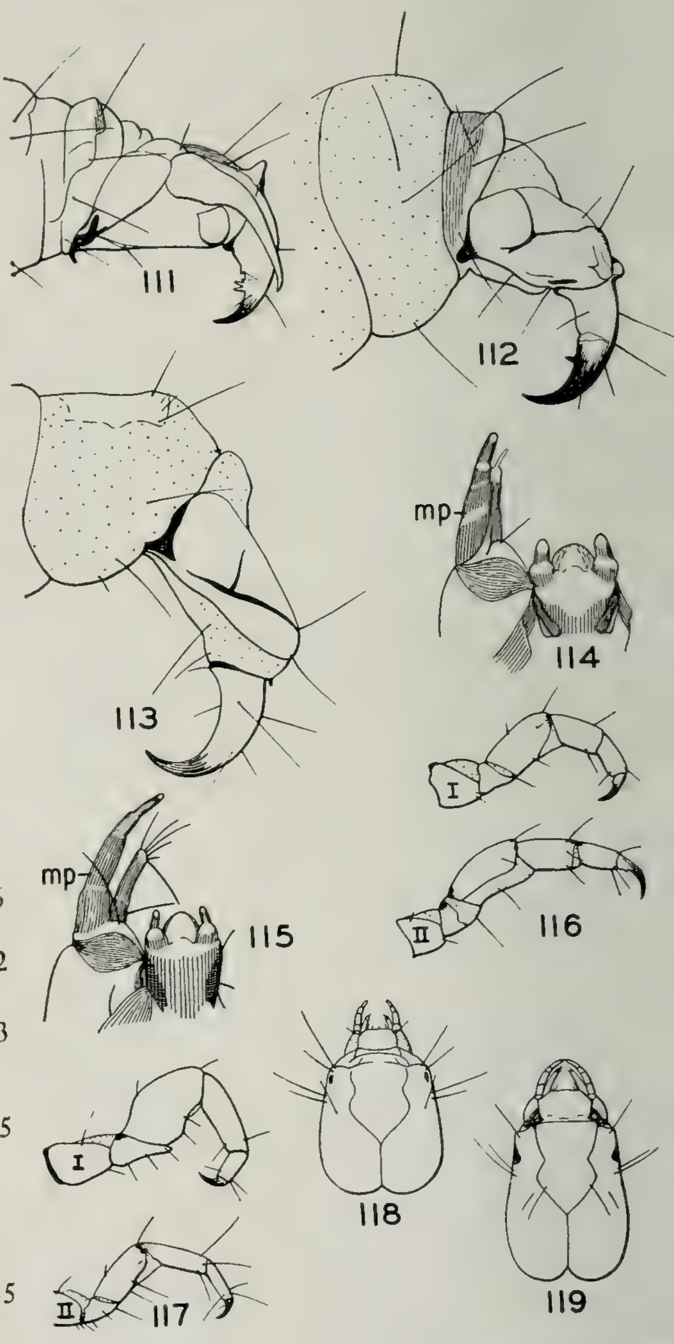


Fig. 111.—*Rhyacophila fuscula* larva, ana leg.

Fig. 112.—*Rhyacophila vibox* larva, anal leg

Fig. 113.—*Rhyacophila fenestra* larva, ana leg.

Fig. 114.—*Rhyacophila glaberrima* larva maxilla and labium; *mp*, maxillary palpus.

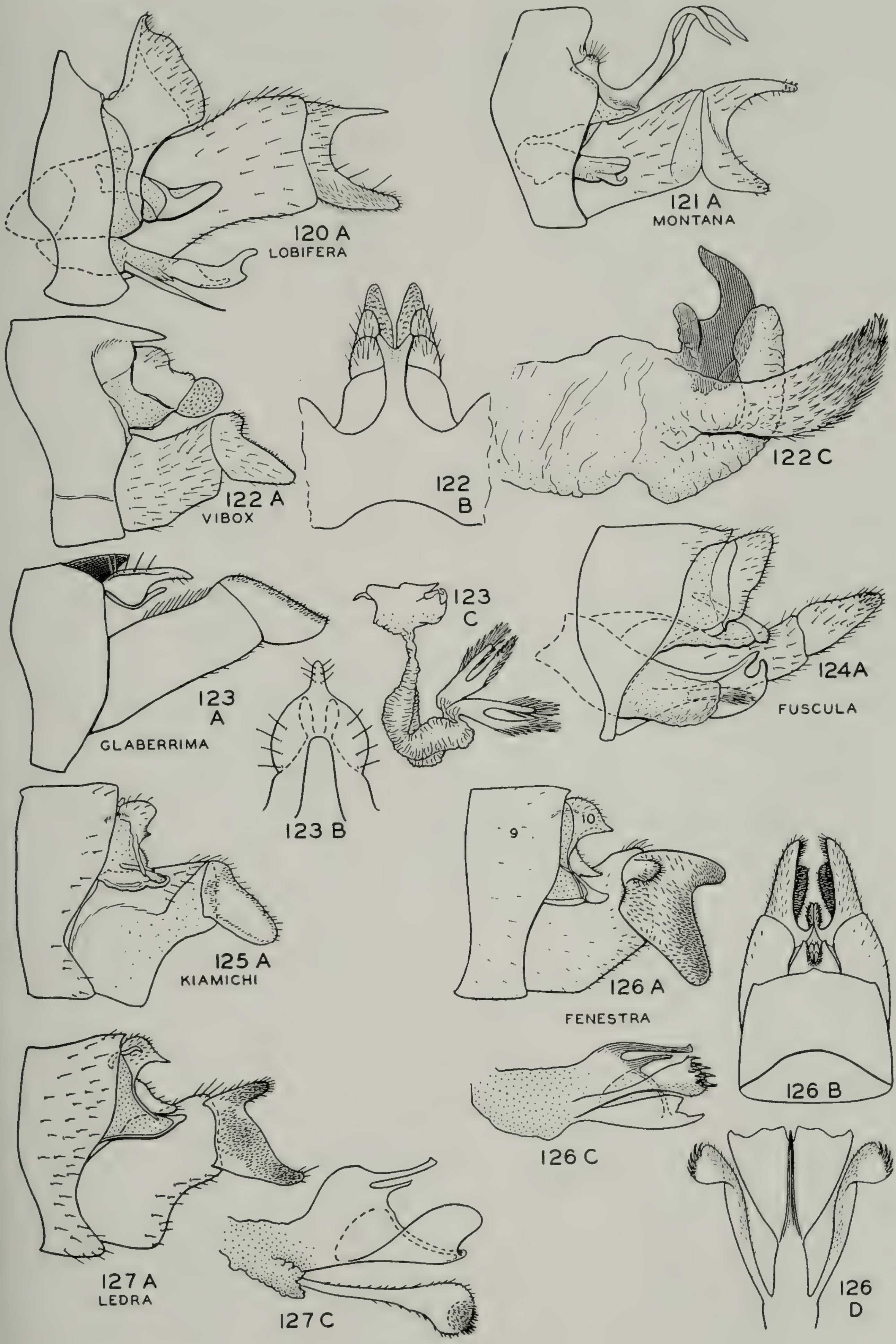
Fig. 115.—*Rhyacophila fenestra* larva, maxilla and labium; *mp*, maxillary palpus.

Fig. 116.—*Rhyacophila lobifera* larva, fron and middle legs.

Fig. 117.—*Rhyacophila fenestra* larva, fron and middle legs.

Fig. 118.—*Rhyacophila fenestra* larva, head

Fig. 119.—*Rhyacophila vibox* larva, head.



Figs. 120–127.—*Rhyacophila*, male genitalia. *A*, lateral aspect; *B*, dorsal aspect; *C*, aedeagus, lateral aspect; *D*, aedeagus, dorsal aspect.

moderately incised, fig. 126, or not incised at all, fig. 124 3

3. Ninth tergite produced into a long, narrow, forked process which extends over tenth tergite, fig. 122 . . . . **vibox,** p. 36

Ninth tergite not produced into a forked process, fig. 123 4

4. Tenth tergite heart shaped and pointed at apex, fig. 123, long and shallow; aedeagus with a U-shaped process at the end of the lateral arms of the aedeagus . . . . **glaberrima,** p. 35

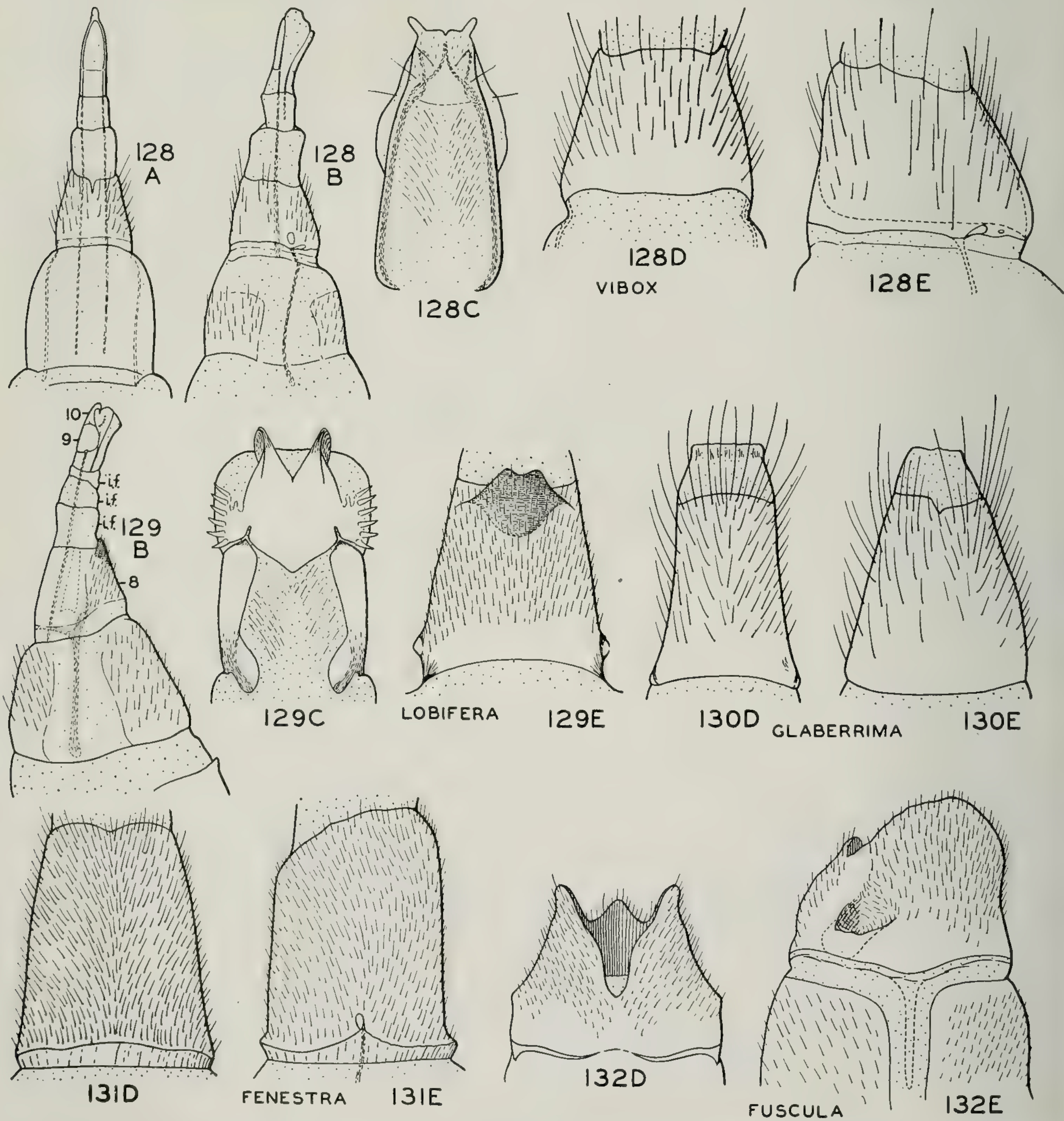
Tenth tergite short and deep, divided down meson, not forming a round, dorsal plate; aedeagus without U-shaped processes at the end of the lateral arms, figs. 124, 126 5

5. First segment of claspers with ventral margin almost straight from base to apex; aedeagus without a ventral plate, fig. 124 . . . . **fuscula,** p. 36

First segment of claspers with ventral margin humped to form a definite shoulder near base; aedeagus with large, scoop-shaped ventral plate below central portion, fig. 126 6

6. Apical segment of clasper incised to form a definite dorsal heel, figs. 126, 127 7

Apical segment of clasper not incised, only sinuate, fig. 125, so that the



Figs. 128–132.—*Rhyacophila*, female genitalia. *A* and *B*, apex of abdomen, ventral and lateral aspect; *C*, tenth tergite; *D*, eighth sternite; *E*, eighth segment, lateral aspect.

dorsal portion is low and rounded instead of forming a distinct heel. . . . . **kiamichi**, p. 37

7. Apical segment of clasper with a mesal, setose flap; arms of aedeagus at apex with several stout spines, each surrounded by smaller setae, fig. 126. . . . . **fenestra**, p. 36

   Apical segment of clasper without a mesal flap; arms of aedeagus with a brush of setae of almost equal size, fig. 127. . . . . **ledra**, p. 37

8. Eighth segment with apex of sternite deeply excavated and apex of tergite bi-emarginate, fig. 132. . . **fuscula**, p. 36

   Eighth segment neither with sternite deeply incised nor with tergite bi-emarginate 9

9. Apex of eighth sternite with a produced mesal plate which is differentiated in texture from remainder of segment, fig. 129; tenth tergite sclerotized and spined, fig. 129. . . . . **lobifera**, p. 35

   Eighth sternite without such a plate; tenth tergite chiefly membranous, without spines, fig. 128. 10

10. Eighth sternite short and stout, venter distinctly bulged near base, fig. 128 . . . . **vibox**, p. 36

   Eighth sternite longer and more slender, without ventro-basal bulge, fig. 130. 11

11. Eighth tergite with an apical incision, fig. 131; entire segment with only moderately long hair; size larger, 10 mm. or more. . . . . **fenestra**, p. 36; **ledra**, p. 37

   Eighth tergite without a marked incision, fig. 130; entire segment clothed with long hair; size smaller, 8 mm. or less. . . . . . . **glaberrima**, p. 35

Rhyacophila lobifera Betten

Rhyacophila lobifera Betten (1934, p. 131); ♂, ♀, larva.

LARVA.—Length 15 mm.; head and pronotal shield straw color, with scattered brown dots; body greenish.

ADULTS.—Length 11–13 mm.; color dark bluish gray, with some yellowish patches of hair on head, body and wings. Legs yellow to greenish. Male genitalia, fig. 120, with claspers very long, the apical segment incised to form a sharp dorsal point; tenth tergite large and somewhat triangular. Female genitalia as in fig. 129 (note the intersegmental folds, *i.f.*, between segments 8 and 9).

This species at times has been considered a synonym of *montana* Carpenter, described from the Great Smoky Mountains of North Carolina, but the two differ radically in the shape of the tenth tergite. That of *montana* has long, slender, sclerotized processes, fig. 121, and that of *lobifera* comprises a single, stout, triangular protuberance.

Originally described from Lake Bluff, Illinois, *lobifera* has since been taken in widely scattered localities in the state, principally in the eastern portion. It frequents small, rapid, clear streams that are of a temporary nature in drought years. The adults appear during April and May in southern Illinois and during May and June in northern Illinois.

Known also from Indiana, Ohio, Oklahoma.

Illinois Records.—Many males, females and pupae, taken April 3 to June 3, and many larvae and cases, taken March 5 to May 1, are from Alto Pass (Union Spring Creek), Brockton (Catfish Creek), Carbondale (Clay Lick Creek), Dixon Springs, Eddyville (Eddy Creek), Filson, Fox Ridge State Park, Grayville, Harrisburg (Blackman Creek), Herod (Gibbons Creek), Hill (tributary of Bishop Creek), Hurd (small stream), Marshall, Mazon (Mazon Creek), Muncie (Stony Creek), New Columbia (Clifty Creek), Oakwood (West Branch), Red Bud, Ritchie (small stream), Rosecrans, St. Elmo (South Fork Creek), Toledo, Tuscola, Urbana, Waltersburg, Watson, Willow Springs.

Rhyacophila glaberrima Ulmer

Rhyacophila glaberrima Ulmer (1907*b*, p. 85); ♂.

Rhyacophila fairchildi Banks (1930*a*, p. 130); ♂.

Rhyacophila andrea Betten (1934, p. 127); ♂.

LARVA.—Length 12 mm. Body long and slender. Head, pronotum, legs and anal sclerites light yellow with suffused brown markings. Anal hooks stout, each with one large and one small inner tooth.

ADULTS.—Length 7–8 mm. Head and body dark brown; legs pale, slightly greenish; wings dark, without pattern. Male genitalia, fig. 123, with tenth tergite projecting; claspers very long, and with curious "forks" at apex of lateral appendages of aedeagus. Female genitalia, fig. 130, with eighth segment simple in structure, with very long, fine hair.

Allotype, female.—Gatlinburg, Tennessee: Sept. 4, 1940, B. D. Burks.

Our only Illinois records are a single mature male pupa taken under a damp stone in the dry bed of Gibbons Creek at Herod, October 7, 1937, Ross & Burks, and 4 larvae taken in a small, spring-fed stream 2 miles away, May 30, 1940, B. D. Burks. These records are from the heart of the Illinois Ozarks region. The main range of *glaberrima* is in the Appalachian states; the species is known from Massachusetts, New York, North Carolina, Nova Scotia, Tennessee and Virginia. In view of this, our Illinois record is a significant extension of its range.

Rhyacophila vibox Milne

Rhyacophila vibox Milne (1936, p. 101); ♂, ♀.

LARVA.—Length 11 mm. Body stout. Head golden yellow with most of dorsal area brownish; pronotum golden yellow; legs and anal sclerites pale yellow. Abdomen whitish with purplish blotches.

ADULTS.—Length 8–10 mm. Color of body and appendages various shades of brown; head and wings without definite pattern. Male genitalia, fig. 122, with ninth tergite produced into a long dorsal process bifid at apex; tenth tergite forming a complex of small, paired plates; claspers short; aedeagus with a central hook and lateral, spinose lobes. Female genitalia, fig. 128, with eighth sternite stocky, short and simple.

In Illinois we have taken this species only in the small, spring-fed brooks in the Elgin Botanical Gardens. In view of the other known captures of the species, from Ontario and Quebec, it would appear that the species is chiefly northern and its occurrence in Illinois represents a localized capture at the extreme edge of the present range.

Illinois Records.—ELGIN: April 19, 1939, Burks & Riegel, 1 larva; May 9, 1939, Ross & Burks, 5 larvae; May 23, 1939, Burks & Riegel, 2 pupae; June 6, 1939, Burks & Riegel, 2 ♂; June 13, 1939, Frison & Ross, 3 ♂, many ♂ and ♀ pupae; Sept. 19, 1939, Ross & Mohr, 1 larva; preceding Elgin records from Botanical Gardens; Trout Spring, May 7, 1940, Burks & Mohr, 4 larvae.

Rhyacophila fuscula (Walker)

Neuronia fuscula Walker (1852, p. 10); ♂.

This species is the most common *Rhyacophila* found in a large number of the eastern states. It has not yet been taken in Illinois, but may eventually be found within the state. Known from Maine, Michigan, New Brunswick, New Hampshire, New York, North Carolina, Nova Scotia, Ontario, Pennsylvania, Quebec, Tennessee, Virginia, West Virginia.

Rhyacophila fenestra Ross

Rhyacophila fenestra Ross (1938*a*, p. 102); ♂, ♀.

LARVA.—Fig. 133. Length 14 mm. Body stocky. Head orange, spotted with brown at the side, most of dorsum brown enclosing an orange spot in the center of the frons; pronotum, front legs and anal hooks orange, pronotum with brown spots; middle and

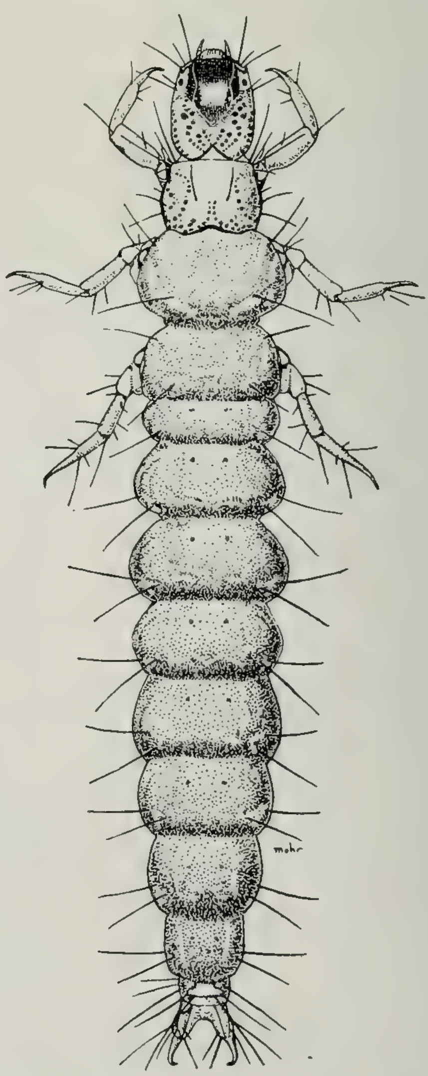


Fig. 133.—*Rhyacophila fenestra* larva.

hind legs pale yellow. Abdomen with an irregular purplish pattern.

Adults.—Fig. 134. Length 10–12 mm. Head, body and legs various shades of light and medium brown; fronto-dorsal area of head with a distinct, dark, quadrate spot;

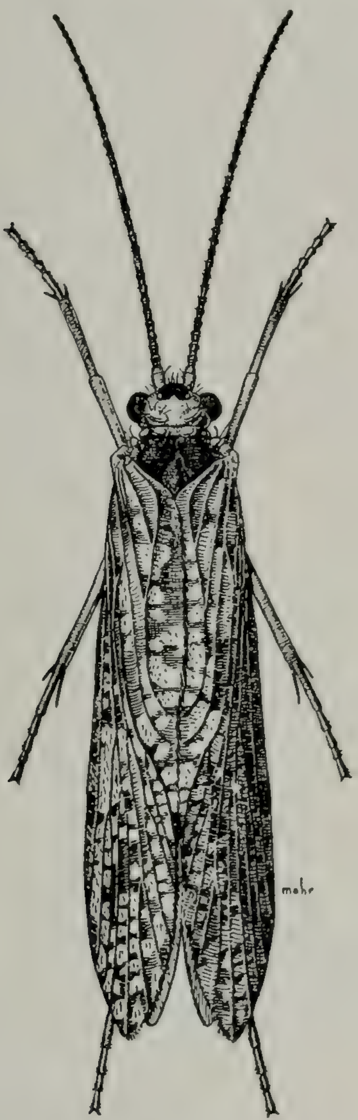


Fig. 134.—*Rhyacophila fenestra* ♀.

wings fenestrate with light and dark brown. Male genitalia, fig. 126, with short, beaked tenth tergite; claspers short, the apical segment incised; aedeagus with a central scoop-like structure and lateral processes. Female genitalia as in fig. 131, eighth segment simple in shape.

This species, known only from Illinois, is with one exception restricted to the Ozarkian area, where it is abundant in all the clear, rapid streams, most of them flowing only in winter and spring.

The one exception is a single colony of *fenestra* located in a small, temporary stream at Oakwood.

Illinois Records.—Many males, females and pupae, taken April 21 to June 6, and many larvae and cases, taken March 23 to May 26, are from Aldridge, Alto Pass, Carbondale, Dixon Springs, East Peoria, Eddyville, Eichorn, Elizabethtown, Golconda, Herod (Gibbons Creek), Jonesboro, Karbers Ridge, New Columbia (Clifty Creek), Oakwood, Vienna, Wolf Lake.

Rhyacophila ledra Ross

Rhyacophila ledra Ross (1939*a*, p. 65); ♂.

Similar to *fenestra* in color and general structure, differing in characters of the male genitalia, fig. 127, particularly the apical segment of the claspers, the lateral arms of the aedeagus and the humped central ridge of the aedeagus. To date, characters have not been found to separate the larvae or females of these two species.

Our sole Illinois record for this species consists of two fully matured male pupae collected in Union Spring, a small, temporary stream near Alto Pass in the Ozark Hills of southern Illinois, May 26, 1940, Mohr & Burks. The species is known otherwise only from the type material collected in Tennessee.

Rhyacophila kiamichi new species

Male.—Length 9 mm. Color dark brown with very little mottling, the wings with only slight indications of an irrorate pattern. General structure typical for genus. Male genitalia, fig. 125: ninth segment cylindrical, considerably narrowed near ventral margin, tenth tergite composed of a pair of dorsal lobes which are round, project over the rest of the tergite, and bear a short, sclerotized tooth on the posterior margin; below this is a group of small sclerites very similar to those in other members of the *carolina* group; claspers with basal segment very wide at base, the ventral margin conspicuously angulate just beyond base and curving gradually to a narrowed apex; apical segment of clasper with dorsal corner rounded and short, posterior margin only slightly concave, the ventral portion of the segment wide and rounded at apex, the mesal face with an irregular peripheral brush of short, flat setae arranged as illustrated; aedeagus very similar to that of *fenestra*, with a sharp, dorsal, keel-like structure divided at apex into dorsal and ventral prongs, ventral portion large and scoop shaped, and lateral arms membran-

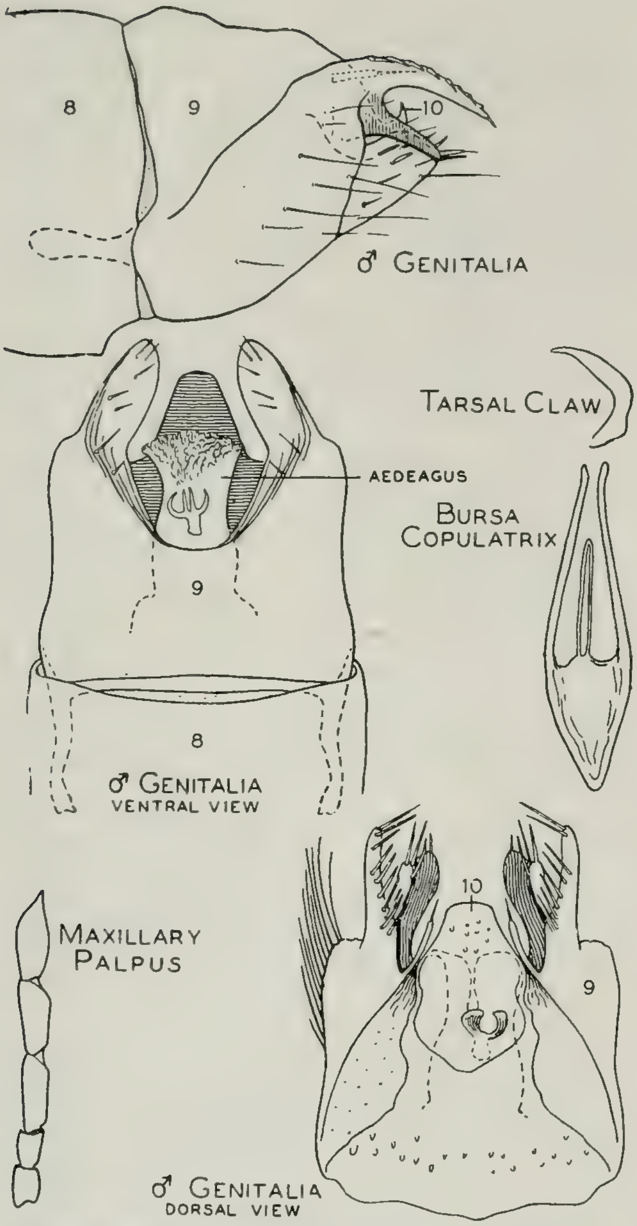


Fig. 135.—*Palaeagapetus celsus*, genitalia.

ous, tipped with a broad brush of curved spines.

Holotype, male.—Cloudy Creek near Cloudy, Oklahoma: May 4, 1940, Mrs. Roy Weddle.

Paratypes.—Same data as for holotype, 1♂.

The broad, scoop-shaped ventral portion of the aedeagus places this species immediately as a member of the *carolina* group. It is distinguished from all the previously described species of this group, however, by the absence of a well-developed dorsal heel on the apical segment of the clasper and by the shape of the tenth tergite.

The species has not been collected in Illinois. The types are from the Kiamichi Mountains of Oklahoma and may indicate an extensive range through the Ozarks, in which case it might eventually be found in Illinois.

Palaeagapetus Ulmer

Palaeagapetus Ulmer (1912, p. 35). Genotype, monobasic: *Palaeagapetus rotundatus* Ulmer (described from Baltic amber).

No representative of this genus has yet been taken in Illinois. The only species known from the eastern states, *celsus*, has been collected in North Carolina and Tennessee and is easily recognized in the male by the curious genitalia, fig. 135. Larva unknown. The genus may belong to the Rhyacophilinae.

GLOSSOSOMATINAE

This subfamily embraces several genera, three of which have been found in Illinois. The larvae make a saddle case formed of a dome-shaped upper portion with a flat strap across the underside, figs. 136, 137; the larva moves along with the anal portion protruding on one side of the strap and the front end protruding from the other. Before pupation the bottom strap is cut away and the dome-shaped upper portion is cemented to a rock or other support. The adults resemble *Rhyacophila* in shape and

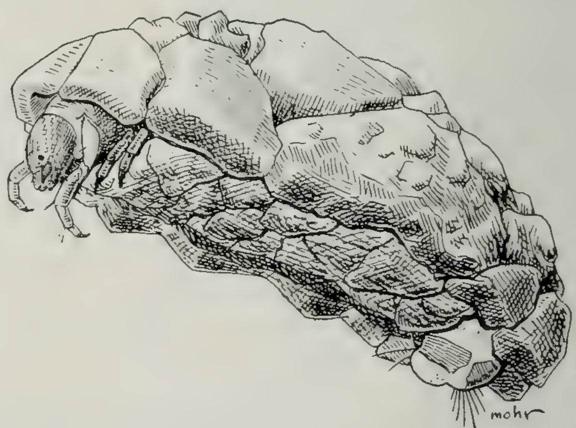


Fig. 136.—*Glossosoma intermedium* case.

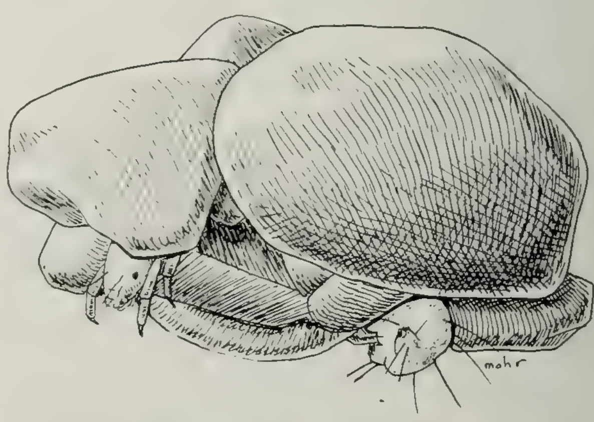


Fig. 137.—*Protoptila maculata* case.

general characteristics, and in general appearance differ from each other chiefly in size. The adults are secretive in habit and are very seldom captured except around their stream; the notable exception is *Protoptila*, which is taken frequently at lights in large numbers.

The larvae of this entire subfamily are very uniform in shape and appearance, differing chiefly in the characters mentioned in the key to genera. Reliable characters have not yet been discovered in the larvae for separating the species within the genus.

Glossosoma Curtis

Glossosoma Curtis (1834, p. 216). Genotype, monobasic: *Glossosoma boltoni* Curtis.

Mystrophora Klapálek (1892, p. 19). Genotype, monobasic: *Mystrophora intermedia* Klapálek. New synonymy.

The group of species with the short and platelike apical spur on the hind tibiae of the male has usually been considered as a separate genus, *Mystrophora*. Since there appears to be no corresponding diagnostic character in either the females or larvae, I am considering this division as of subgeneric importance at the most.

Only one species has been captured in Illinois; two others occur in the eastern states and many are known from the Rocky Mountain region.

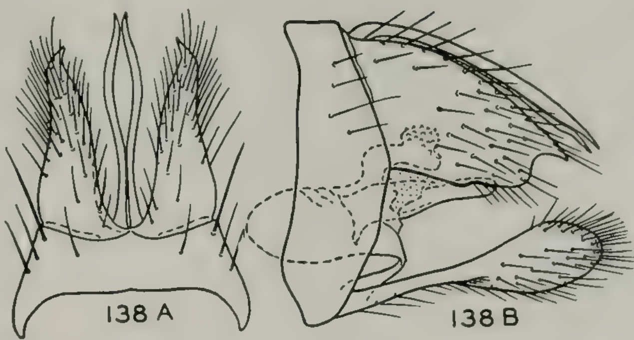
Glossosoma intermedium (Klapálek)

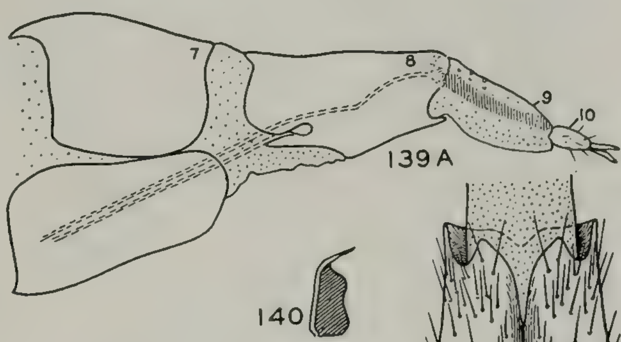
Mystrophora intermedia Klapálek (1892, p. 19).

LARVA.—Fig. 136. Length 6–9 mm. Head, pronotum, legs and anal sclerites dark brown, body pinkish to very light brown.

ADULTS.—Length 7–10 mm. Body appendages dark brown, appearing almost black. Male with a flattened apical spur on hind tibiae, fig. 140. Male genitalia, fig. 138: tenth tergite divided to base into large lobes pointed at apex and provided at base with a long, sclerotized rod; claspers narrow at base, expanded at apex. Female genitalia, fig. 139, typical in general proportions for subfamily; eighth sternite deeply incised to form a deep, narrow V on meson.

This species, described and recorded from various points in Europe, has recently been found in Illinois, Minnesota and Missouri. In Illinois, it is apparently confined to the small set of spring-fed brooks in the Elgin Botanical Gardens, where the species occurs in such numbers that the cases literally pave the bottoms of the streams.





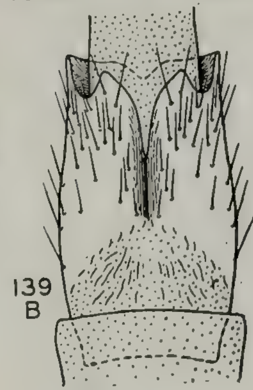


Fig. 138.—*Glossosoma intermedium*, male genitalia. *A*, dorsal aspect; *B*, lateral aspect.

Fig. 139.—*Glossosoma intermedium*, female genitalia. *A*, lateral aspect; *B*, ventral aspect.

Fig. 140.—*Glossosoma intermedium* ♂, spur of hind tibia.

Illinois Records.—ELGIN: April 19, 1939, Burks & Riegel, 1 pupa; May 9, 1939, Ross & Burks, ♂♂, ♀♀, many pupae and larvae; May 23, 1939, Burks & Riegel, 3♂, 1♀; June 6, 1939, Burks & Riegel, 2♂, 3♀; June 13, 1939, Frison & Ross, 6♂, 7♀; Sept. 19, 1939, Ross & Mohr, ♂♂, ♀♀, many larvae and pupae; March 20, 1940, B. D. Burks, 5♂, 2♀, 1 ♂ pupa, 1 mating pair; all of preceding Elgin records from Botanical Gardens; Rainbow Spring, May 19, 1939, Ross & Burks, 3♂, 2♀.

Agapetus Curtis

Agapetus Curtis (1834, p. 217). Genotype, by subsequent designation of Westwood (1840, p. 51): *Agapetus fuscipes* Curtis.

Only one species, *illini*, has been taken in Illinois. Three other species occur in the Ozarks and neighboring hills of nearby states. These resemble our Illinois form in size and color, but are readily separable on the basis of male genitalia as follows:

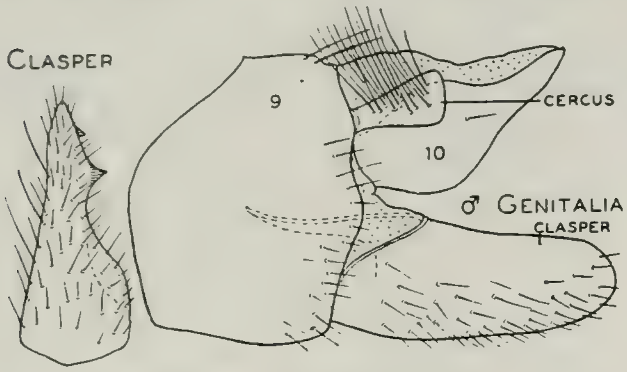


Fig. 141.—*Agapetus artesus.*

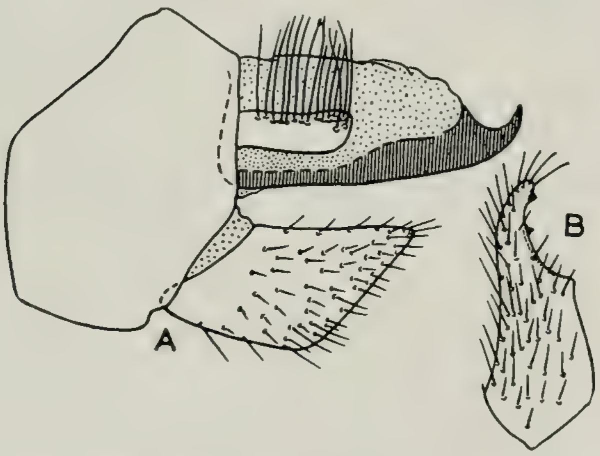


Fig. 142.—*Agapetus crasmus.*

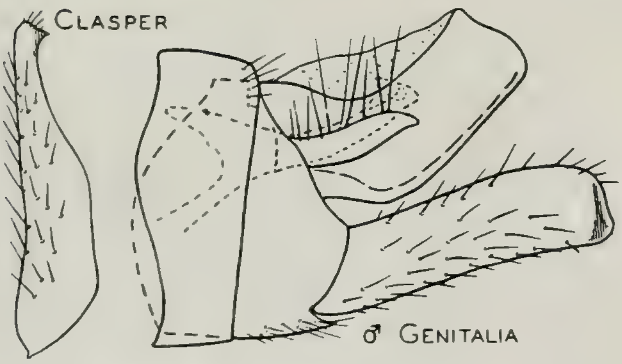


Fig. 143.—*Agapetus medicus.*

artesus, fig. 141, known from Missouri, has a somewhat pear-shaped, pointed tenth tergite and medium length, rounded claspers; *crasmus*, fig. 142, known from Tennessee, has a long tenth tergite with a hook at apex and very short, truncate claspers; and *medicus*, fig. 143, known from Arkansas, has a cleaver-shaped tenth tergite and long, rectangular claspers. Satisfactory characters have not yet been found to identify the females of species in this group.

Agapetus illini Ross

Agapetus illini Ross (1938*a*, p. 106); ♂, ♀.

LARVA.—Similar in size and color to that of *Glossosoma*.

ADULTS.—Length 7–8 mm. Body and appendages dark brown. Male genitalia, fig. 144, with apex of tenth tergite irregularly and sharply serrate, claspers tapering to apex. Female genitalia as in fig. 145.

Restricted in Illinois to clear streams in the Ozarkian region, where it becomes very abundant in early spring in these temporary streams. It has one generation per year.

Known also from Arkansas, Kentucky, Missouri and Oklahoma; apparently confined to the Ozarkian uplift and adjacent hilly regions.

Illinois Records.—East of ALDRIDGE: May 14, 1940, Mohr & Burks, 3 pupae, many larvae. ALTO PASS, Union Spring:

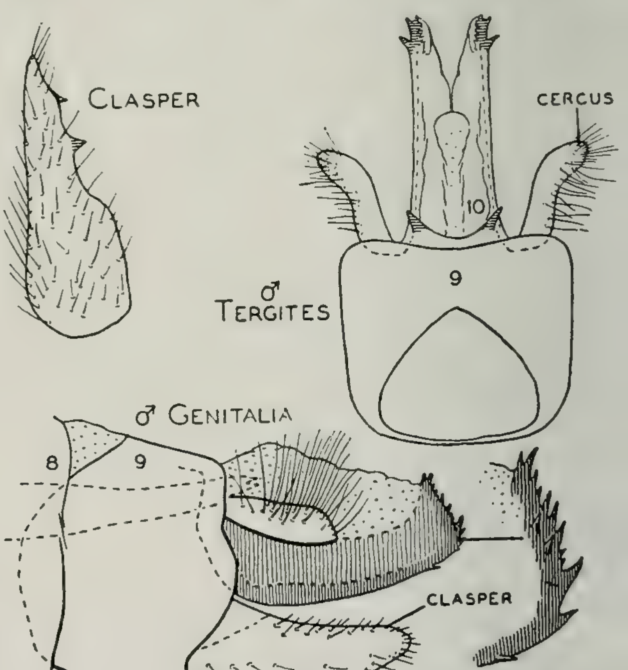


Fig. 144.—*Agapetus illini.*

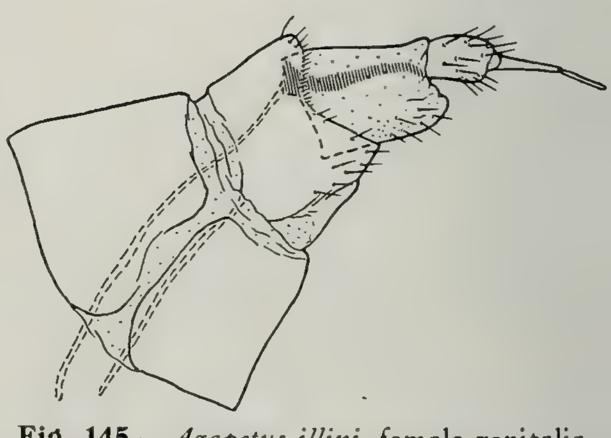


Fig. 145.—*Agapetus illini*, female genitalia.

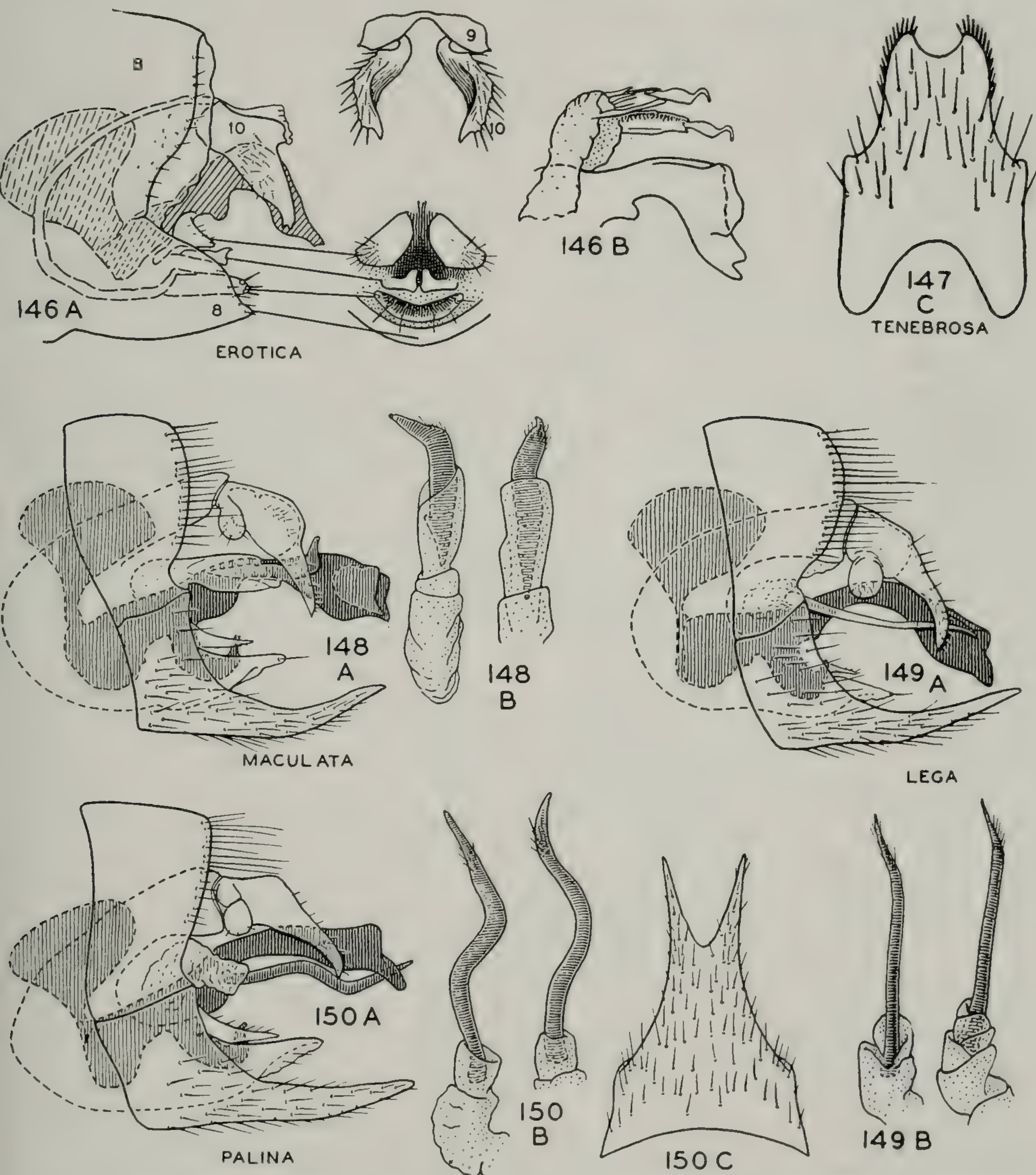
May 26, 1940, Mohr & Burks, 1♂. Eddyville, Lusk Creek: June 1, 1940, B. D. Burks, 9♂. Eichorn: May 11, 1935, C. O. Mohr, 4♂. Herod: May 29, 1928, T. H. Frison, 1♂; Gibbons Creek, May 29, 1928, T. H. Frison, ♂♂; May 10, 1935, C. O. Mohr, ♂♂, 1♀; May 29, 1935, Ross & Mohr, ♂♂, 7♀; July 11, 1935, Ross & DeLong, 1♂; May 1, 1936, Ross & Mohr, ♂♂, 1♀; May 12, 1936, Mohr & Burks, 7♂, 3♀; May 29, 1936, Ross & Mohr, 1♀; May 13, 1937, Frison & Ross, ♂♂, 7♀.

Protoptila Banks

Clymene Chambers (1873, p. 114); preoccupied. Genotype, monobasic: *Clymene aegerfasciella* Chambers (described in Lepidoptera, placed here by Banks).

Protoptila Banks (1904*d*, p. 215). Genotype, by original designation: *Beraea? maculata* Hagen.

Of the 10 known Nearctic species, 3 have been taken in Illinois and 2 others, known from neighboring states, may ultimately turn up here. No differences have been found to



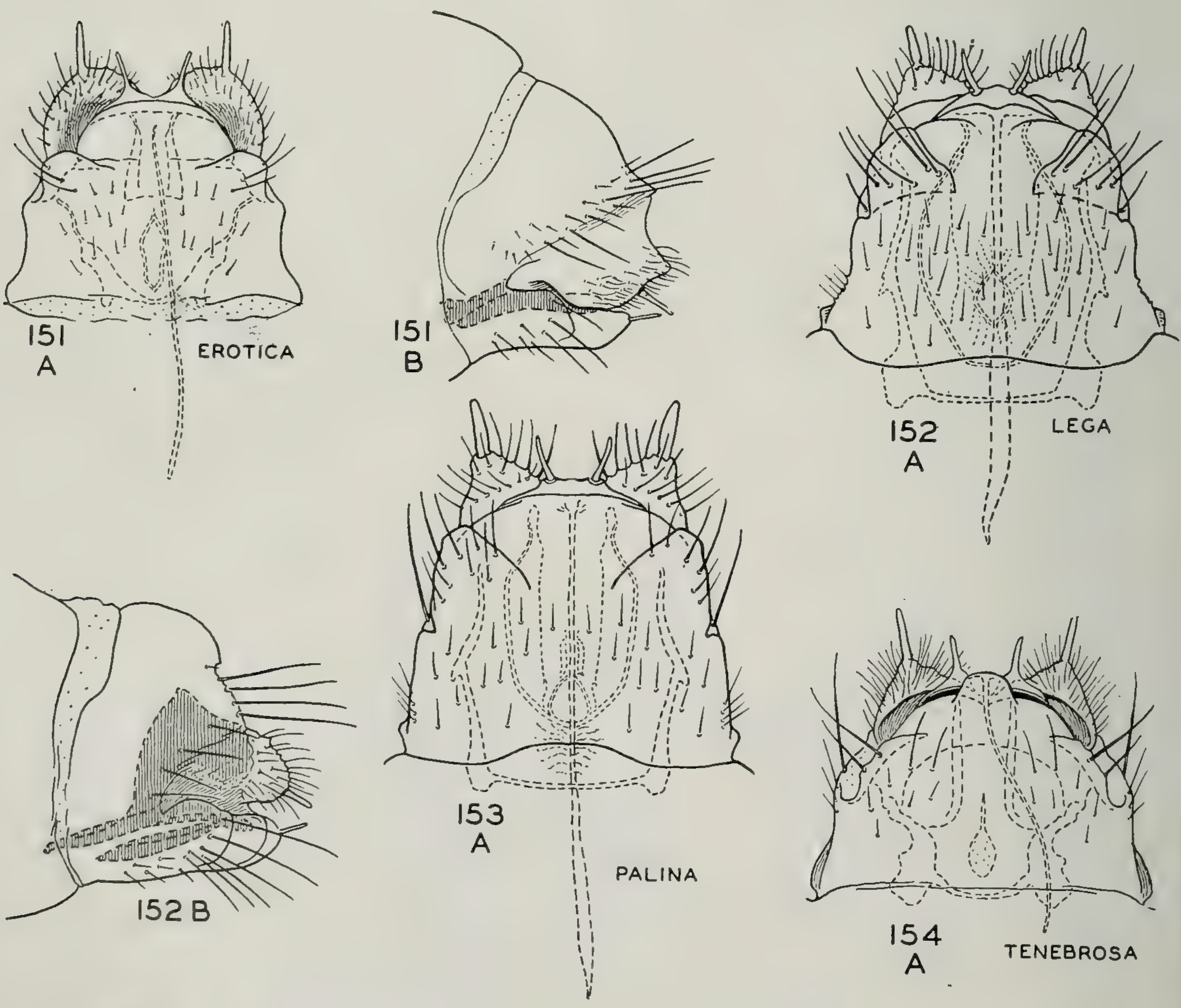
Figs. 146–150.—*Protoptila*, male genitalia. *A*, lateral aspect; *B*, aedeagus or its spines; *C*, eighth sternite.

divide the larvae to species. The adults of all species resemble each other very closely in appearance and general structure, differing chiefly in characters listed in the key.

KEY TO SPECIES

Adults

1. Apex of abdomen with assemblage of sclerotized rods and plates (males), fig. 146 2
   Apex of abdomen cylindrical (females), fig. 151 6
2. Eighth sternite scoop-shaped, not produced into a bifid process, fig. 146 .... **erotica**, p. 44
   Eighth sternite produced into a bifid process, fig. 150 3
3. Eighth sternite with apico-lateral corner produced into a brushy lobe, and with apex massive and deeply and widely excavated, fig. 147 .... **tenebrosa**, p. 43
   Eighth sternite with apico-lateral corner angulate, not produced, and with apex more slender, fig. 150 4
4. Lateral spine of aedeagus stout and abruptly angled near apex, fig. 148 .... **maculata**, p. 43
   Lateral spine of aedeagus slender and only gradually curved, fig. 150 5
5. Lateral spine of aedeagus curved only near apex; apex of aedeagus abruptly narrowed at base, fig. 149 .... **lega**, p. 43
   Lateral spine of aedeagus sinuate; apex of aedeagus only gradually narrowed at base, fig. 150 .... **palina**, p. 43
6. Internal plate of ninth tergite with a dorsal, bandlike prolongation which is joined to the base of the tenth tergite, fig. 152*B*; apico-lateral lobes of eighth sternite long, trianguloid, fig. 152*A* ....
   maculata, p. 43; **lega**, p. 43; **palina**, p. 43
   Internal plate of ninth tergite without dorsal prolongation, fig. 151*B*; apico-lateral lobes of eighth sternite narrow, fig. 151*A* 7
7. Internal sternal "whip" attached to a



Figs. 151–154.—*Protoptila*, female genitalia. *A*, ventral aspect; *B*, lateral aspect.

small, projecting, mesal sclerite; lobes of tenth tergite conical, fig. 154 . . . . **tenebrosa,** p. 43
Internal sternal "whip" attached to large, rounded plate which spans almost the entire width of the segment, fig. 151*A* . . . . **erotica,** p. 44

Protoptila maculata (Hagen)

Beraea? maculata Hagen (1861, p. 296); ♂.
Protoptila lloydi Mosely (1934*b*, p. 151); ♂.

Larva.—Length 3–4 mm. Head, legs and body sclerites yellow.

Case.—Fig. 137. Constructed of small, flat stones and forming a typical saddle case, complete with ventral strap. Due to its small size and somewhat irregular appearance it is overlooked easily when collecting.

Adults.—Length 3–4 mm. Head and body medium and light shades of brown, wings dark brown with a whitish band across the "cord" of the front wings. Both wings long and narrow, front ones with crossveins grouped to form an irregular cord near middle. Male genitalia, fig. 148: eighth sternite produced into a long, narrow, bifid process; tenth tergite produced into a divided, beaklike portion narrow at tip; aedeagus with a large, ovoid, internal lobe, a pair of lateral, style-bearing lobes and a sinuate central portion expanded at apex; styles short, stout and sharply curved at tip. Female genitalia similar to those in fig. 152, with essentially the same shaped internal whip and plates.

Allotype, female.—Momence, Illinois, along Kankakee River: May 29, 1939, Frison & Ross.

This species has been taken in Illinois from only two points on its eastern margin, in the Salt Fork River and the Kankakee River. Mature pupae have been collected in the Kankakee River. Adult records from May to August indicate two or more generations per year.

The range of the species is extensive through the northeastern states, with records from the District of Columbia, Illinois, Indiana, Kentucky, New York and Pennsylvania; these indicate that our Illinois records are near the western limit of its range.

Illinois Records.—Momence: Kankakee River, May 29, 1939, Frison & Ross, ♂♂, 1 mating pair; Aug. 21, 1936, Ross & Burks, ♂♂, 2♂ (reared); Kankakee River, May 26, 1936, H. H. Ross, ♂♂. Oakwood: June 14, 1935, C. O. Mohr, 1♂.

Protoptila lega Ross

Protoptila lega Ross (1941*b*, p. 48); ♂, ♀.

Larva.—Not associated, but undoubtedly present in material collected in the Salt Fork River and not distinguished from *maculata.*

Adults.—Similar in size, color and general structure of genitalia to *maculata*; differing in the long, straight lateral styles of the aedeagus and the shape of the apex of the aedeagus, fig. 149. Female genitalia variable in minute details, a typical condition shown in fig. 152, but with variations occurring which are very similar to fig. 153.

To date this species has been taken in Illinois only from the upper Sangamon River, Salt Fork River, Middle Fork River and Embarrass River; confined to the stony riffles of these relatively clear streams. Mature pupae, linking the larvae with the adults, were collected in the Middle Fork River at Danville.

Known also from Missouri and Wisconsin.

Illinois Records.—Charleston: Sept. 8, 1931, H. H. Ross, 1♂, 1♀. Danville, Middle Fork River: Aug. 27, 1936, 1♂, 1♀. Mahomet: Aug. 3, 1937, Ross & Burks, ♂♂, ♀♀. Oakwood: Aug. 14, 1935, C. O. Mohr, 5♂, 2♀; June 14, 1935, C. O. Mohr, 5♂, 3♀.

Protoptila palina Ross

Protoptila palina Ross (1941*b*, p. 46); ♂, ♀.

This species frequently occurs in company with *maculata* and *erotica.* Since both of these last species occur in Illinois, there is a good possibility that *palina* will eventually be taken in this state also. It is known from Kentucky, Pennsylvania and West Virginia.

Protoptila tenebrosa (Walker)

Hydroptila tenebrosa Walker (1852, p. 134); ♂, ♀.

This species has not yet been taken in Illinois but is known from Arkansas, Montana, Ontario, Wisconsin and Wyoming, and may eventually be found in one of the colder Illinois streams.

Protoptila erotica Ross

Protoptila erotica Ross (1938*a*, p. 113); ♂, ♀.

Larva.—Not associated, but undoubtedly present in material collected from the Kankakee River and undifferentiated from *maculata.*

Adults.—Length 3.0–3.5 mm. Head and body brown, front wings with a narrow, light band across "cord." Male genitalia, fig. 146: eighth sternite short and scooplike; tenth tergite divided into a pair of beaklike processes; aedeagus with a large, ovoid, internal lobe, a pair of lateral, style-bearing arms and a heavy, angled central portion. Female genitalia as in fig. 151.

This widely distributed northern species has been taken only at Momence, along the Kankakee River, in which the larvae undoubtedly live in company with *maculata.* Adult records from May to August indicate two or more generations per year.

Known from Illinois, Wisconsin and Wyoming.

Illinois Records.—Momence: Aug. 21, 1936, Ross & Burks, 6♂; Kankakee River, May 26, 1936, H. H. Ross, ♂♂; May 24, 1937, H. H. Ross, 1♂; June 4, 1932, Frison & Mohr, 1♂, 1♀; Aug. 24, 1936, Ross & Burks, 2♂.

PHILOPOTAMIDAE

Of the three North American genera belonging to this family, two have been taken in Illinois, and the third occurs in Indiana at a locality 17 miles from the Illinois state line.

The larvae frequent rapid streams or brooks. They are very active and make silken nets which form long, narrow pockets shaped like a long funnel. When the net is taken out of the water the whole structure collapses into a mass of silken folds.

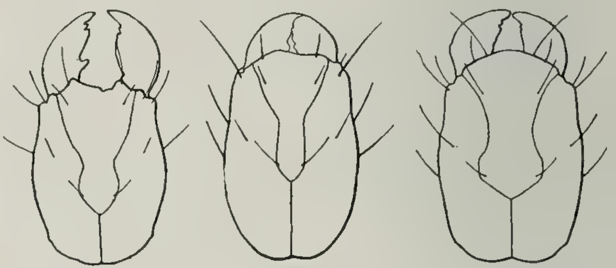
For pupation each larva constructs an ovoid cocoon of small stones and debris which is lined with several folds of silk. This is attached on the underside of a stone or other object in the water.

The adults of *Trentonius* and *Dolophilus* are secretive; those of *Chimarra,* slightly less so. They can be collected by sweeping foliage hanging over water or in humid shady portions of the stream's course, especially during early evening.

KEY TO GENERA

Larvae

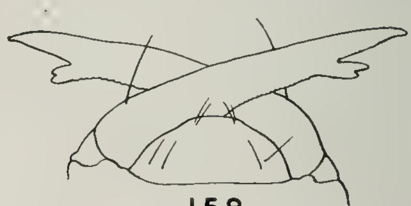
1. Apex of frons markedly asymmetrical, with a large or pointed left lobe and a smaller right one, figs. 155, 179–182 .... **Chimarra,** p. 48
   Apex of frons at most slightly asymmetrical, as in fig. 156 2



155 156 157

Fig. 155.—*Chimarra feria* larva, head.
Fig. 156.—*Trentonius distinctus* larva, head.
Fig. 157.—*Dolophilus shawnee* larva, head.

2. Frons almost perfectly symmetrical, with posterior portion widened, separated by a constriction from anterior portion, fig. 157 .... **Dolophilus,** p. 45
   Frons slightly asymmetrical, without constriction, posterior portion uniform in width, fig. 156 .... **Trentonius,** p. 47



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159 160 161

Fig. 158.—*Chimarra obscura* pupa, mandibles.

Fig. 159.—*Trentonius distinctus* pupa, mandibles.

Fig. 160.—*Dolophilus shawnee* pupa, mandibles.

Fig. 161.—*Dolophilus moestus* pupa, mandibles.

Pupae

1. Mandibles with a single, incised cusp below apical tooth, fig. 158 .... **Chimarra,** p. 48
   Mandibles with 2 or 3 sharp teeth below apical tooth, fig. 159 2
2. Mandibles broad, subapical teeth close together, fig. 159 .... **Trentonius,** p. 47
   Mandibles narrower, subapical teeth farther apart, figs. 160, 161 .... **Dolophilus,** p. 45

Adults

1. Wings reduced to stubs, fig. 171 .... **Trentonius,** p. 47
   Wings normal, reaching beyond apex of abdomen, fig. 170 2
2. Front tibiae with 1 apical spur .... **Chimarra,** p. 48
   Front tibiae with 2 apical spurs 3

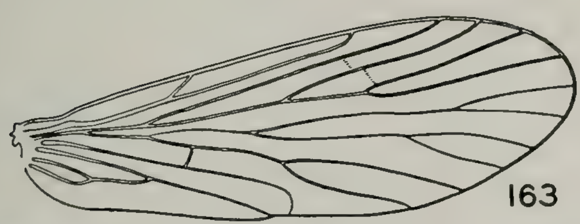


Fig. 162.—*Trentonius distinctus*, front wing.
Fig. 163.—*Dolophilus shawnee*, front wing.

3. Front wings with vein R_{2+3} branching beyond radial crossveins, near margin of wing, fig. 162 .... **Trentonius,** p. 47
   Front wings with vein R_{2+3} either branching at or near radial crossveins, or not branched, fig. 163 .... **Dolophilus,** p. 45

Dolophilus McLachlan

Dolophilus McLachlan (1868, p. 303). Genotype, monobasic: *Dolophilus copiosus* McLachlan.

Paragapetus Banks (1914, p. 202). Genotype, monobasic: *Paragapetus moestus* Banks.

Dolophiliella Banks (1930*b*, p. 230). Genotype, by original designation: *Dolophiliella gabriella* Banks.

Of the nine described North American species, only two have been taken in Illinois. The remainder have been collected only as far east as Oklahoma with the exception of one species, *major*, which occurs in the Great Smoky Mountains of North Carolina and Tennessee.

KEY TO SPECIES

Larvae

1. Apex of fore coxae with a stout, curved spur, fig. 164 .... **shawnee,** p. 46

Fig. 164.—*Dolophilus shawnee* larva, front leg.
Fig. 165.—*Dolophilus moestus* larva, front leg.

   Apex of fore coxae with a slender spur, fig. 165 .... **moestus,** p. 47

Adults

1. Apex of abdomen with a pair of 2-segmented claspers (males) 2
   Apex of abdomen simple and tubular (females) 3
2. Claspers with basal segment short and bulbous, apical segment much longer and spatulate; apico-mesal projection of seventh sternite short, fig. 166 .... **shawnee,** p. 46
   Apical segment of claspers subequal in

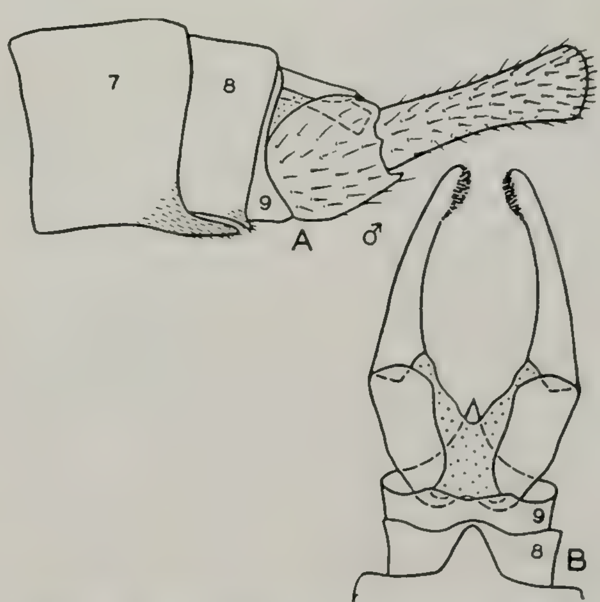


Fig. 166.—*Dolophilus shawnee*, male genitalia. *A*, lateral aspect; *B*, ventral aspect.

length to basal segment; apicomesal process of seventh sternite very long, fig. 167...... **moestus,** p. 47

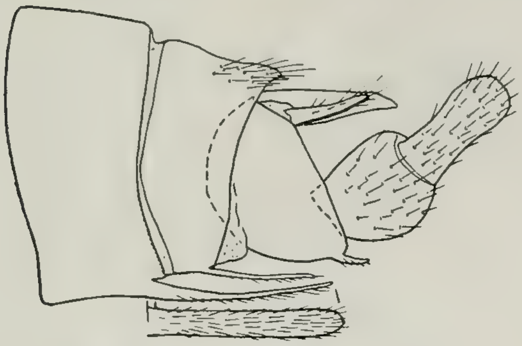
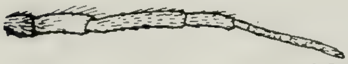


Fig. 167.—*Dolophilus moestus*, male genitalia.



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169

Fig. 168.—*Dolophilus moestus* ♀, maxillary palpus.

Fig. 169.—*Dolophilus shawnee* ♀, maxillary palpus.

3. Maxillary palpi with second segment cylindrical, of the same diameter as first segment, fig. 168.... **moestus,** p. 47
   Maxillary palpi with second segment swollen on the mesal side, so that at this point it is considerably wider than the first segment, fig. 169.... .... **shawnee,** p. 46

Dolophilus shawnee Ross

Dolophilus shawnee Ross (1938*a*, p. 133); ♂, ♀.

Larva.—Length 11–12 mm. Body slender. Head, pronotum, legs and anal hooks golden yellow. Head with a few long, scattered setae and with a pair of transverse brown bars near the posterior angle of the frons; mandibles relatively small with fine teeth near apex, fig. 173. Pronotum with a row of scattered setae along the anterior margin and another similar row across the segment at the point of the attachment of the legs. Body whitish when preserved, each segment with two pairs of slender setae. Anal hooks without inner teeth. Legs of similar shape and proportions, only the first pair with coxal spur.

Adults.—Fig. 170. Length 7–9 mm. Color of head, body and legs varying shades of brown; antennae annulate with tawny and dark brown; wings uniformly gray. Head and thorax bearing tufts of thick tawny hair, and wings with fine, short, black setae which give them a purplish shade. Male genitalia, fig. 166, with claspers long, the apical segment twice the length of the basal segment.

This species is very abundant locally in clear, rapid, temporary streams in the Ozark Hills of southern Illinois. The adults are secretive and seldom captured even in localities where the larvae and pupae are abundant beneath almost every stone. The species is single brooded, the adults appearing in early spring.

In addition to Illinois, known only from Hopkinsville, Kentucky.

Illinois Records.—Alto Pass, Union Spring: May 26, 1940, Mohr & Burks, 3 larvae, 5 pupae. Eddyville, Lusk Creek: May 24, 1940, Mohr & Burks, 5 larvae, 6 pupae; June 1, 1940, B. D. Burks, 1

Fig. 170.—*Dolophilus shawnee.*

larva, 1 pupa. Eichorn: May 11, 1935, C. O. Mohr, 1 larva. Elizabethtown, Hog Thief Creek: May 10, 1935, C. O. Mohr, many larvae. Golconda: May 11, 1935, C. O. Mohr, many larvae; April 30, 1940, Burks & Mohr, many larvae. Herod, Gibbons Creek: March 10, 1935, C. O. Mohr, 1 pupa; May 10, 1935, C. O. Mohr, many larvae, 1 pupa; May 29, 1935, Ross & Mohr, 6 pupae; May 26, 1936, Mohr & Burks, 1 ♂ (reared); May 29, 1936, Ross & Mohr, 5 ♂, 8 ♀; May 15, 1941, Mohr & Burks, 1 larva. Karbers Ridge: May 11, 1935, C. O. Mohr, 1 pupa. Waltersburg: April 30, 1940, Mohr & Burks, 1 larva.

Dolophilus moestus (Banks)

Paragapetus moestus Banks (1914, p. 202); ♂.
Dolophilus breviatus Banks (1914, p. 254); ♂, ♀.

Larva.—Length 10–11 mm. Similar in size and general structure to *shawnee*, differing in lacking the stout coxal spine on the front legs and in having the transverse bars of the frons only faintly indicated.

Adults.—Size 6–8 mm. Similar in general appearance and structure to those of *shawnee*. Male abdomen with long apical processes on seventh and eighth sternites; genitalia, fig. 167, with short, stocky claspers.

Our only Illinois records are from a group of small, spring-fed brooks in the Elgin Botanical Gardens, where we have taken larvae, mature pupae and adults. This species shares with *Chimarra feria* the distinction of being one of the earliest Illinois caddis flies to appear on the wing, adults having been taken as early as March 7.

The species is widespread throughout the eastern portion of the continent. In addition to Illinois, it is known from Georgia, Indiana, New York, North Carolina, Ohio, Ontario, Tennessee, Virginia, West Virginia and Wisconsin.

Illinois Records.—Elgin: May 9, 1939, Ross & Burks, 2 ♂; May 23, 1939, Burks & Riegel, 1 ♂; June 13, 1939, Frison & Ross, 3 ♀; Sept. 19, 1939, Ross & Mohr, 1 larva, 1 pupa, 2 ♂, 1 ♀; preceding Elgin records from Botanical Gardens; Trout Spring, March 7, 1940, Burks & Mohr, 3 ♀.

Trentonius Betten & Mosely

Trentonius Betten & Mosely (1940, p. 11). Genotype, by original designation: *Philopotamus distinctus* Walker.

Apparently only the genotype occurs in the northeastern states. For many years this genus has been identified in North American literature as *Philopotamus*.

Trentonius distinctus (Walker)

Philopotamus distinctus Walker (1852, p. 104); ♂, ♀.
Philopotamus americanus Banks (1895, p. 316); ♂.

This species has not yet been captured in Illinois, but is known from Turkey Run State Park, Indiana, which is only 17 miles from the Illinois state line. It is distributed throughout the northeastern states, with records available for Indiana, Maine, Maryland, Michigan, Minnesota, New Brunswick, North Carolina, Nova Scotia, Ontario, Pennsylvania, Tennessee and Virginia.

This species is remarkable because of the production of adults during the entire year, including the winter months, and the wingless condition of most of the females, fig. 171. Extensive records in the Illinois Natural History Survey files indicate that fe-

Fig. 171.—*Trentonius distinctus.*

males produced during the colder months are all wingless. Examination of pupae shows that in these brachypterous females the wings are abortive even in the pupal stage. Winged females have been taken only during the warmer months of the year. No

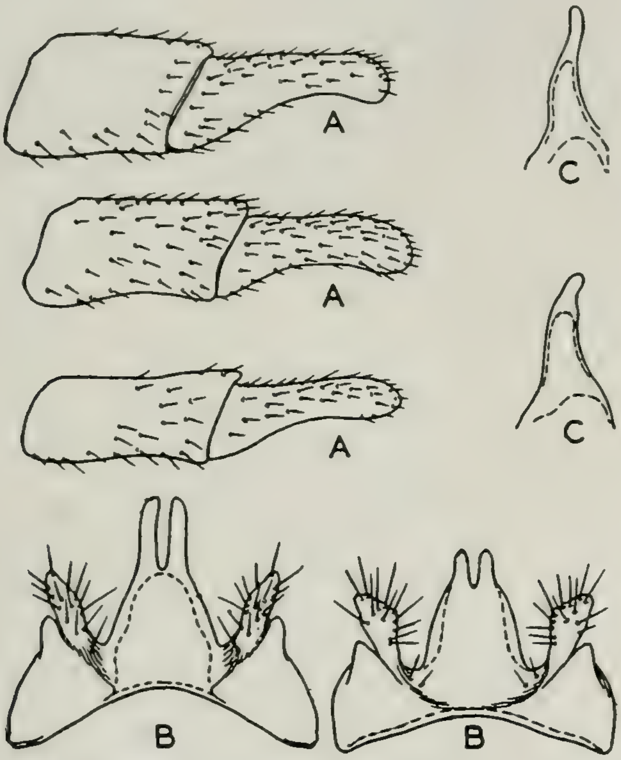


Fig. 172.—*Trentonius distinctus*, male genitalic parts, showing variation. *A*, claspers; *B*, tenth tergite, dorsal aspect; *C*, tenth tergite, lateral aspect.

intergradations between the normally winged specimens and practically wingless specimens have been observed. It would seem from this that these two conditions of the wings are probably caused by a temperature reaction influencing the late larvae, similar in behavior to certain characters observed in genetic studies of *Drosophila*. There is considerable variation in the relative proportions of the claspers in this species, apparently correlated to a large degree with size of individual: large individuals have the claspers very wide; smaller specimens have them much narrowed, fig. 172. As a general rule, the larger specimens of the males occur during the colder months of the year, so there is also an apparent correlation between width of clasper and seasonal appearance.

Chimarra Stephens

Chimarra Stephens (1829, p. 318). Genotype, monobasic: *Phryganea marginata* Linnaeus.

Chimarrha Burmeister (1839) and many other authors, an emendation.

Four species of this genus occur in Illinois and a fifth may be taken in future collecting. The larvae and adults of all our species are identical in external appearance, differing in the characters mentioned in the key.

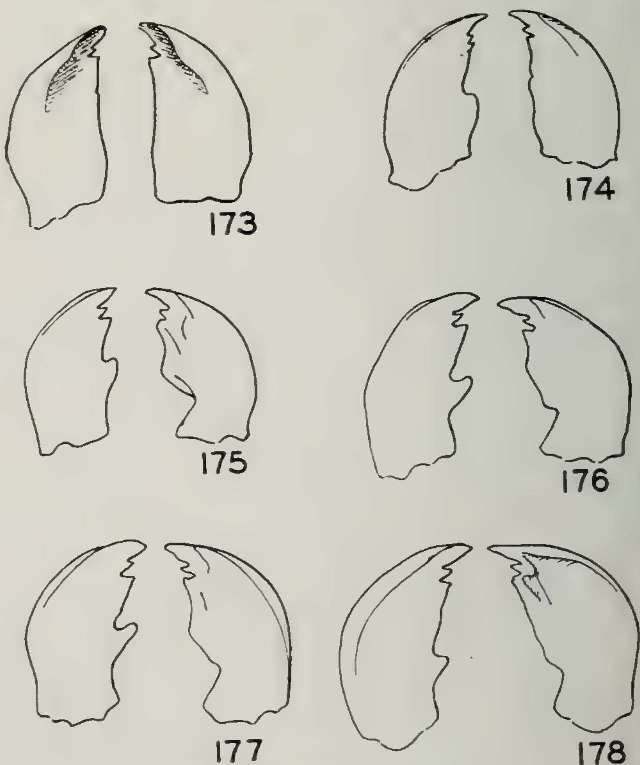
LARVAE.—Length 11–12 mm. Head and pronotum golden brown, legs and anal hooks straw colored. Body whitish with two or three pairs of fine setae on each segment. Legs having short claws with a short tooth at base; anal hooks small and without inner teeth.

ADULTS.—Length 6–8 mm. Color dark brown, almost black, the sides of the abdomen and sometimes portions of the femora creamy white.

KEY TO SPECIES

Larvae

1. Apex of frons bearing a pair of large, rounded lobes, fig. 179 .... **obscura,** p. 51
   Apex of frons bearing smaller, pointed lobes, figs. 180–182 2



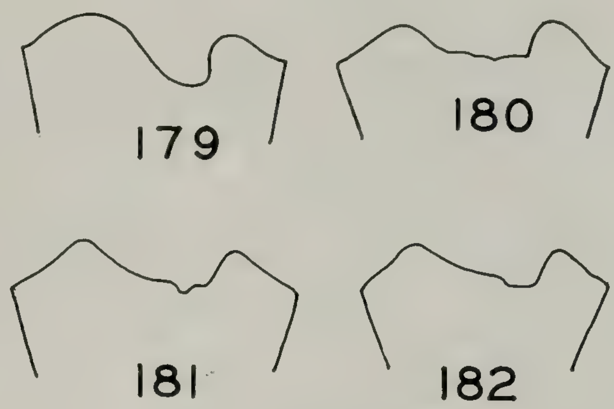
Larval Mandibles

Fig. 173.—*Dolophilus shawnee.*
Fig. 174.—*Trentonius distinctus.*
Fig. 175.—*Chimarra socia.*
Fig. 176.—*Chimarra feria.*
Fig. 177.—*Chimarra aterrima.*
Fig. 178.—*Chimarra obscura.*

2. Basal incision of right mandible very deep, fig. 175............. **socia,** p. 51
   Basal incision of right mandible shallow, fig. 177..................... 3
3. Marginal lobes of frons slightly farther apart, fig. 181; basal incision of right mandible more conspicuous, fig. 176.................. **feria,** p. 50
   Marginal lobes of frons slightly closer together, fig. 182; basal incision of right mandible less conspicuous, fig. 177.................. **aterrima,** p. 50

Adults

1. Apex of abdomen with a pair of well differentiated claspers (males); all characters for couplets 2–5 are illustrated in fig. 183.................. 2
   Apex of abdomen without claspers (females)......................... 6
2. Clasper with upper portion elongated into a narrow, rounded, finger-like lobe; ventro-mesal process of ninth sternite long and projecting, e.g., *obscura*......................... 3
   Clasper with upper portion short, either pointed or rounded and blunt; ventro-mesal process of ninth sternite short and triangular, e.g., *angustipennis, feria*............... 4
3. Aedeagus ending in a heavy, sclerotized hook; ventro-mesal process of ninth sternite long and narrow............................ **obscura,** p. 51
   Aedeagus ending in a pair of semimembranous lobes sclerotized at the



Apex of Larval Frons

Fig. 179.—*Chimarra obscura.*
Fig. 180.—*Chimarra socia.*
Fig. 181.—*Chimarra feria.*
Fig. 182.—*Chimarra aterrima.*

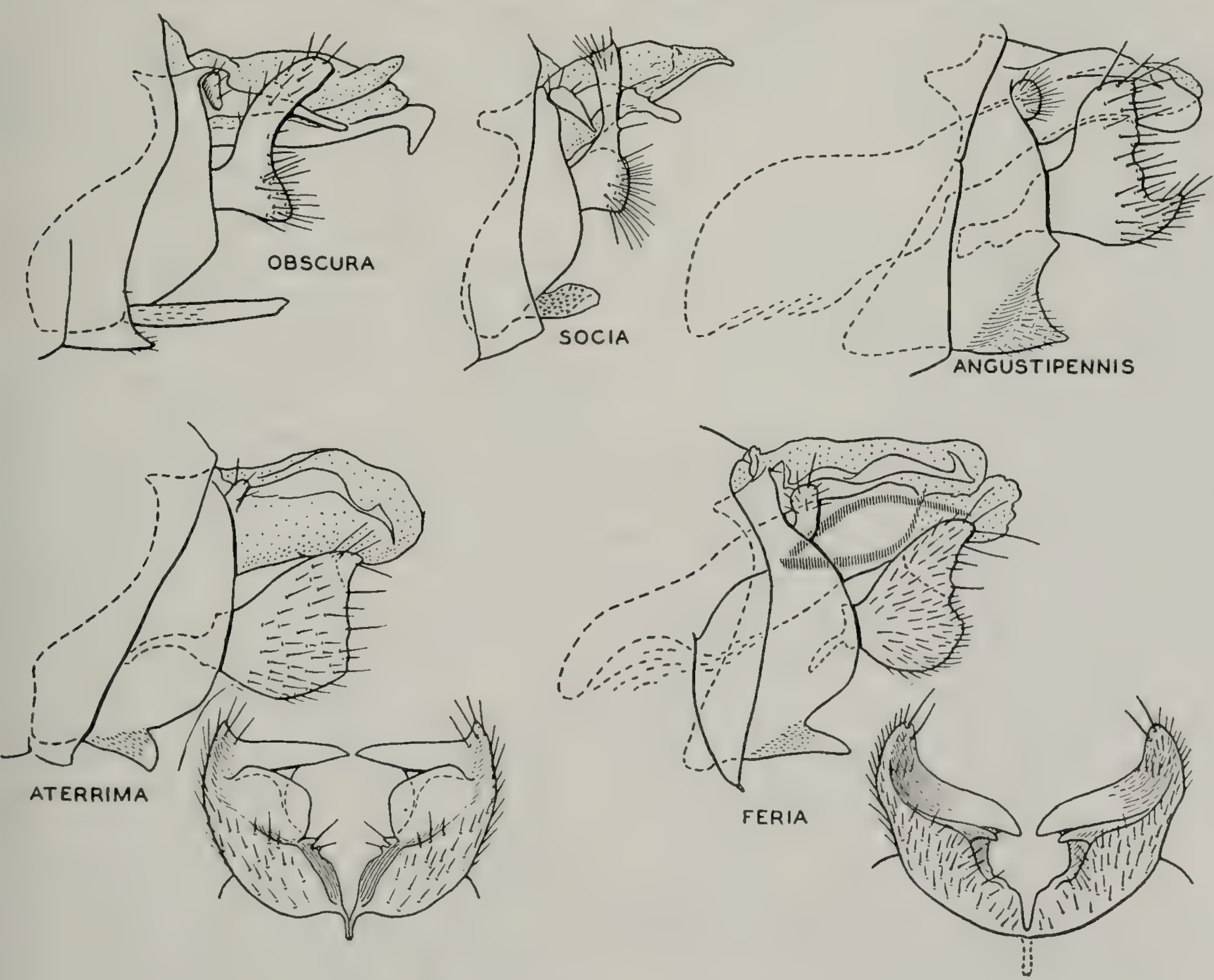
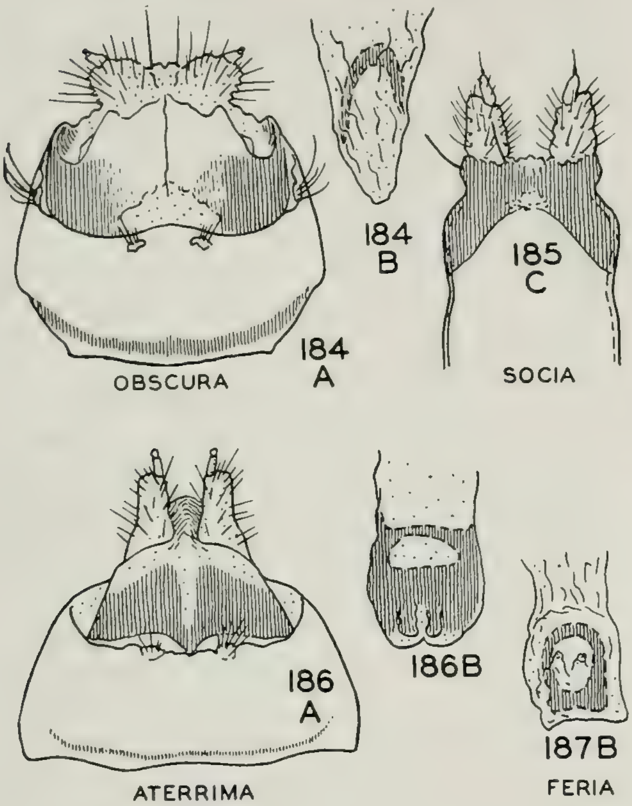


Fig. 183.—*Chimarra,* male genitalia.

sides; ventro-mesal process of ninth tergite shorter and spatulate.. **socia,** p. 51

4. Ventral margin of claspers produced into a slightly upturned lobe......................... **angustipennis,** p. 51

Ventral margin of claspers not produced, forming a rounded lobe e.g., *feria*........................ 5



Figs. 184–187.—*Chimarra*, female genitalia. *A*, ventral aspect; *B*, bursa copulatrix; *C*, dorsal aspect.

5. Claspers with caudal face flat, transverse dorsal spur straight and dorsal shoulder projection small or lacking .... **aterrima,** p. 50

Claspers with caudal face excavated, transverse dorsal spur curved basad and dorsal shoulder projection high and triangular............ **feria,** p. 50

6. Ninth tergite constricted sharply near apex, fig. 185............. **socia,** p. 51

Ninth tergite with lateral margins straight to apex................. 7

7. Ninth sternite produced into well-defined, lateral, sclerotized "ears"; bursa copulatrix with only a single, delicate, U-shaped sclerite, fig. 184 .... **obscura,** p. 51

Lateral margin of ninth sternite without lateral extensions; bursa copulatrix with at least a complete sclerotized ring, figs. 186, 187.......... 8

8. Sclerite of bursa copulatrix ringlike, with a circular central clear area, fig. 187................... **feria,** p. 50

Sclerite of bursa copulatrix purselike, with a semicircular central clear area, fig. 186.......... **aterrima,** p. 50

Chimarra aterrima Hagen

Chimarrha aterrima Hagen (1861, p. 297); ♂, ♀.

Our only Illinois records for this species are from small, spring-fed brooks in the northern fourth of the state. Our records are from April and May, indicating a single generation per year in Illinois. In northern states the species has been collected throughout the summer months.

This species is very abundant throughout the eastern states, fig. 17, with records from Florida, Illinois, Indiana, Kentucky, Maine, Michigan, Minnesota, New Brunswick, New York, North Carolina, Nova Scotia, Ontario, Pennsylvania, Tennesse, Virginia, West Virginia and Wisconsin. Illinois appears, therefore, to be on the western limit of its main range. It has been collected farther west only once, at Malvern, Arkansas.

Illinois Records.—COUNCIL HILL, tributary of Galena River: April 9, 1941, Ross & Mohr, many larvae. DUNDEE: May 23, 1939, Burks & Riegel, ♂♂, ♀♀, many larvae. UTICA, Split Rock Brook: May 24, 1941, 1♂.

Chimarra feria Ross

Chimarrha feria Ross (1941*b*, p. 51); ♂, ♀.

This species is very common in many of the rapid clear streams in the Ozark region of southern Illinois. Most of these streams are dry during the summer and autumn period. In these dry situations we have collected larvae of this species in a normal, active, healthy condition under stones in portions of the river bed which were damp beneath the surface. The adults are among the earliest caddis flies to appear on the wing in this state, having been found at Herod as early as March 28.

The range of the species embraces roughly the western edge of the oak-hickory forest region, fig. 17. Records are available from Arkansas, Illinois, Kansas, Minnesota, Missouri, Oklahoma, Texas and Wisconsin. Illinois is on the extreme eastern edge of its range.

Illinois Records.—DIXON SPRINGS: July 9, 1935, DeLong & Ross, 1♂. GOLCONDA:

May 11, 1935, C. O. Mohr, 1 larva. HEROD: Grand Pierre Creek, July 29, 1898, Hart, many larvae; Gibbons Creek, March 28, 1935, Ross & Mohr, ♂♂, ♀♀, many pupae, pupal skins and larval parts; June 21, 1935, DeLong & Ross, ♂♂; July 11, 1935, DeLong & Ross, ♂♂, 2♀; May 1, 1936, Ross & Mohr, ♂♂; May 12, 1936, Mohr & Burks, 2♂; June 24, 1936, DeLong & Ross, 5♂; Gibbons Creek, Sept. 11, 1937, H. H. Ross, 3 larvae; Oct. 7, 1937, Ross & Burks, 1♂; July 27, 1938, Burks & Boesel, 3♂, 1 mating pair; Oct. 1, 1941, B. D. Burks, many larvae. VIENNA: May 29, 1939, Burks & Riegel, ♂♂, ♀♀, 1 mating pair; May 1, 1940, Mohr & Burks, 2♂, 1♀. WALTERSBURG: March 24, 1939, Ross & Burks, 8 larvae. WEST VIENNA, Branch Cache River: May 13, 1939, Burks & Riegel, ♂♂, 6 larvae.

Chimarra angustipennis Banks

Chimarrha angustipennis Banks (1903*a*, p. 242); ♂.

This species, not yet taken in Illinois, occurs in Oklahoma and Arkansas. It is a close relative of the two preceding species. The larva is unknown.

Chimarra obscura (Walker)

Beraea? obscura Walker (1852, p. 121); ♂.
Wormaldia plutonis Banks (1911, p. 358); ♂.
Chimarrha lucia Betten (1934, p. 175); ♂, ♀.

Frequenting rapid and clear streams, this species has been taken at many points in northern, eastern and extreme southern Illinois. In each case our catches have been small, except in a few localities in the Ozark Hills of southern Illinois. Mature male pupae have been collected from many localities.

This species is the most widely distributed in the genus, fig. 18, being known from Arkansas, Illinois, Indiana, Kentucky, Maine, Maryland, Michigan, Minnesota, Missouri, New York, Ohio, Oklahoma, Ontario, Pennsylvania, Texas, Virginia and Wisconsin.

Illinois Records.—Many males and females and three pupae, taken May 11 to October 5, and many larvae, taken April 10 to August 27, are from Aurora, Danville (Middle Fork River), Golcondo, Herod (Grand Pierre Creek), Jonesboro (Clear Creek), Kankakee (Kankakee River, Rock Creek), Momence, Oakwood (Salt Fork River), Oregon, Spring Grove, West Havana, West Vienna, Wilmington (Kankakee River), Wolf Lake (Hutchins Creek).

Chimarra socia Hagen

Chimarrha socia Hagen (1861, p. 297).
Wormaldia femoralis Banks (1911, p. 358).

Our only records for Illinois are along the Kankakee River. The species is apparently restricted to the northern and eastern states, and these collections for Illinois represent a local occurrence at the extreme western edge of its range. Association of larvae and adults is on the basis of a mature male pupa collected at Spooner, Wisconsin.

Known from Florida, Georgia, Indiana, Kentucky, Maine, Maryland, Michigan, New Brunswick, New York, Ohio, Ontario, Pennsylvania, Quebec, South Carolina and West Virginia in addition to Wisconsin.

Illinois Records.—KANKAKEE, Kankakee River: Aug. 1, 1933, Ross & Mohr, 6 larvae. MOMENCE, Kankakee River: May 26, 1936, H. H. Ross, 2♂.

PSYCHOMYIIDAE

The adults of this family range in size from fairly large species which might readily be confused with the Hydropsychidae to very small ones which, in general sorting, are frequently confused with Hydroptilidae. The larva, fig. 188, is active and spins a long silken net; when taken out of the water the net collapses and appears only as an irregular mass from which the larva wriggles free. Certain species are restricted to rapid streams, whereas others have an extremely wide ecological tolerance and are found in situations varying from lakes to rapid rivers.

The group formerly was divided into two families, the Psychomyiidae, containing *Psychomyia*, *Lype* and *Tinodes*, and the Polycentropidae, containing *Phylocentropus*,

Fig. 188.—*Polycentropus interruptus* larva.

Neureclipsis, Plectrocnemia, Polycentropus, Holocentropus, Nyctiophylax and *Cyrnellus.* An interesting link between the two groups, *Cernotina,* was recently described.

KEY TO GENERA

Larvae

1. Anal hooks with a row of 4 or 5 long teeth along inner ventral margin, fig. 189; tenth segment short, with scarcely any ventral margin, fig. 191; mentum forming a pair of distinct, sclerotized plates, fig. 194. . . . . **Psychomyia,** p. 75

   Anal hooks with at most very short, inner teeth, fig. 190; tenth segment longer and tubular, figs. 192, 193; mentum not divided into two sclerotized plates, fig. 195. 2

2. Mandibles short and triangular, each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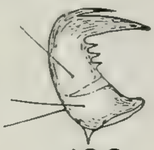
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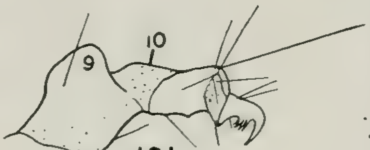

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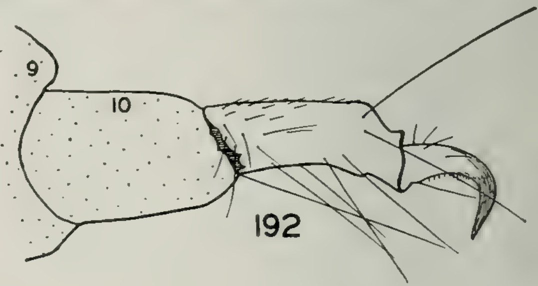

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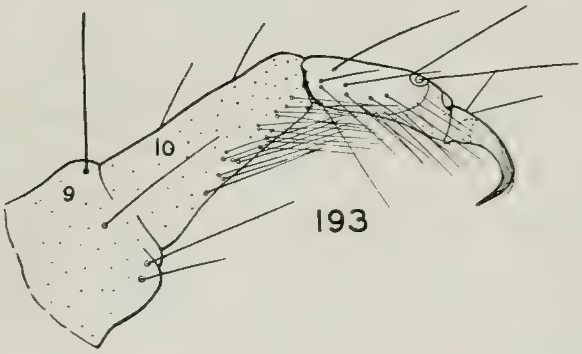

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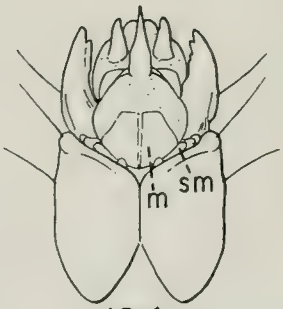

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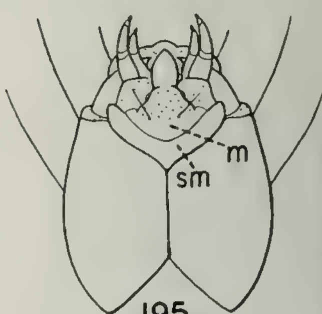

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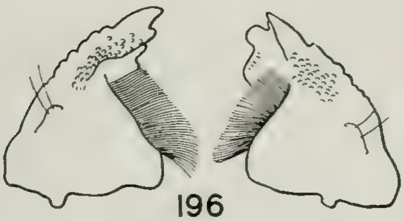
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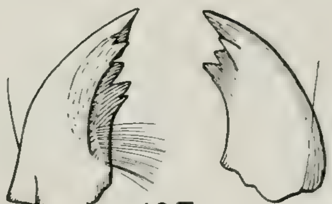
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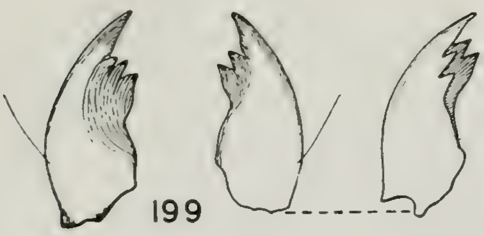
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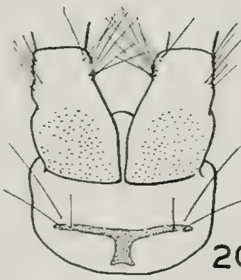
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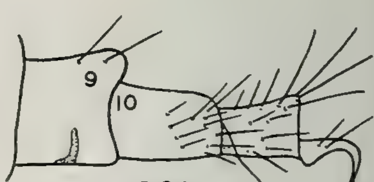

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Fig. 189.—*Psychomyia flavida* larva, anal hook.

Fig. 190.—*Psychomyiid Genus A* larva, anal hook.

Fig. 191.—*Psychomyia flavida* larva, apex of abdomen.

Fig. 192.—*Neureclipsis crepuscularis* larva, apex of abdomen.

Fig. 193.—*Polycentropus interruptus* larva, apex of abdomen.

Fig. 194.—*Psychomyia flavida* larva, head, ventral aspect; *m,* mentum; *sm,* submentum.

Fig. 195.—*Polycentropus interruptus* larva, head, ventral aspect; *m,* mentum; *sm,* submentum.

Fig. 196.—*Phylocentropus placidus* larva, mandibles. (After Vorhies.)

Fig. 197.—*Neureclipsis crepuscularis* larva, mandibles.

Fig. 198.—*Polycentropus interruptus* larva, mandibles.

Fig. 199.—*Psychomyiid Genus A,* mandibles.

Fig. 200.—*Psychomyiid Genus B,* venter of ninth and tenth segments.

Fig. 201.—*Psychomyiid Genus B,* apex of abdomen.

with a large, thick brush on the mesal side, fig. 196. . . . . **Phylocentropus,** p. 54

Mandibles longer, fig. 197, with only a thin brush on left mandible, none on right. 3

3. Right mandible with a single dorsal tooth which only partially hides the ventral row of teeth; on the left mandible the dorsal row of teeth does not hide the ventral row, figs. 197, 198. 4

Right mandible with two large dorsal teeth which completely overhang and hide the ventral row; on the left mandible the dorsal row of teeth overhangs and hides the ventral row, fig. 199. 5

4. Basal segment of anal appendages (tenth segment) without hair, fig. 192; left mandible with basal tooth small and with a linear brush on mesal face near base, fig. 197. . . . .**Neureclipsis,** p. 56

Basal segment of anal appendages (tenth segment) with long hair, fig. 193; left mandible with basal tooth large, subequal to one above and with brush small, fig. 198. . . . .**Polycentropus,** p. 58

5. Ninth sternite with a wide, T-shaped, reticulate area; tenth segment short, with an extensive patch of minute spinules on venter, figs. 200, 201. . . . .**Psychomyiid Genus B,** p. 74

Ninth sternite without a reticulate area; tenth segment long, without spinules but with an extensive patch of long hair on venter, similar to fig. 193. . . . .**Psychomyiid Genus A,** p. 73

Pupae

1. Apex of mandibles with a long, terminal "whip," fig. 202. . . . . **Psychomyia,** p. 75

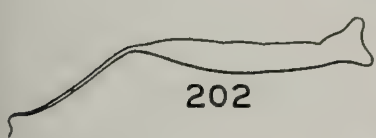

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Fig. 202.—*Psychomyia flavida* pupa, mandible.

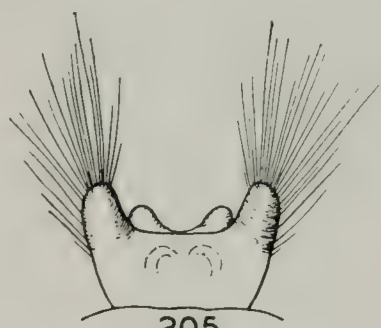
Fig. 203.—*Polycentropus cinereus* pupa, mandible.

Fig. 204.—*Phylocentropus placidus* pupa, mandible. (After Vorhies.)

Apex of mandibles without a terminal "whip," fig. 203. 2

2. Terminal segment of abdomen with 4 bushy processes, 2 apical and 2 basolateral. . . . .**Phylocentropus,** p. 54

Terminal segment with only 2 apical bushy processes, fig. 205. 3



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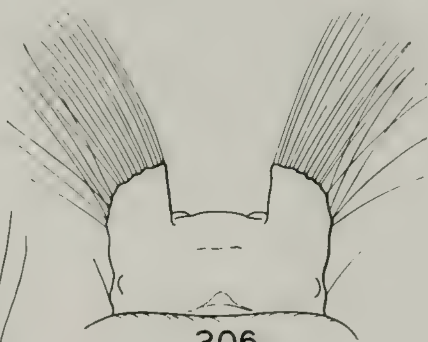

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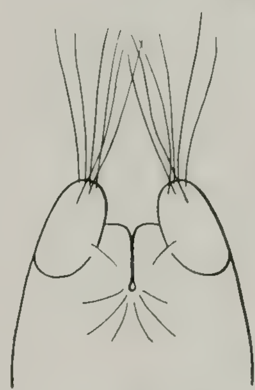

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Fig. 205.—*Polycentropus cinereus* pupa, apical processes.

Fig. 206.—*Neureclipsis crepuscularis* pupa, apical processes.

Fig. 207.—*Psychomyia flavida* pupa, apical processes.

3. Apical lobes of abdomen evenly rounded at apex, fig. 205. . . . .**Polycentropus,** p. 58

Apical lobes of abdomen with mesal margin straight, mesal angle sharp and outer margin curved, fig. 206. . . . .**Neureclipsis,** p. 56

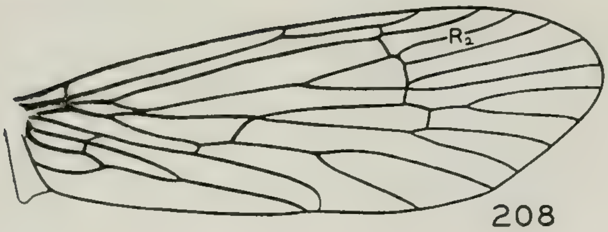
Adults

1. Front tibiae with a preapical spur. . . . 2

Front tibiae without a preapical spur 6

2. Both pairs of wings with R_2 present and branching from R_3 at radial crossvein, fig. 208. . . . .**Phylocentropus,** p. 54

Both pairs of wings with R_2 either



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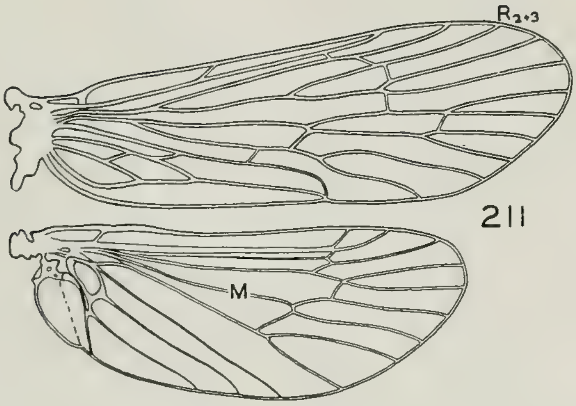

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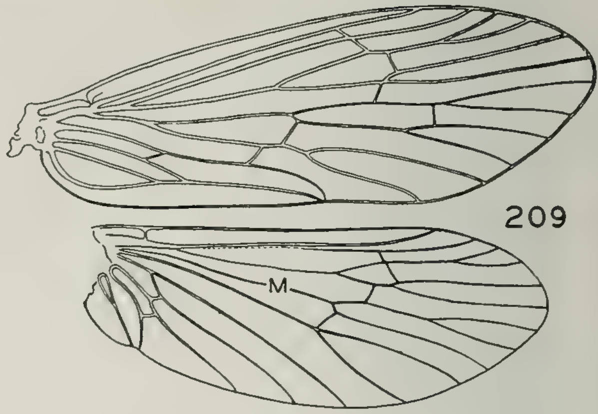

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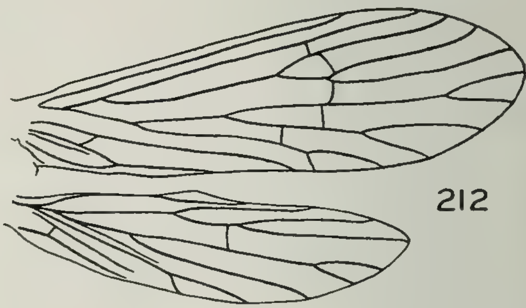

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Fig. 208.—*Phylocentropus placidus*, front wing.

Fig. 209.—*Neureclipsis crepuscularis*, front and hind wings.

Fig. 210.—*Polycentropus cinereus*, wings.

Fig. 211.—*Nyctiophylax vestitus*, wings.

Fig. 212.—*Psychomyia nomada*, wings.

Fig. 213.—*Lype diversa*, hind wing.

absent or branching from R_3 near margin of wing, fig. 210 3

3. Hind wings with M 3-branched, fig. 209 . . . . **Neureclipsis**, p. 56
   Hind wings with M 2-branched, fig. 211 4
4. Front or hind wings, or both, with R_2 present, fig. 210 . . . **Polycentropus**, p. 58
   Both wings with R_2 absent, fig. 211 . . . 5

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Fig. 214.—*Cyrnellus marginalis*, maxillary palpus.

Fig. 215.—*Nyctiophylax vestitus*, maxillary palpus.

Fig. 216.—*Cernotina oklahoma*, maxillary palpus.

Fig. 217.—*Lype diversa*, maxillary palpus.

5. Maxillary palpi with second segment long, third only slightly longer than second, fifth short, fig. 214 . . . . **Cyrnellus**, p. 71
   Maxillary palpi with second segment short, third three times as long as second, fifth long, fig. 215 . . . . **Nyctiophylax**, p. 69
6. Maxillary palpi with second segment only one-half to one-third as long as third segment and with the apex enlarged into a small cushion, fig. 216 . . . . **Cernotina**, p. 72
   Maxillary palpi with second segment as long as third and uniformly cylindrical, fig. 217 7
7. Hind wings with apex evenly rounded, fig. 213 . . . . **Lype**, p. 74
   Hind wings with apex tapering and somewhat pointed, fig. 212 . . . . **Psychomyia**, p. 75

Phylocentropus Banks

Phylocentropus Banks (1907*a*, p. 130). Genotype, by original designation: *Holocentropus placidus* Banks.

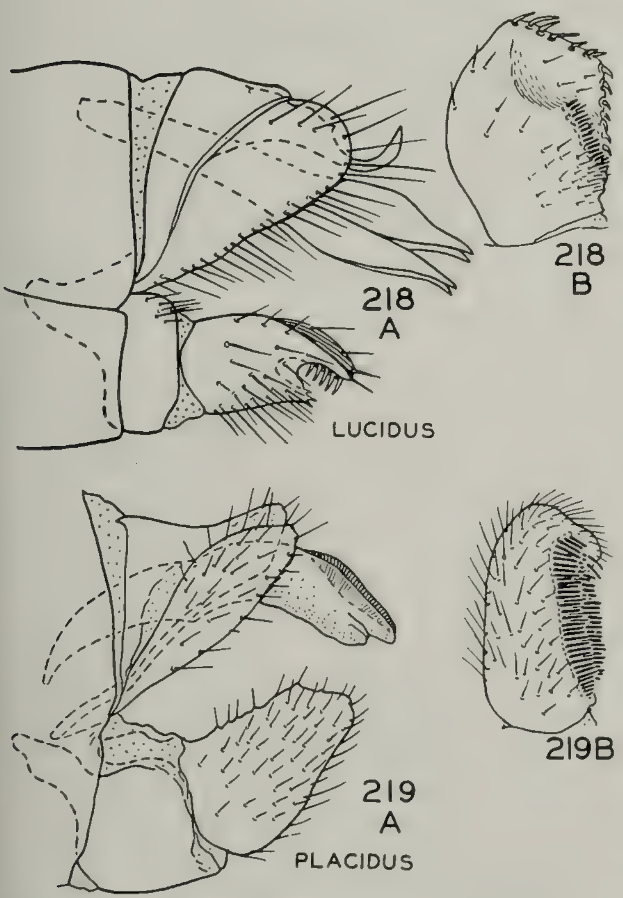
Acrocentropus Betten (1934, p. 213). Genotype, monobasic: *Polycentropus lucidus* Hagen.

Only one species of this genus has been taken in the state. A second species, *lucidus*, occurs in the northeastern states and may eventually be found in Illinois. We have not reared this genus in Illinois, but descriptions of the larvae by Vorhies (1909) and others indicate characters for a clear-cut generic diagnosis.

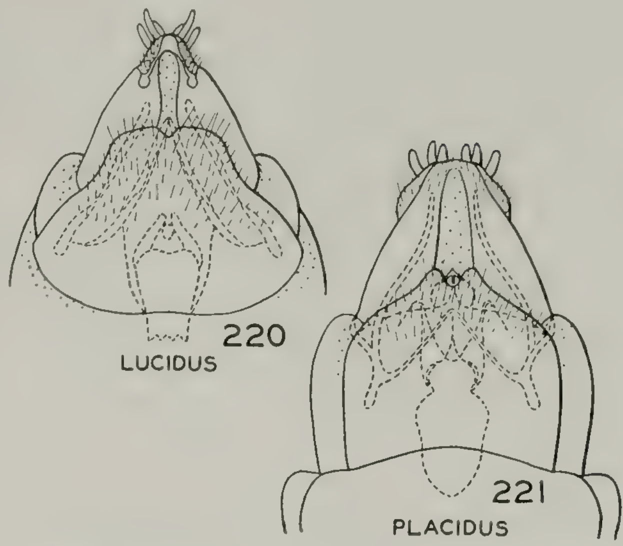
KEY TO SPECIES

Adults

1. Apex of abdomen with dorsal and ventral appendages, figs. 218, 219 (males) 2
   Apex of abdomen conical with a pair of flaplike ventral appendages, figs. 220, 221 (females) 3
2. Tenth tergite sclerotized and produced into a heavy, upturned hook; apex of aedeagus sharp, fig. 218 .... **lucidus**, p. 56
   Tenth tergite broad and truncate, not sclerotized; aedeagus tubular with the apex obliquely truncate, fig. 219 .... **placidus**, p. 55



Figs. 218–219.—*Phylocentropus*, male genitalia. *A*, lateral aspect; *B*, claspers, caudoventral aspect.



Figs. 220–221.—*Phylocentropus*, female genitalia.

3. Apex of eighth sternite broad, the mesal incision forming 2 wide lobes, fig. 220 .... **lucidus**, p. 56
   Apex of eighth sternite narrowed and divided into 2 small lobes, fig. 221 .... **placidus**, p. 55

Phylocentropus placidus (Banks)

Holocentropus placidus Banks (1905*b*, p. 15); ♂.

Phylocentropus maximus Vorhies (1909, p. 711); ♂, larva and pupa.

Larva (after Vorhies).—Length 15–16 mm. Head, pronotum and legs straw yellow, pronotum with posterior half of lateral border and all posterior border black; body colorless. Labium elongate and styliform. Mandibles short and stocky, dorsal surface with more or less granular teeth and mesal portion provided with a dense large brush.

Adults.—Length 9–11 mm. Color various shades of brown; wings finely and almost evenly speckled with light brown. Front wings with R_s angled near base and touching stem of M. Male genitalia, fig. 219: cerci ovate, tenth tergite wide, unsclerotized and almost truncate at apex; claspers appearing ovate from side view, ventral aspect more or less quadrate with a dense brush of black setae along mesal margin; aedeagus tubular, the apex obliquely truncate. Female genitalia, fig. 221: eighth sternite tapered at apex and incised to form a pair of small lobes.

Our Illinois records of this species are from two southern localities in the Ozark Hills. The account of its biology is given by Vorhies, who found it making tubular cases embedded in the sand bottoms of southern Wisconsin streams. These cases he records as sometimes 65 mm. long, the greater portion buried, only 10–20 mm. of the case projecting from the stream bed. Within this case the pupa spins its cocoon.

This species is fairly widely distributed throughout the Northeast. Our records from Indiana and Illinois appear to be on the southern limit of the western portion of the range. It is known from Georgia, Illinois, Indiana, Maine, Michigan, Minnesota, New Brunswick, New York, Nova Scotia, Ohio, Ontario, Quebec and Wisconsin.

Illinois Records.—GOLCONDA: April 17, 1930, Frison & Ross, 2♂, 1♀. HEROD: May 10, 1935, C. O. Mohr, 1♀.

Phylocentropus lucidus (Hagen)

Polycentropus lucidus Hagen (1861, p. 294); ♂.

This species has not yet been taken in Illinois. It is known from New York, Nova Scotia, Pennsylvania and Tennessee. In the front wing R_s does not join M, and on this basis the species was referred to a new genus, *Acrocentropus*, by Betten. The structures of the male and female genitalia, however, indicate clearly that it belongs with *placidus*. The female is similar to the male in color and in general structure; the genitalia, fig. 220, have the eighth sternite heavily sclerotized, the apex broad, slightly indented on the meson, resulting in very wide lobes; bursa copulatrix long, semimembranous, and attached to sclerotized rods of the ninth segment.

Allotype, female.—Bear Brook near Blue Mountain Lake, New York: June 19, 1941, Frison & Ross.

Neureclipsis McLachlan

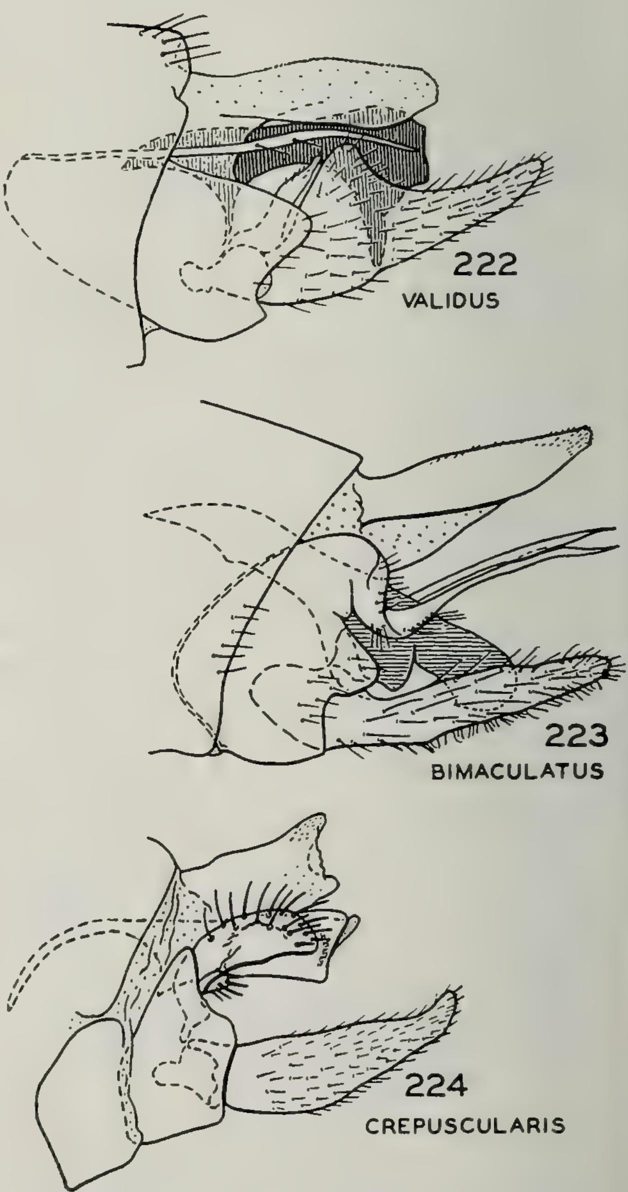
Neureclipsis McLachlan (1864, p. 30). Genotype, monobasic: *Phryganea bimaculata* Linnaeus.

Of the three species known from North America, two have been taken from Illinois, and the third occurs to the northeast. We have reared only *crepuscularis*; this larva agrees very well with Ulmer's description of *bimaculatus*, and it is possible that all three species have larvae similar in color and general structure.

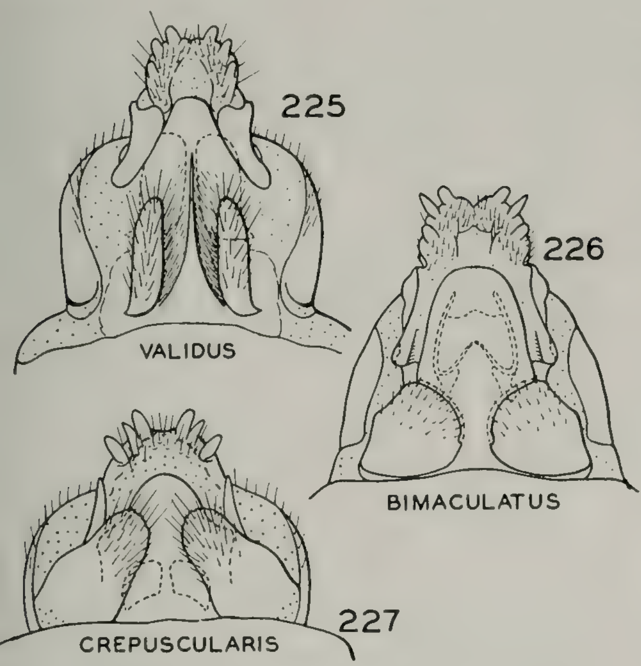
KEY TO SPECIES

Adults

1. Genitalia with a distinct aedeagus, figs. 222–224 (males) 2
   Genitalia without an aedeagus, figs. 225–227 (females) 4
2. Base of left clasper with a large dorsal projection near base, fig. 222 . . . . **validus**, p. 58
   Base of left clasper without a dorsal projection, dorsal margin almost uniformly straight from base to apex, fig. 223 3
3. Cerci represented by long, heavily sclerotized filaments, fig. 223; tenth tergite very long . . . . **bimaculatus,** p. 57
   Cerci lobelike and not heavily sclerotized, fig. 224; tenth tergite short . . . . **crepuscularis,** p. 57
4. Eighth sternite with a long, high mesal ridge, the lateral lobes long and nar-



Figs. 222–224.—*Neureclipsis*, male genitalia.



Figs. 225–227.—*Neureclipsis,* female genitalia.

row, fig. 225............**validus,** p. 58
Eighth sternite without a long mesal ridge, the lateral lobes short and wide, fig. 226.................... 5

5. Apex of eighth sternite projecting beyond lateral lobes the length of the lobes; ninth sternite with a heavily sclerotized, vasiform structure, fig. 226...............**bimaculatus,** p. 57
Apex of eighth sternite projecting only a short distance beyond lateral lobes; ninth sternite with only indistinct structures, fig. 227.........
..................**crepuscularis,** p. 57

Neureclipsis crepuscularis (Walker)

Brachycentrus crepuscularis Walker (1852, p. 87); ♀.
Neureclipsis parvula Banks (1907*b*, p. 163); ♂.

LARVA.—Length 12 mm. Head, pronotum and legs straw color with black setae, the head and pronotum with dark brown spots; those on the frons arranged as in fig. 233; body pale with irregular purplish areas on the dorsum and lateral portion of each segment.

ADULTS.—Length 7.5 mm. Color reddish brown, the legs and venter straw color. Male genitalia, fig. 224: cerci ovate with a round ventral lobe; claspers long, evenly tapering from base to apex, tip curved mesad; tenth tergite long, tapering and semimembranous. Female genitalia, fig. 227: eighth sternite with distinct corners and a rounded apex projecting a distance beyond lateral lobes; lateral lobes fairly broad, rounded at apex and with abundant setae; internal sclerites of ninth segment semimembranous and irregular.

A study of large series of males and females leaves no doubt regarding the association of the two sexes, thus upholding the synonymy of *parvula* with *crepuscularis,* as proposed by Milne (1936).

In Illinois this species is widely distributed over the entire state. It is most abundant along the larger rivers. It is seldom taken in large numbers, but we have at times captured large series along the Mississippi River. The adults emerge over a wide period; our records extend from May 3 to October 2. The association of larvae and adults is made on the basis of mature pupae collected in Wisconsin and Indiana.

The range of the species includes most of the Northeast, with a southwestward extension through the Ozarks. We have records from Arkansas, Illinois, Indiana, Kentucky, Michigan, Missouri, New Brunswick, New York, North Carolina, Nova Scotia, Ohio, Pennsylvania, Tennessee, Virginia and Wisconsin.

Illinois Records.—Many males and females, taken May 3 to October 2, are from Alton, Champaign, Danville, Deer Grove (Green River), Elizabethtown, Florence, Fort Massac State Park, Grafton (wing dam), Grand Tower, Hardin (Illinois River), Harrisburg, Havana (Spoon River), Homer (Salt Fork River), Kampsville, Kankakee, Keithsburg, La Rue (McCann Spring), Milan (Rock River), Momence (Kankakee River), Monticello, Mount Carmel, Morris, Oakwood, Pontiac, Quincy (Burton Creek), Rock Island, Rosiclare, Savanna, Serena (Indian Creek), Sterling, Venedy Station (Kaskaskia River).

Neureclipsis bimaculatus (Linnaeus)

Phryganea bimaculata Linnaeus (1758, p. 548).

LARVA.—Similar to that of *crepuscularis,* according to Ulmer (1909, p. 229).

ADULTS.—Length 7.5–9.0 mm. Color brown, the venter and legs straw color. Male genitalia, fig. 223: cerci ribbon-like, produced into long, fairly straight ribbons as long as claspers; claspers slender, elongate and straight; tenth tergite semimembranous, long and slightly rounded at apex; aedeagus with a straight base and with the apex divided by a ventral incision into two large lobes. Female genitalia, fig. 226: eighth sternite projecting far beyond lateral lobes, the apex rounded; lateral lobes short and somewhat ovate; ninth segment with a somewhat vasiform, sclerotized, internal structure in addition to other membranous parts.

The few Illinois records for this species are scattered from the extreme northern portion to the southern tip of the state. The species is Holarctic, its distribution on this continent extending southeastward to Quebec, Wisconsin and Illinois. It has been taken in a variety of habitats, and the records indicate an adult emergence which continues through the warmer months of the summer.

Illinois Records.—GOLCONDA: April 17, 1930, Frison & Ross, 1 ♀. HOMER: July 6, 1927, at light, Frison & Glasgow, 1 ♀. SAVANNA: June 2, 1942, at light, H. Hersey, ♂ ♂, 6 ♀. North of WADSWORTH, Des Plaines River: July 7, 1937, Frison & Ross, 1 ♂. WAUKEGAN: July 16, 1938, Ross & DeLong, 1 ♀.

Neureclipsis validus (Walker)

Polycentropus validus Walker (1852, p. 100); ♂.

Hydropsyche dubitans Walker (1852, p. 113); ♀.

Polycentropus signatus Banks (1897, p. 30); ♂.

This species has not yet been taken in Illinois but has been recorded from Ontario and western New York.

Polycentropus Curtis

Polycentropus Curtis (1835*a*, pl. DXLIV). Genotype, by subsequent designation of Westwood (1840, p. 49): *Polycentropus irroratus* Curtis.

Many of the species included under this genus were formerly placed in *Plectrocnemia* and *Holocentropus*. The characters of the larvae and pupae, as well as certain characters of the adults, indicate that these species together form a single unit as contrasted with other generic groups in the family. I am making no attempt at this time to judge the validity of either *Plectrocnemia* or *Holocentropus*; the study of larvae of the species from various continents, as well as a critical study of the genotypes, will be necessary before the names can be applied even to subgeneric categories of North American species.

About 25 species are known in North America, of which 9 have been taken in Illinois. Many of the species are rare but widely distributed, and it is probable that further collecting will yield new state records in this genus.

KEY TO SPECIES

Larvae

The following larval key is based on relative characters and few species. For these reasons it should not be used indiscriminately for specific identifications. It is of considerable use for separating to species larvae in a particular habitat of known taxonomic composition, and it should be used primarily for this purpose.

1. Basal segment of anal appendages with setae fairly short and distributed uniformly over ventral surface, fig. 228 2
   Basal segment of anal appendages with setae longer and grouped in two lateral linear areas, fig. 228 3
2. Spots on upper part of frons definite and forming an angle, fig. 230 .... **cinereus,** p. 67
   Spots on upper frons indefinite and forming a straight line or even arc, fig. 231 .... **centralis,** p. 64
3. Head almost uniformly brown, spots present but of only a slightly differ-

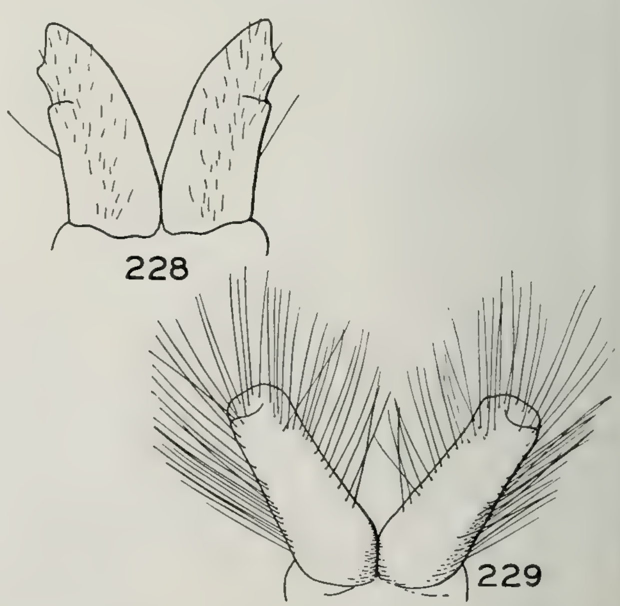
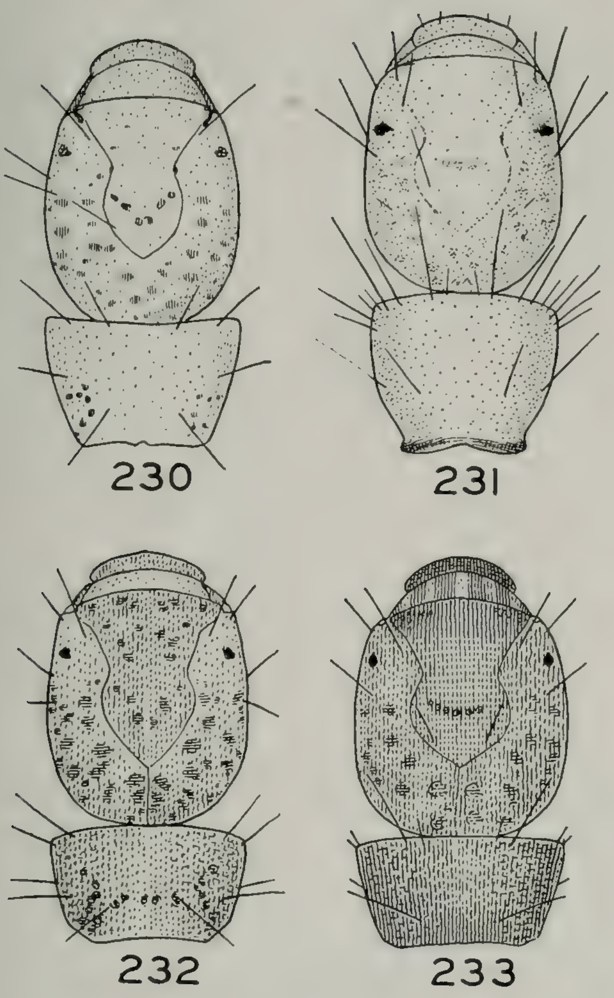


Fig. 228.—*Polycentropus cinereus* larva, lobes of tenth segment, ventral aspect.

Fig. 229.—*Polycentropus interruptus* larva, lobes of tenth segment, ventral aspect.



Polycentropus Larvae, Heads

Fig. 230.—*P. cinereus.*
Fig. 231.—*P. centralis.*
Fig. 232.—*P. remotus.*
Fig. 233.—*P. interruptus.*

ent shade than background. . . . . **flavus**, p. 68
Head with spots conspicuous. 4

4. Upper part of frons long, subequal in length to lower portion, fig. 232; hair on basal segment of anal appendages in irregular lateral areas. . . . . **remotus**, p. 67
Upper part of frons shorter than lower portion, fig. 233; hair on basal segment of anal appendages in regular rows, fig. 229. 5

5. Dorsum of head usually clouded with reddish brown; major pair of setae of upper frons with a small pale area around base. . . . . **interruptus**, p. 69
Dorsum of head usually not clouded with reddish brown; major pair of setae of upper frons with a brown ring around base. . . . . . . **glacialis**, p. 68

Adults

1. Genitalia complex, with an aedeagus, figs. 234–248 (males). 2
Genitalia without an aedeagus, figs. 249, 250 (females). 16

2. Eighth sternite produced into a long, apical projection, figs. 234, 235. . . . 3
Eighth sternite not produced into an apical projection, fig. 236. 4

3. Apical projection of eighth sternite wide and incised on meson, fig. 234 . . . . **aureolus**, p. 64
Apical projection of eighth sternite narrow and pointed, fig. 235. . . . . **crassicornis**, p. 64

4. Cerci with dorsal angle produced into a long, down-curved, sclerotized needle, fig. 242. 5
Cerci without such a sclerotized process, fig. 236. 11

5. Ninth sternite narrow; cerci with a narrow, finger-like projection from latero-caudal margin, fig. 242. . . . . **pentus**, p. 65
Ninth sternite wide; cerci without a finger-like projection from latero-caudal margin, fig. 243. 6

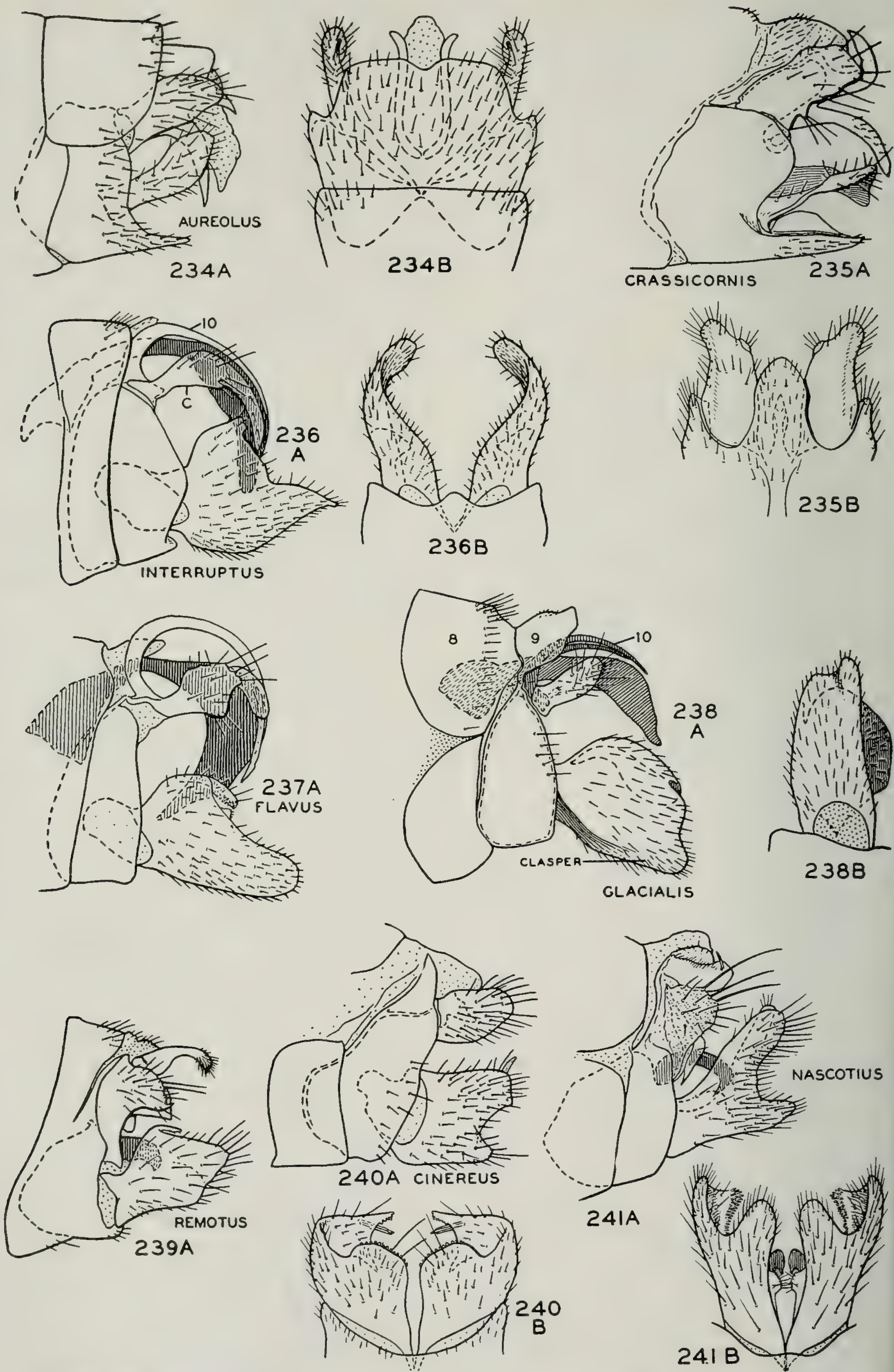
6. Aedeagus long and U-shaped, fig. 243 . . . . **maculatus**, p. 65
Aedeagus straight or only slightly curved, figs. 244, 246. 7

7. Baso-dorsal appendage of clasper almost sessile, without a definite stalk, fig. 244, and projecting laterad of clasper. . . . . **confusus**, p. 65
Baso-dorsal appendage with a definite stalk so that the dark mesal point is some distance from the basal part of the clasper, figs. 246, 247, and not projecting laterad of it. 8

8. Ventral aspect of claspers wide on basal portion, tapering suddenly to a narrow apex, figs. 245, 246. 9
Ventral aspect of claspers tapering gradually or imperceptibly from base to apex, figs. 247, 248. 10

9. Claspers with base wide and subparallel two-thirds of its length, the apex short and digitate; filaments of cerci long and sinuate, their apex curved dorsad; baso-dorsal appendage of clasper with a subtriangular apex well differentiated from stalk, fig. 245. **elarus**, p. 65
Claspers with base wide for only one-third its length, the apex long and curved; filaments of cerci curved ventrad and closer to basal portion; baso-dorsal appendage with apex smaller and merging gradually with stalk, fig. 246. . . . . . . **carolinensis**, p. 66

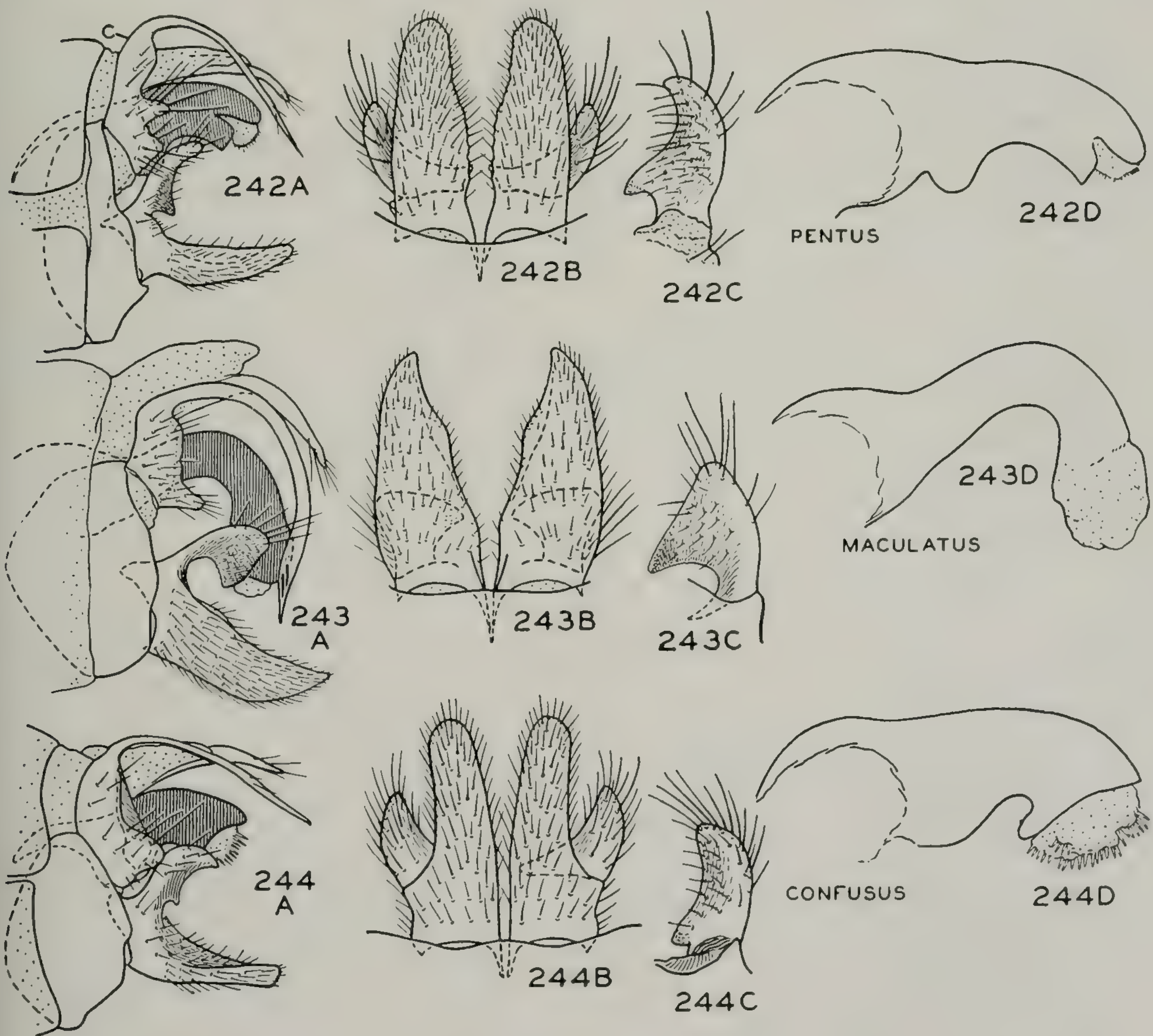
10. Baso-dorsal lobe of claspers long and narrow, the mesal point round, the entire lobe arched; aedeagus widened at tip, fig. 247. . . . . **pixi**, p. 66



Figs. 234–241.—*Polycentropus*, male genitalia. *A*, lateral aspect; *B*, ventral aspect, usually showing only the claspers.

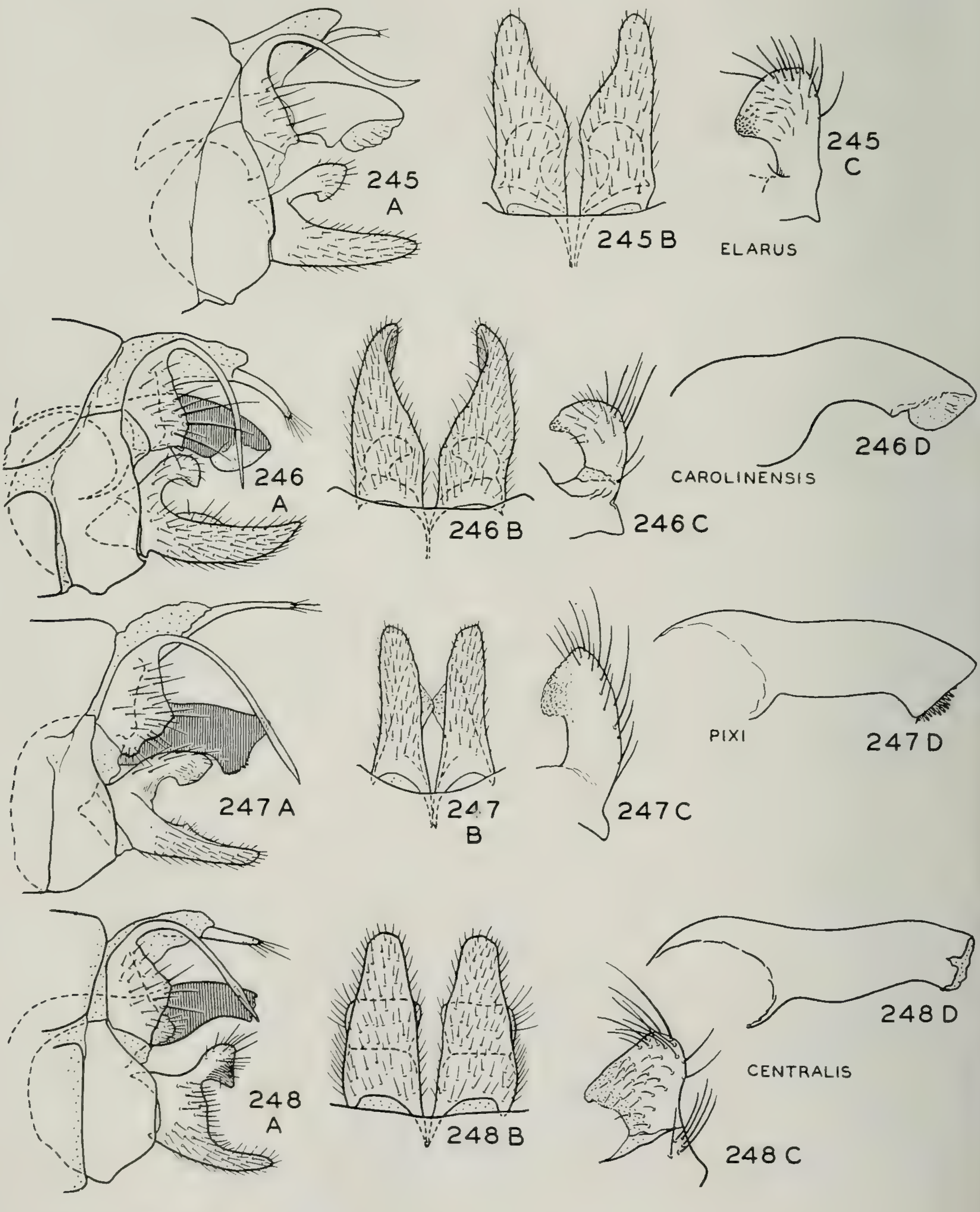
Baso-dorsal lobe of claspers shorter and wide, the mesal point sharp, the entire lobe erect; aedeagus narrowed at tip, fig. 248 .... **centralis**, p. 64

11. Processes of tenth tergite long, sclerotized and arched, fig. 236 12
    Processes of tenth tergite either semimembranous or short, fig. 239 14
12. Apex of cerci long and tapering to a sharp point, fig. 236 .... **interruptus**, p. 69
    Apex of cerci shorter, rounded at apex, fig. 237 13
13. Aedeagus and filaments of tenth tergite long; claspers with only a short dorso-mesal flap, fig. 237 .... **flavus**, p. 68
    Aedeagus and filaments of tenth tergite short; claspers with a large, rhomboidal dorso-mesal flap, fig. 238 .... **glacialis**, p. 68
14. Tenth tergite with a pair of curved, hornlike, sclerotized processes, fig. 239 .... **remotus**, p. 67
    Tenth tergite without such processes, fig. 240 15
15. Claspers with lateral aspect quadrate, posterior margin only narrowly incised, fig. 240 .... **cinereus**, p. 67
    Claspers with lateral aspect expanded at apex, posterior margin deeply and widely incised, fig. 241 .... **nascotius**, p. 68
16. Genital segment long and tapering, lateral lobes of eighth sternite with footlike base and stylelike blade on meso-apical corner, fig. 249 .... **crassicornis**, p. 64
    Genital segment shorter and broader, lateral lobes of eighth sternite not so shaped, fig. 250 17
17. Base of eighth sternite with a pointed elevation, fig. 250 .... **flavus**, p. 68
    Base of eighth sternite without a pointed elevation, fig. 251 18

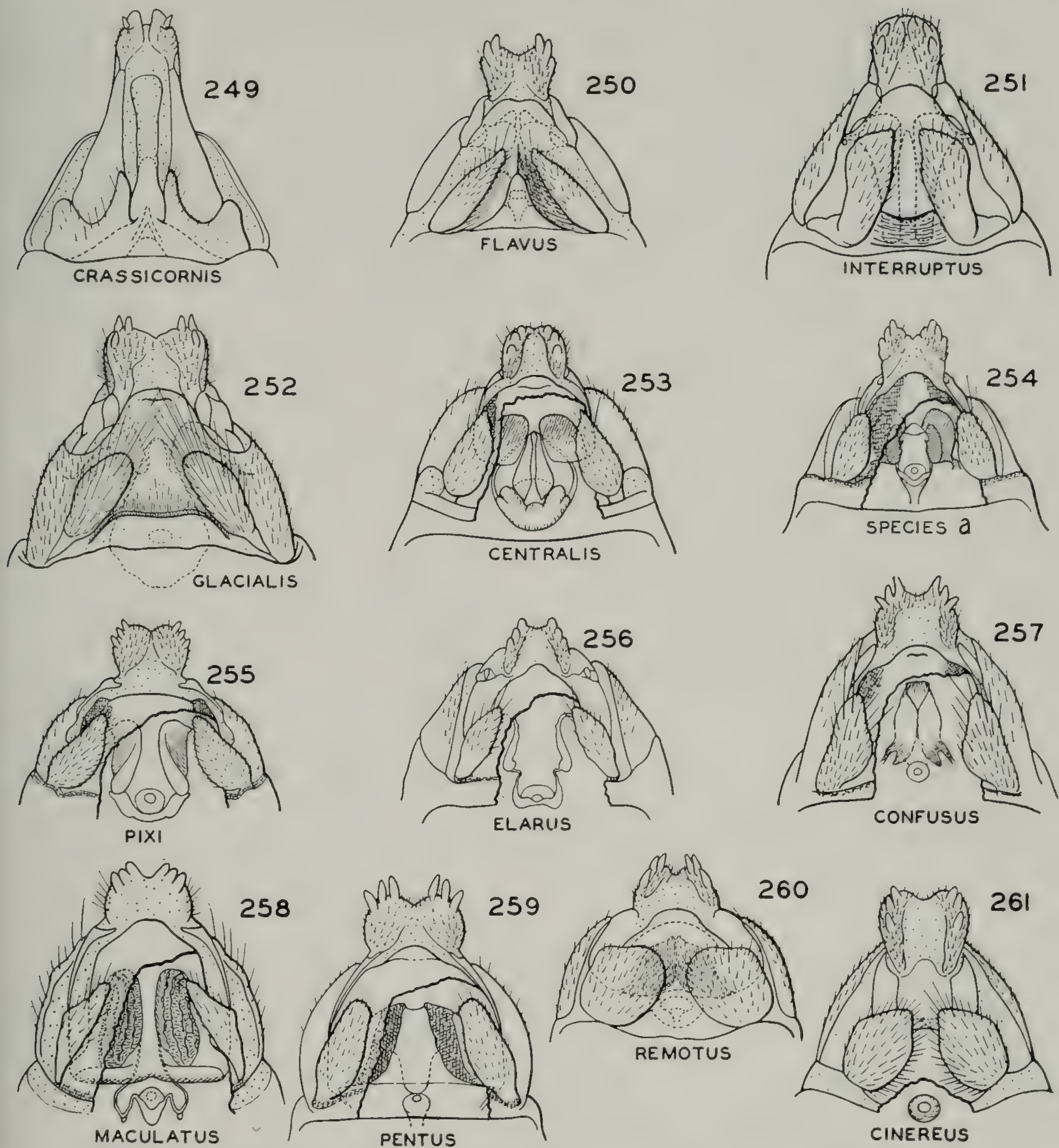


Figs. 242–244.—*Polycentropus*, male genitalia. *A*, lateral aspect; *B*, ventral aspect; *C*, baso-dorsal appendage of clasper; *D*, aedeagus.

18. Lateral lobes of eighth sternite long and narrow, figs. 251, 253........ 19
    Lateral lobes of eighth sternite shorter and wider, almost quadrate, figs. 260, 261........................ 27
19. Base of eighth sternite with a definite shelf or ledge with a sharp edge, situated between lateral lobes, figs. 251, 252........................ 20
    Base of eighth sternite without a ledge situated between lateral lobes, figs. 253–259........................ 21
20. Eighth sternite with basal ledge narrow; lateral lobes long, slightly expanded near apex and with an angulate foot, fig. 251...**interruptus**, p. 69
    Eighth sternite with basal ledge wide; lateral lobes therefore farther apart,



Figs. 245–248.—*Polycentropus*, male genitalia. *A*, lateral aspect; *B*, ventral aspect; *C*, baso dorsal appendage of clasper; *D*, aedeagus.



Figs. 249–261.—*Polycentropus*, female genitalia, ventral aspect.

shorter, without expanded apex and with foot not angulate, fig. 252. . . . .**glacialis,** p. 68

21. Bursa copulatrix with a wide base and long, vasiform, sclerotized apical structures; internal structure of ninth segment as in fig. 253, with rounded, nearly approximate apical lobes which are sclerotized only at apex. . . . .**centralis,** p. 64
    Bursa copulatrix shaped differently, figs. 254–259; internal structure with longer lobes which are farther apart. 22
22. Ninth sternite with ovoid sclerotized lobes on each side of bursa; eighth sternite nearly triangular with the sides slightly sinuate, fig. 254. . . . .**species a,** p. 66
    Ninth sternite without ovoid lobes as in fig. 254; eighth sternite with apex more rounded, often nearly truncate, figs. 255–259. 23
23. Ninth sternite without sclerotized bands; bursa supports sometimes heavily sclerotized, figs. 255–257. . 24
    Ninth sternite with sclerotized bands in addition to supports of bursa copulatrix, figs. 258, 259. 26
24. Upper portion of bursa supports thick, wide and twisted, fig. 255, and lower portion forming a thick bridge below bursa. . . . .**pixi,** p. 66
    Bursa supports much more slender,

fig. 256, or very little sclerotized, fig. 257 25

25. Bursa supports distinct, sclerotized, slender and sinuate, fig. 256 .... **elarus**, p. 65
Bursa supports chiefly membranous, with only a small basal portion and a curious sclerotized forklike piece near bursa, fig. 257 .... **confusus**, p. 65

26. Sclerotized bands of ninth tergite more rectangular, parallel, and closer together at base, fig. 258 .... **maculatus**, p. 65
Sclerotized bands of ninth tergite sinuate, pointed at apex, wide apart at base, and converging rapidly to apex, fig. 259 .... **pentus**, p. 65

27. Ninth sternite with a pair of somewhat quadrate sclerotized plates pointed at apex; bursa copulatrix not heavily sclerotized, fig. 260 .... **remotus**, p. 67
Ninth sternite without sclerotized plates; bursa copulatrix heavily sclerotized, fig. 261 .... **cinereus**, p. 67

Polycentropus crassicornis Walker

Polycentropus crassicornis Walker (1852, p. 101); ♂, ♀.
Plectrocnemia adironica Banks (1914, p. 256); ♂.
Pletrocnemia australis Banks (1907*a*, p. 131); ♀.

LARVA.—Unknown.

ADULTS.—Length 9–10 mm. Color brown, the front wings irrorate over their entire surface with brown and yellowish spots. Male genitalia, fig. 235: ninth segment produced into a long, pointed tongue which projects to the apex of claspers; cerci short and ovate; claspers very heavily sclerotized, lateral margin narrow, apical margin expanded, with a sharp mesal tooth at apex pointed ventrad; tenth tergite submembranous and small; connecting this and the cerci is a heavily sclerotized plate which is divided at its apex into a pair of heavily sclerotized prongs, one angled sharply dorsad, the other curved ventrad; aedeagus with a tubular base, the apex narrowed and consisting of membranous folds and internal sclerotized rods. Female genitalia, fig. 249, forming a long, tapering, heavily sclerotized structure, divided on the venter by a long, narrow tongue, at the base of which are lateral lobes produced into sharp, long points on their meso-apical corner.

We have only four Illinois records for this species, two from marsh areas in the extreme northeastern corner of the state (see p. 12), another from the east-central margin and the fourth from the extreme southern portion. Little is known regarding the biology of the species or its habitat preference. It is widespread throughout the eastern United States and Canada, with records from Florida, Illinois, Massachusetts, Michigan, New York, Ontario and South Dakota.

Illinois Records.—ALTO PASS, Union Spring: May 26, 1940, Mohr & Burks, 1 ♀. ROSECRANS, Des Plaines River: June 9, 1938, at light, Ross & Burks, 1 ♂, 1 ♀. URBANA: June 1, 1938, light trap, G. T. Riegel, 1 ♂. ZION, Dead River: June 3, 1938, Mohr & Burks, 1 ♂.

Polycentropus aureolus (Banks)

Plectrocnemia aureola Banks (1930*a*, p. 130); ♂, ♀.

Described from Nova Scotia, this species has been taken also in New Hampshire and Minnesota. It has not yet been taken in Illinois.

Polycentropus centralis Banks

Polycentropus centralis Banks (1914, p. 258); ♂.

LARVA.—Length 11 mm. Head, pronotum and legs yellow, the head with very indistinct spots arranged in the same pattern as in fig. 231; posterior margin of pronotum dark brown.

ADULTS.—Length 7–9 mm. General color brown with irregular light areas on the wings and definite pale spots around their border. Male genitalia, fig. 248: cerci stocky, apical filament fairly short; claspers short, the baso-dorsal appendage trapezoidal, its inner point sharp and serrulate; aedeagus slightly sinuate but its general outline straight. Female genitalia, fig. 253: eighth sternite broad, its apical margin fairly evenly rounded, lateral lobes moderately short and pointed at apex; ninth sternite with two short, broad, rounded lobes; bursa copulatrix porelike, its supports forming a broad base and a pair of fusiform supports which run close together to give the entire structure a more or less vasiform appearance.

Allotype, female.—Wolf Lake, Illinois, along Hutchins Creek: May 31, 1940, B. D. Burks.

In Illinois we have taken this species only in the extreme southern portion and in the extreme northwestern corner. In the former area we found the species very abundant in Hutchins Creek where larvae, pupae and adults were associated. All our records are along small, fairly clear and rapid streams.

The range of the species includes the Ozarks and adjacent ranges with a northeastward extension into New York. We have records from the following states: Arkansas, Illinois, Missouri, New York and Oklahoma.

Illinois Records.—Galena, Sinsinawa River: June 5–6, 1940, Mohr & Burks, 1 ♂. Herod: May 29, 1936, Ross & Mohr, 1 ♀. La Rue, McCann Spring: May 26, 1939, Burks & Riegel, 4 ♂, ♀ ♀. Wolf Lake, Hutchins Creek: Oct. 5, 1938, Frison & Burks, 4 ♀; May 25, 1940, Mohr & Burks, 1 ♀; May 31, 1940, B. D. Burks, ♂ ♂, ♀ ♀.

Polycentropus pentus Ross

Polycentropus pentus Ross (1941*b*, p. 71); ♂, ♀.

Larva.—Unknown.

Adults.—Length 8–10 mm. General color mottled brown, the wings with a few light spots along periphery. Male genitalia, fig. 242: cerci narrow, with a finger-like projection near middle, apical filament relatively short; ninth segment narrow; claspers long, ventral aspect slightly irregular and tapering slightly toward apex, baso-dorsal appendage long, the apex pointed and the mesal point sharp; aedeagus slightly curved with a large hump on ventral margin near base. Female genitalia, fig. 259: eighth sternite wide, apex fairly evenly curved and slightly produced at tip, lateral lobes long and lanceolate; ninth sternite with a pair of sclerotized bars wide apart at base and converging markedly toward apex; bursa copulatrix conical, its supports poorly defined except for the apical rods, which are narrow and sinuate.

Our only record for this species in Illinois is a single male collected at Split Rock Brook, Utica, July 11, 1941, Ross & Ries (see p. 7).

The range of the species is not well defined, but it is apparently widely distributed through the Northeast, our Illinois record being the most western point from which it is known. Records are available from Illinois, New Hampshire and Ontario.

Polycentropus maculatus Banks

Polycentropus maculatus Banks (1908*a*, p. 65); ♂.

This species has not been taken in Illinois but is distributed through the eastern states. Records are available from Newfoundland, New Hampshire, New York and Tennessee. The male genitalia, fig. 243, are distinctive. The female is similar to the male in color and general structure and is readily distinguished by the widely separated, narrow and frequently angulate lateral lobes of the eighth sternite and the parallel, rugose, sclerotized bands of the ninth sternite, fig. 258.

Allotype, female.—Chimneys Camp Grounds, Great Smoky Mountains National Park, Tennessee: July 16, 1939, at light, A. C. Cole.

Polycentropus confusus Hagen

Polycentropus confusus Hagen (1861, p. 293); ♂, ♀.

While not as yet found in Illinois, this species is almost certain to be taken with additional collecting. Its range, apparently general throughout the Northeast, extends southwestward through the Ozarks, and includes Arkansas, Michigan, Missouri, New York, Ohio, Ontario, Quebec and Tennessee.

As explained in a previous article (Ross 1941*b*, p. 71), the type male lacks the abdomen, and the male characters are based on the plesiotype male set up in that paper. Since the specific characters for the female of this species have not been pointed out and illustrated before, I am designating a specimen to represent the female sex.

Plesio-allotype, female.—Costello Lake, Algonquin Park, Ontario: July 11, 1938, Cage No. 4, W. M. Sprules.

Polycentropus elarus new species

Male.—Length 8.5 mm. Color various shades of brown, the hind tibiae not markedly annulate, the front wings with numerous inconspicuous light areas forming an indistinct, irrorate pattern. General structure typical for genus. Front and hind wings with R_2 present. Male genitalia, fig. 245, typical in general for the *maculatus* group; ninth sternite deep; cerci fairly stocky, the ventral corner fairly sharp, the dorsal angle produced into a long, slender, sclerotized, sinuate rod which curves dorsad at the tip; claspers with baso-dorsal lobe of moderate length, its neck long and slender, the apex large and produced into a large mesal point; ventral aspect of claspers with base large and rectangular, narrowing suddenly to a slender and somewhat digitate tip; aedeagus curved ventrad and slightly enlarged at apex.

Female.—Length 9.5 mm. In color and structure similar to male. Genitalia, fig. 256, with eighth sternite fairly narrow, its extreme apex produced into a slight lobe; lateral lobes wide apart at base, fusiform and narrow.

Holotype, male.—Costello Lake, Algonquin Park, Ontario: June 22, 1939, Cage No. 1, W. M. Sprules.

Allotype, female.—Same data as for holotype.

Paratypes.—New York.—Bear Brook near Blue Mountain Lake, Adirondack State Park: June 19, 1941, Frison & Ross, 1 ♂.

Ontario.—Same data as for allotype, 1 ♀; same data except June 11, 1 ♂.

The elongate, sinuate and upturned filament of the cerci will distinguish this species from others in the *maculatus* group, to which it belongs. The ventral aspect of the claspers, fig. 245, is also unique for the group.

Not known from Illinois but may be taken in future collecting.

Polycentropus species a

Larva.—Unknown.

Adults.—Length 7–9 mm. Male unknown. Female genitalia, fig. 254, with eighth sternite almost evenly tapering from base to apex, more or less triangular, the lateral margins sclerotized; lobes slender and pointed. Ninth segment with ovate sclerotized processes which are short, rounded at apex, and connected to conical bursa copulatrix by a narrow ribbon which forms a narrow ventral bridge ventrad of bursa.

This form is known only from Herod, Illinois, and Hopkinsville, Kentucky. It is either the female of *carolinensis* or represents a new species.

Illinois Records.—Herod: May 8, 1936, Ross & Mohr, 1 ♀; May 10, 1935, C. O. Mohr, 2 ♀.

Polycentropus carolinensis Banks

Polycentropus carolinensis Banks (1905*a*, p. 217); ♂.

This species, known only from the unique male type, has not been taken in Illinois. There is a possibility, however, that the unassociated female, *Polycentropus species a*, may be *carolinensis*. This has no statistical basis but is a possibility because, in the *maculatus* group of seven species, *carolinensis* is the only male with which a female has not been associated definitely, and *species a* is the only female not definitely associated with a male.

Polycentropus pixi new species

Male.—Length 7 mm. Color various shades of brown, the legs paler, the hind tibiae dark brown with a basal white annulus, the front wings with only a few indistinct light spots. General structure typical for genus. Wing venation with R_2 present in both wings, but only faintly indicated in the hind wings. Male genitalia, fig. 247, typical for the *maculatus* group in general structure as follows: ninth sternite deep; cerci fairly wide, the apical needle-like projection nearly straight and extending considerably posterad, not recurving toward ventral margin of cerci; tenth tergite long, the pair of sclerotized styliform processes very long; claspers with ventral aspect only slightly narrowed at apex, the dorsal margin with a sharp lateral edge and with the mesal margin produced into a sharp tooth near middle; baso-dorsal lobe of clasper long, arched, the mesal point not sharp but well differentiated at the end of the long, necklike portion; aedeagus only slightly curved at apex, which is slightly enlarged.

Female.—Length 8 mm. In color and general structure similar to male. Eighth sternite, fig. 255, very broad, the corners heavily sclerotized; lateral lobes of sternite long, narrow and widely separated at base.

Holotype, male.—North Woodstock, New Hampshire: June 21, 1941, at light, Frison & Ross.

Allotype, female.—Same data as for holotype.

Paratypes. — NEW HAMPSHIRE. — Same data as for holotype, 1 ♀.

NEW YORK.—EUBA MILLS, Adirondack State Park: June 20, 1941, Frison & Ross, 1 ♂. VARYSBURG: June 18, 1941, Frison & Ross, 1 ♀.

This species is most closely related to *centralis*, from which it differs in the long, arched, baso-dorsal lobe of the claspers, in having the mesal angle of this point round, in the widened tip of the aedeagus, and other characters of the genitalia.

Although not yet taken in Illinois, because this species is fairly widely distributed in the northeastern states, it may be taken here in future collecting.

Polycentropus cinereus Hagen

Polycentropus cinereus Hagen (1861, p. 293); ♂, ♀.

Polycentropus canadensis Banks (1897, p. 31); ♂.

Holocentropus flavicornis Banks (1907*b*, p. 162); ♂.

Plectrocnemia pallescens Banks (1930*b*, p. 231); ♂, ♀.

Plectrocnemia lutea Betten (1934, p. 219); ♂, ♀.

LARVA.—Fig. 230. Length 14 mm. Head, pronotum and legs straw color, head and sometimes pronotum with conspicuous brown spots, those of the upper portion of frons arranged in an angle; sometimes, also, the dorsal part of head is suffused with yellowish brown. Remainder of body pale, without markings.

ADULTS.—Length 7–9 mm. Color various shades of brown, the wings mottled with brown and light areas resulting in a checkerboard mottling. Front and hind wings with R_2 present. Male genitalia, fig. 240: tenth tergite short, stocky and semimembranous; cerci short and ovate; claspers appearing quadrate from lateral view, the posterior margin incised to form a dorso-mesal hook and a ventro-mesal lobe. Female genitalia, fig. 261: eighth sternite short, lateral lobes large and somewhat circular; ninth segment with its structures membranous; bursa copulatrix dark, cone-like and conspicuous.

This species has been taken commonly in all parts of Illinois. It is found in a wide variety of situations, ranging from lakes to large rivers, showing a marked preference for cool and clear water. Adult emergence occurs from May to September. Larvae are found chiefly under stones. Association of larval and adult forms was established by collections of all stages in Channel Lake.

The range of the species is very wide, occurring throughout the eastern states, north and westward through Canada and the northern states to the Pacific Coast and extending southwestward through the Ozarks to Oklahoma. We have records from British Columbia, the District of Columbia, Illinois, Indiana, Kentucky, Maine, Maryland, Michigan, Minnesota, Missouri, New Brunswick, New Hampshire, New York, North Carolina, Nova Scotia, Ohio, Oklahoma, Ontario, Pennsylvania, Saskatchewan, South Dakota, Tennessee, Washington and Wisconsin.

Illinois Records.—Many males and females and seven pupae, taken May 24 to September 20, and many larvae, taken May 5 to October 28, are from Algonquin, Antioch, Channel Lake, Danville (Middle Fork River), Eddyville (Lusk Creek), Eldorado, Elgin (Botanical Gardens), Fox Lake, Galena (Sinsinawa River), Homer, Johnsburg (Fox River), Kankakee (Kankakee River), McHenry, Momence (Kankakee River), Oakwood, Pontiac, Richmond, Round Lake, St. Joseph, Serena (Indian Creek), Spring Grove (Nippersink Creek), Wilmington (Kankakee River), Zion (Dead River).

Polycentropus remotus Banks

Polycentropus remotus Banks (1911, p. 359); ♂.

LARVA.—Length 14 mm. Head, pronotum and legs straw color, the head with well-marked spots. Upper portion of frons subequal in length to lower portion, fig. 232. Body pale, without markings.

ADULTS.—Length 7–9 mm. Color various shades of brown with a checkered pattern of small pale areas on the brown wings. Both pairs of wings with R_2 present. Male genitalia, fig. 239: tenth tergite composed chiefly of a pair of stocky, outcurved horns, slightly expanded and provided with a short spine at apex; cerci long and leaflike, the upper portion produced into a lobe, and the ventro-mesal corner bearing a stout, heavily sclerotized projection curved ventrad at apex; claspers appearing quadrate from lateral view, with a slender, digitate dorsomesal projection. Female genitalia, fig. 260: eighth sternite short, its lateral lobes large, almost quadrate, and close together along meson, covered with short setae; ninth sternite with a pair of distinctive, small, quadrate sclerotized plates which are narrowed and pointed at apex; other internal structures membranous or irregular.

Allotype, female.—Zion, Illinois, along Dead River: June 6, 1940, Mohr & Burks.

As with *flavus*, this species has been taken in Illinois chiefly along the Dead River, and our main collection is a series of larvae, pupae and adults taken along with the allotype. This species is widely distributed, occurring from the Atlantic to the Pacific. So few collections are known, however, that a very local distribution is indicated. Records are available from British Columbia, Illinois, Minnesota, New Hampshire and New York.

Illinois Records.—RICHMOND: June 4, 1938, Ross & Burks, 2 ♀. SPRING GROVE: Aug. 12, 1937, at light, Ross & Burks, 1 ♀. ZION, Dead River: June 3, 1938, Mohr & Burks, 1 ♂; June 6, 1940, Mohr & Burks, 2 ♂, 4 ♀, 3 larvae.

Polycentropus nascotius Ross

Polycentropus nascotius Ross (1941*b*, p. 73); ♂.

Not yet taken in Illinois, but to be looked for in future collecting. It is a rare species with a wide distribution, known from New Brunswick, Nova Scotia and Wisconsin.

Polycentropus flavus (Banks)

Holocentropus flavus Banks (1908*a*, p. 66); ♂.

LARVA.—Length 14 mm. Head somewhat uniformly reddish brown of a dusky shade, the typical spots present but inconspicuous, being almost the same color as the ground color. Pronotum and legs yellowish brown. Remainder of body pale without markings.

ADULTS.—Length 7–9 mm. Color brown with a checkered pattern on the wings similar to that of *nascotius*. Front wings with R_2 present, hind wings with R_2 absent. Male genitalia, fig. 237: tenth tergite with a pair of very long, curved sclerotized rods following the curve of the aedeagus; cerci fairly long and narrow, the apex provided with a short, appendage-like prolongation; claspers with a high lobe at base, apex narrow and rounded; at the top of the lobe is a small, triangular flap projecting mesad, and below this there is frequently a tooth-like projection. Female genitalia, fig. 250: eighth sternite long, slightly incised at apex, and extending well beyond the lateral lobes, which are narrow and pointed; between them the eighth sternite is raised into a pyramid, sloping sharply at the sides.

Allotype, female.—Zion, Illinois, along Dead River: June 6, 1940, Mohr & Burks.

Our only recent Illinois records are from the extreme northeastern portion of the state. The two sexes and immature stages were associated by a series of males, females, pupae and larvae collected at Zion in and along the Dead River (see p. 12).

The species has been recorded over a wide but scattered range, probably indicating a very local distribution. Records are available from Illinois, Newfoundland, New York and Ontario.

Illinois Records.—URBANA: May 17, 1887, C. A. Hart, 1 ♂, 1 ♀; May 19, 1887, C. A. Hart, 1 ♂, 2 ♀; May 20, 1887, C. A. Hart, 1 ♀; June 20, 1888, Forbes, Marten & Hart, 1 ♀. ZION, Dead River: May 20, 1940, Mohr & Burks, 2 larvae; June 6, 1940, Mohr & Burks, 1 ♂, 3 ♀.

Polycentropus glacialis (Ross)

Holocentropus glacialis Ross (1938*a*, p. 135); ♂.

LARVA.—Length 13 mm. Head, pronotum and legs yellowish, the head frequently with slight brownish suffusions; spots on head distinct, the two major setae on upper part of frons surrounded by a small brown area. Remainder of body without markings.

ADULTS.—Length 8–9 mm. Color, general structure and venation similar to those of *flavus*. Male genitalia, fig. 238: tenth tergite composed of a pair of long, curved, sclerotized rods; cerci narrow and spatulate, without an appendage; claspers appearing somewhat quadrate from lateral view, the dorsal margin curved over into a trapezoidal flap projecting meso-ventrad. Female genitalia, fig. 252: eighth sternite with fairly short, ovate, lateral lobes which are wide apart at base; between them is a wide, transverse ledge without abrupt apical margin; internal structures forming a pair of wide, lateral lobes and a single mesal lobe.

Allotype, female.—Spring Grove, Illinois: May 22, 1938, Ross & Mohr.

In Illinois this species has been taken principally in the vicinity of the glacial lakes in the northeastern part of the state (see p. 10). It was recorded from Diamond Lake, Illinois, May 30, as *Holocentropus species 1* Betten (1934, p. 223). Apparently only one generation of adults appears each year as indicated by our collection records, which run from May 9 to August 12.

The range of the species is poorly known. In addition to our Illinois records we have only the following: Michigan (Nottawa) and Wisconsin (Mukwonagon).

Illinois Records.—ANTIOCH: July 1, 1931, Frison, Betten & Ross, ♂♂; July 6, 1931, Frison *et al.*, 5♂; July 6, 1932, Frison *et al.*, 9♂; July 7, 1932, at light, Frison & Metcalf, 1♂. CHANNEL LAKE: May 27, 1936, H. H. Ross, 1 ♂ pupa; June 11, 1936, Ross & Burks, 3♂. FOX LAKE: July 1, 1931, Frison, Betten & Ross, ♂♂; June 30, 1935, DeLong & Ross, 3♂; May 28, 1936, in weeds, H. H. Ross, ♂♂, 3 larvae; May 13, 1938, 1♀. HAVANA: May 9, 1896, Butler, 1♂. SPRING GROVE: Aug. 12, 1937, at light, Ross & Burks, 2♂; May 20, 1938, Ross & Burks, 1♂; May 22, 1938, Ross & Burks, 1♂, 1♀; May 23, 1938, Ross & Burks, 3♂; June 4, 1938, Mohr & Burks, 1♂; May 31, 1♂; June 10, 1♂ (reared). OTTAWA: June 3, 1938, Mohr & Burks, 1♂.

Polycentropus interruptus (Banks)

Holocentropus interruptus Banks (1914, p. 257); ♂.

Holocentropus orotus Banks (1914, p. 257); ♂, ♀.

Holocentropus longus Banks (1914, p. 258); ♂.

LARVA.—Fig. 233. Length 15 mm. Head yellowish with distinct dark spots and with most of the dorsum clouded with reddish brown, the major pair of setae of the upper frons with a small, pale area around base. Pronotum and legs yellowish brown. Remainder of body pale.

ADULTS.—Length 9–10 mm. Color various shades of brown, the wings marked with pale areas making a somewhat checkerboard pattern. Front wings with R_2 present, hind wings with R_2 absent. Male genitalia, fig. 236: tenth tergite with a pair of long, curved processes which are sclerotized, slender and curved to follow the outline of the aedeagus; cerci with the basal portion long and widened at apex, bearing a short, sausage-shaped apical projection; claspers broad at base, tapering to a sharp, upcurved point, and with only small flaps on the mesal base. Female genitalia, fig. 251: eighth sternite long and rounded at apex, lateral lobes long and spatulate, with a footlike angular base; between these lobes there is a deep depression in the tergite; ninth sternite with a pair of long, sclerotized rods.

In Illinois we have taken this species recently only in lakes and ponds in the extreme northeastern corner of the state. The larvae were taken in weed beds and beneath stones in these situations and locally were very abundant. Our adult records indicate only one generation per year, all falling between May 26 and July 15. Numerous mature pupae from Channel Lake, Fox Lake and Dead River (see p. 12) have established the association of the larvae and adults.

The range of the species is extensive, including Colorado, Illinois, Massachusetts, Michigan, New Hampshire and New York. These records, however, are based on a minimum of definite localities, so that the species appears to be very local in its occurrence.

Illinois Records.—Many males, females and pupae, taken May 26 to July 15, and many larvae, taken May 27–28, are from Algonquin, Antioch, Channel Lake, Fox Lake, Grass Lake, Pistakee Lake, Richmond, Spring Grove, Urbana, Volo, Zion.

Nyctiophylax Brauer

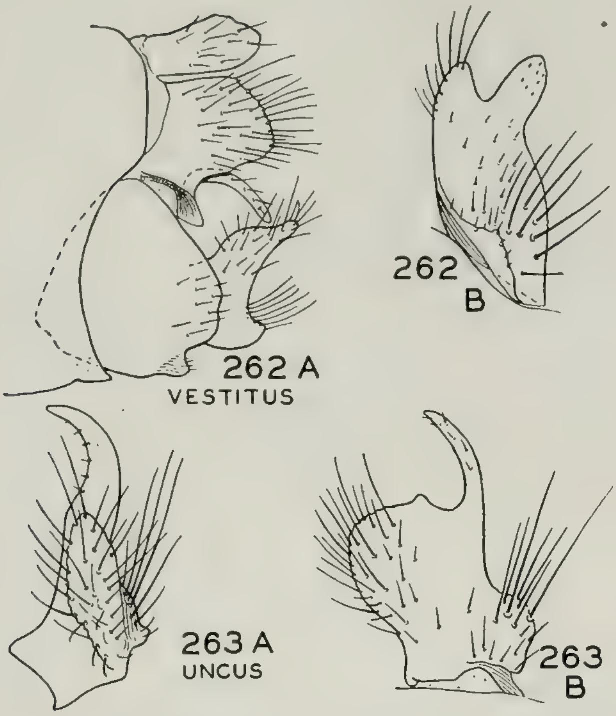
Nyctiophylax Brauer (1865, p. 419). Genotype, monobasic: *Nyctiophylax sinensis* Brauer.

Only two Nearctic species are known for this genus, one of them from Illinois, the other from the Northeast. The larva has not been associated with the adult, although one species is very common and widespread (see *Genus A* and *Genus B*, pp. 73 and 74).

KEY TO SPECIES

Adults

1. Apex of abdomen with cerci and claspers, figs. 262, 263 (males).... 2



Figs. 262–263.—*Nyctiophylax*, male genitalia. *A*, lateral aspect; *B*, clasper, caudal aspect.

Apex of abdomen with platelike lateral lobes, fig. 264 (females) ....not keyed

2. Posterior aspect of claspers with mesal lobe produced into a long finger, fig. 263 .... **uncus,** p. 70
Posterior aspect of claspers with mesal lobe no higher than lateral lobe, fig. 262 .... **vestitus,** p. 70

Nyctiophylax vestitus (Hagen)

Polycentropus vestitus Hagen (1861, p. 293); ♀.
Polycentropus affinis Banks (1897, p. 30); ♂.
Nyctiophylax moestus Banks (1911, p. 359); ♂.

LARVA.—Unknown.

ADULTS.—Length 5–7 mm. Color various shades of brown, the wings with light spots in an irregular pattern. Male genitalia, fig. 262: tenth tergite semimembranous, short, narrowed at apex; cerci forming a somewhat ovate lobe with a sharp process on the mesal face near venter; claspers appearing narrow from lateral view, the extreme base produced into a short shelf, the apical portion with a broad, concave, posterior face which is divided at apex into a pair of short lobes, the inner one small. Female genitalia, fig. 264: lateral lobes of eighth sternite short and wide; bursa copulatrix variable, but always with a shieldlike structure.

In Illinois this species occurs associated with a wide variety of small to large streams over most of the state. Adult emergence begins in May and continues until at least September.

The species is apparently widespread through the Northeast and continues southwestward through the Ozarks to Oklahoma. We have records from Arkansas, Illinois, Indiana, Kentucky, Maryland, Michigan, Minnesota, New York, North Carolina, Ohio, Oklahoma, Ontario, Quebec, Tennessee and Wisconsin.

Illinois Records.—Many males and females, taken May 19 to September 20, are from Algonquin, Alto Pass (Union Spring), Antioch, Apple River State Park, Bartonville (Kickapoo Creek), Charleston, Council Hill (Galena River), Danville (Middle

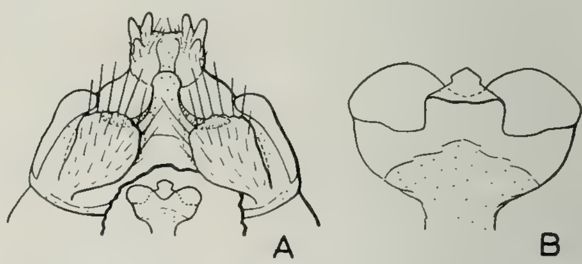


Fig. 264.—*Nyctiophylax vestitus*, female genitalia. *A*, ventral aspect; *B*, dorsal aspect of bursa copulatrix.

Fork River), Downs (Kickapoo Creek), Eddyville (Lusk Creek), Eichorn (Hicks Branch), Elgin (Botanical Gardens), Fox Lake, Galena (Sinsinawa River), Grass Lake, Herod, Kankakee (Kankakee River), McHenry, Momence (Kankakee River), Mount Carroll, Muncie, Oakwood (Salt Fork, Middle Fork, Vermilion River), Oregon, Ottawa, Pontiac, Quincy (stream near Cave Spring), Serena (Fox River, Indian Creek), Springfield (Sangamon River), Spring Grove (Nippersink Creek), Sugar Grove, Venedy Station (Kaskaskia River), Wadsworth (Des Plaines River), Waukegan, White Pines Forest State Park, Wilmington.

Nyctiophylax uncus new species

MALE.—Length 6.5 mm. Color various shades of brown, the wings only indistinctly spotted, the antennae and legs straw colored except for the hind tibiae which have the apical five-sixths dark brown, forming a conspicuous pale annulus at base. Wings with R_2 absent. Male genitalia with general features as in fig. 262: ninth sternite narrowed on ventral margin and produced on meson into a low, sharp hump; tenth tergite short, semimembranous, and divided at apex into just a pair of short approximate points; cerci broad, rounded at apex with a long, curved sclerotized hook arising from ventral mesal corner; claspers, fig. 263, appearing narrow from lateral view, the extreme base produced into a hump, the posterior face wide, slightly convex, with a wide, lateral, setate area, the apical mesal corner produced into a long, slender, sclerotized rod curved dorsad; aedeagus somewhat tubular with a pair of dorsal sclerotized rods and with a cushion of short, black spines at apex.

FEMALE.—Size 7.5 mm. In color and general structure similar to male. Eighth sternite with lateral lobes large and ovate; bursa copulatrix very similar to that in fig. 264.

Holotype, male.—Blue Mountain Lake, Adirondack State Park, New York: June 19, 1941, Frison & Ross.

Allotype, female.—Same data as for holotype.

Paratypes.—NEW YORK.—Same data as for holotype, 5♂, 1♀. LIMA: June 19, 1941, Frison & Ross, 2♂.

NEW HAMPSHIRE.—WOODSTOCK: June 21, 1941, at light, Frison & Ross, 1♀.

This species is closely related to *vestitus*, differing in the male in the large, expanded lateral lobe and the elongate mesal lobe of the apex; the female differs little in the shape of the bursa copulatrix.

Although not yet taken in Illinois, the species is so widely distributed to the north and northeast that it can be expected in the state in future collecting.

Cyrnellus Banks

Cyrnellus Banks (1913, p. 88). Genotype, by original designation: *Cyrnellus minimus* Banks.

Only one North American species, *marginalis*, is known for this genus. The immature stages have never been discovered. The significant generic characters for this complex (which includes *Nyctiophylax*) have not been worked out clearly, but I am following Mosely (1934*a*) in assigning *marginalis* to *Cyrnellus*. Future association of adults and larvae will help to clarify the status of these genera.

Cyrnellus marginalis (Banks)

Nyctiophylax marginalis Banks (1930*b*, p. 231); ♂.

Cyrnellus zernyi Mosely (1934*a*, p. 142); ♂.

LARVA.—Unknown.

ADULTS.—Length 4.5–5.5 mm. Color various shades of brown; antennae, legs and venter much paler. Male genitalia, fig. 265: tenth tergite semimembranous and subquadrate; cerci lanceolate, with a short, ventral, styliform process; claspers long and nearly straight, the apex with a sharp, large, black mesal triangle. Female genitalia, fig. 266, with parts weakly sclerotized; eighth sternite short, slightly carinate between lateral lobes, which are large, approximate on

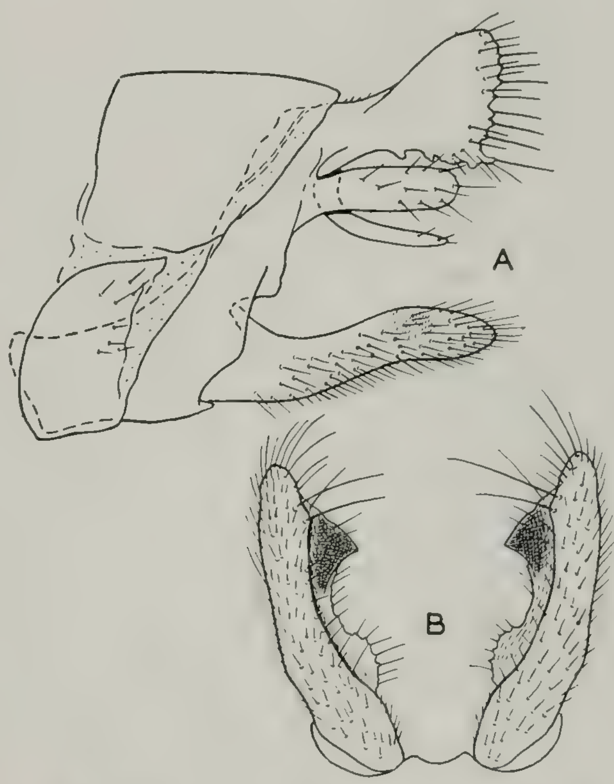


Fig. 265.—*Cyrnellus marginalis*, male genitalia. *A*, lateral aspect; *B*, ventral aspect of claspers.

Fig. 266.—*Cyrnellus marginalis*, female genitalia.

meson and reach beyond sternite; ninth segment long and somewhat vasiform, without conspicuous internal processes.

Taken in all parts of the state, this species shows a marked preference for large rivers such as the Illinois, Kaskaskia and Mississippi; however, we have taken it in numbers along many small streams. Usually it is taken in only small numbers, but occasionally large swarms are encountered. The adult emergence occurs from May until October.

The species is widely distributed through the central states; records include Alabama, Arkansas, Illinois, Kentucky, Michigan, Minnesota, Missouri, Ohio, Oklahoma, Tennessee and Wisconsin. It is also known from near the mouth of the Amazon River in South America.

Illinois Records.—Many males and females, taken May 29 to October 10, are from Algonquin, Antioch, Bartonville (Kickapoo Creek), Danville, Deer Grove (Green River), Dixon, East Dubuque, Elgin (Botanical Gardens), Grafton, Hamilton, Hardin, Havana (Spoon River), Herod, Kankakee (Kankakee River), Milan (Rock River), Olive Branch (Horse Shoe Lake), Ottawa, Palos Park (Mud Lake), Pontiac, Ripley (La Moine River), Rockford, Rock Island, Springfield (Sangamon River), Spring Grove, Thebes, Venedy Station (Kaskaskia River).

Cernotina Ross

Cernotina Ross (1938*a*, p. 136). Genotype, by original designation: *Cernotina calcea* Ross.

No larva of this genus has been discovered. The adults of both sexes are 5–6 mm. long, with the head, body and appendages straw color, the wings and parts of the legs darkened with brown hair. The female genitalia are similar in all species known, the genital segments forming a conical structure with only simple parts, fig. 267.

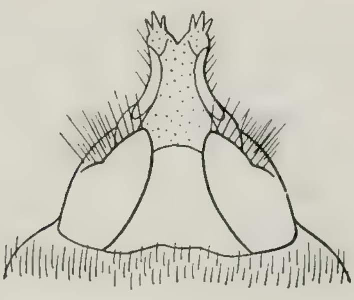


Fig. 267.—*Cernotina calcea,* female genitalia.

Of the six North American species, only one has been taken in Illinois, but three others are known from Michigan and Ohio and may eventually be found in the state.

KEY TO SPECIES

Males

1. Cerci with 3 or 4 long, black teeth on mesal side near base, fig. 268 . . . . **calcea,** p. 72
   Cerci without long, black mesal teeth 2
2. Apex of cerci long and ribbon-like, the inner margin just beyond apex set with a row of 5 to 7 small teeth, fig. 269 . . . . **pallida,** p. 73
   Apex of cerci shorter and whiplike, the inner margin without teeth, fig. 270 3
3. Base of clasper with a sclerotized, ovoid plate attached underneath it, fig. 270 . . . . **spicata,** p. 73
   Base of clasper without this plate, fig. 271 . . . . **ohio,** p. 73

Cernotina calcea Ross

Cernotina calcea Ross (1938*a*, p. 137); ♂, ♀.

ADULTS.—Length 5–6 mm. Head and body straw color, typical for genus. Male genitalia, fig. 268: tenth tergite merging with ninth, the resulting structure with a deep, V-shaped incision on meson; cerci with three to four large, black mesal teeth near middle, the apex lengthened into a long, slender sinuate rod; claspers stocky, the apex formed into a clawlike structure, and the dorsal margin with a slender arm at middle; aedeagus tubular and only slightly sclerotized. Female genitalia, fig. 267, conical, without heavily sclerotized internal parts or supports.

Our only Illinois records are from Kankakee and Oakwood. The species is always found along clear, cool streams. Adult emergence extends over a considerable period; our Illinois records indicate a span from June 29 to August 1.

The range of the species is incompletely known. It is apparently quite widely but locally distributed in cooler streams as indicated by records from Illinois, Florida, Missouri, Oklahoma and Texas.

Illinois Records.—KANKAKEE: Aug. 1, 1933, Ross & Mohr, 1 ♀; July 21, 1935, Ross & Mohr, 1 ♂; June 29, 1939, Burks & Ayars, 2 ♂. OAKWOOD: July 18, 1933, Ross & Mohr, 1 ♂.

Cernotina pallida (Banks)

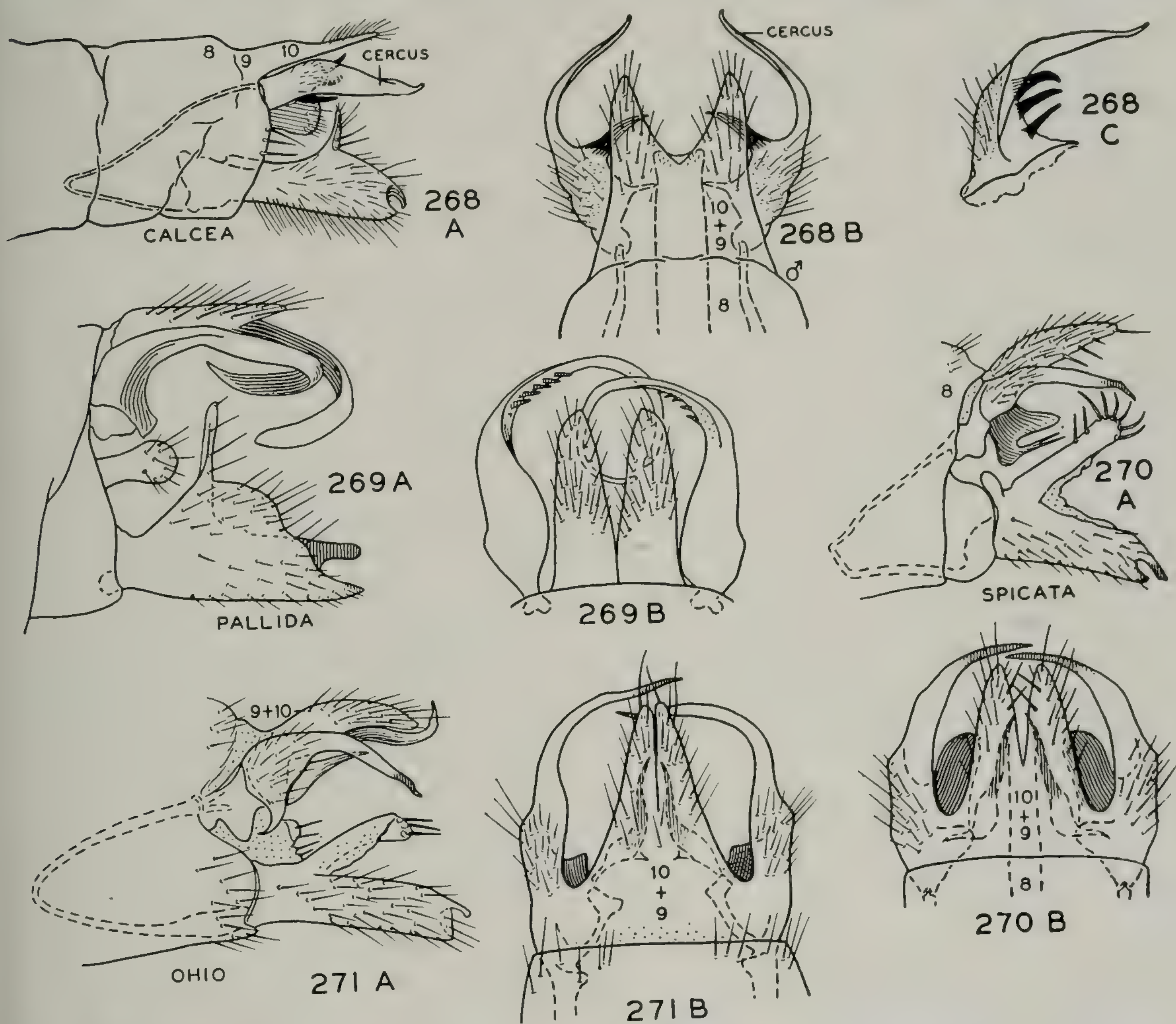
Cyrnus pallidus Banks (1904*d*, p. 214); ♂.

This species, described from Maryland, has not yet been taken in Illinois but has been found as close as central Ohio. It is similar in general appearance to *calcea*, differing in the long, whiplike cerci, which are armed with small teeth near the apex, instead of long black teeth near the base.

Cernotina spicata Ross

Cernotina spicata Ross (1938*a*, p. 138); ♂.

This species has not yet been found in Illinois. Records from Maine, Michigan and Oklahoma indicate a widely scattered range and the possibility of its being found in Illinois in future collecting.



Figs. 268–271.—*Cernotina*, male genitalia. *A*, lateral aspect; *B*, dorsal aspect; *C*, cercus showing inner teeth.

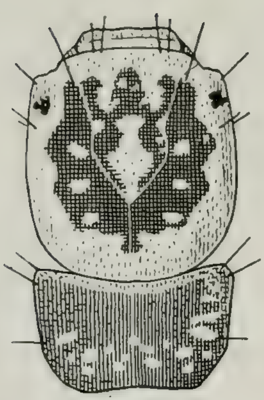
Cernotina ohio Ross

Cernotina ohio Ross (1939*b*, p. 628); ♂.

This species has not been taken in Illinois but occurs in Ohio. It is a close relative of *spicata* but may be readily distinguished by the male genitalia, fig. 271. The cerci lack a baso-mesal plate and the claspers have fewer setae on their dorsal arms.

Psychomyiid Genus A

LARVA.—Fig. 272. Length 9 mm. Head cream with a dorsal, spotted, purplish brown pattern; pronotum cream around edges, central portion brown; legs white; body colorless. Mandibles with dorsal and ventral rows of teeth, fig. 199, in both mandibles the dorsal row concealing the ventral row. Legs spinose, tarsal claws long and sharp. Tubular processes of tenth segment long; anal legs and hooks large, very similar to



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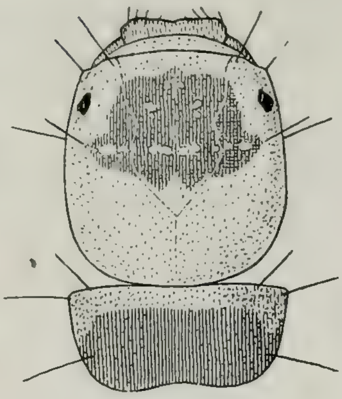

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Fig. 272.—*Psychomyiid Genus A*, larva, head.
Fig. 273.—*Psychomyiid Genus B*, larva, head.

those in fig. 201; anal hooks with inner teeth minute, fig. 190.

Adults.—Unknown.

This curious larva has been taken in small to medium-sized, rapid streams, including the Salt Fork River and Rock Creek. Only scattered records are available, a few in the northern half of Illinois, and others from Florida, Michigan and Wisconsin. No accurate statement can be made as to the identity of this larva, but it is probably one of those now known only from the adult stage, such as *Nyctiophylax*, *Cyrnellus* or *Cernotina* (see the following).

Illinois Records.—Bartelso: Aug. 16, 1898, on logs, C. A. Hart, 1 larva. Erie, Rock Creek: June 5, 1940, Mohr & Burks, 1 larva. Oakwood: June 6, 1920, T. H. Frison, 2 larvae.

Psychomyiid Genus B

Larva.—Fig. 273. Length 8 mm. Head creamy yellow with a large brown mark covering most of anterior portion of dorsum;

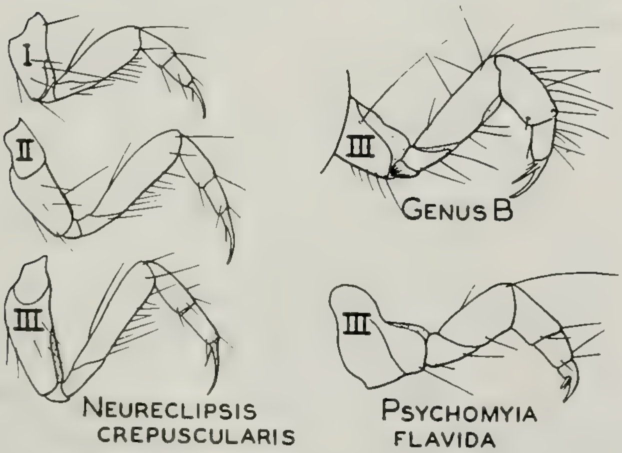


Fig. 274.—Psychomyiidae larvae, legs. I, front leg; II, middle leg; III, hind leg.

pronotum brown with anterior margin yellow; legs cream to white. General structure of mandibles and legs similar to above, fig. 274; ninth sternite bearing a T-shaped, reticulate area and having tubular processes of tenth segment short, with an extensive patch of minute spinules, figs. 200, 201.

Adults.—Unknown.

We collected a single specimen of this larva in rapids of the Kankakee River at Momence, Illinois, May 26, 1936, H. H. Ross. The similar mandibles and anal hooks show a marked affinity with the larva described above as *Genus A*; they will doubtless prove to be *Nyctiophylax*, *Cyrnellus* or *Cernotina*.

Lype McLachlan

Lype McLachlan (1879, p. 422). Genotype, here designated: *Lype phaeopa* (Stephens).

To date only one species of the genus has been recorded for North America. We have one record of it from Illinois.

In recent years there has been considerable juggling of generic names in this complex. I believe that the genital structures indicate clearly that Betten's (1934) definition of this and the following genus is correct.

Larvae of this genus are not available for study. The genotype has been reared in Europe, but no North American species have had the adults and larvae associated.

Lype diversa (Banks)

Psychomyia diversa Banks (1914, p. 253); ♂.
Lype griselda Betten (1934, p. 229); ♂. New synonymy.

Adults.—Length 5–7 mm. General color very dark, almost black, with only a few irregular light marks along the sutures. Male genitalia, fig. 275: tenth tergite large and hood shaped, with a dorsal horn; cerci long and lanceolate; claspers long and narrow; aedeagus arcuate. Female genitalia, fig. 276, produced into a long, tapering ovipositor, without conspicuous processes.

Allotype, female.—Elkmont, Tennessee, along Little River: June 12, 1938, T. H. Frison & T. H. Frison, Jr.

The dorsal horn of the male tenth tergite varies conspicuously from a very short, sharp projection to a long, sinuate structure enlarged at the tip. The type of *diversa*

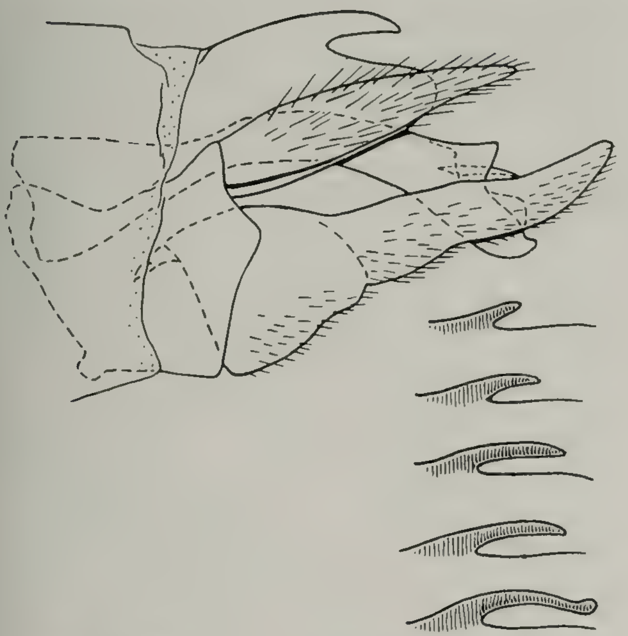


Fig. 275.—*Lype diversa*, male genitalia, showing variations of dorsal horn of tenth tergite.

represents the latter, the type of *griselda* a more or less intermediate condition. Examination of considerable material indicates that this entire range is merely variation within the species. Representative conditions found, showing the two extremes and intermediate steps, are illustrated in fig. 275.

Our only Illinois record of this species is a male collected along Quiver Creek at Havana, May 29, 1936, Mohr & Burks.

The range of the species is widespread

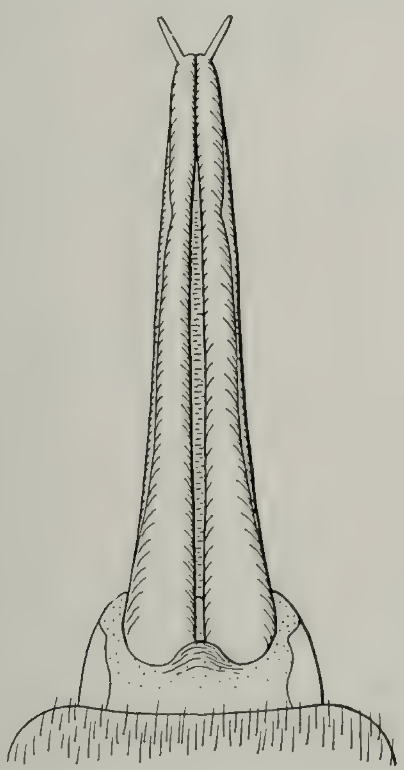


Fig. 276.—*Lype diversa*, female genitalia.

through the eastern states, extending westward to Wisconsin and Illinois. We have records from Florida, Michigan, New Hampshire, New York, North Carolina, Ohio, Ontario, Tennessee, Vermont, Virginia and Wisconsin.

Psychomyia Pictet

Psychomyia Pictet (1834, p. 222). Genotype, here designated: *Psychomyia annulicornis* Pictet.

Quissa Milne (1936, p. 89). Genotype, monobasic: *Psychomyia flavida* Hagen.

Of the three described North American species, only *flavida* has been taken in Illinois. Of the other two species, *nomada* is known only from the eastern states, and *lumina* is known only from Oregon.

The genus was described without any included species. Pictet was the first to place species in the genus, and since no genotype has apparently been designated, I propose his first included species, *annulicornis*, in that capacity.

Psychomyia flavida Hagen

Psychomyia flavida Hagen (1861, p. 294); ♀.
Psychomyia pulchella Banks (1899, p. 217); ♀.
Psychomyia moesta Banks (1907*a*, p. 131); ♀.

Larva.—Fig. 277. Length 6 mm. Head and pronotum yellowish brown, other sclerites straw color, body green. Frons with anterior margin sinuate. Legs short, claws short and angled, fig. 274.

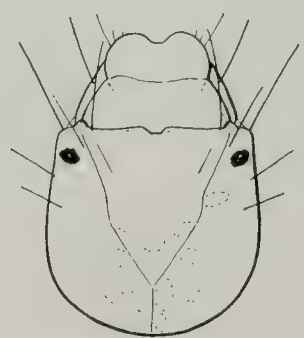


Fig. 277.—*Psychomyia flavida* larva, head.

Adults.—Length 4–6 mm. Head, body and appendages straw color with a slight purplish tinge on many areas. Male genitalia, fig. 278: tenth tergite divided into two large, flaplike lateral lobes to which are fused the cerci; claspers short, flat and truncate; aedeagus with a central arcuate stem ending in a knob, with a pair of long needle-like styles following the stem, and another pair of styles arising from a ventral complex of internal sclerites. The short dorsal processes of the male genitalia are in marked contrast to the long structures of the other eastern species, *nomada*, fig. 279. Female genitalia, fig. 280, conical with a single ventral sclerite.

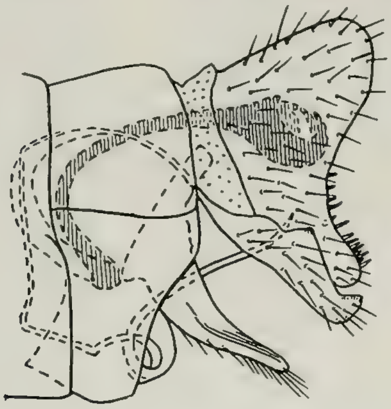


Fig. 278.—*Psychomyia flavida*, male genitalia.

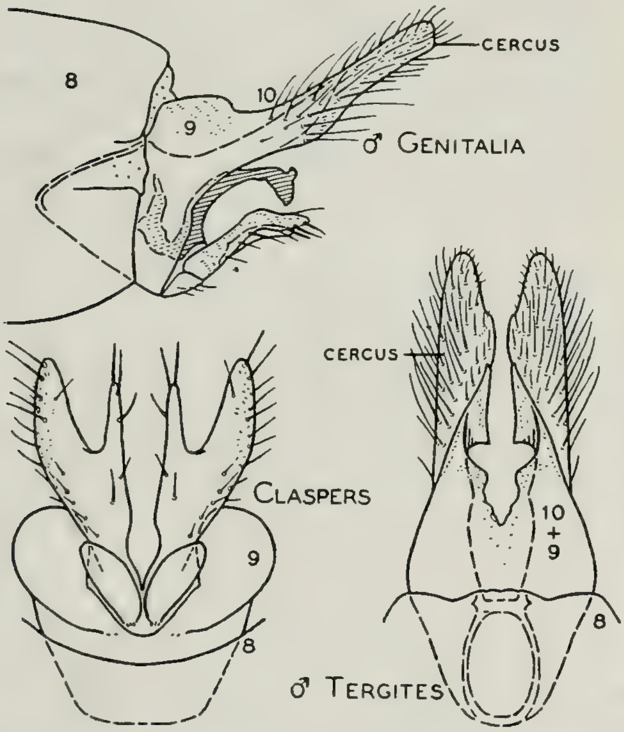


Fig. 279.—*Psychomyia nomada*, male genitalia.

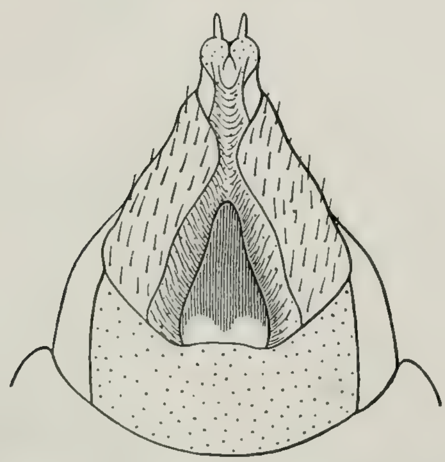


Fig. 280.—*Psychomyia flavida*, female genitalia.

This species is rare in Illinois. We have collected it in only two places, along the Kankakee River at Momence, and in Apple River Canyon State Park, in the northeast and northwest parts of the state, respectively. Immature stages were collected in Apple River Canyon State Park in one of the swift rapids of the Apple River.

The species has a very wide and extensive range which almost completely encircles the Great Plains. It is restricted to swift, cold streams in which it is frequently taken in enormous numbers. Records are available for the following: Arkansas, Colorado, Idaho, Illinois, Indiana, Kentucky, Michigan, Missouri, Montana, New Hampshire, New York, North Carolina, Ohio, Oklahoma, Ontario, Pennsylvania, Saskatchewan, Tennessee, West Virginia, Wisconsin and Wyoming.

Illinois Records.—Apple River Canyon State Park: May 24, 1940, H. H. Ross, 1 pupa; June 6, 1940, Mohr & Burks, 1♀. Momence: June 4, 1932, Frison & Mohr, 1♀.

HYDROPSYCHIDAE

Unquestionably this family is the most abundant caddis fly group in Illinois. Not only is our fauna rich in species, but various species of Hydropsychidae form the most abundant faunal element in most of the rivers and streams. This same condition holds true for almost the entire Corn Belt. By far the largest genus is *Hydropsyche.* Next comes *Cheumatopsyche*; then the remaining genera contain at the most a few species each.

The adults are diverse in size, shape and numerous structural characteristics. Both sexes have five-segmented maxillary palpi. All genera lack scutal warts, ocelli and preapical spurs on the front tibiae.

The larvae of all genera are remarkably uniform in habits and appearance. They are wormlike, active and pugnacious, and possess rows of bushy abdominal gills, fig. 281. They prefer the more rapid locations in streams, usually being concentrated around riffles, spillways and rapids, although they may also be found wherever there is an appreciable current. They make a retreat under and about trash, logs, stones and any other haven. In front of this retreat they build a net which is reputed to strain food from the flowing water, fig. 4. For

Fig. 281.—*Hydropsyche simulans*, larva.

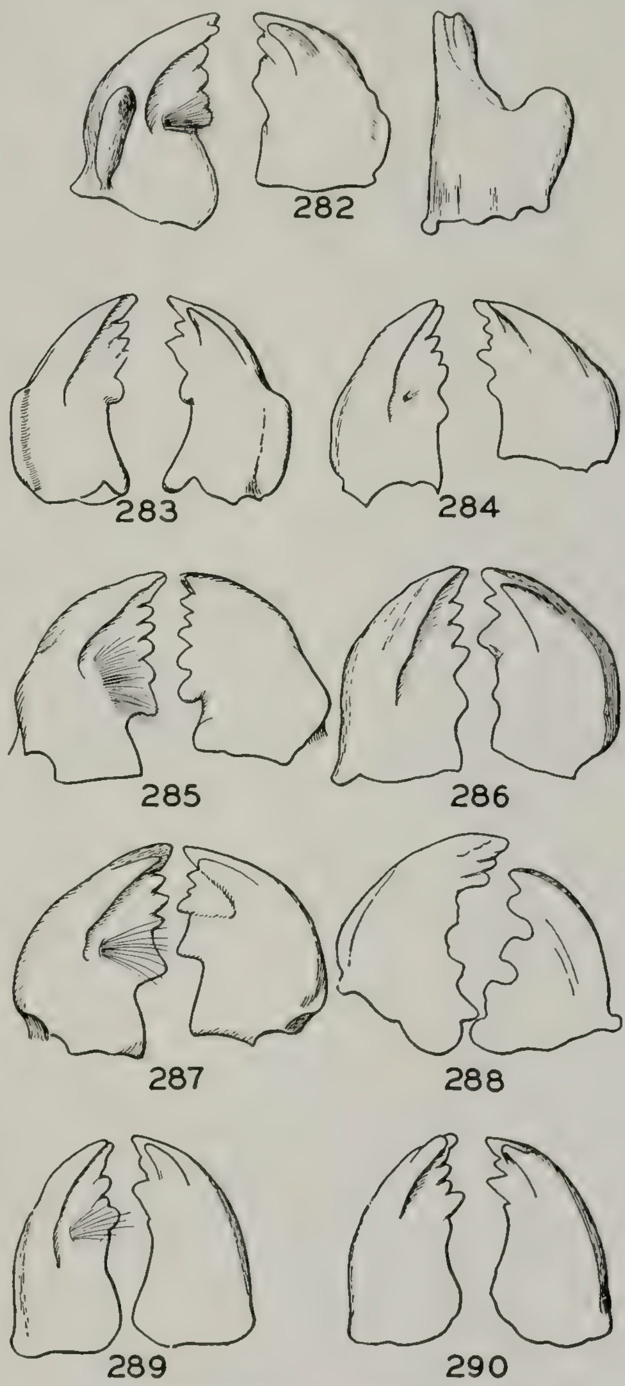
pupation they spin an ovoid cocoon near the retreat, generally using sand, stones and bits of trash.

Characters of both mature and immature stages show no real benefit to be derived by dividing this family in subfamilies. Because it simplifies the keys to treat the entire family as a unit with no established groupings and combinations of genera to follow, subfamily treatment has been disregarded.

KEY TO GENERA

Larvae

1. Head with a broad, flat dorsal area set off by an extensive arcuate carina, fig. 415. . . . **Macronemum,** p. 114
   Head without a dorsal area set off by a carina, fig. 304. 2
2. Left mandible with a high thumblike, dorso-lateral projection, fig. 282. . . . . **Genus A,** p. 83
   Left mandible without a dorso-lateral projection, at most with a carina, fig. 283. 3
3. Stridulator of front leg forked, fig. 291 4
   Stridulator of front leg not forked, fig. 292. 5
4. Prosternal plate with a pair of posterior sclerites, fig. 293. Basal tooth of mandibles single, fig. 284. . . . . **Hydropsyche,** p. 86
   Prosternal plate without a pair of sclerites posterior to it, fig. 294. Basal tooth of mandibles double, fig. 285. . . . . . **Cheumatopsyche,** p. 108
5. Gula rectangular and long, separating genae completely, fig. 296; each branched gill with all its branches arising at top of basal stalk, fig. 298. 6
   Gula triangular and short, genae therefore fused for most of their length,



Hydropsychidae Larvae, Mandibles

Fig. 282.—*Hydropsychid Genus A.*
Fig. 283.—*Potamyia flava.*
Fig. 284.—*Hydropsyche cheilonis.*
Fig. 285.—*Cheumatopsyche campyla.*
Fig. 286.—*Diplectrona modesta.*
Fig. 287.—*Smicridea fasciatella.*
Fig. 288.—*Macronemum zebratum.*
Fig. 289.—*Parapsyche cardis.*
Fig. 290.—*Arctopsyche grandis.*

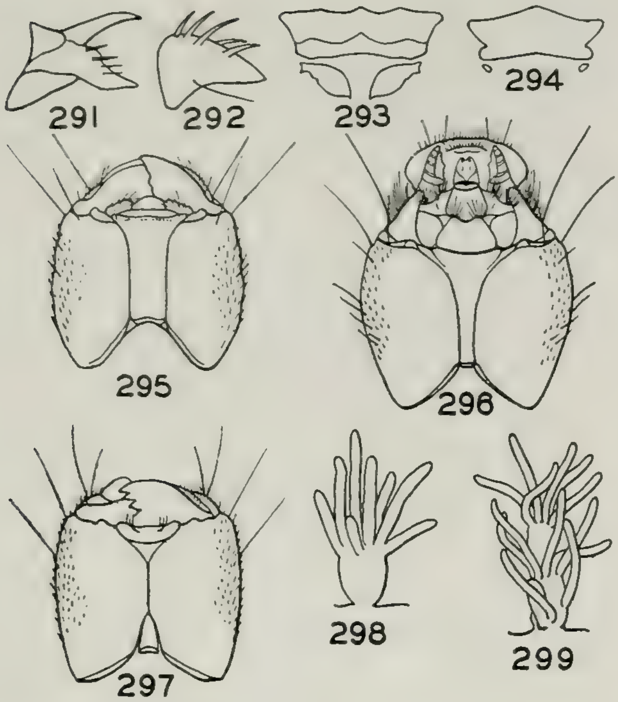


Fig. 291.—*Hydropsyche cheilonis* larva, stridulator of front leg.

Fig. 292.—*Smicridea fasciatella* larva, stridulator of front leg.

Fig. 293.—*Hydropsyche cheilonis* larva, prosternal plates.

Fig. 294.—*Cheumatopsyche campyla* larva, prosternal plates.

Fig. 295.—*Parapsyche cardis* larva, head, ventral aspect.

Fig. 296.—*Arctopsyche* sp. larva, head, ventral aspect.

Fig. 297.—*Diplectrona modesta* larva, head, ventral aspect.

Fig. 298.—*Parapsyche cardis* larva, gill with terminal branches.

Fig. 299.—*Diplectrona modesta* larva, gill with terminal branches.

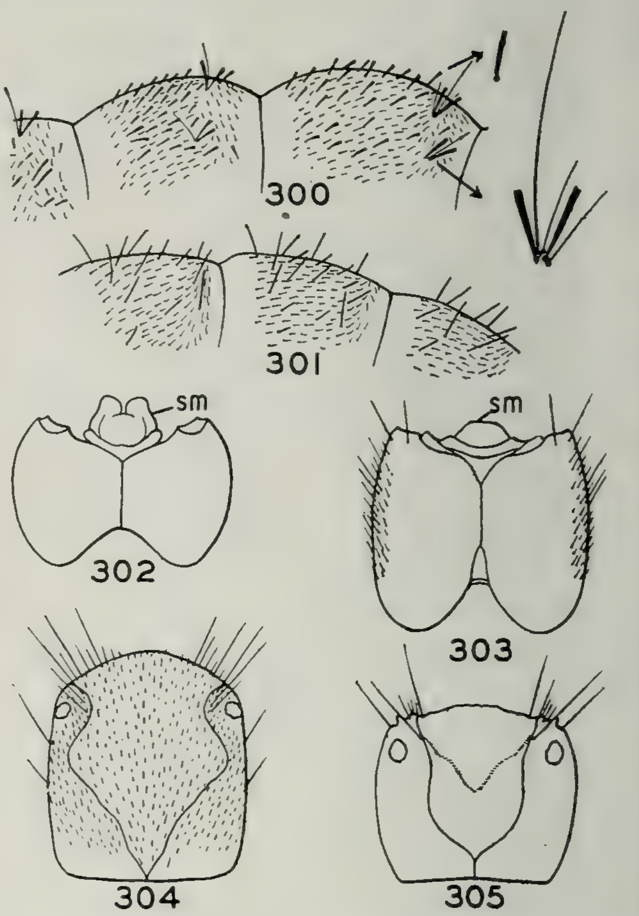


Fig. 300.—*Parapsyche cardis* larva, portion of abdomen.

Fig. 301.—*Arctopsyche* sp. larva, portion of abdomen.

Fig. 302.—*Potamyia flava* larva, submentum (sm).

Fig. 303.—*Diplectrona modesta* larva, submentum (sm).

Fig. 304.—*Diplectrona modesta* larva, head, dorsal aspect.

Fig. 305.—*Smicridea fasciatella* larva, head, dorsal aspect.

fig. 297; each branched gill with branches arising from both sides and top of basal stalk, fig. 299 7

6. Gula rectangular and of even width, fig. 295; abdomen with stout, short, black, scalelike hairs arranged in tufts along dorsum near sides, frequently with broad scales scattered between them, fig. 300 .... **Parapsyche,** p. 83

   Gula narrowed posteriorly, fig. 296; abdomen without distinct setal tufts, with coarse hairs of varying lengths, some of them scalelike but narrow and long, fig. 301 .... **Arctopsyche,** p. 83

7. Mandibles with winglike dorso-lateral flanges along basal half, fig. 283; submentum cleft, fig. 302 .... **Potamyia,** p. 85

   Mandibles without distinct dorso-lateral flanges, fig. 286; submentum sub-conical, not cleft, fig. 303 8

8. Frons expanded laterad, its lateral extensions sharp, fig. 304 .... **Diplectrona,** p. 84

   Frons not expanded laterad, its lateral extensions scarcely produced, fig. 305 .... **Smicridea,** p. 85

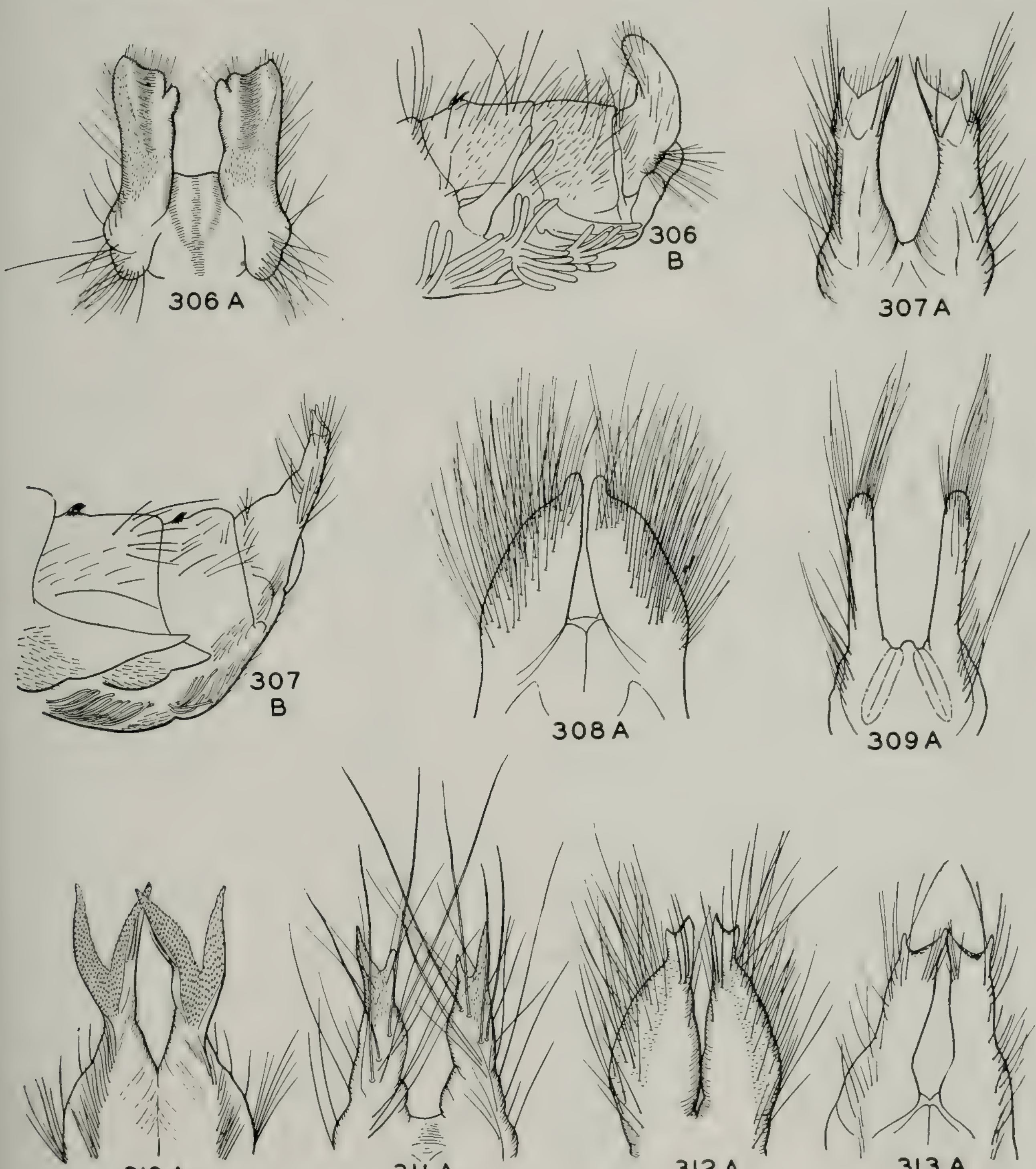
Pupae

N. B.—In connection with this key, characters of the mandibles should be used for checking identifications, fig. 316.

1. Apical processes sharply recurved, fig. 306*B*, excavated along caudo-ventral aspect and tip without points, fig. 306 .... **Parapsyche,** p. 83

   Apical processes not recurved, fig. 307, either not excavated along caudo-ventral aspect or with tip bifid 2

2. Apical processes rounded at apex, not bifurcate, figs. 308, 309 3
   Apical processes bifurcate at apex, figs. 310–313 4
3. Apical processes flat, wide and appressed, hairy along lateral and dorsal margins, fig. 308; second hook-bearing plate of third segment narrow and linear . . . . **Macronemum**, p. 114
   Apical processes finger-like and widely separated, hairy chiefly at apex, fig. 309; second hook-bearing plate of third segment ovoid . . . . **Smicridea**, p. 85
4. Tips of apical processes very long and sharp, fig. 310 . . . . . **Diplectrona**, p. 84



Apical Processes of Pupae

A, caudo-ventral aspect; *B*, lateral aspect.

Fig. 306.—*Parapsyche cardis.*
Fig. 307.—*Hydropsyche simulans.*
Fig. 308.—*Macronemum zebratum.*
Fig. 309.—*Smicridea fasciatella.*
Fig. 310.—*Diplectrona modesta.*
Fig. 311.—*Arctopsyche* sp.
Fig. 312.—*Potamyia flava.*
Fig. 313.—*Cheumatopsyche campyla.*

Tips of apical processes not so long or sharp, figs. 311, 312. 5


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Fig. 314.—*Cheumatopsyche campyla* pupa, hook-bearing plate 3P.

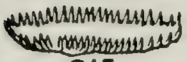
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Fig. 315.—*Hydropsyche orris* pupa, hook-bearing plate 3P.

5. Apical processes with a group of 3 or 4 long, stout spines and with mesal point much shorter than lateral point, fig. 311. . . . . . **Arctopsyche,** p. 83
   Apical processes without such a group of spines and with mesal point as long as or longer than lateral point, fig. 307. 6
6. Apical processes with base large and inflated, apex short and narrow, fig. 312. . . . . **Potamyia,** p. 85
   Apical processes fairly uniform in

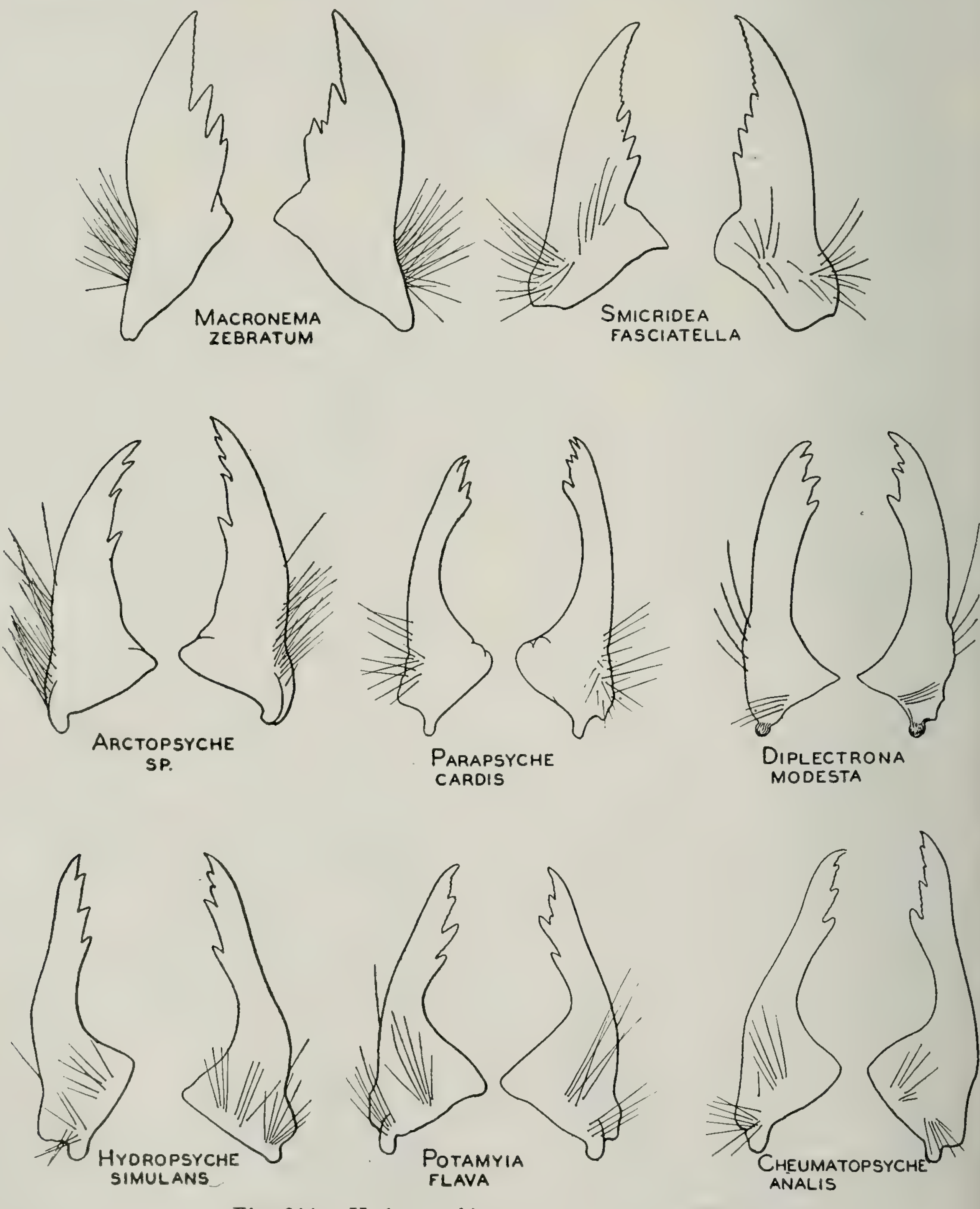


Fig. 316.—Hydropsychidae, pupal mandibles.

width, apex not narrowed, figs. 307, 313 7

7. Third abdominal tergite with posterior plates ovoid, fig. 314 .... **Cheumatopsyche**, p. 108

Third abdominal tergite with posterior plates long and linear, fig. 315 .... **Hydropsyche**, p. 86

Adults

1. Head with anterior warts large and swollen, posterior warts much smaller, fig. 317; slender species with very long antennae and with pictured wings, fig. 420 .... **Macronemum**, p. 114

Head with anterior warts small or indistinct, posterior warts large, figs. 318–320 2

2. Front wings with R_4 and R_5 running very close together at base and forming a long, narrow V, fig. 330 .... **Smicridea**, p. 85

Front wings with R_4 and R_5 separating rapidly at base and not running close together, figs. 331–334 3

3. Hind wings with apex round and with Sc and R_1 bowed deeply at apex, fig. 331 .... **Diplectrona**, p. 84

Hind wings either with Sc and R_1 not markedly bowed, fig. 333, or both wings with apical margin incised, fig. 332 4

4. Second segment of maxillary palpi distinctly shorter than third segment, fig. 322 5

Second segment of maxillary palpi as long as or longer than third segment, fig. 323 8

5. Genitalia with aedeagus and claspers (males) 6

Genitalia without aedeagus or claspers (females) 7

6. Eighth segment with sternite forming a short, wide projection extending under genital capsule .... **Parapsyche**, p. 83

Eighth segment with sternite not projecting under genital capsule .... **Arctopsyche**, p. 83

7. Middle tibiae with basal two-thirds almost cylindrical, fig. 324 .... **Parapsyche**, p. 83

Middle tibiae greatly widened and flattened, fig. 325 .... **Arctopsyche**, p. 83

8. Front tibiae without apical spurs, fig. 326 .... **Potamyia** ♂, p. 85

Front tibiae with well-developed spurs, fig. 327 9

9. Eyes situated distinctly forward from posterior margin of head, figs., 318, 319; front and hind wings similar in shape, figs. 332, 333 10

Eyes situated at or near posterior margin of head, fig. 320; front wings

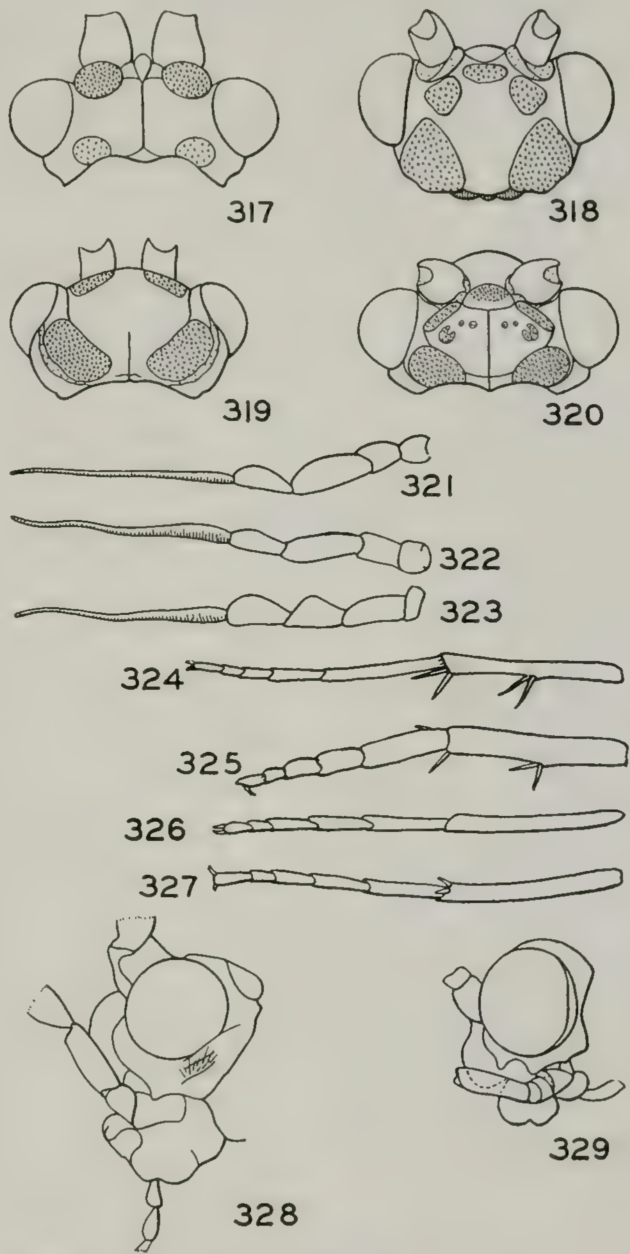


Fig. 317.—*Macronemum zebratum*, head.
Fig. 318.—*Oropsyche howellae*, head.
Fig. 319.—*Aphropsyche aprilis*, head.
Fig. 320.—*Potamyia flava*, head.
Fig. 321.—*Macronemum zebratum*, maxillary palpus.
Fig. 322.—*Arctopsyche lagodensis*, maxillary palpus.
Fig. 323.—*Hydropsyche betteni*, maxillary palpus.
Fig. 324.—*Parapsyche elsis* ♀, middle tibia.
Fig. 325.—*Arctopsyche lagodensis* ♀, middle tibia.
Fig. 326.—*Potamyia flava* ♂, front tibia.
Fig. 327.—*Potamyia flava* ♀, front tibia.
Fig. 328.—*Potamyia flava* ♀, head.
Fig. 329.—*Cheumatopsyche campyla*, head.

narrow with straight hind margin, much different in shape from hind wings, which have the hind margin arcuate, fig. 334.................. 11

10. Both wings with apical margins incised; front wings with first fork of R_s as far basad as first fork of M, fig. 332.............**Oropsyche,** p. 83

 Both wings with apical margins evenly rounded; front wings with first fork of R_s distad of first fork of M, fig. 333...............**Aphropsyche,** p. 83

11. Malar space wide, fig. 328; flagellum with first two segments partly or completely fused, fig. 328; body and wings straw color with tawny or light brown on dorsum.......... ....**Potamyia** ♀, p. 85

 Malar space narrow, fig. 329; flagellum with first two segments always separated by a distinct annular suture; body and wings darker, wings either dark or irrorate, figs. 392, 393..... 12

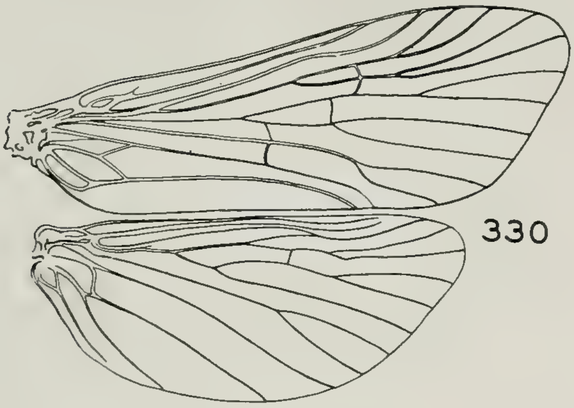
12. Males.............................. 13

 Females............................ 14

13. Base of aedeagus cylindrical, figs. 358–383..............**Hydropsyche,** p. 86

 Base of aedeagus bulbous, figs. 394–403.........**Cheumatopsyche,** p. 108

14. Sternal plates of eighth segment separated to base of segment, fig. 391 ....**Cheumatopsyche,** p. 10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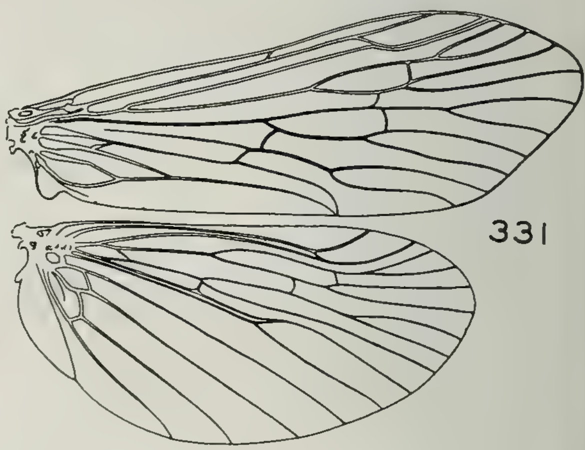
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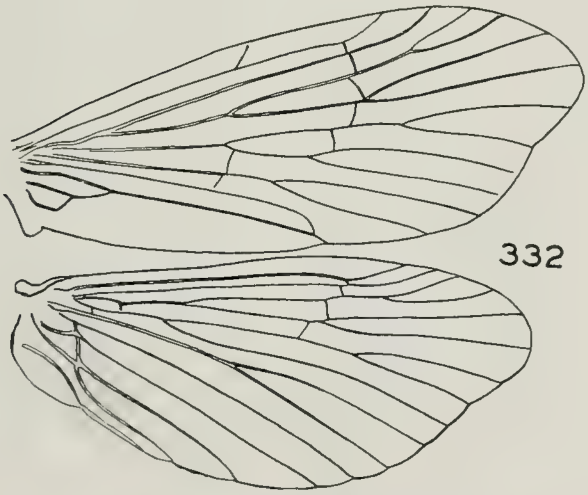
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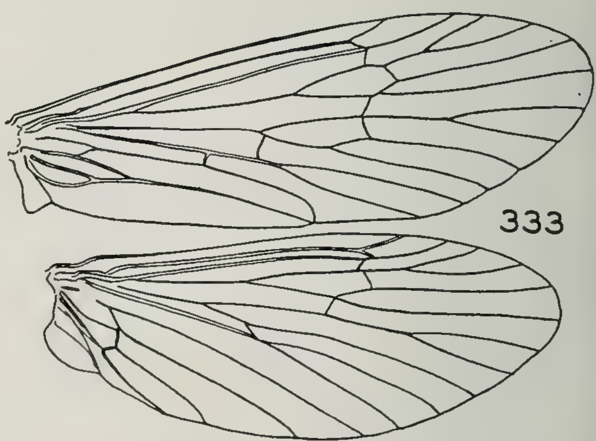
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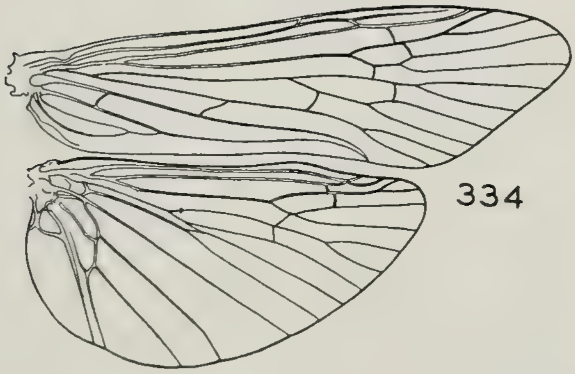
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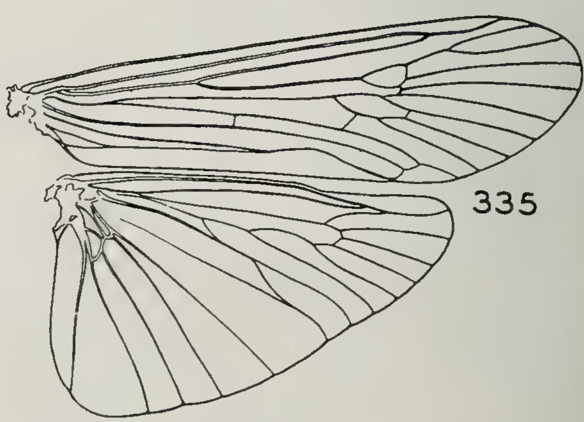
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Hydropsychidae Wings

Fig. 330.—*Smicridea fasciatella.*
Fig. 331.—*Diplectrona modesta.*
Fig. 332.—*Oropsyche howellae.*
Fig. 333.—*Aphropsyche aprilis.*
Fig. 334.—*Hydropsyche simulans.*
Fig. 335.—*Macronemum zebratum.*

Sternal plates of eighth segment separated only two-thirds distance to base of segment, fig. 390 .... **Hydropsyche,** p. 86

Parapsyche Betten

Parapsyche Betten (1934, p. 181). Genotype, monobasic: *Arctopsyche apicalis* Banks.

No species of this genus have been recorded from Illinois. Two species, *apicalis* and *cardis*, are recorded from the eastern states.

Arctopsyche McLachlan

Arctopsyche McLachlan (1868, p. 300). Genotype, monobasic: *Aphelocheira ladogensis* Kolenati.

As with the preceding, no species of this genus have been taken in Illinois. Two eastern species, *ladogensis* and *irrorata*, have been recorded from the eastern states and eastern Canada.

Oropsyche Ross

Oropsyche Ross (1941*b*, p. 79). Genotype, by original designation: *Oropsyche howellae* Ross.

This primitive genus has not yet been taken from Illinois and is known only from the genotype, described from North Carolina. The distinctive genitalia, fig. 336, will serve to verify identifications of this species.

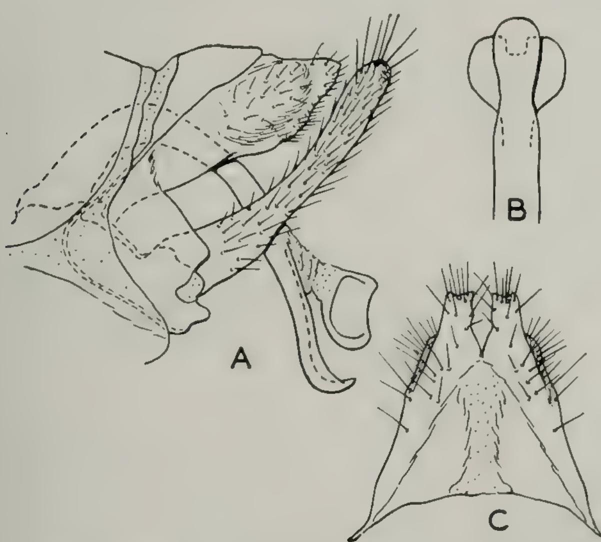


Fig. 336.—*Oropsyche howellae*, male genitalia. *A*, lateral aspect; *B*, aedeagus, ventral aspect; *C*, tenth tergite.

Aphropsyche Ross

Aphropsyche Ross (1941*b*, p. 78). Genotype, by original designation: *Aphropsyche aprilis* Ross.

Only one species of this genus is known, the genotype, described from Tennessee. The male genitalia, fig. 337, are distinctive.

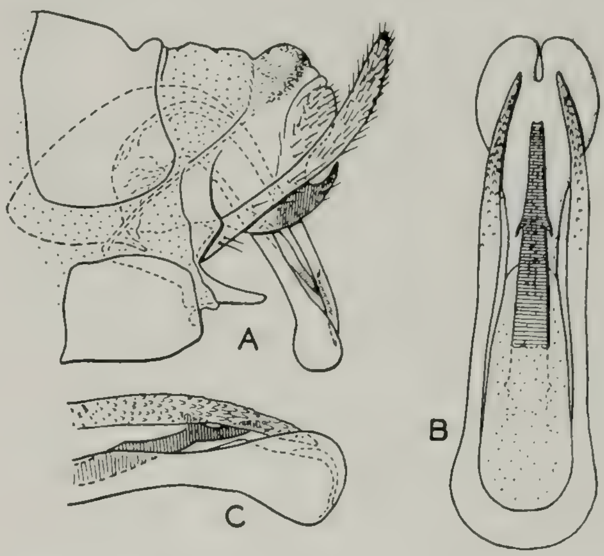


Fig. 337.—*Aphropsyche aprilis*, male genitalia. *A*, lateral aspect; *B* and *C*, aedeagus, dorsal and lateral aspects.

Although we have no definite adult record for this species in Illinois, there is considerable suspicion that the larva of the genotype might be *Genus A* described below. This larva was found in the stream at Parksville, Tennessee, along which the type series of the genotype was collected.

Hydropsychid Genus A

LARVA.—Fig. 338. Head bright brownish yellow with a few darker suffusions along the frontal area; thoracic shields and legs brownish yellow with irregular darker markings. Head with gula small and triangular, frontal area without prominent carinae; mandibles stout, fig. 282, the left

Fig. 338.—*Hydropsychid Genus A*, head.

one much larger than the right, with a large dorsal projection from the lateral margin, this projection somewhat thumb shaped and very high; a single brustia is present; and the row of teeth is even. The right mandible has only a slight flange on the dorsal lateral portion, a large tooth dorsad of the regular series, the regular series itself composed of three or four irregular teeth.

ADULTS.—Unknown.

Larvae of this distinctive form have been taken in small numbers at the mouth of Union Spring, a small underground river in the Ozark Hills near Alto Pass, Illinois, as well as at Parksville, Tennessee (see *Aphropsyche aprilis*). Efforts to rear this species have so far been unsuccessful, but such a large proportion of the genera of the Hydropsychidae are known that there seems good likelihood of this species proving to belong to one of the rare primitive genera such as *Aphropsyche.*

Diplectrona Westwood

Diplectrona Westwood (1840, p. 49). Genotype, by original designation: *Hydropsyche flavo-maculata* Stephens *nec* Pictet = *Diplectrona felix* McLachlan.

Only a single species of this genus occurs in Illinois. In addition to this one species, *californica* is known from the western states, and another species, *doringa*, has been described from New Hampshire. Dr. Milne informs me that the holotype of the latter may be lost; hence no diagnosis of the genitalia can be given.

Diplectrona modesta Banks

Diplectrona modesta Banks (1908*b*, p. 266); ♂, ♀.

LARVA.—Length 15 mm. Color of head, thoracic shields, and legs dark reddish brown to almost black; if reddish brown, the head has several indistinct darker markings. Head convex, frons sharply widened at middle, fig. 304. Mandibles sharp and stocky without lobes on the lateral margin, and with the teeth of both mandibles irregular in size, fig. 286. Abdomen with a mixture of short, appressed pubescence and erect, flattened hairs; each segment has in addition two pairs of tufts of a few long, slender hairs.

ADULTS.—Length 12–14 mm. Color of head, body and wings dark brown with a reddish tinge, the wings without mottling or pattern. Male genitalia composed of quite simple parts, fig. 339: tenth tergite divided into a mesal and a lateral pair of lobes; claspers with basal segment very long, apical segment short and narrow; aedeagus tubular and curved, with sharp sclerites set in the apex.

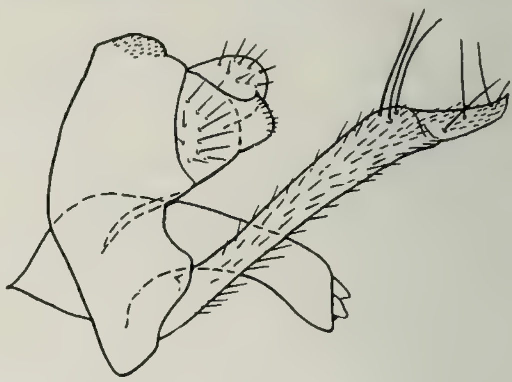


Fig. 339.—*Diplectrona modesta*, male genitalia.

We have taken this species commonly in two spring-fed streams in Illinois, one of them at Elgin in the northern part of the state, the other at Alto Pass in extreme southern Illinois. Scanty Illinois collections have been made along other small spring-fed streams, also. The adult emergence is confined to late spring and early summer, May and June. In more northern states adults have been taken as late as July, and in southern states as early as the month of April.

The species ranges throughout the wooded portions of the eastern states and extends through the Ozarks into Oklahoma. Throughout its range it frequents rapid, clear brooks and streams. We have records for Arkansas, Florida, Georgia, Illinois, Indiana, New Hampshire, New York, North Carolina, Oklahoma, Ontario, Pennsylvania, South Carolina, Tennessee and West Virginia.

Illinois Records.—ALTO PASS, Union Spring: May 31, 1938, B. D. Burks, 2 larvae, 1 ♀; May 12, 1939, Burks & Riegel, 1 larva, 1 ♀; May 23, 1939, Ross & Burks, many larvae; May 29, 1939, Burks & Riegel, 1 ♀; May 14, 1940, Mohr & Burks, 3 larvae; May 26, 1940, Mohr & Burks, many larvae, 2 ♂, 2 ♀; May 31, 1940, B. D. Burks, many larvae; June 20, 1940, Mohr & Riegel, 1 ♂. ELGIN, Botanical Gardens: April 19, 1939, Burks & Riegel, 1 larva; May 9, 1939, Ross & Burks, 4 pupae, 3 larvae; May 23, 1939, Burks & Riegel, 2 ♂, 1 ♀, 3 larvae; June 6, 1939, Burks & Riegel, 4 ♂, 3 ♀; June 13, 1939, Frison & Ross, 3 ♂, many larvae; Sept. 19, 1939, Ross & Mohr, 3 larvae. Fountain Bluff: May 14, 1932, Frison, Ross & Mohr, 1 ♀; May 15, 1932, Ross & Mohr, 1 ♀. Oakwood, small tributary Middle Fork River: July 14, 1939, Burks & Riegel, 1 larva. Utica, Split Rock Brook: Feb. 1, 1941, Frison, Ries & Ross, 2 larvae; May 24, 1941, Ross & Burks, 1 ♀.

Smicridea McLachlan

Smicridea McLachlan (1871, p. 134). Genotype, here designated: *Smicridea fasciatella* McLachlan.

This genus has not yet been recorded from Illinois. The genotype has been taken commonly in Texas and Oklahoma and may ultimately be found in southern Illinois. The distinctive larval mandibles, fig. 287, pupal mandibles and apical processes, figs. 309, 316, adult venation, fig. 330, and male genitalia, fig. 340, will readily identify this species. The larvae have been collected in small spring-fed streams in both Texas and Oklahoma. I have found the adults especially abundant in this latter state.

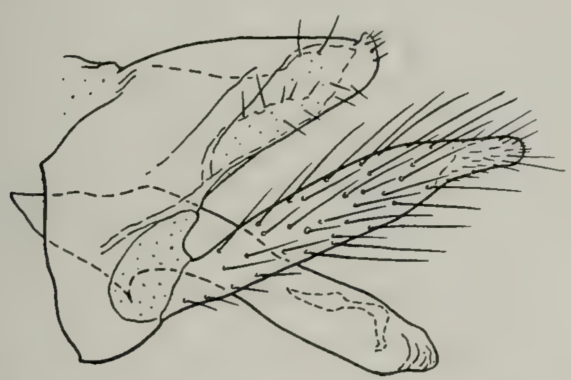


Fig. 340.—*Smicridea fasciatella*, male genitalia.

Potamyia Banks

Potamyia Banks (1900*a*, p. 259). Genotype, by original designation: *Macronema flavum* Hagen.

Only one species of this genus is known. In structure the female is very similar to that of *Hydropsyche*, but the male, larva and pupa are so distinctive that there is no question as to the separate generic status of *Potamyia*.

Potamyia flava (Hagen)

Macronema flavum Hagen (1861, p. 285); ♂.

Hydropsyche kansensis Banks (1905*b*, p. 15); ♀.

Larva.—Length 13 mm. Head, thoracic sclerites and legs brownish yellow, the frontal area of head with a reddish cast, and the thoracic sclerites bordered by a narrow, black line. Frons subtriangular. Mandibles, fig. 283, with long, wide, lateral flanges along basal half. Hair on abdomen short and appressed.

Adults.—Length 10–11 mm. Color almost uniformly light brownish yellow, with a slight pinkish tinge. Male with very long, slender antennae and without spurs on the front tibiae; male genitalia, fig. 341, with simple parts. Female with shorter antennae and normal spurs on front tibiae, in both these respects resembling *Hydropsyche*.

This is one of the most common large-stream to large-river species, not only in Illinois but throughout the Middle West. We have abundant records of the species from all parts of Illinois and have taken it repeatedly in huge swarms along such rivers as the Illinois, Mississippi, Ohio and Rock. The adults begin emerging in May and continue through September.

An interesting feature of the species' habits has been observed in a few small streams where the larvae were accessible. Here it was found that, instead of hiding under the rocks, the larvae tended to frequent less rapid portions of the stream and construct their retreats on top of the rocks. In many of these situations their nets could be seen sticking up into the current like miniature fences.

The range of the species seems to be restricted to midwestern and southern states, with a preference for the larger and slower

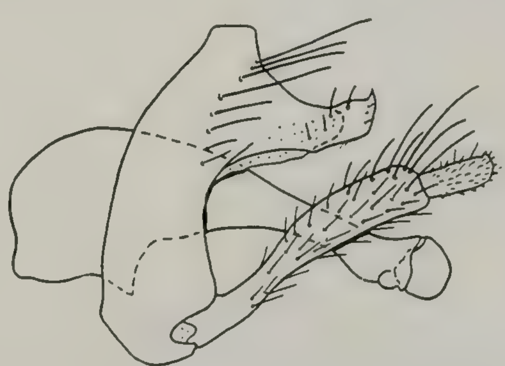


Fig. 341.—*Potamyia flava*, male genitalia.

streams. Records are available for Arkansas, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Ohio, Oklahoma, South Dakota, Tennessee, Texas and Wisconsin.

Illinois Records.—Many males, females and pupae, taken May 6 to October 10, and many larvae, taken April 24 to September 11, are from Alton, Apple River Canyon State Park, Arcola, Aurora, Bath, Cairo, Carbondale, Charleston, Clinton, Como (below mouth of Elkhorn Creek, Rock River), Crystal Lake near Gulfport, Danville (Middle Fork River), Dixon (Rock River), Downs, Dundee, East Dubuque, Effingham, Eichorn, Elgin (Botanical Gardens, Fox River), Elizabethtown, Florence, Fox Lake, Freeport, Fulton, Galena (Sinsinawa River), Gilman, Golconda, Grafton (Mississippi River), Grand Tower, Gulfport (Crystal Lake), Hamilton, Hanover, Hardin (Illinois River), Harrisburg, Harvard, Havana, Henry, Herod, Hillsdale, Homer, Horse Shoe Lake, Jerseyville, Kampsville, Kankakee (Kankakee River), Kappa (Mackinaw River), Keithsburg, Lawrenceville, Le Roy, Massac County, Meredosia, Metropolis, Milan (Rock River), Momence, Monticello, Morris, Mount Carmel, Muncie, New Boston, New Milford (Kishwaukee River), Oakwood (Salt Fork River), Oregon (Castle Rock, Rock River), Oswego, Ottawa, Pere Marquette State Park, Pontiac, Putnam (Lake Senachwine), Quincy (Burton Creek, Mississippi River), Richmond, Ripley (La Moine River), Rockford, Rock Island, Rockton, Rosiclare, Savanna (Mississippi River), Serena (Indian Creek, Fox River), Shawneetown, Shelbyville, South Beloit, Springfield (Sangamon River), Sterling (Rock River), Sugar Grove, Thebes, Urbana, Valley City (Illinois River), Venedy Station (Kaskaskia River), Wadsworth (Des Plains River), Waukegan, Wilmington, Yorkville, Zeigler, Zion.

Hydropsyche Pictet

Hydropsyche Pictet (1834, p. 199). Genotype, here designated: *Hydropsyche cinerea* Pictet.

In Illinois we have taken 18 species of this genus, the various species living in practically every kind of permanent stream in the state. Some are found abundantly in large rivers; others appear restricted to small spring-fed brooks.

The genus contains about 50 species, for a large proportion of which females and larvae have been identified. It is interesting to note that in the *scalaris* group the larvae can be identified with considerable ease, but in the *bifida* group few characters have yet been found by which to identify them. In the females the opposite is true; those of the *scalaris* group present many small complexes in which final specific identification is extremely critical and unreliable, whereas in the *bifida* group reliable specific characters are known for most of the species.

Fine pioneer work outlining diagnostic characters for the females of *Hydropsyche* and *Cheumatopsyche* has been done by Denning (1943). Denning has used the median plate as a source of supplementary characters. Due to the difficulty of seeing this plate in many species, its characters are not used in the present keys, and for information regarding them the student is referred to Denning's work.

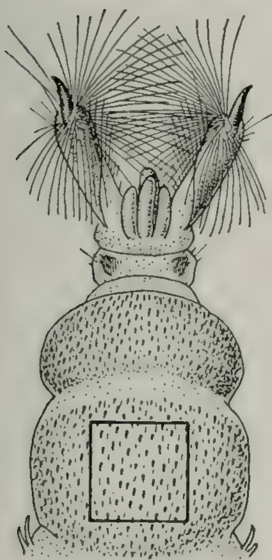
Westwood (1840, p. 49) designated *instabilis* Curtis as the genotype of *Hydropsyche*, but since this name was not included in the original description of the genus, it cannot function as the type species. *H. cinerea* Pictet, an originally included species, is here designated the genotype. Pictet's species *cinerea* is considered a synonym of *instabilis*.

KEY TO SPECIES

Larvae

1. Frons with two short, upturned, stocky "horns" on anterior margin, fig. 346 .... **orris,** p. 106
   Frons without teeth on anterior margin 2
2. Frons with anterior margin produced into a low, wide, angular portion, fig. 347 .... **phalerata,** p. 102
   Frons with anterior margin almost straight 3
3. Head entirely black or blackish brown, including extreme posterior portion, excepting only a small area around eye which is yellowish, fig. 348 .... **betteni,** p. 99
   Head with at least red or yellowish areas leading from eye to posterior part of head or venter, fig. 352; usually with venter or back of head yellowish, figs. 351, 355 4

4. Dorsum of abdomen with wide, short, scalelike hairs mixed with plain hairs, fig. 342, these scales sometimes sparse but usually conspicuous on the sixth, seventh or eighth tergites........................ 5
   Dorsum of abdomen with only narrow, long, scalelike hairs mixed with plain hairs, fig. 344.................... 10



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342 A

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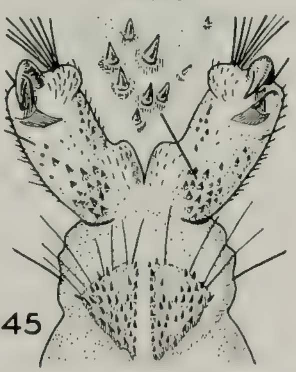

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Fig. 342.—*Hydropsyche simulans* larva, apex of abdomen, dorsal aspect; *A*, enlarged portion of epidermis.

Fig. 343.—*H. arinale* larva.

Fig. 344.—*H. recurvata* larva.

Fig. 345.—*H. aerata* larva, apex of abdomen, ventral aspect.

5. Head chiefly yellow or straw color with a dorsal mark resembling a cross, fig. 349, the surface shining and without short, black hair; base of anal legs with a patch of brown, flat spines, fig. 345.....**aerata,** p. 101
   Head either with more extensive dark markings, fig. 354, or with abundant, short, black hair, or base of anal legs without a patch of spines..... 6
6. Entire dorsum and lateral portion of head bright brownish red, uniform except for a fine pattern of yellowish spots, fig. 350; preclypeus with sclerotized areas at sides, labrum with yellow or pale hair...**cuanis,** p. 100
   Dorsum of head with either a definite pale and yellow pattern, fig. 353, or mostly dark brown; preclypeus without lateral sclerotized areas, labrum usually with pale hair....... 7
7. Scale-hairs sparse on dorsum of abdomen, on sixth segment no more abundant than in fig. 343........ ....**arinale,** p. 104
   Scale-hairs at least as abundant as in fig. 342......................... 8
8. Head with dorsal pattern merging gradually and not contrasting much with ground color, fig. 352........ ....**simulans,** p. 104
   Head with a well-delimited dorsal, dark brown mark contrasting with ground color, figs. 353, 354....... 9
9. Dorsal mark on head wider, extending full width of head, ending in line with eyes, cut off with a sharper and straighter margin, fig. 353; simple hairs on abdomen as dark and conspicuous as scale-hairs...**hageni,** p. 103
   Dorsal mark of head not extending to margin of head, margin irregular, fig. 354; simple hairs on abdomen much lighter than scale-hairs..... ....**frisoni,** p. 105
10. Head mostly black or blackish brown with one or two mesal yellow squares, fig. 355......**slossonae,** p. 99
    Head with a definite checkered pattern, the checks either surrounded by black, fig. 356, or indicated by dark bars on a yellow ground, fig. 357.......**bifida,** p. 97; **bronta,** p. 98; **cheilonis,** p. 98; **recurvata,** p. 99

Adults

1. Genitalia with a prominent aedeagus, fig. 358 (males).................. 2
   Genitalia without an aedeagus, fig. 390 (females).................... 28
2. Aedeagus with a pair of ovoid, dorsal sclerites near apex, figs. 358–367.. 3
   Aedeagus without a pair of ovoid, dorsal sclerites near apex, figs. 368–383.............................. 13
3. Apex of aedeagus with a lateral pair of membranous arms directed basad, fig. 358......................... 4
   Apex of aedeagus with lateral processes sessile or lacking, fig. 361.... 6
4. Aedeagus just basad of dorsal sclerites bearing a dorsal pair of large, stout hooks curved laterad, fig. 358.... ....**walkeri,** p. 96

Aedeagus with a dorsal pair of small hooks, figs. 359, 360 5

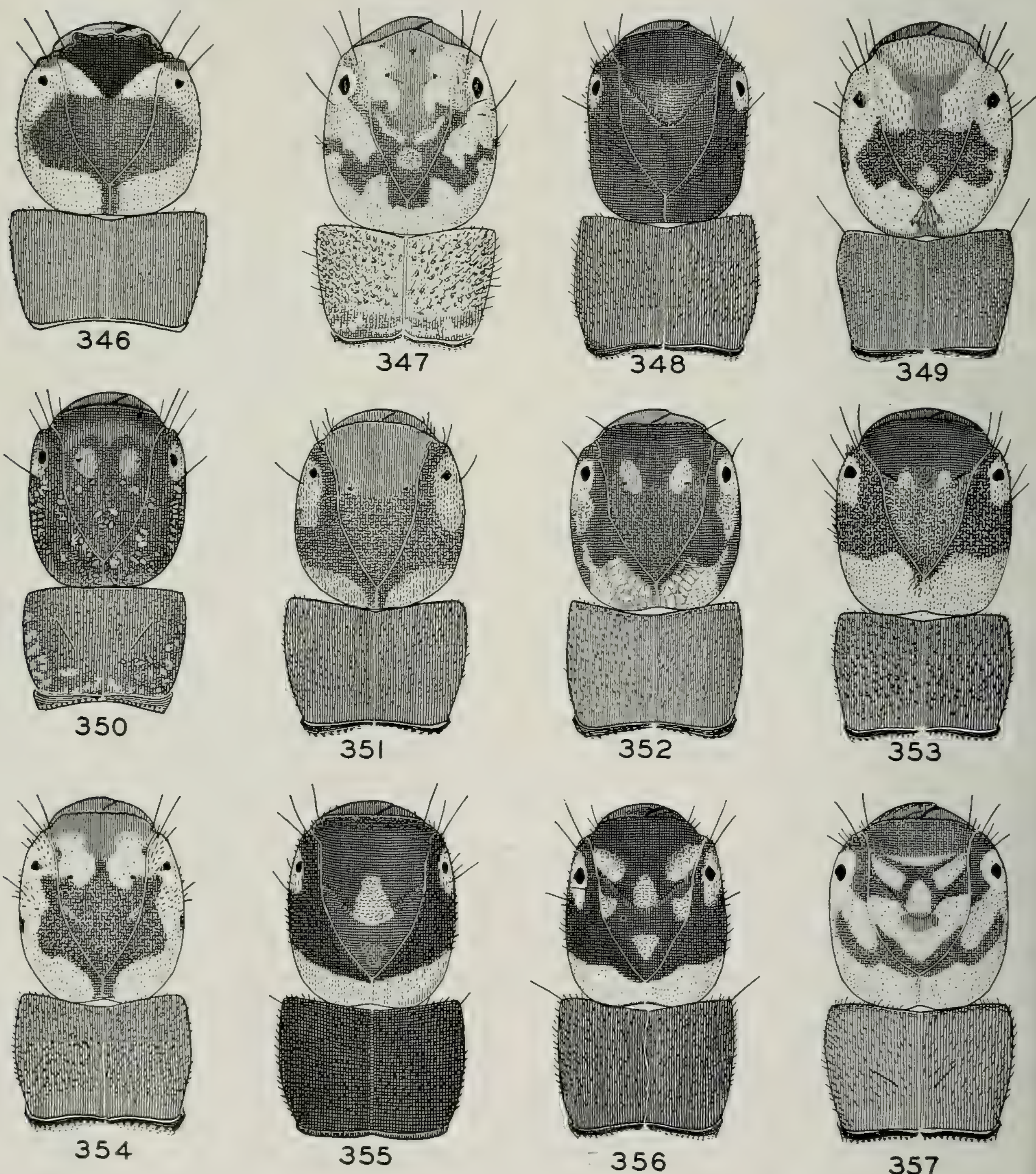
5\. Lateral arms of apex of aedeagus with end containing a protrusible bundle of pale but sclerotized spicules, fig. 359 .... **vexa,** p. 97

Lateral arms of apex of aedeagus with end surmounted by a ring of short setae but without a bundle of spicules, fig. 360 .... **piatrix,** p. 97

6\. Dorso-lateral arms of aedeagus with a conspicuous lateral spine before apex and a bundle of spicules at apex, fig. 361 .... **sparna,** p. 97

Dorso-lateral arms of aedeagus with spine either absent or apical, fig. 362, or arms absent 7

7\. Main body of aedeagus sinuate, almost Z-shaped, fig. 362 .... **slossonae,** p. 99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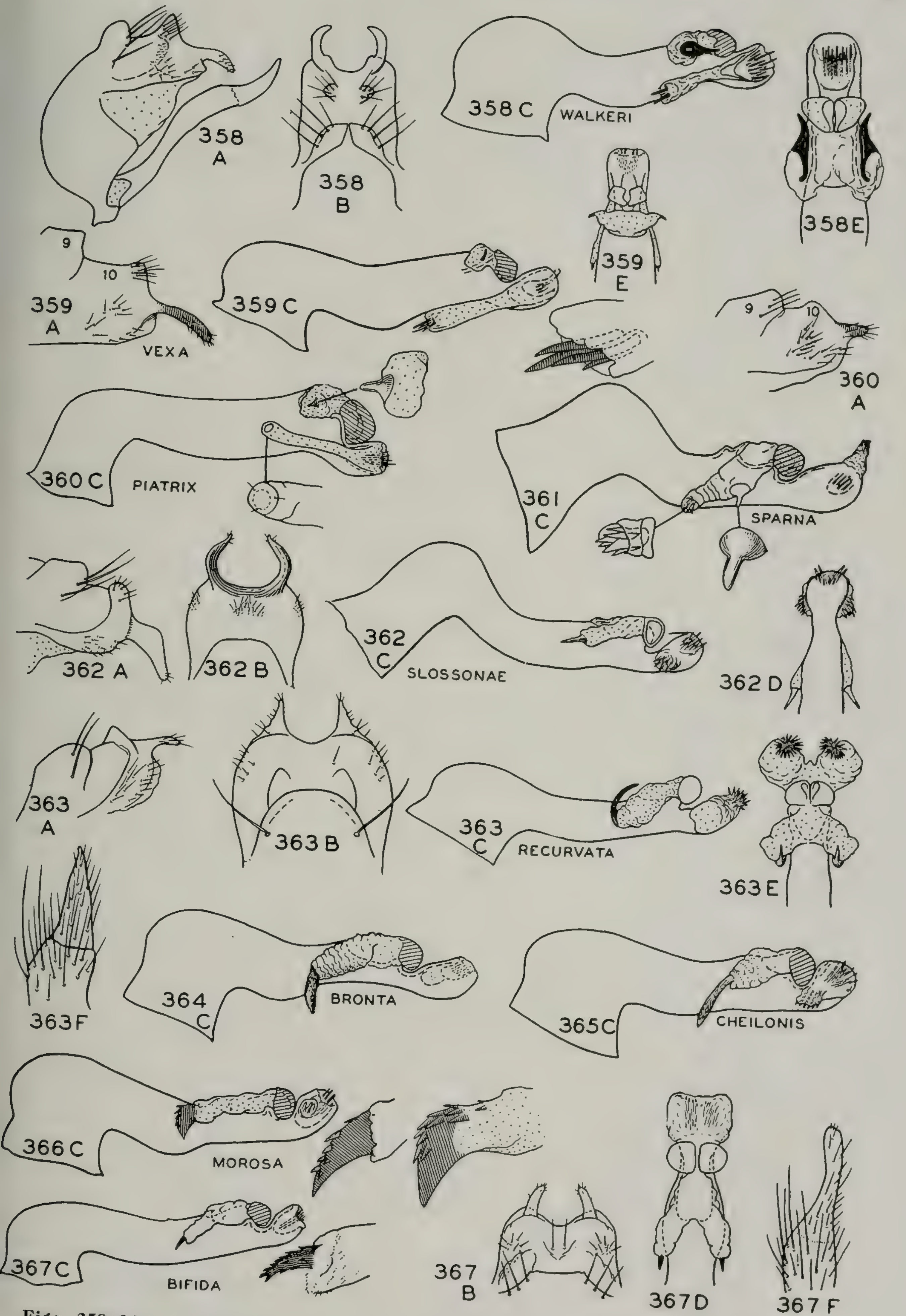
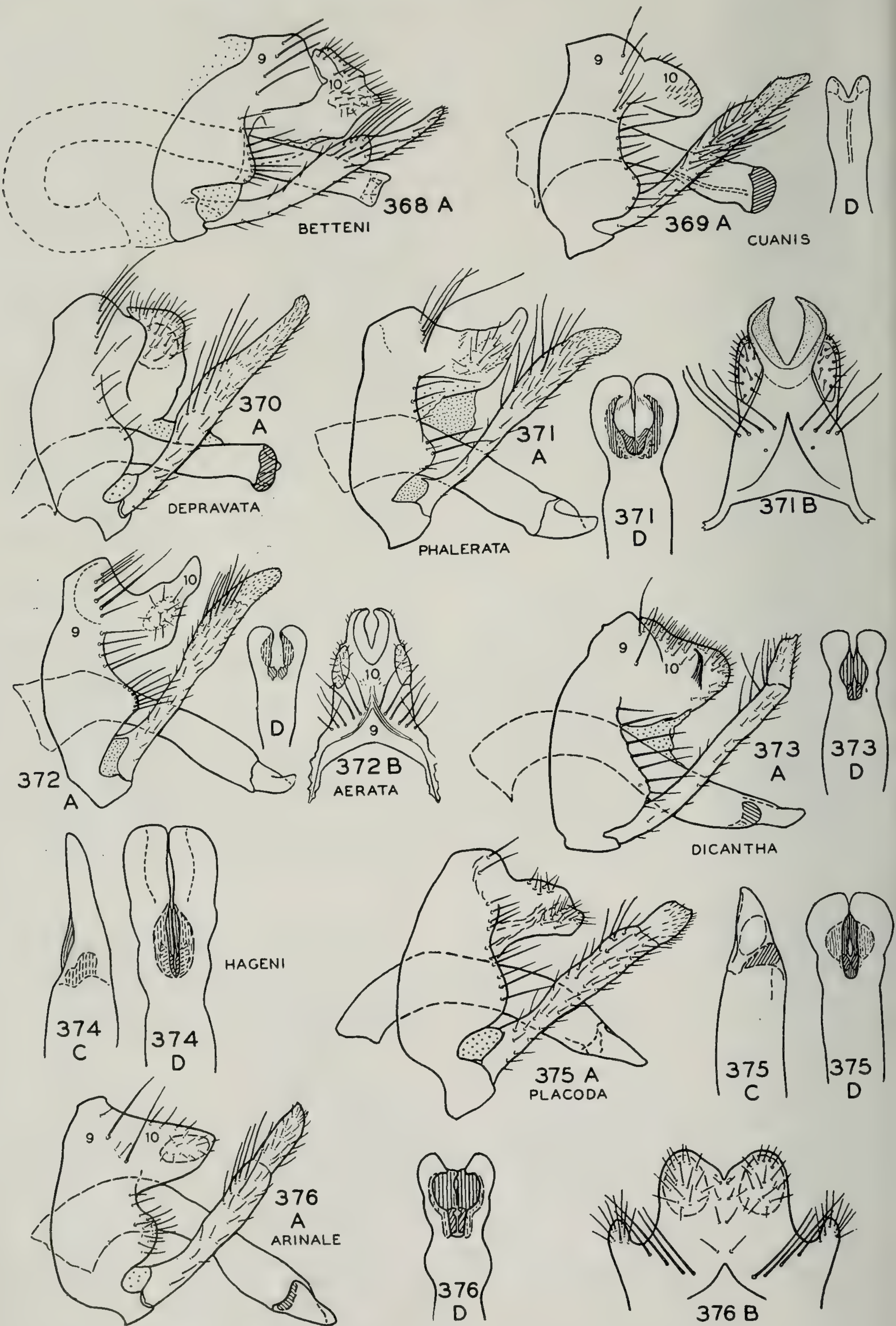
Hydropsyche Larvae, Head and Pronotum

Fig. 346.—*H. orris.*
Fig. 347.—*H. phalerata.*
Fig. 348.—*H. betteni.*
Fig. 349.—*H. aerata.*
Fig. 350.—*H. cuanis.*
Fig. 351.—*H. arinale.*
Fig. 352.—*H. simulans.*
Fig. 353.—*H. hageni.*
Fig. 354.—*H. frisoni.*
Fig. 355.—*H. slossonae.*
Fig. 356.—*H. bifida.*
Fig. 357.—*H. recurvata.*



Figs. 358–367.—*Hydropsyche*, male genitalia. *A*, lateral aspect; *B*, dorsal aspect; *C*, *D* and *E*, respectively, aedeagus, lateral, ventral and dorsal aspects; *F*, apex of clasper.



Figs. 368–376.—*Hydropsyche*, male genitalia. *A*, lateral aspect; *B*, dorsal aspect; *C*, aedeagus, lateral aspect; *D*, aedeagus, ventral aspect.

Main body of aedeagus with only the angle at base pronounced, fig. 363.. 8

8. Lateral arms tipped with an upturned spur, fig. 363.........**recurvata**, p. 99
   Lateral arms tipped with no spur or one that is not upturned.......... 9

9. Spur of lateral arms long, robust and hanging down with tip well below ventral margin of aedeagus, figs. 364, 365........................ 10
   Spur of lateral arms shorter, flat, fig. 366, finger-like, fig. 367, or sometimes absent.................... 11

10. Apex of aedeagus with lateral pockets scarcely extruded and containing only a few weak spicules, fig. 364.. ....**bronta**, p. 98
    Apex of aedeagus with lateral pockets extruded to form a sessile flap containing a cluster of strong, dark spicules, fig. 365......**cheilonis**, p. 98

11. Spur of lateral arms large and flat, as in fig. 366..............**morosa**, p. 98
    Spur of lateral arms small and finger-like, fig. 367, sometimes even smaller or absent...................... 12

12. Apical segment of clasper with apex appearing attenuated, as in fig. 367, seen from side ....**bifida**, p. 97
    Apical segment of clasper conical, its apex appearing pointed, as seen from side, fig. 363....**recurvata**, p. 99

13. Apex of aedeagus round, fig. 369, or truncate, fig. 368................ 14
    Apex of aedeagus produced into a flattened area composed of two lateral processes and a mesal body, figs. 371–383.................... 16

14. Aedeagus curved at base to form a complete semicircle, fig. 368...... ....**betteni**, p. 99
    Aedeagus curved not more than 90 degrees, fig. 370.................. 15

15. Vertical cleft at apex of aedeagus deep and not containing extruded mesal plates, fig. 369..........**cuanis**, p. 100
    Vertical cleft at apex of aedeagus shallower and containing a pair of prominent mesal plates, fig. 370... ....**depravata**, p. 100

16. Apex of tenth tergite turned up and deeply cleft, fig. 371............. 17
    Apex of tenth tergite rounded and at most cleft as deeply as shown in fig. 376......................... 18

17. Apex of aedeagus as wide as stem, without an open area between lateral processes, fig. 371....**phalerata**, p. 102
    Apex of aedeagus narrower than stem, with an open area between lateral processes, fig. 372.......**aerata**, p. 101

18. Tenth tergite armed on each side with a stout, long spine, fig. 373....... ....**dicantha**, p. 102
    Tenth tergite without such a conspicuous spine....................... 19

19. Aedeagus with lateral lobes produced far beyond mesal cavity, fig. 374... ....**hageni**, p. 103
    Aedeagus with lateral lobes produced only slightly beyond mesal cavity.. 20

20. Apical segment of claspers appearing obliquely truncate, from side view, fig. 375...............**placoda**, p. 103
    Apical segment of claspers appearing sinuate, from side view, fig. 376... 21

21. Apex of aedeagus moniliform, fig. 376 ....**arinale**, p. 104
    Apex of aedeagus with only one constriction and that at base......... 22

22. Apex of aedeagus robust and surmounted by a shallow caplike continuation of the basal portion, fig. 377 ....**simulans**, p. 104
    Apex of aedeagus either not surmounted by a "cap" or dorso-ventrally flattened, fig. 380........... 23

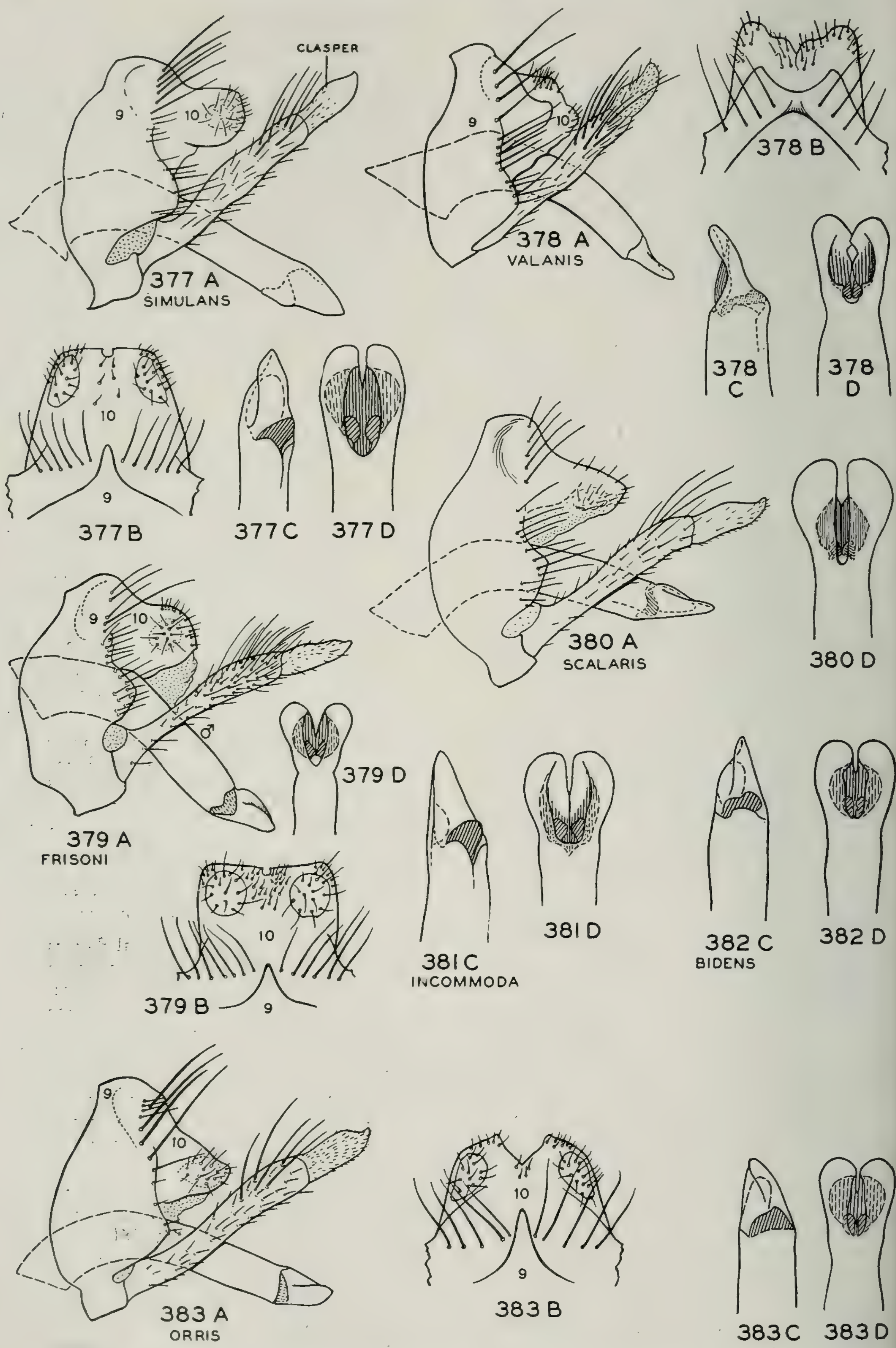
23. Apex of aedeagus with lateral processes thin and long, as in fig. 378.. ....**valanis**, p. 105
    Apex of aedeagus with lateral processes much more robust............... 24

24. Apex of aedeagus with mesal dome elevated above level of lateral flange and also above level of stem and forming a distinct angle with it, fig. 379................**frisoni**, p. 105
    Apex of aedeagus with mesal dome either not elevated above level of lateral flange or confluent with dorsal margin of stem, figs. 380–383... 25

25. Apex of aedeagus with lateral flanges wide, the apical portion of each almost as large as the entire mesal cavity; dorso-lateral edge of flange confluent with dorsal line of stem, fig. 380...............**scalaris**, p. 106
    Apex of aedeagus with lateral flanges narrow, the mesal cavity occupying all of the apex except narrow lateral and apical portions; dorso-lateral edge of flange various........... 26

26. Apex of aedeagus with a long, narrow profile, and with two-thirds of mesal cavity open ventrad, fig. 381...... ....**incommoda**, p. 106
    Apex of aedeagus with a shorter, stockier profile and with mesal cavity only one-third open ventrad...... 27

27. Apex of aedeagus with apico-lateral corners of flange sharp, projecting almost directly posterad and as wide as in fig. 382...........**bidens**, p. 107



Figs. 377–383.—*Hydropsyche*, male genitalia. *A*, lateral aspect; *B*, dorsal aspect; *C*, aedeagus, lateral aspect; *D*, aedeagus, ventral aspect.

Apex of aedeagus with apico-lateral corners of flange blunt, in profile appearing to merge with apex of dome, and narrow, as in fig. 383... ....**orris**, p. 106

28. Eighth tergite with ventral margin concave, the apico-lateral lobe bearing a wide, compact brush of long setae, fig. 384*B*; clasper receptacle appearing deeply invaginated, large and round, especially as seen from dorsal aspect, fig. 385.......... .....**betteni**, p. 99; **depravata**, p. 100

Either ventral margin of eighth tergite with no apico-lateral lobe or only a small brush, fig. 384*A*, or clasper receptacle much smaller or more slender, fig. 387.................... 29

29. Clasper groove not well-marked, clasper receptacle either not evident or appearing from lateral view as only a shallow crescent beneath dorsal cap, fig. 386*A–D*................ 30

Either clasper groove well marked, fig. 387*A*, or clasper receptacle represented by a definite pocket, fig. 387*B–I*, or by an invagination, fig. 386*H–N*, projecting beneath dorsal cap........................... 36

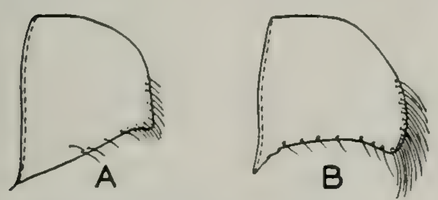


Fig. 384.—*Hydropsyche*, lateral aspect of female eighth tergite. *A*, *bifida*; *B*, *betteni*.

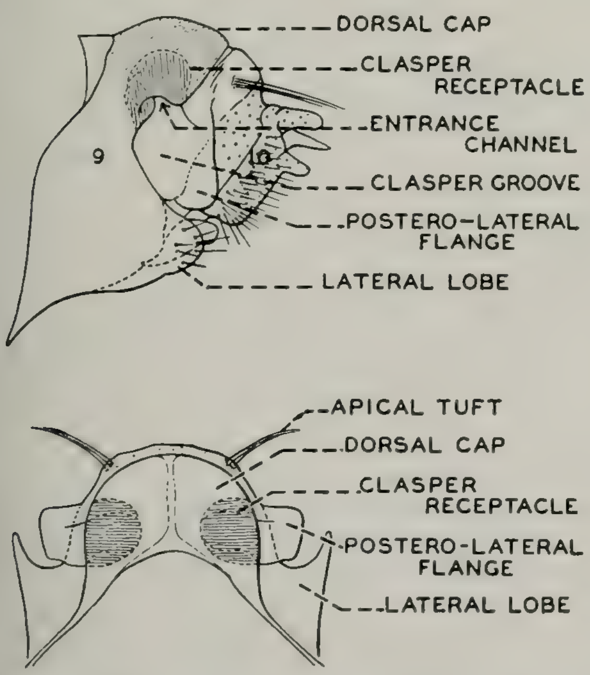


Fig. 385.—*Hydropsyche betteni*, female tergites. Upper figure, lateral view including tenth tergite; lower figure, dorsal view of ninth tergite alone.

30. Ninth tergite with lateral lobe not developed; clasper groove small and very shallow, scarcely any indentation visible beneath dorsal cap from dorsal view, fig. 386*A*............ ....**dicantha**, p. 102

Ninth tergite with lateral lobe distinctly developed, either narrow, fig. 386*K*, or broad, fig. 386*C*; clasper groove well-marked, larger and forming a deep concavity visible beneath dorsal cap from dorsal view 31

31. Clasper groove with a small, distinct pit near dorsal margin, fig. 386*B*... ....**placoda**, p. 103

Clasper groove without a pit........ 32

32. Lateral lobes of eighth sternite with mesal and lateral margins parallel, fig. 388*C*; head and thorax mostly dark purplish brown, basal segments of antennae pale, with only light V-marks, wings without irrorate pattern............**cuanis**, p. 100

Lateral lobes of eighth sternite with mesal margin sloping decidedly laterad toward apex, fig. 388*D*; either body much lighter, wings with irrorate wing pattern or basal segments of antennae with very dark V-marks 33

33. Lateral lobe of ninth tergite thickened at base, triangular in cross section, fig. 386*D*........**hageni**, p. 103

Lateral lobe of ninth tergite thin and leaflike......................... 34

34. Clasper groove, from dorsal view, appearing wider and slightly angulate at middle, fig. 386*E*......... ....**arinale**, p. 104

Clasper groove shallower and evenly rounded, fig. 386*F*, *G*............ 35

35. Clasper groove, from dorsal view, appearing shallower, narrowing more rapidly anteriorly, fig. 386*F*....... ....**phalerata**, p. 102

Clasper groove deeper, the anterior portion wide, fig. 386*G*...**aerata**, p. 101

36. Clasper groove forming a well-marked, curved trough, the upper end of which projects only slightly under dorsal cap, fig. 387*A*.....**walkeri**, p. 96

Clasper groove either indistinct, fig. 386*K*, or running into a pocket-like clasper receptacle, fig. 387*B*...... 37

37. Clasper receptacle forming a wide triangular, crescentic or irregular pocket which is not narrowed ventrad, fig. 386*H–N*............... 38

Clasper receptacle forming a pouch with a narrow ventral opening, fig. 387*B–I*....................... 44

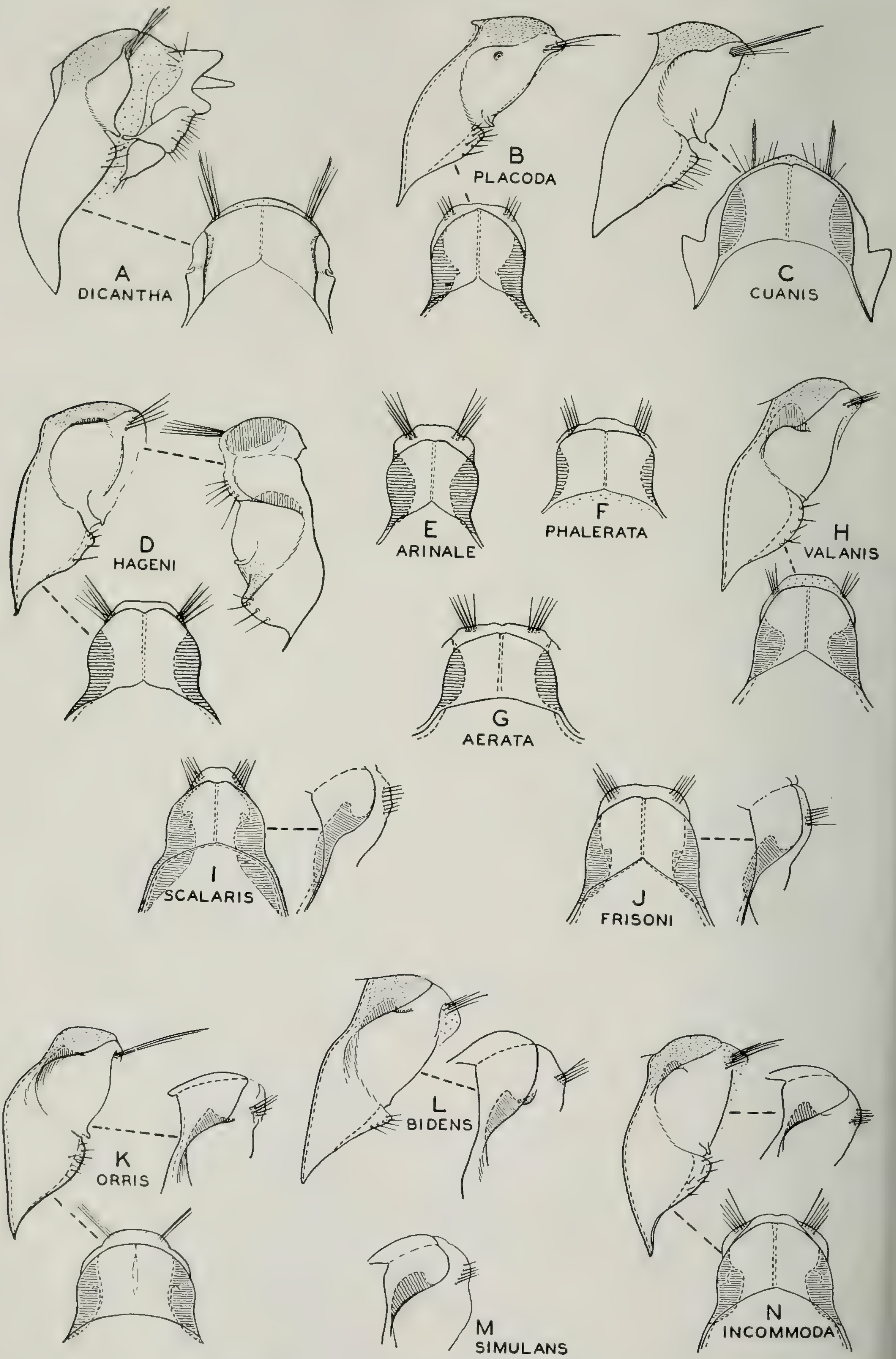


Fig. 386.—*Hydropsyche*, female ninth tergite.

38. Clasper receptacle large, nearly as high as long, fig. 386*H*. . . **valanis,** p. 105
    Clasper receptacle much shallower, but usually wide, fig. 386*K–N*. 39
39. Lateral lobes of eighth sternite close together at base, mesal margins forming a wide V, figs. 389*A*, 390. . . 40
    Lateral lobes of eighth sternite farther apart, their mesal margins diverging less, fig. 389*B*. 41
40. Clasper receptacle appearing, from dorsal view, with a swollen portion basad of dorsal point, fig. 387*I*. . . . . **scalaris,** p. 106
    Clasper receptacle appearing, from dorsal view, with basal portion confluent in outline with dorsal point, fig. 387*J*. . . . . **frisoni,** p. 105
41. Clasper receptacle appearing, from lateral view, with dorsal point acute and near middle, its posterior "tail" slender, long and slightly concave dorsad, fig. 386*K*, *L*. 42
    Clasper receptacle appearing, from lateral view, with dorsal point rounded or near posterior margin and with posterior "tail" consequently short, fig. 386*M*, *N*. 43
42. Antero-lateral lobe of ninth tergite long and narrow, its apex rounded, its contour following its demarcation line, fig. 386*K*. . . . . **orris,** p. 106
    Antero-lateral lobe of ninth tergite narrower at base, wider at apex, which is produced as a somewhat angulate lobe, fig. 386*L*. . . . . **bidens,** p. 107
43. Clasper receptacle with dorso-mesal portion narrow, fig. 386*N*. . . . . **incommoda,** p. 106
    Clasper receptacle with dorso-mesal portion wide and arcuate, with a pronounced posterior loop, fig. 386*M* . . . . **simulans,** p. 104
44. Clasper receptacle nearly globular and small, fig. 387*B*. . . . . **bronta,** p. 98

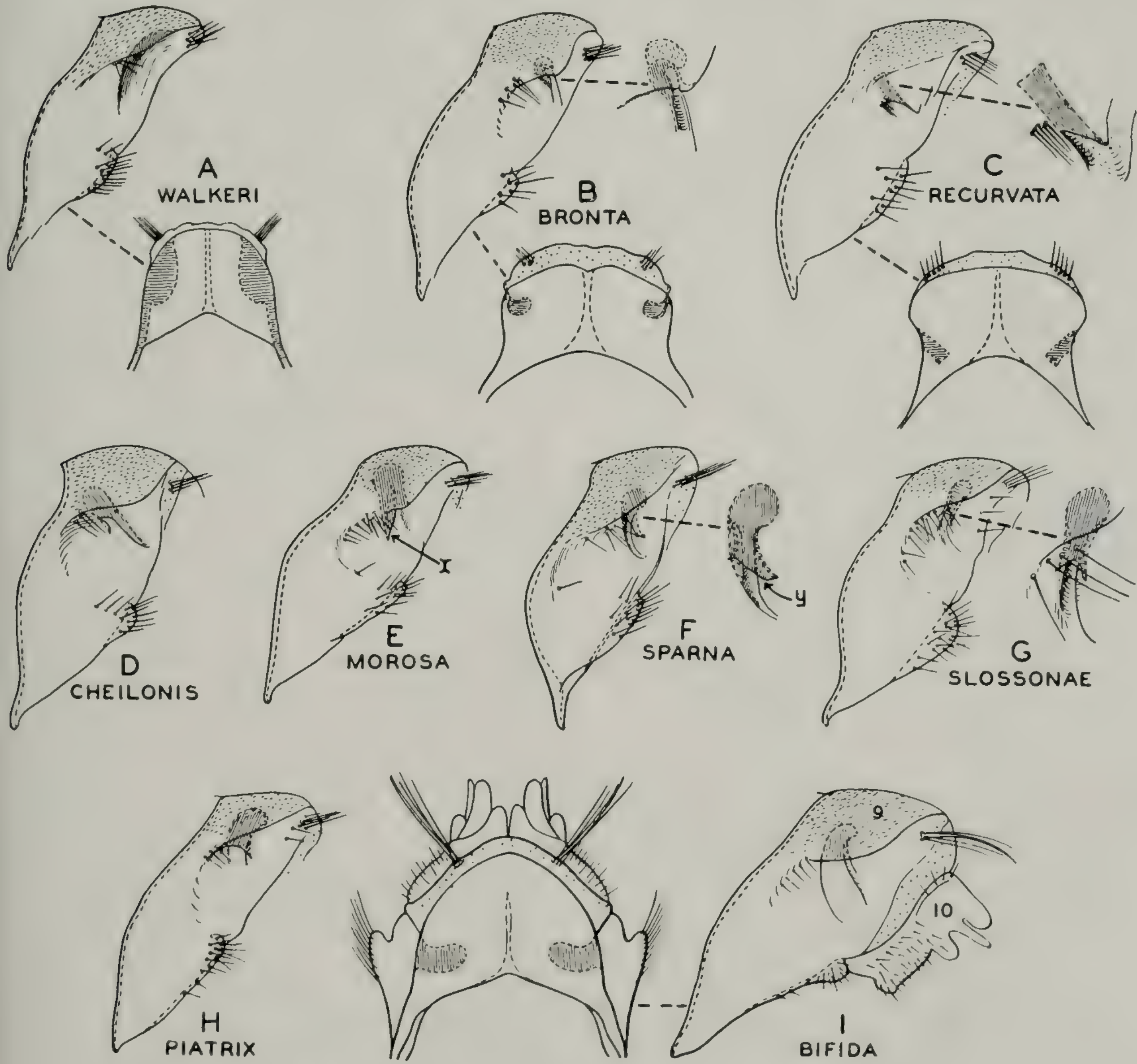


Fig. 387.—*Hydropsyche*, female ninth tergite.

Clasper receptacle tubular, fig. 387*C–I* 45

45. Clasper receptacle directed nearly anterad, diagonal to segment, fig. 387*C*, *D*. 46

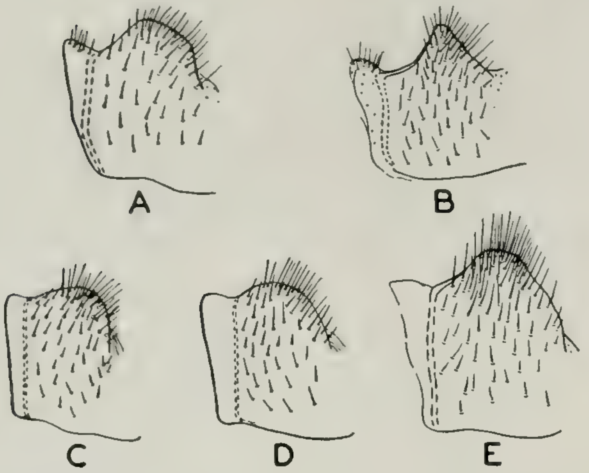


Fig. 388.—*Hydropsyche*, lateral lobe of female eighth sternite. *A*, *bifida*; *B*, *recurvata*; *C*, *cuanis*; *D*, *phalerata*; *E*, *betteni*. This set is drawn at right angles to the face of the lateral lobe.

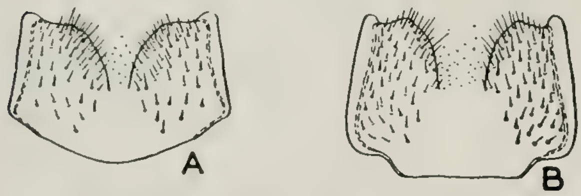
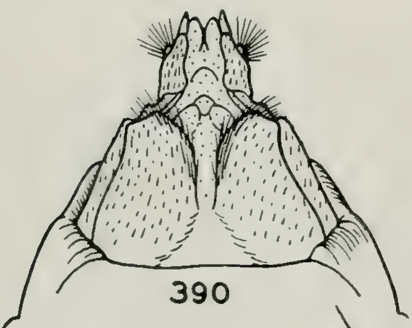


Fig. 389.—*Hydropsyche*, female eighth sternite. *A*, *scalaris*; *B*, *incommoda*.



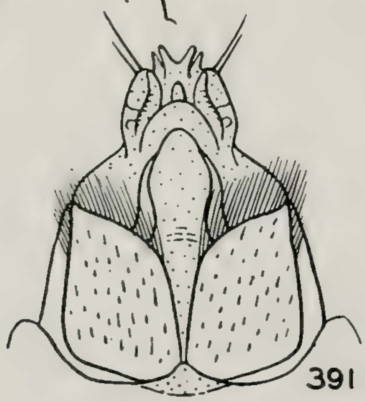


Fig. 390.—*Hydropsyche scalaris*, female genitalia, ventral aspect.

Fig. 391.—*Cheumatopsyche campyla*, female genitalia, ventral aspect.

Clasper receptacle directed or curved dorsad or posterad, fig. 387*E–I*. . . 47

46. Clasper receptacle narrow and truncate at tip, fig. 387*C*. . . . . **recurvata**, p. 99

Clasper receptacle wider and rounded at tip, fig. 387*D*. . . . . . . **cheilonis**, p. 98

47. Clasper receptacle long, the anterior side of its entrance channel with a long, overhanging flange, *x*, fig. 387*E*. . . . . **morosa**, p. 98

Either clasper receptacle much shorter, or the anterior side of entrance channel with only an inconspicuous flange, fig. 387*G*. 48

48. Posterior side of entrance channel to clasper receptacle with a sinuate overhanging flange, *y*, fig. 387*F*. . . . . **sparna**, p. 97

Posterior side of entrance channel with no flange extending down ventral portion. 49

49. Entrance channel reduced to a narrow slit, fig. 387*G*. . . . . **slossonae**, p. 99

Entrance channel much wider, fig. 387*H*, *I*. 50

50. Clasper receptacle long, narrowed and with tip markedly curved, fig. 387*I* . . . . **bifida**, p. 97

Clasper receptacle shorter and more bulbous. 51

51. Clasper receptacle situated near middle of tergite. . . . . **vexa**, p. 97

Clasper receptacle situated along lower edge of posterior side of tergite, fig. 387*H*. . . . . **piatrix**, p. 97

Bifida Group

Hydropsyche walkeri Betten & Mosely

Hydropsyche maculicornis Walker (1852, p. 113); ♂. Preoccupied.

Hydropsyche walkeri Betten & Mosely (1940, p. 23). New name.

To date this species has not been discovered in Illinois, although it may eventually be taken in the northern part of the state. It was originally described from Ontario; we have additional specimens from New York, Quebec and Wisconsin.

FEMALE.—Length 10 mm. In color and general structure similar to male, which in these characters is practically indistinguishable from *bifida*, described below. Female genitalia, fig. 387*A*, with clasper groove well marked, wide and curved at apex, the upper portion of the groove partly invaginated beneath dorsal cap of ninth tergite; lateral lobe long but narrow, with abundant setae; from dorsal view the clasper groove appears as a well-marked posterior swelling.

Allotype, female.—Niagara Falls, New York: June 23, 1941, J. A. Ross. The allotype is one of a mating pair.

Hydropsyche vexa Ross

Hydropsyche vexa Ross (1938*a*, p. 148); ♂.

This species is known only from the states of Minnesota and Wisconsin. As with *Hydropsyche walkeri*, it may ultimately be taken in Illinois. The female genitalia are illustrated by Denning (1943).

Hydropsyche piatrix Ross

Hydropsyche piatrix Ross (1938*a*, p. 148); ♂.

This species has been taken at the mouth of large springs in Missouri and Arkansas, but so far has not been taken in Illinois.

FEMALE.—Length 9 mm. Color and general structure typical for group as described for *bifida* below. Female genitalia, fig. 387*H*, with clasper groove more or less indistinct, leading to the distinct clasper receptacle invaginated under the dorsal cap of the ninth tergite. The receptacle is large, wide and fairly long, slightly swollen dorsad and curving slightly posterad; its ventral opening is wide. Lateral lobe of ninth tergite of moderate length but narrow, with scattered setae.

Allotype, female.—Greer Springs, Missouri: June 7, 1937, H. H. Ross. This is the type locality for the species.

Hydropsyche bifida Banks

Hydropsyche bifida Banks (1905*b*, p. 15); ♂, ♀.

LARVA.—Fig. 356. Length 14 mm. Ground color of head yellow with a dorsal checkerboard pattern; thoracic sclerites light brown, legs brownish yellow; abdomen gray with brown hair. Frons slightly concave, its interior margin straight. Hair of abdomen a combination of slender appressed hair with a few erect, flattened but narrow hairs.

ADULTS.—Length 8–10 mm. Head, thorax and abdomen various shades of brown; legs straw color; antennae alternate bands of straw color and brown; wings with a mottled irrorate pattern resulting in a salt-and-pepper mixture which is slightly checkered. Male genitalia, fig. 367: apical processes of tenth tergite finger-like and round; apical segment of clasper long and slender; aedeagus with dorso-lateral processes tipped with a small short spur; this spur may be absent in some specimens. Female genitalia, fig. 387, with the eighth tergite bearing an apical comb, fig. 384*A*, and with the lobes of the sternite produced, slightly flared ventrad and rather densely haired, fig. 388*A*; ninth tergite as in fig. 387*I*.

This is one of the very common species of *Hydropsyche* in several streams in northern Illinois, in particular the rapid portion of the Rock River, Apple River and Nippersink Creek. To date all our records of the species are confined to the northern fourth of the state. The adults begin emerging early in May and continue through September.

As is common with many other predominantly northeastern species with a wide seasonal emergence, *bifida* has a heavy flight early in the season and a lesser one for the remainder of the summer.

The species has a wide range, appears to be most abundant in the northcentral states, and has not yet been taken east of central New York. Records are available for the following: Colorado, Illinois, Minnesota, New York, Oklahoma, Ontario, Wisconsin and Wyoming.

Illinois Records.—Many males, females and pupae, taken May 10 to August 23, and many larvae, taken June 5 to June 12, are from Amboy (Green River), Apple River Canyon State Park, Dundee, Erie (Rock Creek), Galena, Oregon, Rockford, Rockton, Savanna, Spring Grove (Nippersink Creek), Sycamore (tributary South Kishwaukee River).

Hydropsyche sparna Ross

Hydropsyche sparna Ross (1938*a*, p. 150); ♂, ♀.

This distinctive species has not yet been taken in the state. It has been captured in extreme southwestern Michigan and can be looked for in future collecting in Illinois. It occurs abundantly to the north and east, including Georgia, Michigan, Minnesota, New York, North Carolina, Nova Scotia, Ontario, South Carolina, Virginia and West Virginia.

Hydropsyche morosa Hagen

Hydropsyche morosa Hagen (1861, p. 287); ♂.
Hydropsyche chlorotica Hagen (1861, p. 290); ♂.

LARVA.—Unknown.

ADULTS.—Size, color and general structure identical with *bifida.* Male genitalia, fig. 366, differing from *bifida* chiefly in the aedeagus, which has the base larger, the stem slightly sinuate, and the membranous dorsal appendages tipped with a flat, sclerotized denticulate plate.

We have not taken this species in Illinois in our recent survey, but the locality, "Chicago" was mentioned by Hagen in his original description of *chlorotica.* These Chicago specimens, however, prove to be females of the genus *Cheumatopsyche* so that we still have no definite record for the state.

The species is known from Michigan, New York, Ontario, Virginia and West Virginia and may ultimately be found in Illinois.

Hydropsyche bronta Ross

Hydropsyche bronta Ross (1938*a*, p. 149); ♂, ♀.

LARVA.—Length 14 mm. In coloration similar to *bifida*, especially with reference to the checkered type of pattern on the head. As with *bifida*, there is considerable variation in the details of this pattern.

ADULTS.—In size, color and general structure similar to *bifida.* Male genitalia, fig. 364, with apical processes of tenth tergite short and finger-like; apical segment of claspers conical; aedeagus with dorsal membranous processes tipped by a long, spinose spur which is directed ventrad and projects considerably beyond the ventral margin of the stem. Female genitalia similar in general with those of *bifida*, differing in characters of the clasper receptacle, fig. 387*B*.

In Illinois this species is restricted with few exceptions to small and medium-sized streams in northern Illinois. Most of these are spring fed; all are permanent. The adults emerge from April to the latter part of August.

The range of the species includes most of the Northeast, as follows: Illinois, Maryland, Michigan, New Brunswick, Ohio, Ontario, Pennsylvania and Virginia; in addition we have a large collection from Wyoming.

Illinois Records.—Many larvae, taken March 2 to May 30, and many females and two pupae, taken April 25 to August 23, are from Amboy (Green River), Apple River Canyon State Park, Cedarville, Council Hill (Galena River), Elgin (Botanical Gardens), Fox Lake, Galena (Sinsinawa River), Havana (Quiver Creek), Leland, Marengo, Momence, Mount Carroll, Oregon, Rock City, Sycamore (tributary South Kishwaukee River), Utica (Split Rock Brook), White Pines Forest State Park, Wilmington.

Hydropsyche cheilonis Ross

Hydropsyche cheilonis Ross (1938*a*, p. 149); ♂, ♀.

LARVA.—Similar to *bifida* in size and color, especially in the checkered head pattern, as in fig. 356.

ADULTS.—In size, color and general structure identical with *bifida.* Male genitalia, fig. 365, differing from those of *bronta* chiefly in aedeagus, which has shorter membranous lobes tipped by a narrow spur constricted at the base; in addition, the apical bulb of the aedeagus has four pockets (two meso-dorsal and two lateral), each bearing a group of at least 6 relatively long and heavy sclerotized spicules, the lateral pockets exserted on a short stalk. Female typical for the *bifida* group, genitalia as in fig. 387*D*.

To date this species has been found in Illinois only in the Middle Fork and Salt Fork of the Vermilion River in the neighborhood of Oakwood. In these streams this species is fairly abundant, and the only member of the *bifida* group occurring in them. A scattering of adults has been taken from May 4 to September 20.

Practically nothing can be stated regarding the range of this species, since we have only two records from Michigan (Aurelius and East Lansing) in addition to the Illinois records. This indicates a spotted and local distribution pattern.

Illinois Records.—MUNCIE: Sept. 20, 1935, Frison & Mohr, 2♂; May 4, 1936, Ross & Burks, 1♂; July 6, 1936, Mohr & Burks, 1 larva. OAKWOOD: Salt Fork River, July 18, 1933, Ross & Mohr, 3♂, 7♀, many larvae; Middle Fork River, July 18, 1933, Ross & Mohr, 1 ♂; Sept. 20, 1935, DeLong & Ross, 7 ♂, 9 ♀; May 21, 1936, Mohr & Burks, 1 larva, 1 pupa; Salt Fork River, Aug. 25, 1936, H. H. Ross, many larvae; Middle Fork River, July 14, 1939, Burks & Riegel, 2 larvae.

Hydropsyche slossonae Banks

Hydropsyche slossonae Banks (1905*b*, p. 14); ♂, ♀.

LARVA.—Fig. 355. Length 16 mm. Head, thoracic sclerites and legs dark brown, frequently approaching black, with the following areas yellowish: retracted posterior portion of head, one or two small quadrate marks on the dorso-mesal line, and irregular portions of the legs; abdomen purplish gray.

ADULTS.—In size, color and general structure similar to *bifida*. Male genitalia, fig. 362, with the apical processes of the tenth tergite long, enlarged at middle, the mesal face concave, and the two forming a horseshoe-like structure; claspers with apical segment long, narrow and curved mesad; aedeagus with base large, markedly sinuate, the dorsal membranous lobes tipped by a short, sharp spur, and with the apical bulb provided with one mesal and two lateral pockets of spicules. Female typical for the *bifida* group, genitalia as in fig. 387*G*.

In Illinois we have records for this species from only three localities. One of these is the small stream at Elgin fed by Rainbow Springs, in which this species was taken in great abundance. Our Illinois collections, supplemented by those from other states, show that the adult emergence occurs from May to August. The larval head pattern is diagnostic.

The range of this species, fig. 16, includes most of the northeastern states. We have records from Illinois, Michigan, Minnesota, New Hampshire, New York, North Carolina, Pennsylvania, Saskatchewan and Wisconsin.

Illinois Records.—ELGIN, Rainbow Springs: April 19, 1939, Burks & Riegel, many larvae; May 9, 1939, Ross & Burks, many larvae, 4 ♂, 2 ♀, 1 pupa; June 6, 1939, Burks & Riegel, ♂ ♂, ♀ ♀; Aug. 9, 1939, Burks & Riegel, 3 ♂; April 25, 1941, Ross & Burks, many larvae; May 7, 1941, Mohr & Burks, 1 larva. GALENA: June 28, 1892, Hart & Shiga, 2 ♂ pupae. SPRING GROVE: May 29, 1938, Mohr & Burks, 1 ♂.

Hydropsyche recurvata Banks

Hydropsyche slossonae var. *recurvata* Banks (1914, p. 253); ♂.

Hydropsyche codona Betten (1934, p. 187); ♂, ♀.

LARVA.—Length 14 mm. Head varying from the dark checkered pattern in fig. 356 to almost entirely yellow with a few brown markings outlining a skeleton checkerboard, fig. 357; thoracic sclerites and legs usually entirely yellow with a few dark lines, varying to brownish yellow.

ADULTS.—In size, color and general structure similar to *bifida*. Male genitalia, fig. 363, with apical processes of tenth tergite short; claspers with apical segment short, conical and pointed; aedeagus with stem long and nearly straight, dorsal membranous lobes tipped by a stout recurved spur (rarely absent or reduced) and with the apical bulb forming a pair of membranous lobes, each with a pocket of spicules. Female genitalia typical for members of the *bifida* group, ninth tergite as in fig. 387*C*.

Of unusual interest is our only Illinois larval record of this species. At Evanston we found the larvae and pupae under rocks in Lake Michigan, in water which was 2 to 3 feet deep at that time. A few adults were taken around buildings along the beach. Collecting in situations away from Lake Michigan has persistently failed to disclose representatives of this species in the state.

The species is normally taken in swift, cold rivers to the north, fig. 16, including Michigan, Minnesota, New York, Ontario, Quebec, Saskatchewan and Wisconsin, with adult emergence occurring from May to September.

Illinois Records.—EVANSTON, Lake Michigan: May 22, 1938, Ross & Burks, 3 ♂, 1 ♀, many pupae and larvae. WAUKEGAN, Lake Michigan: June 9, 1938, at light, Ross & Burks, 2 ♂, 1 ♀.

Depravata Group

Hydropsyche betteni Ross

Hydropsyche betteni Ross (1938*a*, p. 146); ♂, ♀.

LARVA.—Fig. 348. Length 16 mm. Head and thoracic sclerites dark brown, frequently approaching black, with a light spot surrounding eye; legs yellow to yellowish brown. Frons small, flat, the anterior margin straight. Dorsum of abdomen with conspicuously flattened hairs scattered among the simple appressed ones.

Adults.—Length 12–13 mm. Various shades of brown, antennae with first seven segments of flagellum having a dorsal black V-mark; wings reticulate with various shades of brown, resembling closely the pattern of *bifida*. Male genitalia, fig. 368, with tenth tergite somewhat hood shaped; claspers with apical segment long and tapering; and aedeagus long, curled at base, with stem straight and apex almost truncate. Female similar to male in size, color and structure. Eighth tergite with a long brush on apicoventral corner and with lobes of eighth sternite somewhat produced at apex. Ninth tergite with large clasper receptacle, fig. 385.

This species was treated as *incommoda* by Betten (1934, p. 188). It frequents a variety of small streams throughout the northern two-thirds of Illinois. It has been taken in abundance many times, both in Illinois and elsewhere, in the shallow, swift film of water running over the spillways of small dams. Otherwise its favorite haunt seems to be the riffles of small to medium-sized streams. The adults emerge from April to September.

The species' range seems to include a sort of crescentic area through much of the Northeast and continuing south through the Appalachians. We have records from Georgia, Illinois, Indiana, Michigan, New York, Ohio, Ontario and Wisconsin.

Illinois Records.—Many males, females and pupae, taken April 11 to August 23, and many larvae, taken March 2 to August 13, are from Apple River Canyon State Park, Clinton (Weldon Springs), Elgin (Botanical Gardens, Rainbow Springs), Galena, Gibson City, Havana (Quiver Creek), Marengo (Coon Creek), Matanzas Lake, McHenry, Milan, Momence, Mount Carroll, Oregon, Richmond, Rock City, St. Anne, Utica, Watson, White Pines Forest State Park.

Hydropsyche depravata Hagen

Hydropsyche depravata Hagen (1861, p. 290); ♀.

This species is southern in distribution, roughly occupying the area south of the range of *betteni*. It has not yet been taken in Illinois, but from both Kentucky and Indiana we have records which are very close to the Illinois state line, and it is almost certain that the species will eventually be found in Illinois. At present it is known from Georgia, Indiana, Kentucky and Tennessee.

Cuanis Group

Hydropsyche cuanis Ross

Hydropsyche cuanis Ross (1938*a*, p. 147); ♂, ♀.

Larva.—Fig. 350. Length 15 mm. Head and thoracic sclerites bright brownish yellow, the head with an irregular, fine, reddish brown pattern, the pronotum with fine, reddish brown speckling; legs yellow. Frons almost flat, the apical margin straight. Dorsum of abdomen, especially on the seventh and eighth segments, with conspicuous flattened setae interspersed among the simple appressed ones.

Adults.—Length 10–11 mm. Head and body black with irregular areas of reddish brown; antennae with V-marks faint; wings with a purplish cast, mottled with various shades of brown and without a definite pattern. Male genitalia, fig. 369, with tenth tergite simple and hoodlike, divided into a pair of round lobes; claspers with apical segment oblique at apex; aedeagus curved, rounded at apex, incised on the meson. Female, fig. 386, with eighth tergite having only a very short and inconspicuous apical ventral fringe, eighth sternite with apicomesal corner only moderately produced, fig. 388*C*. Ninth tergite, fig. 386*C*, very similar to that in *scalaris* group.

Most of our Illinois records of this species are from various points along the Kankakee River; in addition we have taken it from two other points in the extreme northeastern corner of the state. The larvae are extremely abundant in swift rapids of the Kankakee River at Wilmington, and here we have taken large flights of the adults. In this locality the spring emergence, during May, is very heavy. Adults continue to emerge later in the year until August but never in the large numbers that we have taken in May.

The range of the species appears to be very restricted, the known records including only Illinois, Indiana and Michigan.

Illinois Records.—Des Plaines, Fox River: May 26, 1936, H. H. Ross, 2 larvae. Kankakee, Kankakee River: May 17, 1935, H. H. Ross, 2 pupae; Aug. 8, 1935, Ross & DeLong, 1 larva. Momence: May 17, 1931, Ross & Burks, 1♂; June 4, 1932, Frison & Mohr, 4♂; Aug. 1, 1935, Ross & Burks, 1♂; May 26, 1936, H. H. Ross, 1♂; July 14, 1936, B. D. Burks, 1♂, 2 larvae; Aug. 3, 1936, C. O. Mohr, 1♂; Aug. 4, 1936, Frison & Burks, ♂♂; May 17, 1937, Ross & Burks, ♂♂, 1 ♂ pupa; Sept. 7, 1937, Frison & Ross, 1♂; May 5, 1938, Ross & Burks, 3♂. St. Charles: June 18, 1931, T. H. Frison, 1♂. Spring Grove: May 14, 1936, Ross & Mohr, 3♂, 1♀, 2 pupae, 8 larvae; June 12, 1936, Ross & Burks, 5♂, 1♀, 1 ♂ pupa; Nippersink Creek, May 19, 1938, Ross & Burks, 2♂. Wilmington, Kankakee River: April 23, 1930, Ross & Mohr, 1 pupa; April 10, 1935, Ross & Mohr, many larvae; April 23, 1935, Ross & Mohr, 7 pupae, many larvae; May, 1935, reared in cage, Ross & Mohr, many pupae; May 12, 1935, Frison & Ross, ♂♂, ♀♀; May 17, 1935, H. H. Ross, ♂♂, ♀♀; May 27, 1935, Ross & Mohr, ♂♂, ♀♀, many pupae and larvae; June 6, 1935, Ross & Mohr, ♂♂, 7♀, many larvae; May 17, 1937, Ross & Burks, ♂♂, ♀♀. Wilmington: Aug. 3, 1937, at light, Ross & Burks, 1♂.

Scalaris Group

Hydropsyche aerata Ross

Hydropsyche aerata Ross (1938*a*, p. 144); ♂, ♀.

Larva.—Fig. 349. Length 13 mm. Head, thoracic sclerites and legs yellow, dorsum of the head with a somewhat cross-shaped dark brown mark, pronotum minutely speckled with brown. Frons almost flat, anterior margin straight. Head and pronotum with only a few scattered long hairs, in general appearing polished.

Adults.—The two sexes are very dissimilar in general appearance. Male, fig. 392: length 9 mm.; head and body dark brown, antennae and legs white; wings white with definite brown markings forming a distinctive pattern; eyes very large, twice as wide as the antero-dorsal distance between them; genitalia, fig. 372, with tenth tergite upturned and deeply incised; apex of aedeagus with an open area between lateral processes. Female: length 10 mm.; color dark brown, the wings mottled with various shades of brown and resembling other females of the genus, similar to fig. 393; genitalia as in fig. 386*G*.

Myriads of this uniquely marked species have been taken at Illinois localities along the Kankakee River, in the rapids of which the larvae and pupae have been found. Other than in this area, we have taken only one or two records from the eastern part of the state. The adults emerge from May through most of August.

The present known range of the species is very small, fig. 15, and includes Illinois, Indiana and southern Michigan. All the records indicate a preference for medium-sized to large, rapid rivers.

Illinois Records.—Aurora: July 17, 1927, at light, Frison & Glasgow, 1♂. Kankakee, Kankakee River: Aug. 1, 1933, Ross & Mohr, 1♂; May 26, 1935, Ross &

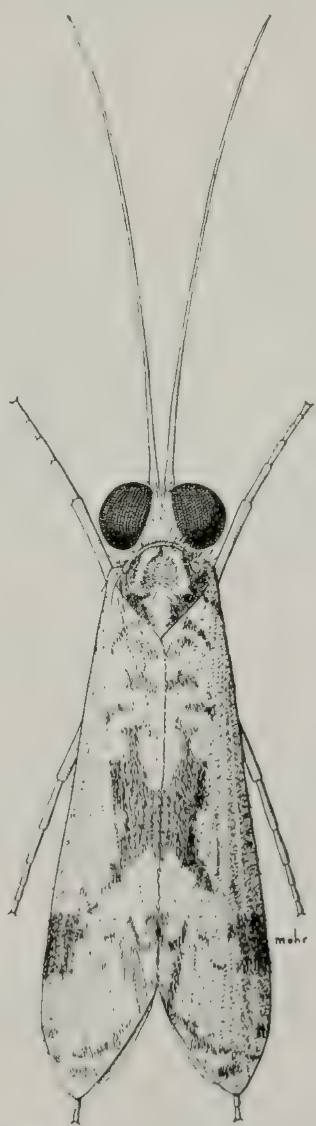


Fig. 392.—*Hydropsyche aerata*, ♂.

Mohr, 1 ♂ (reared); June 6, 1935, Ross & Mohr, ♂ ♂, ♀ ♀; July 21, 1935, Ross & Mohr, ♂ ♂; Aug. 8, 1935, Ross & DeLong, 1 ♂, 1 ♀, 4 larvae; May 17, 1937, Ross & Burks, ♂ ♂, ♀ ♀; May 6, 1938, Ross & Burks, 7 ♂; May 31, 1938, Mohr & Burks, 1 ♂; June 29, 1939, Burks & Ayars, 1 ♂. MOMENCE: Kankakee River, May 26, 1936, H. H. Ross, 1 ♂; Aug. 4, 1936, Frison & Burks, 4 ♂; Aug. 21, 1936, Ross & Burks, 1 ♂, 2 larvae; Kankakee River, March 24, 1937, H. H. Ross, 1 ♂; May 17, 1937, Ross & Burks, 3 ♂. MOUNT CARMEL: July 3, 1906, 1 ♂. SPRING GROVE: May 20, 1938, at light, Ross & Burks, 2 ♂. WILMINGTON: April 23, 1935, Ross & Mohr, 2 larvae; May 12, 1935, Frison & Ross, ♂ ♂, 7 ♀; Kankakee River, May 17, 1935, H. H. Ross, ♂ ♂, ♀ ♀; May 27, 1935, Ross & Mohr, 1 larva, 1 pupa; June 6, 1935, Ross & Mohr, 7 ♂, 7 larvae; July 1, 1935, DeLong & Ross, 1 ♂; Aug. 20, 1935, DeLong & Ross, 2 ♂; Kankakee River, May 17, 1937, Ross & Burks, 1 ♂; June 13, 1938, B. D. Burks, ♂ ♂.

Hydropsyche phalerata Hagen

Hydropsyche phalerata Hagen (1861, p. 287); ♀.

LARVA.—Fig. 347. Length 13 mm. Head, thoracic sclerites and legs with ground color yellow; superimposed on this is an irregular, dark, somewhat T-shaped area on the head bearing a scattering of small black setae, and scattered brown spots on the pronotum and mesonotum, each bearing numerous short, black setae. Frons almost flat and with the apical margin produced into a low triangular point.

ADULTS.—Length 9–10 mm. Head and body brown, wings tawny with brown areas small and forming only a light and indefinite pattern. Eyes of male medium sized, slightly larger than half the area between them. Male genitalia, fig. 371, with tenth tergite upturned and incised to form forceps-like lobes; aedeagus stout throughout, the apex large, the lateral processes close together, and the mesal cavity almost completely open. Female genitalia, fig. 386*F*, very similar to those of *aerata*.

Until the selection of a lectotype by Banks (1936*b*, p. 126), the status of this species had been confused. The species considered as *phalerata* by Betten (1934, p. 189) is *sparna*; and the species considered as *Hydropsyche species 3* by Betten (1934, p. 192) is true *phalerata*. The color pattern of the adults is fairly distinctive but requires actual comparison with specimens to be of practical use.

In Illinois this species is apparently confined to the northern fourth of the state, where it has been taken abundantly in the Kankakee River and in small numbers along the Rock River and other creeks. Larvae and pupae have been taken in rapids of the Kankakee River. The adults emerge from May to October. As in the case of *bifida*, the heaviest flights of *phalerata* are taken during the early summer months.

The range of the species, fig. 15, extends from the southern portion of the eastern states to areas north of Illinois, and includes Georgia, Kentucky, Illinois, Indiana, Michigan, North Carolina, Ohio, Tennessee, Virginia and Wisconsin.

Illinois Records.—Many males, females and pupae, taken May 1 to September 7, and many larvae, taken April 23 to October 28, are from Como (Rock River), Dixon (Rock River), Frankfort (Clear Creek, Hickory Creek), Kankakee, Lyndon (Rock River), Momence (Kankakee River), New Milford (Kishwaukee River), Oregon, Rockford, Rock Island, Rockton, Sterling, Wilmington (Kankakee River).

Hydropsyche dicantha Ross

Hydropsyche dicantha Ross (1938*a*, p. 146); ♂.

This species, readily distinguished by the unique male genitalia, fig. 373, has been taken in extreme southwestern Michigan and may eventually be found in Illinois, although we have not as yet taken it here. Few records are available for the species, but they indicate a wide, scattered range, as follows: District of Columbia, Kentucky, Michigan, New York and Ontario.

FEMALE.—Length 9 mm. Color and general stucture as described for male. Ninth tergite, fig. 386*A*, with areas forming clasper groove small and only indistinctly concave, scarcely any indentation visible beneath dorsal cap from dorsal view; lateral lobe apparently absent, the margin of the segment in this region with a few setae.

Allotype, female.—Costello Lake, Algonquin Park, Ontario, from Station 4, Ontario Fisheries Research Laboratory: July 7, 1938, W. M. Sprules.

Hydropsyche hageni Banks

Hydropsyche hageni Banks (1905*b*, p. 14); ♂.

Larva.—Fig. 353. Length 15 mm. Head and thoracic sclerites brown, legs yellowish brown; head with lateral and posterior portions yellowish, limiting the dark brown of the dorsum to a broad T of which the cross-piece is broad and rather sharply cut off laterally; the brown T area of head and all of the pronotum finely granulate with paler marks. Frons flat, its apical margin straight, the area surrounding the anterior portion of the fronto-genal suture set with abundant, short, black spines.

Adults.—Length 10–11 mm. Color dark brown, the wings mottled with various shades of brown and typical of the common pattern of the *scalaris* group, as in fig. 393. Eyes of male large, each equal to the area between them on the dorsum. Male genitalia, fig. 374, with tenth tergite short and pointed slightly ventrad; aedeagus with straight stem and with lateral processes greatly elongated, flattened and almost truncate at tip. Female readily distinguished from other species of the *scalaris* group by the thickened lateral lobe of the ninth tergite, fig. 386*D*.

Allotype, female.—Momence, Illinois: May 17, 1937, Ross & Burks.

Our Illinois records of this species are confined to the Kankakee River, with the exception of male specimens taken along the Rock River. Along the Kankakee we have taken it consistently but always in small numbers and have found the larvae and pupae in the rapids. The adults have been taken from May to late August.

The range of the species is poorly delineated. Our only records are from Illinois, Kentucky and Maryland. These indicate a marked preference for large, rapid rivers.

Illinois Records.—Kankakee: June 12, 1931, Frison & Mohr, 1♂; June 6, 1935, Ross & Mohr, 1♂; May 6, 1938, Ross & Burks, 9♂; May 31, 1938, Burks & Mohr, 1♂. Momence: May 26, 1936, H. H. Ross, ♂♂, 6 larvae; Aug. 3, 1936, C. O. Mohr, 1♂; Aug. 4, 1936, Frison & Burks, 3♂; May 24, 1937, H. H. Ross, 1♂; May 5, 1938, Ross & Burks, 4♂, 3 larvae; Oct. 28, 1938, Ross & Burks, 2 larvae; preceding Momence records from Kankakee River; Aug. 21, 1936, Ross & Burks, 2♂, 1 pupa; May 17, 1937, Ross & Burks, 1♂ pupa, 5♂, 1♀, 4 larvae; May 5, 1938, Ross & Burks, 4♂, 3 larvae; Aug. 16, 1938, Ross & Burks, 1♂; June 24, 1939, Burks & Ayars, 1♂. Rockford: June 12, 1931, Frison & Mohr, 1♂; May 30, 1936, H. H. Ross, 1♂. Wilmington, Kankakee River: June 6, 1935, Ross & Mohr, 1♂.

Hydropsyche placoda Ross

Hydropsyche placoda Ross (1941*b*, p. 87); ♂, ♀.

Larva.—Unknown.

Adults.—Length 10–11 mm. General color typical for most members of the *scalaris* group, the male differing in having the eyes reddish and the wings slightly lighter. Eyes of male very large, each one equal to the dorsal area between them and almost completely hiding the head from side view. Male genitalia, fig. 375, with tenth tergite somewhat beaklike; apical segment of claspers short and markedly truncate; aedeagus of fairly uniform thickness, the lateral processes triangular from side view and dorsal margin almost confluent with the stem, and the mesal cavity more than half closed. Female with small eyes; genitalia, fig. 386*B*, distinguished by the pit at dorsal portion of clasper groove.

In Illinois this species has been taken in numbers only near the dam on the Illinois River at Starved Rock State Park. Other records are represented by few specimens. We have not yet obtained larvae, but it is probable that they occur in the race below the dam at Starved Rock State Park.

This species has been taken in many of the north central states and as far east as Niagara Falls. In addition to this New York locality, we have records from Illinois, Minnesota, Montana, South Dakota and Wisconsin.

Illinois Records. — Elgin: Botanical Gardens, June 6, 1939, Burks & Riegel, 1♂; Rainbow Springs, June 6, 1939, Burks & Riegel, 1♂. Kankakee: June 12, 1931, Frison & Mohr, 1♂. Ottawa: June 3, 1938, Mohr & Burks, 1♂. Richmond: June 7, 1938, at light, Ross & Burks, 1♂. Rockford: June 29, 1938, at light, B. D. Burks, 2♂. Rock Island: June 23, 1928, at light, Frison & Hottes, 1♂; June 24, 1931, at light, C. O. Mohr, 1♂. Serena: Fox River, June 3, 1938, Ross & Burks, 3♂. Starved Rock State Park: June 28, 1937, G. T. Riegel, 9♂, 2♀; June 28, 1937, Ross & Burks, 4♂, 5♀; June 15, 1938, D. T. Ries, 5♂; June 17, 1938, Frison & Mohr, 4♂; June 18, 1938, Ries & Werner, 6♂; June 22, 1938, D. T. Ries, 6♂; June 27, 1938, F. Werner, 1♂, 1♀; June 5, 1941, Floyd Werner, 1♂, 1♀; July 11, 1941, D. T. Ries, 1♂. SUGAR GROVE: June 13, 1939, Frison & Ross, 1♂.

Hydropsyche arinale Ross

Hydropsyche arinale Ross (1938*a*, p. 143); ♂.

LARVA.—Fig. 351. Length 15 mm. Head mostly brown with yellowish markings around and under the eyes, on the ventral surface and the postero-lateral angles. Thoracic sclerites and legs brownish yellow. Frons flat, its anterior margin straight. Setae on the dorsum of the abdomen relatively sparse.

ADULTS.—Length 9–10 mm. Color various shades of brown similar to the typical pattern for the *scalaris* group, as in fig. 393. Male with eyes of medium size, each equal to at least two-thirds of the dorsal area between them. Male genitalia, fig. 376, with tenth tergite somewhat hood shaped and declivous; claspers with apical segment sinuate and pointed; aedeagus with stem constricted near middle, appearing somewhat moniliform from ventral view, the lateral processes wide and the mesal cavity almost entirely open. Female similar in color and general structure to other members of the *scalaris* group. Ninth tergite as in fig. 386*E*.

Allotype, female.—Serena, Illinois, along Indian Creek: May 12, 1938, Ross & Burks.

We have taken this species at various points in the northern half of the state. It shows a preference for such streams as Indian Creek, which is relatively clear and provided with many riffles or rapids. Our only large collections of adults were taken early in May, but emergence continues through August.

The range of the species seems to follow rather closely the outer fringe of the oak-hickory forest. We have records from Arkansas, Kansas, Missouri, Oklahoma and Wisconsin; these all indicate the same type of stream preference as do our Illinois records and increase the seasonal emergence of adults from April to September.

Illinois Records.—Many males and females and two pupae, taken May 12 to September 5, and many larvae, taken May 12 to May 16, are from Algonquin, Aurora, Baker, Des Plaines (Fox River), Oregon, Pontiac, Quincy (stream near Cave Spring), Richmond, Serena (Indian Creek), Starved Rock.

Hydropsyche simulans Ross

Hydropsyche simulans Ross (1938*a*, p. 139); ♂, ♀.

LARVA.—Fig. 352. Length 18 mm. Head dark brown with irregular light areas on the sides, posterior portion and venter; pronotum brown, remainder of thoracic sclerites and legs straw color to brownish yellow. Frons flat, its apical margin straight. Dorsum of abdominal segments with flattened setae relatively abundant.

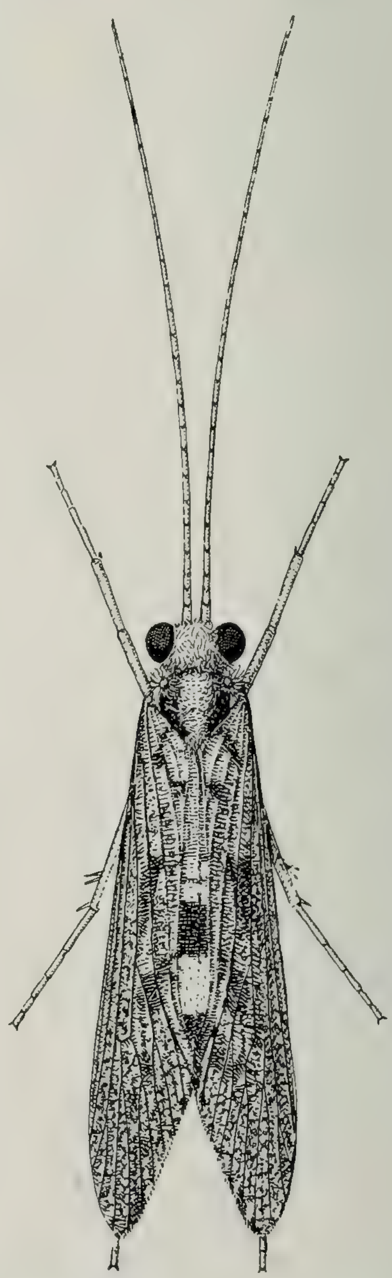


Fig. 393.—*Hydropsyche simulans*, ♂.

ADULTS.—Length 13–15 mm. Color pattern various shades of brown, fig. 393, the pattern typical of many species of the *scalaris* group. Male with eyes of medium size, each equal to about half the dorsal area between them. Male genitalia, fig. 377: tenth tergite somewhat hoodlike, the apex almost truncate; claspers with apical segment long, sinuate and pointed; aedeagus with stem straight and a dorsal continuation of it extending over the apical portion; lateral plates rounded at apex, the lateral flange sharp and sinuate, mesal plates long and curved ventrad, and the mesal cavity about half closed. Female with ninth tergite, fig. 386*M*, very similar to that of *incommoda*.

This species has been taken in abundance at various points along most of the large Illinois rivers; the records cover the entire state. It occurs also in smaller streams, as for example, in Quiver Creek near Havana, where the larvae and pupae were taken in large numbers from a small rapid. It is, however, by no means as widespread along the largest rivers as *orris*. The adults emerge throughout the warmer months, from April to late September.

The range of the species, fig. 14, includes most of the Corn Belt states with extensions westward to Texas and eastern Colorado. States for which we have records are Colorado, Illinois, Indiana, Iowa, Kansas, Kentucky, Minnesota, Missouri, Ohio, Oklahoma, Tennessee and Wisconsin.

Illinois Records.—Many males and females, taken April 15 to September 20, and many larvae, taken May 5 to July 8, are from Alton (Mississippi River), Deer Grove (Green River), Freeport, Grafton, Hardin (Illinois River), Havana (Quiver Creek), Homer, Kankakee, Kappa (Mackinaw River), Lawrenceville, Momence (Kankakee River), Mount Carmel (Wabash River), Oakwood, Olney, Pontiac, Quincy, Rockford, Rock Island, Rockton, Savanna, Shawneetown, Spring Grove, Sterling, Topeka (Quiver Creek), Urbana, Wilmington.

Hydropsyche valanis Ross

Hydropsyche valanis Ross (1938*a*, p. 144); ♂.

LARVA.—Unknown.

ADULTS.—Length 9–10 mm. Color tawny with irregular flecking of light brown over the entire surface of the wings, forming a slightly lighter mottling than that found in *simulans*. Male with eyes large, each slightly larger than dorsal width between them. Male genitalia, fig. 378: tenth tergite short, stubby, and incised on meson; claspers with apical segment sinuate and rounded at apex; aedeagus with stem slightly curved; apex with lateral plates narrow from lateral view, and mesal margin notched, the two overlapping at apex; mesal cavity almost completely open. Female with small eyes, and color pattern slightly lighter than on most of the species. Ninth tergite, fig. 386*H*, with very large clasper receptacle.

Allotype, female.—Noblesville, Indiana: Aug. 10, 1938, Ross & Burks.

We have found this species at scattered localities in northern Illinois, never in great abundance. It has been taken along some of the larger streams only, such as Indian Creek and the Kankakee River. The dates of capture indicate adult emergence from May to late August. To date the larvae have not been identified.

Little is known about the range of the species. Aside from the Illinois records, it is known only from southern Minnesota and central Indiana where again it was found along fairly large rivers.

Illinois Records.—BAKER, Indian Creek: May 12, 1938, Ross & Burks, 1 ♂. KANKAKEE: July 21, 1935, Ross & Mohr, 1 ♂; Kankakee River, May 17, 1937, Ross & Burks, 3 ♂; May 6, 1938, Ross & Burks, ♂ ♂. PONTIAC: Aug. 22, 1938, H. H. Ross, ♂ ♂. ROCK ISLAND: June 23, 1928, Frison & Hottes, 1 ♂. ROCKTON: Rock River, July 2, 1931, Frison, Betten & Ross, ♂ ♂.

Hydropsyche frisoni Ross

Hydropsyche frisoni Ross (1938*a*, p. 142); ♂, ♀.

LARVA.—Fig. 354. Length 15 mm. Head straw color with a dorsal brown area covering the frons and a few irregular areas around it; thoracic sclerites and legs straw color to brownish yellow. Frons flat, its anterior margin straight.

ADULTS.—Length 12–13 mm. Body dark brown, similar in pattern to *simulans*, fig. 393. Male with eyes large, each equal to dorsal area between them. Male genitalia, fig. 379: tenth tergite short, almost truncate at apex; apical segment of clasper somewhat sinuate and pointed; aedeagus with stem straight, constricted at base of apical portion; apex of aedeagus angled dorsad, the lateral plates rounded at apex, the lateral flange considerably lower than mesal dome, mesal cavity half closed, and mesal plates short and somewhat triangular. Female with small eyes, color pattern typical for *scalaris* group. Ninth tergite as in fig. 386*J*.

This species has been taken commonly but not abundantly along the Middle Fork and Salt Fork rivers near Oakwood; aside from this area we have only a single record, from Indian Creek. The adult emergence continues from April to late August.

Little is known regarding the range of this species. Aside from Illinois, we have only three scattered records from lower Michigan. In this respect *frisoni* is remarkably similar to *cheilonis*, which has nearly the same known range and has never been found in Illinois outside the Oakwood area.

Illinois Records. — DANVILLE, Middle Fork River: Aug. 27, 1936, Ross & Burks, 1 pupa, 2 larvae. HOMER: July 11, 1927, at light, Frison & Glasgow, 1 ♂. MUNCIE: July 27, 1927, T. H. Frison, 2 ♂. OAKWOOD, Salt Fork River: April 24, 1925, T. H. Frison, 6 ♂, 1 ♀; June 6, 1925, T. H. Frison, 1 ♀; July 6, 1925, at light, Frison & Glasgow, 5 ♂; July 18, 1933, Ross & Mohr, 2 ♂; Aug. 25, 1936, H. H. Ross, 1 ♂. SERENA, Indian Creek: June 16, 1939, B. D. Burks, 1 ♂.

Hydropsyche scalaris Hagen

Hydropsyche scalaris Hagen (1861, p. 286); ♂, ♀.

This species has not yet been taken in Illinois but will almost certainly be found with future collecting, since it has been collected on practically all sides of the state, with records from Georgia, Indiana, Missouri, Oklahoma, Ontario and Wisconsin.

The name *scalaris* is the one under which many species have been confused. The selection of a lectotype by Banks (1936*b*, p. 127) has given us a definite concept of this species for the first time.

Hydropsyche incommoda Hagen

Hydropsyche incommoda Hagen (1861, p. 290); ♂.

LARVA.—Unassociated with adult.

ADULTS. — Length 13–14 mm. Color brown with the typical mottled pattern similar to that in fig. 393. Male with eyes of moderate size, each subequal to one-half the dorsal area between them. Male genitalia, fig. 381, similar to *simulans* in shape of tenth tergite and male claspers; aedeagus with lateral plates long, lateral flange small, parallel with dorsal outline of stem, mesal cavity almost entirely open, and mesal plates large and projecting ventrad. Female with ninth tergite as in fig. 386*N*.

Allotype, female.—Tavares, Lake County, Florida: March 23, 1936, F. N. Young.

The species treated under the name *incommoda* by Betten (1934, p. 188) is not the true *incommoda*, but is *betteni* (see p. 99).

We have taken this species at several localities in the eastern, central and southern parts of Illinois, usually in small numbers, and never in a heavy flight. The collections are associated with medium-sized to large streams. The adults emerge over a long period, our records being scattered from April 24 to August 27.

In addition to Illinois, the species is known only from Florida, Georgia and North Carolina; presumably it occurs in suitable situations in the intervening area between these southeastern states and Illinois.

Illinois Records.—CARMI, Little Wabash River: April 24, 1935, T. H. Frison, 1 ♂. KAPPA, Mackinaw River: Sept. 14, 1937, Ross & Burks, 4 ♂. MAHOMET: Aug. 3, 1937, Ross & Burks, ♂ ♂, ♀ ♀. MOMENCE: Aug. 16, 1938, Ross & Burks, 1 ♂; Kankakee River, May 29, 1939, Frison & Ross, 1 ♂. MONTICELLO: May 7, 1936, Ross & Burks, 1 ♂. OAKWOOD: Sept. 20, 1935, DeLong & Ross, 1 ♂; Salt Fork River, July 31, 1939, Burks & Riegel, 1 ♂. PONTIAC: Aug. 22, 1938, H. H. Ross, 5 ♂. SHAWNEETOWN: May 27, 1928, at light, T. H. Frison, 1 ♂. VENEDY STATION, Kaskaskia River: Aug. 27, 1940, Mohr & Riegel, 9 ♂, 9 ♀.

Hydropsyche orris Ross

Hydropsyche cornuta Ross (1938*a*, p. 141); ♂, ♀. Preoccupied.

Hydropsyche orris Ross (1938*d*, p. 121). New name.

LARVA.—Fig. 346. Length 14 mm. Head brown with pale areas on lateral and posterior portions and frons; thoracic sclerites and legs straw colored to brownish yellow.

Frons slightly concave and always covered with a grayish hairy mass, the anterior margin straight across the middle, and provided with a pair of short, elevated teeth. Dorsal abdominal segments with abundant flattened setae.

Adults.—Length 12–13 mm. Color pattern brown, the mottling similar to that of *simulans,* fig. 393. Male with eyes small, each equal to less than half the dorsal area between them. Male genitalia, fig. 383: tenth tergite short, declivous and hooklike with a wide mesal incision; claspers with second segment long, sinuate and pointed at tip; aedeagus with stem straight, lateral plates upturned and meeting mesal dome on a line with the dorsal outline of stem, lateral flanges not sharp, and the tip of the plates rounded from side view, the mesal cavity two-thirds closed, and the mesal plates triangular and not projecting ventrad. Female with ninth tergite, fig. 386*K*, very similar to that of *bidens*; clasper receptacle with anterior and posterior dorsal margins usually of about equal slope.

This species is one of the most common along the larger rivers and has been taken quite generally in Illinois. Especially heavy flights have been seen along the Rock, Illinois and Mississippi rivers. Adult emergence continues from April to September.

The range of the species, fig. 14, covers the central Corn Belt states and widens toward the south to include most of the Gulf Coast states. We have records from Alabama, Arkansas, Georgia, Illinois, Indiana, Iowa, Kentucky, Michigan, Minnesota, Ohio, Tennessee, Texas and Wisconsin.

Illinois Records.—Many males and females and six pupae, taken April 24 to October 2, and many larvae, taken April 24 to July 23, are from Alton, Cairo, Chicago, Dixon, East Dubuque, Eddyville (Lusk Creek), Elgin (Botanical Gardens), Elizabethtown, Florence, Golconda, Grafton (Mississippi River), Grand Tower, Hamilton, Harrisburg, Havana (Spoon River), Herod, Homer (Salt Fork River), Horse Shoe Lake, Jerseyville, Kankakee, Keithsburg, Meredosia, Milan (Rock River), Momence (Kankakee River), Mount Carmel, New Boston, Oakwood (Salt Fork River), Oregon (Castle Rock), Ottawa, Putnam (Lake Senachwine), Quincy, Rockford, Rock Island, Rosiclare, St. Joseph, Savanna, Shawneetown, Sterling, Urbana, White Pines Forest State Park.

Hydropsyche bidens Ross

Hydropsyche bidens Ross (1938*a*, p. 142); ♂, ♀.

Larva.—Not definitely reared; we have some statistical evidence that it might be similar to that of *orris.*

Adults. — Length 10–11 mm. Color brown, mottled as in *simulans.* Male with eyes small, each slightly smaller than half the dorsal area between them. Male genitalia similar to those of *orris* in structure of tenth tergite and claspers, differing chiefly in the shape of the aedeagus, fig. 382, which has the lateral plates parallel with the axis of the stem, the lateral flanges sharp and almost pointed at apex, and the mesal dome rounded and curving considerably ventrad to meet the apex of the lateral plates. Female ninth tergite, fig. 386*L*, very similar to that of *orris.* Extreme care must be exercised in identifying females of *bidens*, *orris*, *simulans* and *incommoda.* The differences between them are relative and subject to variation. For this reason, females of this group should not be used for isolated records.

This species is distributed over the entire state. It has been taken along a large variety of streams, ranging from small creeks to large rivers. Most of our collections have been of a few specimens, but occasionally large flights have been encountered. Adult emergence occurs from April to September. The species has been taken throughout most of the Corn Belt states, including Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio and Wisconsin.

Illinois Records.—Many males and females, taken April 24 to September 25, are from Alton, Apple River Canyon State Park, Carmi, Champaign, Charleston, Danville, Deer Grove (Green River), Dundee, East Dubuque, Elgin (Botanical Gardens, Rainbow Springs), Elizabethtown, Freeport, Fulton, Grafton (Mississippi River), Hardin, Havana, Homer, Kampsville, Kankakee (Kankakee River), Kankakee River at Illinois-Indiana state line, Marengo, Meredosia, Momence (Kankakee River), Mount Carmel, New Boston, New Memphis (Kaskaskia River), Oakwood, Pere Marquette State Park, Pike, Pontiac, Quincy (Burton Creek), Richmond, Rockford, Rock Island, St. Marie, Savanna, Spring Grove, Urbana, Venedy Station (Kaskaskia River).

Cheumatopsyche Wallengren

Cheumatopsyche Wallengren (1891, p. 142). Genotype, monobasic: *Hydropsyche lepida* Pictet.

Of the 18 species of this genus described from North America, we have taken 9 in Illinois. The remaining species are distributed in diverse parts of the continent. In Illinois, different members of the genus frequent almost every type of stream in the state. Not only do they occur in streams ranging from small brooks to the largest rivers but can frequently succeed to some extent in streams too polluted for almost any other caddis flies.

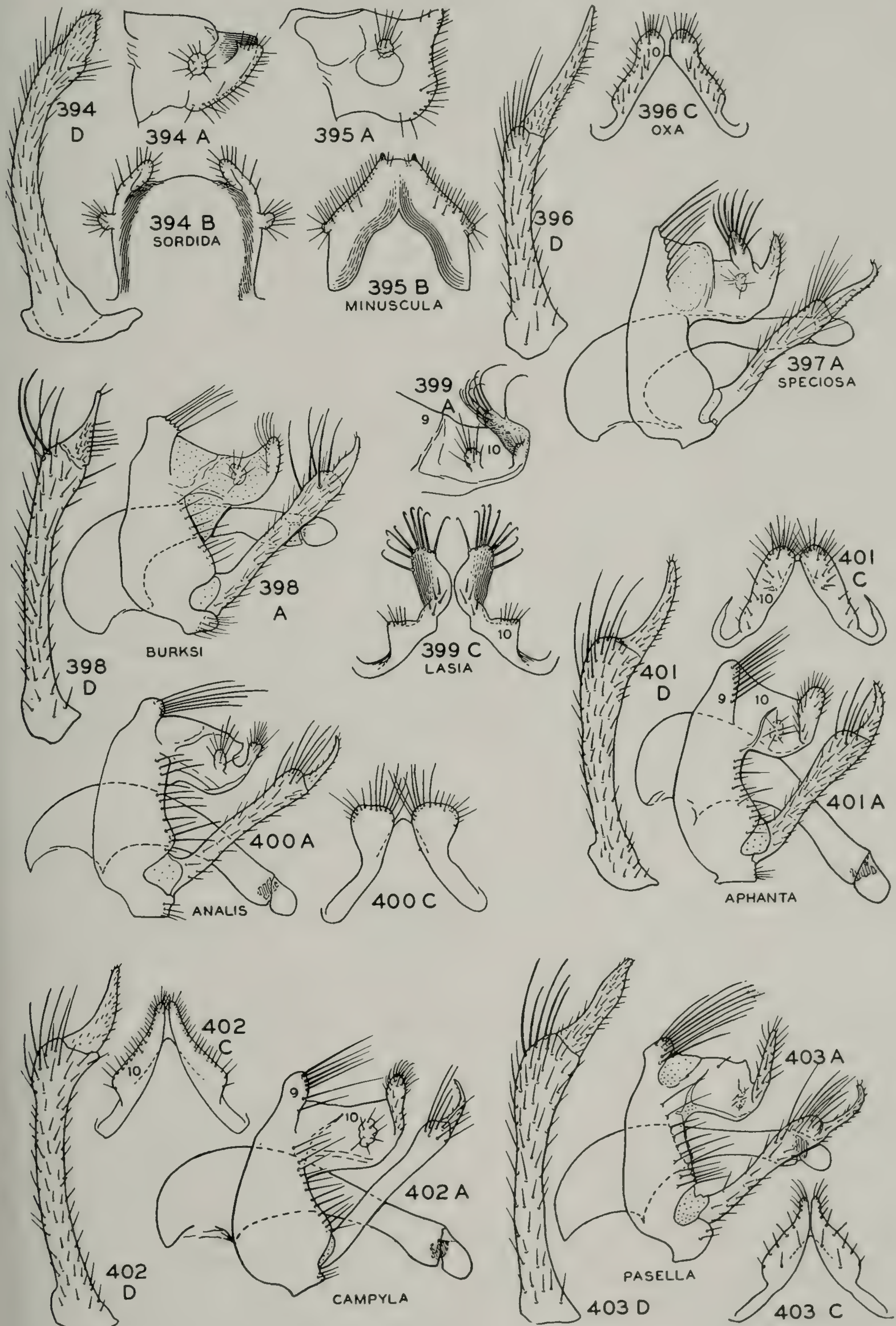
The female genitalia have definite concavities or invaginations in the sides of the ninth tergite. These seem to be correlated very closely in each species with the shape of the apical segment of the male claspers, and give definite indication of a "lock and key" relationship.

To date no structural characters have been found to identify the larvae to species. All five of the reared Illinois species have the larval frons notched in the middle, fig. 414, no conspicuous head or pronotal pattern, and a general habitus similar to that of *Hydropsyche*; *minuscula* differs in lacking the notch in the frons.

KEY TO SPECIES

Adults

1. Apex of abdomen with a pair of long claspers, fig. 397 (males) 2
   Apex of abdomen with no long appendages, fig. 391 (females) 11
2. Apical segment of claspers short, not produced into a tapered point, fig. 394 3
   Apical segment of claspers long, produced into a tapered point, figs. 396, 398 4
3. Apex of tenth tergite bearing a pair of pointed, dorsal lobes which are held close together, fig. 395 .... **minuscula**, p. 110
   Apex of tenth tergite bearing a pair of wide, lateral lobes which are not approximate on meson, fig. 394 .... **sordida**, p. 110
4. Apical segment of claspers half length of basal segment, fig. 396 .... **oxa**, p. 110
   Apical segment of claspers shorter, only one-fourth to one-fifth length of basal segment, fig. 397 5
5. Lobes of tenth tergite reflexed and upturned to form a sharp, pointed, apical ridge and just basad of it a digitate, setose lobe as in fig. 397 .... **speciosa**, p. 114
   Lobes of tenth tergite not reflexed to form such distinct and apparently separated parts 6
6. Apical segment of claspers with a broad, triangular base and a short, tapered apex, fig. 398 .... **burksi**, p. 113
   Apical segment of claspers longer, with base not nearly so wide in relation to apex, fig. 400 7
7. Apical lobes of tenth tergite sharply angled, apex bent back and bearing an apical, thick cluster of stout, curved setae as in fig. 399 ... **lasia**, p. 114
   Apical lobes of tenth tergite not sharply angled 8
8. Apical lobes of tenth tergite short, more or less circular and at right angles to linear body axis, fig. 400 .... **analis**, p.112
   Apical lobes at apex of tenth tergite either longer, fig. 402, or not at all circular, fig. 401 9
9. Apical lobes of tenth tergite appressed to tergite, appearing rounded at apex from both lateral and caudal view, and set diagonally to linear body axis, fig. 401 ..... **aphanta**, p. 111
   Apical lobes of tenth tergite not appearing rounded at apex from lateral and caudal view, and not set diagonally to linear axis, fig. 402 10
10. Apical lobes of tenth tergite perpendicular, rounded at apex and shorter, fig. 402 .... **campyla**, p. 113
    Apical lobes of tenth tergite angled caudad, pointed at apex and longer, fig. 403 .... **pasella**, p. 113
11. Ninth tergite without pouchlike lateral invaginations or pockets, figs. 404, 405 12
    Ninth tergite with pouchlike lateral invaginations or pockets, figs. 406–413 13
12. Dorsal portion of ninth tergite wide; lateral portion with a small pit and a slightly raised line running ventrad from it, fig. 404..... **minuscula**, p. 110
    Dorsal portion of ninth tergite very narrow; lateral portion with a large concave area bounded toward anterior margin by a sinuate ridge and cutting beneath dorsal portion, fig. 405 .... **sordida**, p. 110
13. Lateral invagination short and small and situated far from postero-ventral point of segment, fig. 406 .... **burksi**, p. 113



Figs. 394–403.—*Cheumatopsyche*, male genitalia. *A*, lateral aspect; *B*, dorsal aspect; *C*, caudal aspect of tenth tergite; *D*, claspers, caudal aspect.

Lateral invagination much longer and larger, usually approximate to postero-ventral point of segment, figs. 407–413 14

14\. Lower margin of lateral invagination forming a wide, round lobe extending below postero-ventral corner, and with posterior corner upturned and level with anterior corner, fig. 408 .... **aphanta,** p. 111

Lower margin of lateral invagination either concave, fig. 411, or with anterior corner much higher than posterior corner, figs. 409, 410, never forming the rounded ventral lobe as above 15

15\. Lateral margin of ninth tergite produced into a narrow, ventral angular point in which the lateral invagination ends and which projects slightly beyond the postero-ventral corner, fig. 409 .... **oxa,** p. 110

Lateral margin not forming a ventral angular projection, fig. 410 16

16\. Lateral invagination with inner opening on mesal side, fig. 410 .... **speciosa,** p. 114

Lateral invagination with inner opening on posterior side, figs. 411–413 17

17\. Lateral invagination with lower posterior corner situated a short distance from postero-ventral corner of segment, fig. 407 .... **analis,** p. 112

Lateral invagination with lower posterior corner nearly touching postero-ventral corner of segment, fig. 411 18

18\. Lateral invagination elongate and curved at apex, the two approximate on meson, fig. 413 .... **lasia,** p. 114

Lateral invagination shorter and not curved at apex, fig. 411 19

19\. Lateral invagination smaller, the two divergent and very far apart, fig. 411 .... **campyla,** p. 113

Lateral invagination larger, the two parallel and closer together, fig. 412 .... **pasella,** p. 113

Cheumatopsyche sordida (Hagen)

Hydropsyche sordida Hagen (1861, p. 290); ♂, ♀.

ADULTS.—Length 6–8 mm. Head and body various shades of brown; antennae paler with a brown V-mark on the seven basal segments of the flagellum; wings uniformly dark brown without pattern. Male genitalia, fig. 394, with apical segment of claspers short and stubby; tenth tergite wide, the mesal portion rounded with the apical lateral corners produced into short, flat, truncate lobes.

In Illinois we have taken this species only at Wilmington, along the Kankakee River. This is apparently along the western limits of the species' range; this range includes the denser portions of the beech-oak-hickory forest, with extensions southwestward through the Ozarks and neighboring ranges. Records are available from Arkansas, Illinois, Indiana, Kentucky, Michigan, Missouri, New York, Pennsylvania, Quebec and Wisconsin. Adults emerge from May to September.

Illinois Records.—WILMINGTON, Kankakee River: May 27, 1935, Ross & Mohr, ♂♂, ♀♀, 1 mating pair, 1 larva; June 6, 1935, Ross & Mohr, 11♂, 8♀; July 1, 1935, DeLong & Ross, 1♂, 1♀.

Cheumatopsyche minuscula (Banks)

Hydropsyche minuscula Banks (1907*a*, p. 130); ♂, ♀.

This species has not yet been taken in Illinois but may eventually be found here. It is similar to *sordida* in its dark coloring and has a somewhat similar range, being known from Arkansas, Georgia, Kentucky, New York, Oklahoma, Ontario, Quebec, Tennessee and Wisconsin.

The tenth tergite and short apical segment of the claspers of the male distinguish the species from others in the genus.

Cheumatopsyche oxa Ross

Cheumatopsyche oxa Ross (1938*a*, p. 155); ♂, ♀.

ADULTS.—Length 8–9 mm. Color uniformly dark brown with only a few inconspicuous light areas near the anal angle of the wings. Male genitalia, fig. 396, with apical segment of the claspers very long, slender and pointed; apical lobes of tenth tergite, from caudal view, appearing fairly long, narrowed near middle and slightly widened at tip.

In Illinois, we have three scattered records of this species, each along a small, spring-fed stream. These and records from other states show the adult emergence to extend from March to middle or late October. Records from other states also indicate a preference for small, rapid streams, thus substantiating observations from our few Illinois records. The species usually occurs in small, local colonies.

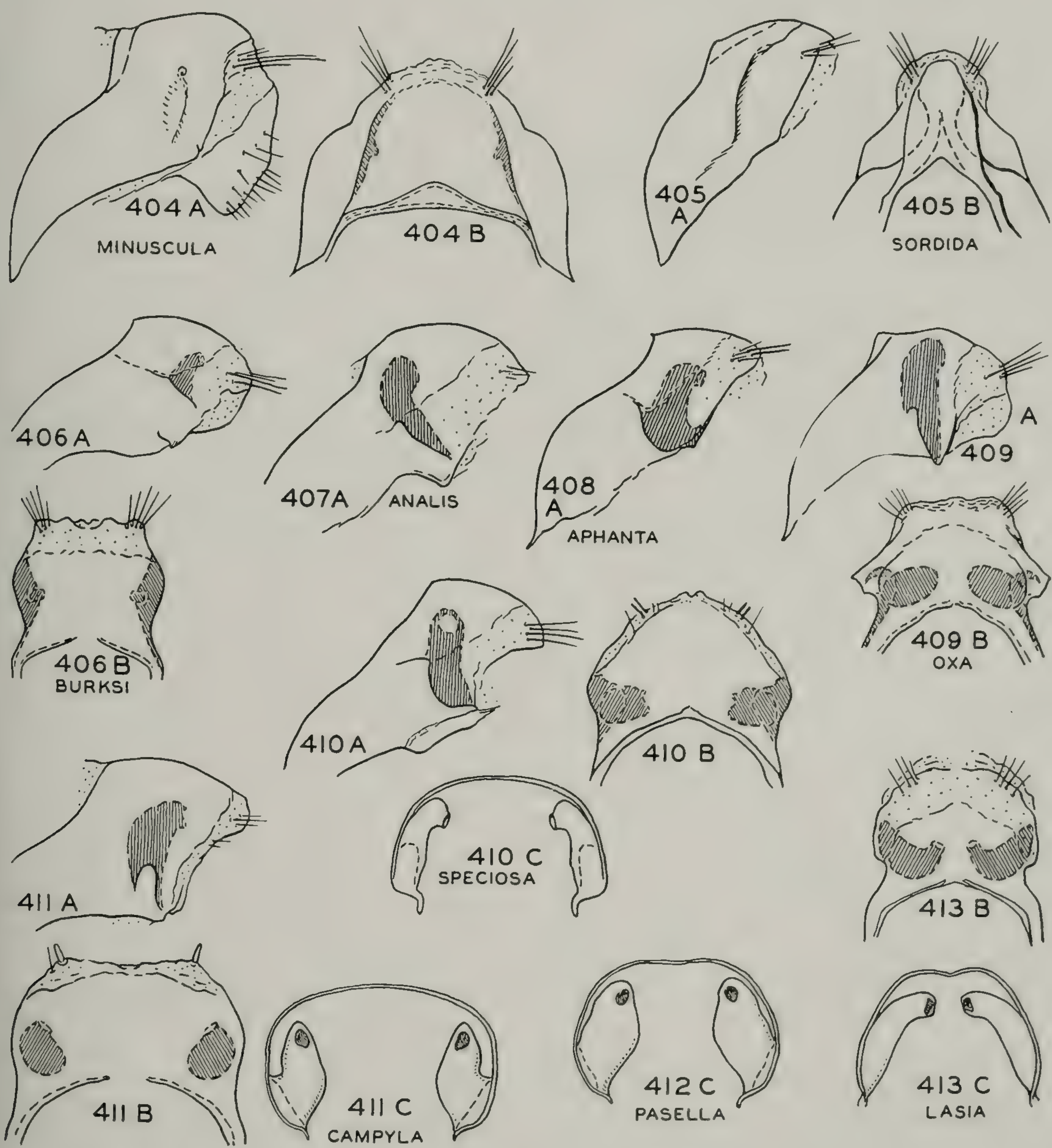
The range of the species apparently covers most of the northeastern deciduous forest region with extensions westward through the Ozarks. We have records from Arkansas, Georgia, Illinois, Michigan, New York, North Carolina, Tennessee and West Virginia.

Illinois Records.—Herod: July 11, 1935, Ross & DeLong, 1 ♂. Springville: Roaring Spring Outlet, Oct. 17, 1938, Ross & Burks, 1 ♂, 1 ♀, many larvae. Utica: Split Rock Brook, June 17, 1941, Burks & Riegel, 1 ♂.

Cheumatopsyche aphanta Ross

Cheumatopsyche aphanta Ross (1938*a*, p. 151); ♂, ♀.

Adults.—Length 7–9 mm. Color dark brown, the wings with a few indistinct, grayish, scattered spots and a large gray spot on the anal margin near apex. Male genitalia, fig. 401: clasper with apical segment long, curved, slender, and pointed at



Figs. 404–413.—*Cheumatopsyche*, ninth and tenth tergites, females. *A*, lateral aspect; *B*, dorsal aspect; *C*, caudal aspect showing lateral invaginations.

apex; tenth tergite short, the apical lobes somewhat ovate, somewhat polished, and appressed on the diagonal to the apex of the tergite.

This species is common in small streams of the northern fourth of the state, in the vicinity of Oakwood and also in the center of the western margin of the state.

The species shows a decided preference for brooks and small creeks, especially those fed by springs and permanent in character. The only exception we have to this is a collection from Oregon, Illinois, which presumably came from the Rock River. The adult emergence extends from May to late September.

The range of the species is poorly delineated. In addition to Illinois records we have only one from Indiana and two from the heart of the Ozarks in western Arkansas.

Illinois Records.—Many males and females and 1 pupa, taken May 11 to September 20, are from Apple River Canyon State Park, Cedarville, Charleston, Chemung, (Piscasaw Creek), Danville (Middle Fork River), Deer Grove, Elgin, Galena (Sinsinawa River), Homer, Howardsville, Mahomet, Mount Carroll, Muncie, Oakwood, Oregon, Quincy (stream near Cave Spring), Rock City, Serena, Sycamore (tributary of South Kishwaukee River), Urbana, White Pines Forest State Park.

Cheumatopsyche analis (Banks)

Hydropsyche analis Banks (1903*b*, p. 243); ♂.

Hydropsyche pettiti Banks (1908*b*, p. 265); ♂.

ADULTS.—Length 9–12 mm. Color varying from almost entirely dark brown with few light spots on the wings to a lighter phase with many small, light spots and the two anal spots as described for *burksi.* Male genitalia, fig. 400: claspers with apical segment long, slightly sinuate and pointed; tenth tergite with apical lobes projecting slightly in front of mesal angle of tergite, low, and with the apex widened into a somewhat round plate which is nearly truncate at apex; these plates vary considerably in proximity to each other.

A re-examination of the type of *analis* convinces me that the curious structure of the tenth tergite of the type is due to mechanical injury, to wit, the breaking off of the apical lobes. The ridging of the tenth tergite, narrow aedeagus and shape of the claspers leave no doubt in my mind that this is the same as *pettiti,* in which type the genitalia are intact. In the type of *analis,* the caudal aspect of the tenth tergite is asymmetrical and appears to end dorsad at fracture lines.

This species exhibits the interesting phenomenon of a dark color phase correlated with the earliest spring emergence and successively lighter color forms as the season advances into warmer weather. The same phenomenon is shown to a certain extent by other caddis flies, but I have observed none in which it is as marked as in this species.

In Illinois the species is very widespread. It shows a preference for small streams but occurs also in the larger rivers. With *campyla,* it is often found in streams carrying considerable pollution and in which few or no other caddis flies are found. It has a wide ecological tolerance.

The range of the species is extremely large, extending from the Atlantic to the Pacific through the northern states and from Georgia and Oklahoma in the south to Minnesota, Ontario and New Hampshire in the north.

Illinois Records.—Many males and females, taken April 16 to September 20, are from Amboy, Apple River Canyon State Park, Aurora, Baker (Indian Creek), Bourbonnais (Rock Creek), Cedarville, Charleston, Chemung (Piscasaw Creek), Chesterville, Clinton (Weldon Springs), Cora, Crescent City, Danville, Dixon Springs, Elgin (Botanical Gardens, Rainbow Springs), Erie, Freeport, Gibson City, Gilman, Greenup (Embarrass River), Halfday, Harrisburg, Havana (Quiver Creek), Herod, Homer, Horse Shoe Lake, Howardsville, Kankakee, Kappa (Mackinaw River), Leland, Mahomet (Sangamon River), Marengo, Mazon (Mazon Creek), McHenry, Momence (Kankakee River), Monticello, Morris, Mount Carroll, Muncie, Oak Hill, Oakwood, Oregon, Ottawa, Palos Park (Mud Lake), Pontiac, Quincy, Richmond, Rock City, Savanna, Serena (Indian Creek), Spring Grove (Nippersink Creek), Starved Rock State Park, Sycamore (tributary of South Kishwaukee River), Urbana (Salt Fork River), Utica (Split Rock Brook), Wadsworth (Des Plaines River), Waukegan, West Vienna, White Heath, White Pines Forest State Park, Wilmington (Kankakee River), Yorkville (Fox River).

Cheumatopsyche burksi Ross

Cheumatopsyche burksi Ross (1941*b*, p. 83); ♂, ♀.

Adults.—Length 9–10 mm. Color brown, the wings with abundant light flecks over the entire surface and with two fairly large white areas along the anal margin, one at the end of the anal veins, the other near the junction of the anal veins. Male genitalia, fig. 398: claspers with apical segment short, the caudal view with base wide and apex narrow and finger-like, the mesal margin straight, the segment in general somewhat triangular; tenth tergite long, the apical lobes short and lanceolate, armed with fairly long setae.

Our only record of this species in Illinois is the holotype male, taken at Havana, along the Spoon River, October 2, 1938, B. D. Burks. The only other record of the species is from Tavares, Florida; hence little can be said regarding the general range of the species.

Cheumatopsyche campyla Ross

Cheumatopsyche campyla Ross (1938*a*, p. 152); ♂, ♀.

Adults. — Length 10–12 mm. Color brown, wings irrorate with light brown and cream and with a large light spot on the anal margin near apex; the irrorate portion is irregularly marked. Male genitalia, fig. 402: claspers with apical segment long and pointed but much shorter than in *oxa* or *aphanta*; tenth tergite fairly long, the apical lobes appearing somewhat clavate at apex from side view, and shouldered and pointed from caudal view; in some specimens this shoulder is more pronounced than in fig. 402.

This species is distributed very widely over Illinois. It seldom frequents small streams, preferring those at least as large as the Salt Fork at Oakwood. It is frequently taken in large numbers along the Illinois, Rock and Mississippi rivers. Adult emergence covers a wide span, from April to October. As mentioned under *analis*, this species is frequently found in streams which are quite unattractive to most caddis flies. The larval head is illustrated in fig. 414.

This species also has a very wide range. It is most abundant through the Corn Belt states but is found over almost all other parts of the continent, with records from Arkansas, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Montana, New Mexico, New York,

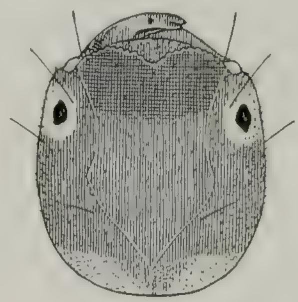


Fig. 414.—*Cheumatopsyche campyla* larva, head.

Ohio, Ontario, Oregon, Pennsylvania, Texas, Utah, Wisconsin and Wyoming.

Illinois Records.—Many males and females, taken April 11 to October 11, are from Algonquin, Alton, Beardstown, Byron, Carmi (on bridge across Little Wabash River), Charleston, Danville (Middle Fork River), Deer Grove (Green River), Des Plaines, Dixon, Dundee, East Dubuque, Elgin (Botanical Gardens), Fieldon, Florence, Grafton, Grand Detour, Grand Tower, Hamilton, Hardin (Illinois River), Harrisburg, Havana, Homer, Horse Shoe Lake, Jerseyville, Kampsville, Kankakee (Kankakee River), Kappa (Mackinaw River), Keithsburg, Mahomet, McHenry, Meredosia, Momence, Montezuma, Morris, Mount Carmel, New Boston, Oakwood, Oregon, Ottawa, Pearl, Pontiac, Quincy (stream near Cave Spring), Richmond, Rockford, Rock Island, Rockton, St. Charles, Savanna, Serena (Fox River), Springfield, Spring Grove (Nippersink Creek), Starved Rock State Park, Sterling, Urbana, Valley City, Waukegan, Wilmington, Yorkville.

Cheumatopsyche pasella Ross

Cheumatopsyche pasella Ross (1941*b*, p. 84); ♂, ♀.

Adults.—Length 7–9 mm. Color dark brown with very few light spots. Male genitalia, fig. 403: claspers with apical segment long and sinuate, pointed at apex. Lobes of tenth tergite very long, angled dorso-caudad, appearing narrow and pointed from lateral view, from caudal view pointed but with the base widened.

We have only two widely separated records of this species for the state, one along the Kaskaskia River, the other along the Kankakee.

Other records from Georgia, Indiana, Kentucky, North Carolina, Pennsylvania, Tennessee and Wisconsin indicate that the main range of the species centers in the eastern states with a preference for rapid streams, and that our isolated records from Indiana, Wisconsin and Illinois are on the extreme western edge of the range.

Illinois Records.—MOMENCE, Kankakee River: May 26, 1936, H. H. Ross, 3♂. VENEDY STATION, along Kaskaskia River: Aug. 27, 1940, Mohr & Riegel, 1♂.

Cheumatopsyche lasia Ross

Cheumatopsyche lasia Ross (1938*a*, p. 154); ♂, ♀.

ADULTS.—Length 7 mm. Color brown, the wings with very fine, uniform and irrorate markings over the entire wing. Male genitalia, fig. 399: claspers with apical segment long, similar to those of *campyla*; tenth tergite with apical lobes produced into a wide, projecting, basal shoulder, the apical portion curved back against the tenth tergite and provided with a heavy brush of setae at the apex.

This species has been taken fairly widely throughout the state, usually along small streams, although occasionally taken along rivers such as the Rock. Many of the streams in which it is found are fairly heavily silted; it is interesting to note in this connection that to the southwest the species has been taken in abundance along heavily silted rivers. Adult emergence extends from May to August with a decided high peak toward July and August.

The range, fig. 12, extending to the south and west of Illinois, includes Illinois, Kansas, Missouri, Oklahoma and Texas; in addition we have a record from eastern Montana which indicates that the species might be fairly widespread in the relatively uncollected Great Plains area.

Illinois Records.—Many males and females, taken May 15 to August 31, are from Amboy (Green River), Bartonville (Kickapoo Creek), Deer Grove, Dixon, Downs (Kickapoo Creek), Elgin (Botanical Gardens), Kappa (Mackinaw River), Mahomet, Milan, Oak Hill (Kickapoo Creek), Pontiac, Quincy (Burton Creek), Ripley, Serena (Indian Creek), Springfield, Spring Grove, White Pines Forest State Park, Wolf Lake.

Cheumatopsyche speciosa (Banks)

Hydropsyche speciosa Banks (1904*d*, p. 214); ♂, ♀.

ADULTS.—Length 7–8 mm. Head brown, wings brown with irregular, fine, light mottling and three large light spots as follows: a pair on the anterior and posterior margins just before the stigma, and the third on the anterior margin just beyond the stigma, sometimes the three marks running together. Male genitalia, fig. 397: claspers with apical segment long, very narrow, pointed, and curved at apex; apical lobes of tenth tergite sharply angled near middle, the apical portion recurved down and back along the tergite and then curved dorsad again, the whole giving the appearance of a pair of sharp, apical projections and a pair of preapical, somewhat hairy lobes.

We have taken this species at several scattered localities in northern Illinois and at one locality along the Wabash River in southern Illinois; this last record probably represents drifts from a nearby large colony at Shoals, Indiana. Our only large Illinois collections have been made at Momence, along the Kankakee River; here the species emerges in swarms. It has a marked preference for large rivers. The adults emerge from April until early September.

The species has a wide range, occurring through the eastern states, extending to the southwest through the Ozarks and to the northwest through Minnesota to Montana. We have records from Arkansas, Indiana, Kentucky, Maryland, Minnesota, Missouri, Montana, New York, Ohio, Oklahoma, Tennessee and Wisconsin.

Illinois Records.—Many males and females, taken May 17 to September 7, are from Champaign, Dixon, Kankakee (Kankakee River), Metropolis, Momence (Kankakee River), Mount Carmel, Putnam, Savanna, Urbana, Wilmington.

Macronemum Burmeister

Macronema Pictet (1836, p. 399). Genotype, monobasic: *Macronema lineatum* Pictet. Preoccupied.

Macronemum Burmeister (1839, p. 915). Emendation.

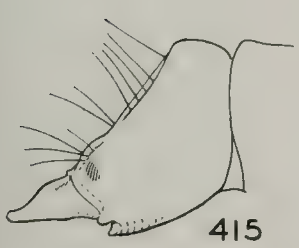
The larvae and pupae are readily distinguished from other members of the family by characters used in the key. The adults may be distinguished also by the large, slender outline, extremely long antennae, and the polished, brightly colored and patterned wings.

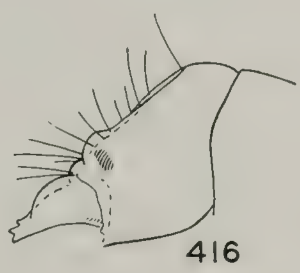
The species frequent large, rapid rivers. The larvae, which may attain a length of nearly an inch, frequently net together large areas of small and medium sized stones if a large number of larvae spin their retreats close together. Only three species have been described for Nearctic America. Two of them have been taken in Illinois, and the other occurs in Indiana not many miles away. At some time we may expect to find adults of this third species which have drifted into Illinois.

KEY TO SPECIES

Larvae

1. Head yellow, the posterior portion of the dorsal flange raised into a pair of tubercles, fig. 417 . . . . **transversum**, p. 117
   Head reddish brown, the posterior portion of the dorsal flange even, not tuberculate, fig. 416 2
2. Tubercles near eye larger, fig. 416 . . . . **carolina**, p. 116





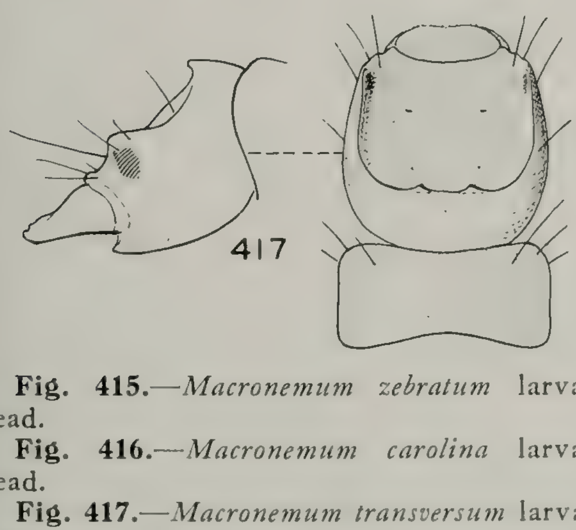
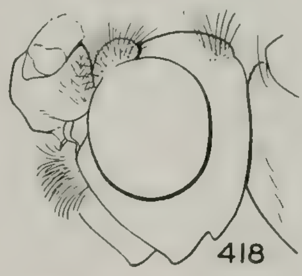


Fig. 415.—*Macronemum zebratum* larva, head.
Fig. 416.—*Macronemum carolina* larva, head.
Fig. 417.—*Macronemum transversum* larva, head.

   Tubercles near eye smaller, fig. 415 . . . . **zebratum**, p. 115

Adults

1. Wings pale yellow with narrow, transverse brown stripes . . . . **transversum**, p. 117
   Wings brown with large yellow spots and stripes, fig. 420 2



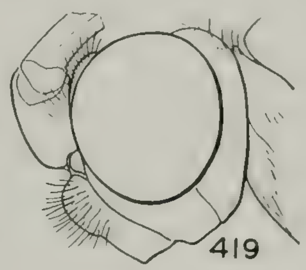


Fig. 418.—*Macronemum zebratum*, head.
Fig. 419.—*Macronemum carolina*, head.

2. Eyes small, malar space large, fig. 418 . . . . **zebratum**, p. 115
   Eyes large, malar space narrow, fig. 419 . . . . **carolina**, p. 116

Macronemum zebratum (Hagen)

Macronema zebratum Hagen (1861, p. 285); ♂, ♀.

Larva.—Fig. 415. Length 22 mm. Head, thoracic sclerites and legs reddish brown. Head with a sharp, U-shaped ridge surrounding a flat area embracing almost all the dorsal portion of the head, this ridge elevated into a distinct tubercle above each eye. Mandibles with base very large and apex narrow, fig. 288. Front legs with a heavy brush on the tibiae.

Adults.—Fig. 420. Length 15–18 mm. Color of head and thorax metallic bluish brown; antennae dark brown at base, gradually becoming lighter toward apex; mouthparts and legs yellow. Front wings brown with yellow markings forming a pattern as in fig. 420. Eyes small, fig. 418, malar space large. Male genitalia with parts simple, fig. 421.

In Illinois we have taken this species at many localities in the northern half of the state, particularly along the Fox, Kankakee, Rock and Mississippi rivers. We have taken the larvae and pupae very abundantly in the rapids of the Kankakee River. Adult emergence begins during the latter part of May and continues into September. During the middle of the summer it is not unusual to encounter large flights of these beautifully colored insects.

The range includes most of eastern North America, with records available from Connecticut, Georgia, Illinois, Indiana, Kentucky, Maine, Michigan, Minnesota, New York, Ohio, Ontario, Pennsylvania, Virginia, West Virginia, Wisconsin; in addition we have an isolated record from Utah.

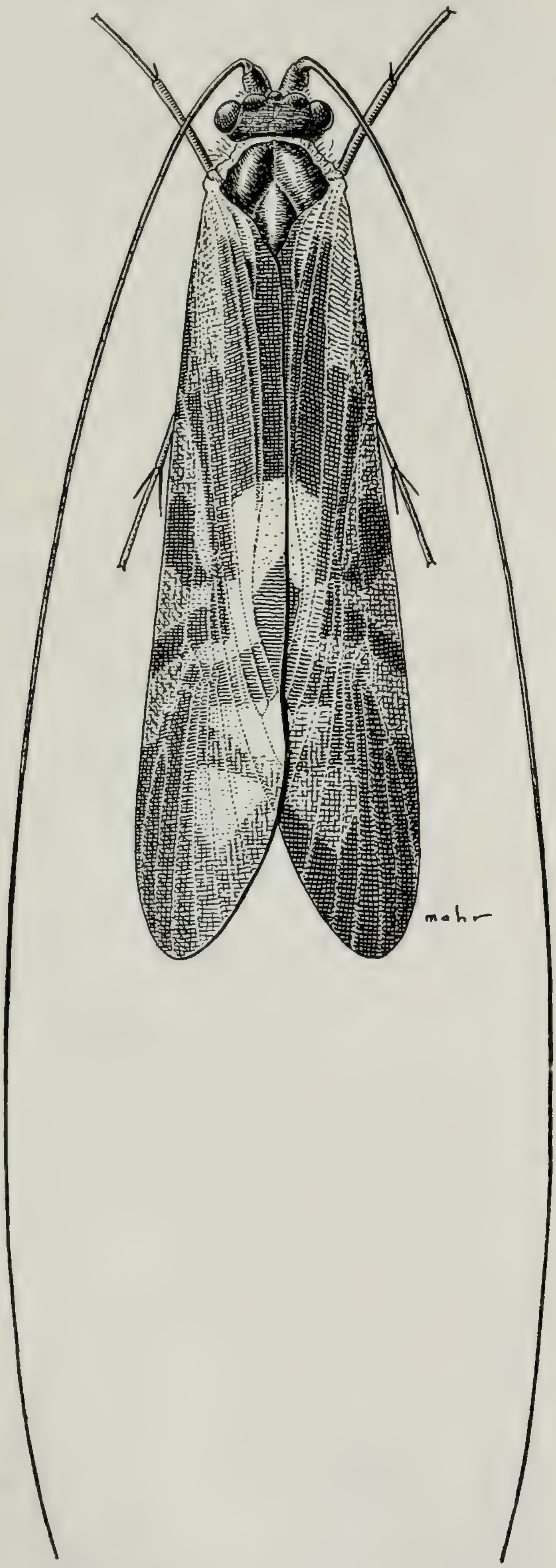


Fig. 420.—*Macronemum zebratum* ♂.

Illinois Records.—Many males and females, collected May 22 to September 7, and many larvae, collected April 27 to October 28, are from Algonquin, Antioch, Aurora, Como (Rock River), Dixon (Rock River), Hamilton, Kankakee (Kankakee River), Momence (Kankakee River), Normal, Oregon, Quincy (Mississippi River), Rockford, Rock Island, Sterling (Rock River), Wilmington (Kankakee River).

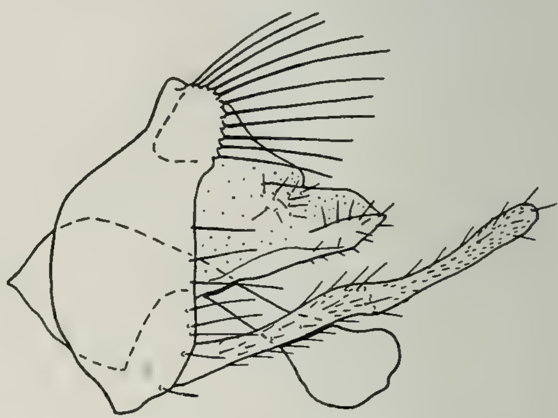


Fig. 421.—*Macronemum zebratum* ♂, genitalia.

Macronemum carolina (Banks)

Macronema carolina Banks (1909, p. 342); ♂.

The genitalia appear identical with *zebratum*, but *carolina* is always smaller, 12–13 mm., has a slightly darker pattern, and has much larger eyes, resulting in a narrower malar space. The larvae, reared at Shoals, Indiana, are remarkably similar to those of *zebratum*, but the differences between them are very critical. It is advisable to use comparison material to aid identification.

Allotype, female.—Swainsboro, Georgia, along Ohoopee River: May 31, 1931, P. W. Fattig.

We have taken only a single specimen in Illinois, a female collected at light in Fox Ridge State Park, near the Embarrass River, July 9, 1944, Sommerman & Ross.

The species is fairly widely distributed through the southern states, and records are available from Florida, Georgia, Indiana, Louisiana, New York, Oklahoma, Pennsylvania and South Carolina.

Macronemum transversum (Walker)

Hydropsyche transversa Walker (1852, p. 114); ♀.
Macronema polygrammatum McLachlan (1871, p. 129); ♂.
Macronema polygrammaticum Betten (1934, p. 204). *Misspelling.*

As in the case of *carolina*, we have not yet taken this species in Illinois but have found it in small numbers in the White River at Shoals and Petersburg, Indiana. We have not actually reared the yellow-headed larva of this genus which we are considering as this species. By a process of elimination, however, there seems no question as to the association. This larva, fig. 417, differs from the others not only in color but in having the posterior portion of the head ridge produced into a pair of tubercles.

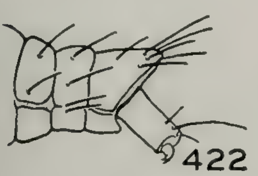
Little is known regarding the distribution of the species. Available records are from Georgia and Indiana.

HYDROPTILIDAE

This family comprises most of the "micro" caddis flies. Various members of the family frequent diverse situations, and in Illinois one or more species may be found in almost any unpolluted lake or stream. Every known Nearctic genus has a representative in the central or eastern states.

The adults are hairy and usually have a mottled pattern; the maxillary palpi are five-segmented in both sexes and the wings have either reduced or compressed venation. The pupae, fig. 44, are very uniform in structure and no characters have been found to key them to genus.

The larvae are unique in possessing a modified type of hypermetamorphosis. In at least some genera (see *Ochrotrichia*, p. 125, and *Mayatrichia*, p. 160) the early instars have a slender body fitted for free, active life and have no case. These forms, fig. 557, have a slender abdomen with the dorsum of each segment sclerotized. The *Mayatrichia* larva studied has structures similar to the mature form, fig. 422, but the *Ochrotrichia* larva differs in having long tarsal claws and long anal legs and claws, fig. 423. Later instars make a case and are modified for life in a case; the abdomen enlarges, at least some tarsal claws are stout, and the anal legs and hooks are reduced to small, stout hooks. Early instars are known for very few genera. Perhaps because they are exceedingly minute (about 1–2 mm. long), they are seldom collected.



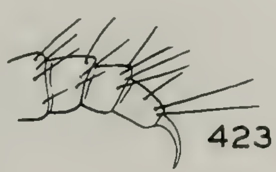


Fig. 422.—*Mayatrichia ayama*, apex of abdomen of early instar larva.

Fig. 423.—*Ochrotrichia* sp., apex of abdomen of early instar larva.

The larvae and cases possess many generic characters and few specific characters, so that in the treatment of this family the generic characters are described in some detail under the first species in each genus.

Many of the genera of the Nearctic Hydroptilidae occur throughout the Americas, frequently with as many species in the Neotropical region as in the Nearctic, or more. Much pioneer work has been done in the study of the Neotropical fauna by Mosely, and the North American students of the group will find much valuable material in his two papers on the Mexican and Brazilian Hydroptilidae (Mosely 1937, 1939).

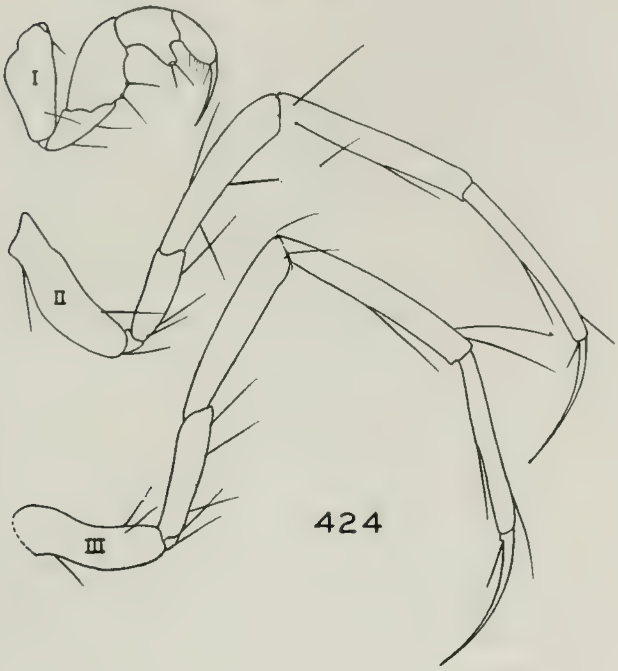
KEY TO GENERA

Larvae

1. Abdomen enlarged, at least some part of it much thicker than thorax, figs. 541; 557*B*, living in case (later instars) 2
   Abdomen slender, not appreciably thicker than thorax, fig. 557*A*; free living, not with case (early instars) .... not keyed
2. Each segment of abdomen with a dark, sclerotized dorsal area, figs. 449, 464*A* 3
   Abdomen with at least segments 2–7 without dark, sclerotized dorsal area, at most with a small, delicate ring, fig. 464*B* 4
3. Abdomen with dorsal sclerites solid; segments 1 and 2 small, 3–6 greatly expanded, fig. 449. Case translucent, ovoid and water-penny shaped, fig. 450 .... **Leucotrichia,** p. 120
   Abdomen with dorsal sclerites membranous across middle, fig. 464*A*; segments 1–6 evenly expanded, as in fig. 541 .... **Ochrotrichia,** p. 125

4. Abdominal segments with lateral projections, fig. 456 .... **Ithytrichia**, p. 123

   Abdominal segments without lateral projections, fig. 541 5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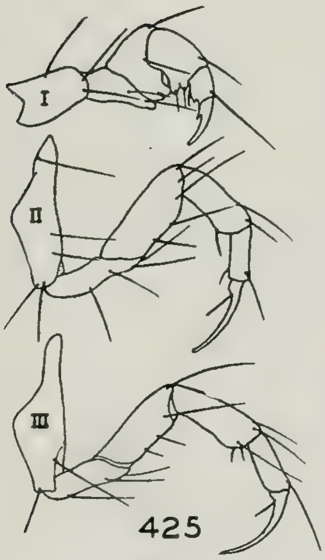
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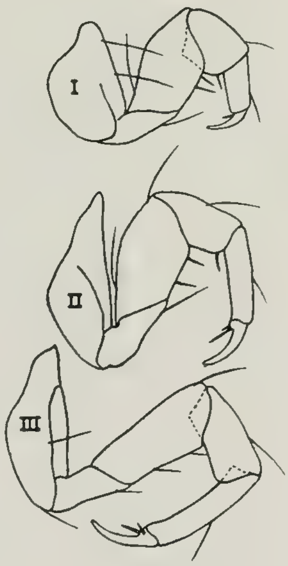
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Fig. 424.—*Oxyethira dualis* larva, legs.
Fig. 425.—*Agraylea multipunctata* larva, legs.
Fig. 426.—*Mayatrichia ayama* larva, legs.

5. Middle and hind legs almost three times as long as front legs, fig. 424 .... **Oxyethira**, p. 133

   Middle and hind legs not more than one and one-half times as long as front legs, fig. 425 6

6. Middle and hind legs with very long, slender tarsal claws which are much longer than tarsi, fig. 425; case purselike, fig. 465..... **Agraylea**, p. 122

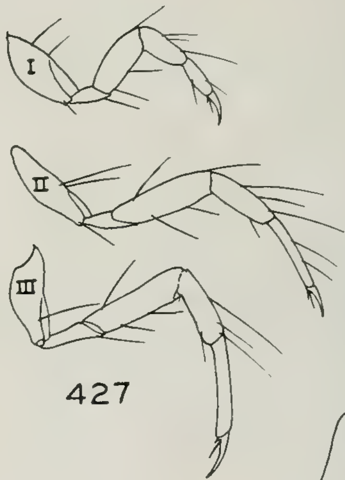
   Middle and hind legs with tarsal claws shorter or stouter, figs. 427, 429; cases of various types 7

7. Anal legs distinctly projecting from body mass, fig. 422; eighth abdominal tergite with a brush of setae, fig. 433 8

   Anal legs apparently combined with body mass and only the claws projecting, fig. 541; eighth abdominal tergite with only one or two pairs of weak setae, fig. 541 9

8. Thoracic tergites clothed with long, slender, erect, inconspicuous setae, fig. 431; case of sand grains, evenly tapered and without posterior slit .... **Neotrichia**, p. 154

   Thoracic tergites clothed with shorter, stout, black setae which are conspicuous and appressed to the sur-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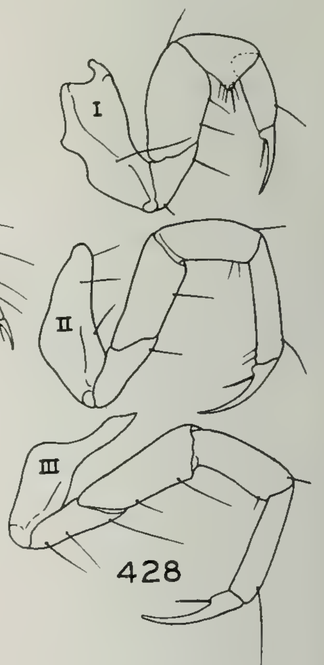
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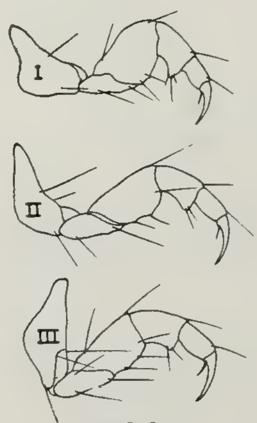
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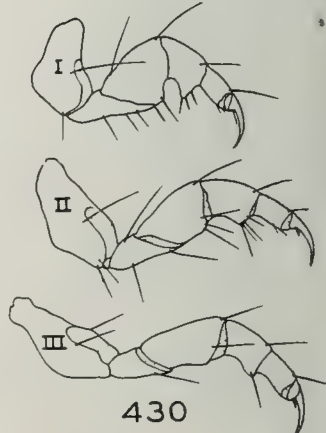
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Fig. 427.—*Neotrichia* sp. larva, legs.
Fig. 428.—*Orthotrichia* sp. larva, legs.
Fig. 429.—*Hydroptila ajax* larva, legs.
Fig. 430.—*Ochrotrichia unio* larva, legs.

face of the body, fig. 432; case translucent, evenly tapered and with dorsal side either ringed or fluted with raised ridges, fig. 558 . . . . **Mayatrichia**, p. 160

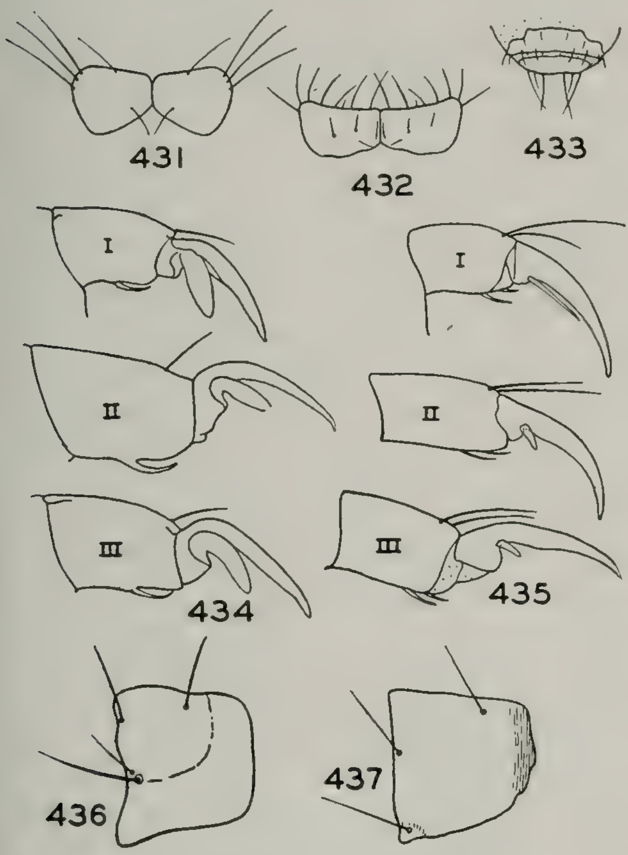
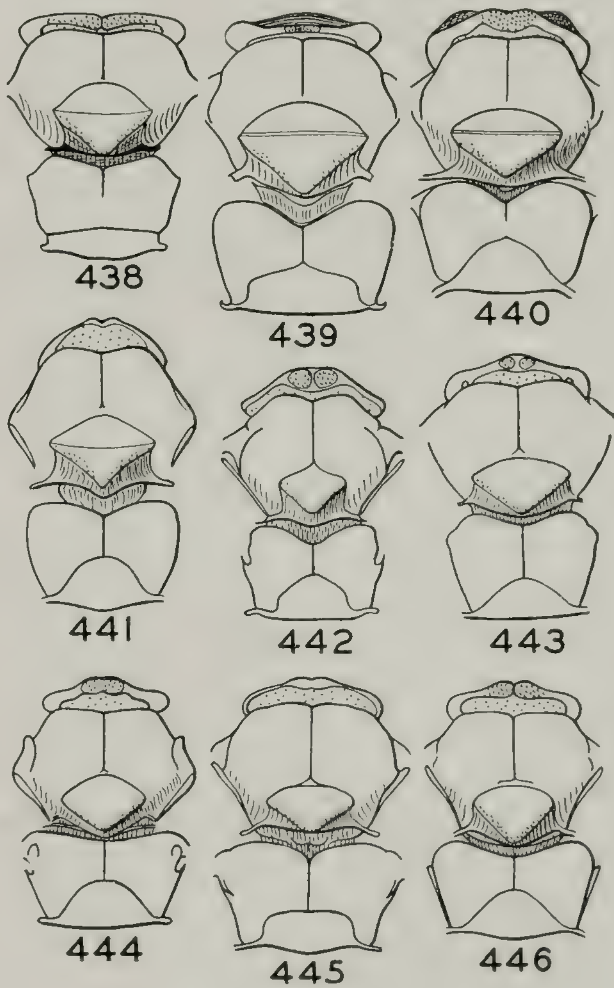


Fig. 431.—*Neotrichia* sp. larva, metanotum.
Fig. 432.—*Mayatrichia ayama* larva, metanotum.
Fig. 433.—*Mayatrichia ayama* larva, eighth tergite.
Fig. 434.—*Tascobia palmata* larva, tarsal claws.
Fig. 435.—*Ochrotrichia unio* larva, tarsal claws.
Fig. 436.—*Ochrotrichia tarsalis* larva, metanotum.
Fig. 437.—*Hydroptila waubesiana* larva, metanotum.

9. Tarsal claws with long, stout inner tooth, fig. 434; case purselike, robust . . . . **Tascobia**, p. 124
   Tarsal claws without prominent inner tooth, fig. 435; case either purselike or cylindrical 10
10. Middle and hind legs with tibiae cylindrical and long, fig. 428; case long, smooth and round in cross section, tapered at each end and with an indented slit at both ends . . . . **Orthotrichia**, p. 139
   Middle and hind legs with tibiae stout and widened at apex, fig. 429; case of purse type 11
11. Metanotum with a distinct, widened ventro-lateral area, fig. 436 . . . . **Ochrotrichia**, p. 125
   Metanotum without a widened, lateral area, fig. 437 . . . . **Hydroptila**, p. 141

Adults

1. Ocelli absent 2
   Ocelli present 4
2. Front tibiae with an apical spur . . . . **Dibusa**, p. 121
   Front tibiae without an apical spur . . 3
3. Metascutellum almost rectangular, fig. 445 . . . . **Orthotrichia**, p. 139
   Metascutellum pentagonal to triangular, fig. 446 . . . . **Hydroptila**, p. 141
4. Metascutellum as wide as scutum; short and rectangular, fig. 438 . . . . **Tascobia**, p. 124



Hydroptilidae, Thorax
Fig. 438.—*Tascobia brustia.*
Fig. 439.—*Leucotrichia pictipes.*
Fig. 440.—*Metrichia nigritta.*
Fig. 441.—*Ochrotrichia tarsalis.*
Fig. 442.—*Agraylea multipunctata.*
Fig. 443.—*Oxyethira pallida.*
Fig. 444.—*Ithytrichia clavata.*
Fig. 445.—*Orthotrichia americana.*
Fig. 446.—*Hydroptila hamata.*

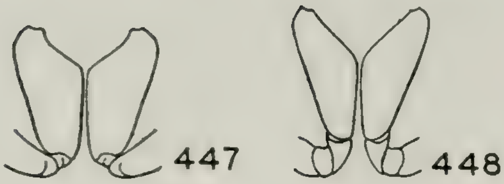


Fig. 447.—*Leucotrichia pictipes*, front coxae.
Fig. 448.—*Metrichia nigritta*, front coxae.

Metascutellum either triangular, fig. 440, or markedly narrower than scutum, fig. 439 5

5. Front tibiae with an apical spur 6
   Front tibiae without an apical spur .. 7
6. Front coxae wide, fig. 447 ....**Leucotrichia,** p. 120
   Front coxae narrow, fig. 448 ....**Metrichia,** p. 121
7. Hind tibiae with only 1 preapical spur ....**Neotrichia,** p. 154
   Hind tibiae with 2 preapical spurs ... 8
8. Middle tibiae without a preapical spur.............**Mayatrichia,** p. 160
   Middle tibiae with a preapical spur .. 9
9. Mesoscutellum with a slightly arcuate, linelike fracture running from one lateral angle to the other, fig. 441, and dividing the area of the sclerite almost equally....**Ochrotrichia,** p. 125
   Mesoscutellum without a transverse, linelike groove 10
10. Mesoscutellum narrow and diamond-shaped, with a wide area posterior to postero-dorsal edge; metascutellum with sides parallel to median line and anterior margins forming a corner with sides, fig. 442 ....**Agraylea,** p. 122
   Mesoscutellum wider, anterior margin evenly curved, with postero-dorsal edge close to or touching posterior margin; metascutellum triangular, arcuate or nearly so, figs. 443, 444 11
11. Postero-dorsal edge of mesoscutellum touching posterior margin on meson; metascutellum with posterior margin extending to lateral margin of segment, fig. 443.....**Oxyethira,** p. 133
   Postero-dorsal edge of mesoscutellum separated from posterior margin by a narrow strip; metascutellum with posterior margin not extending to lateral margin but joined to it by a short, straplike piece, fig. 444..... ....**Ithytrichia,** p. 123

Leucotrichia Mosely

Leucotrichia Mosely (1934*b*, p. 157). Genotype by original designation: *Leucotrichia melleopicta* Mosely.

Only one of the four Nearctic species has been taken in Illinois. The remainder are western or southwestern in distribution. A key to Nearctic males is on page 271.

Leucotrichia pictipes (Banks)

Orthotrichia pictipes Banks (1911, p. 359); ♂, ♀.

LARVA (mature type).—Fig. 449. Length 4.5 mm. Sclerites dark brown. Segments of thorax somewhat flattened, legs short and stout. Abdomen with first two segments very small, third to sixth greatly expanded; each segment of abdomen with a conspicuous, rectangular, dark sclerite on the dorsum, each sclerite bearing several setae, segments separated by a conspicuous constriction. Anal hooks sessile and fairly long.

CASE.—Fig. 450. Round and convex, similar in appearance to a leech egg, attached like a water-penny, made of translucent material which appears gelatinous but is actually quite tough. Underside of case formed of a weak, irregular sheet.

ADULTS.—Length 4.0–4.5 mm. Body and appendages dark brown to black, the antennae and tarsi banded with white, the wings with a few scattered, small light areas.

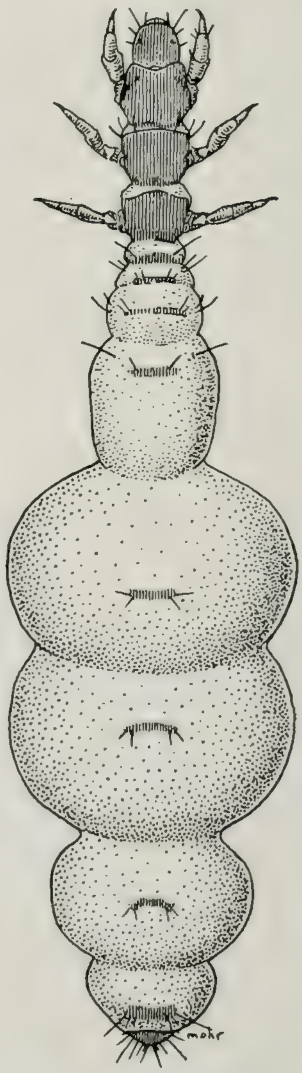


Fig. 449.—*Leucotrichia pictipes* larva.

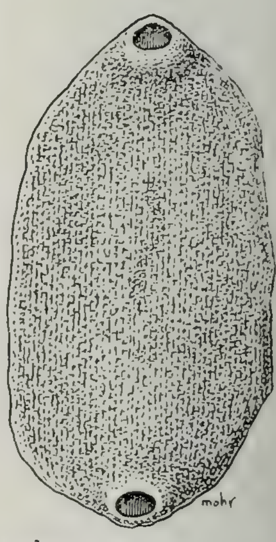


Fig. 450.—*Leucotrichia pictipes* case.

Male genitalia, fig. 916, (see p. 272): eighth sternite bilobed, forming a pair of widely spaced triangles; ninth tergite with a brush of long setae; claspers fused to form a short, broad spatula; aedeagus as in fig. 916. Female genitalia with segments simple; bursa copulatrix as in fig. 921 (see p. 273).

The larva was described by Lloyd (1915*a*) under the name *Ithytrichia confusa* (misidentification).

Our only Illinois records of this species are from the Apple River in Apple River Canyon State Park, situated in the Jo Daviess hills of extreme northwestern Illinois. In one or two of the swiftest rapids of the river we have taken larvae and pupae on large stones in the center of the current.

In the northern states, the species' range is practically transcontinental, with definite records from Colorado, Idaho, Michigan, Minnesota, New York, Oregon, Wisconsin and Wyoming.

Illinois Records.—APPLE RIVER CANYON STATE PARK: Aug. 23, 1939, Ross & Riegel, 7♂, 2♀; Apple River, May 24, 1940, H. H. Ross, 1♂, 2 larvae, many pupae; June 6, 1940, Mohr & Burks, 2♂; April 9, 1941, Ross & Mohr, many larvae.

Metrichia Ross

Metrichia Ross (1938*c*, p. 9). Genotype, by original designation: *Orthotrichia nigritta* Banks.

The genotype is the sole species in the genus and is known from Texas and Okla-

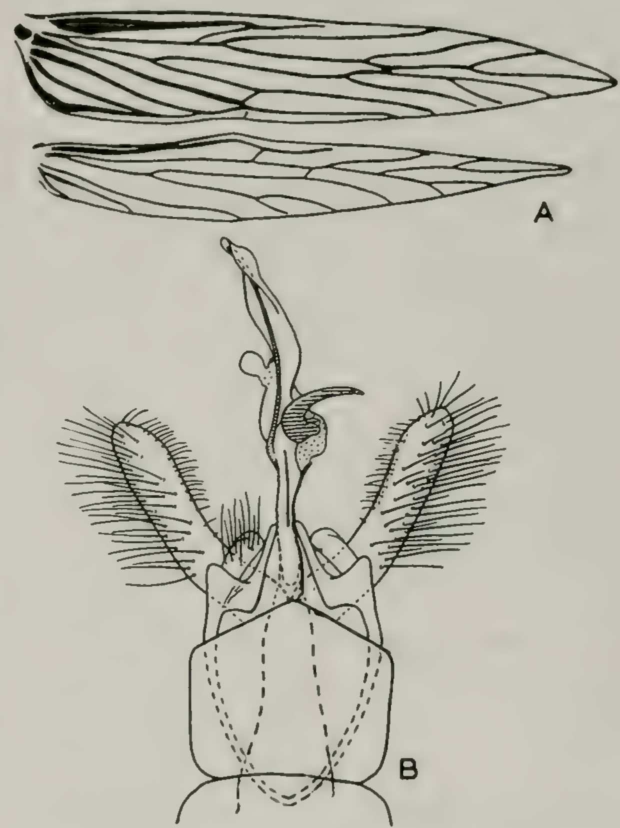


Fig. 451.—*Metrichia nigritta. A*, wings; *B*, male genitalia.

homa. The larva is unknown. The male genitalia and wings are illustrated in fig. 451.

Dibusa Ross

Dibusa Ross (1939*a*, p. 66). Genotype by original designation: *Dibusa angata* Ross.

In this genus, as in *Metrichia*, the genotype is the sole species. Originally described

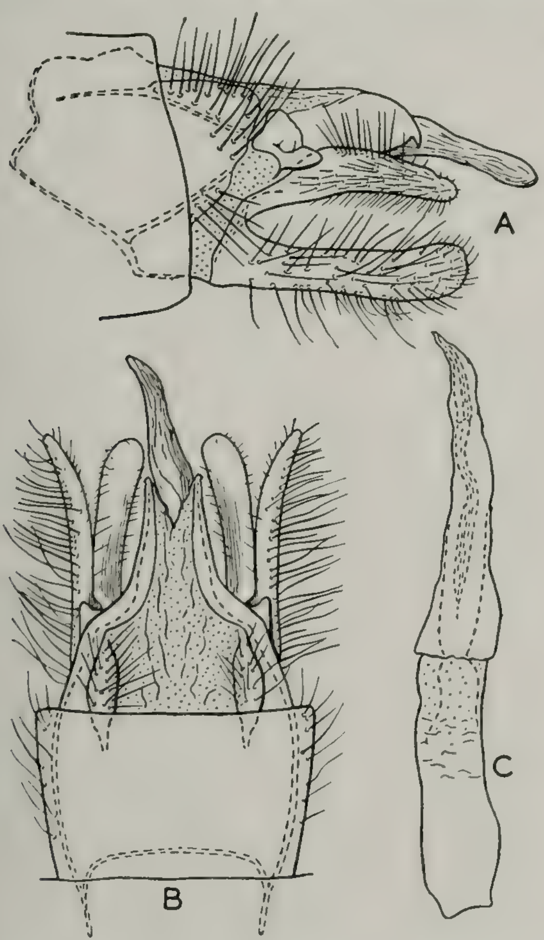


Fig. 452.—*Dibusa angata. A* and *B*, male genitalia, lateral and dorsal aspects; *C*, aedeagus; *D*, wings.

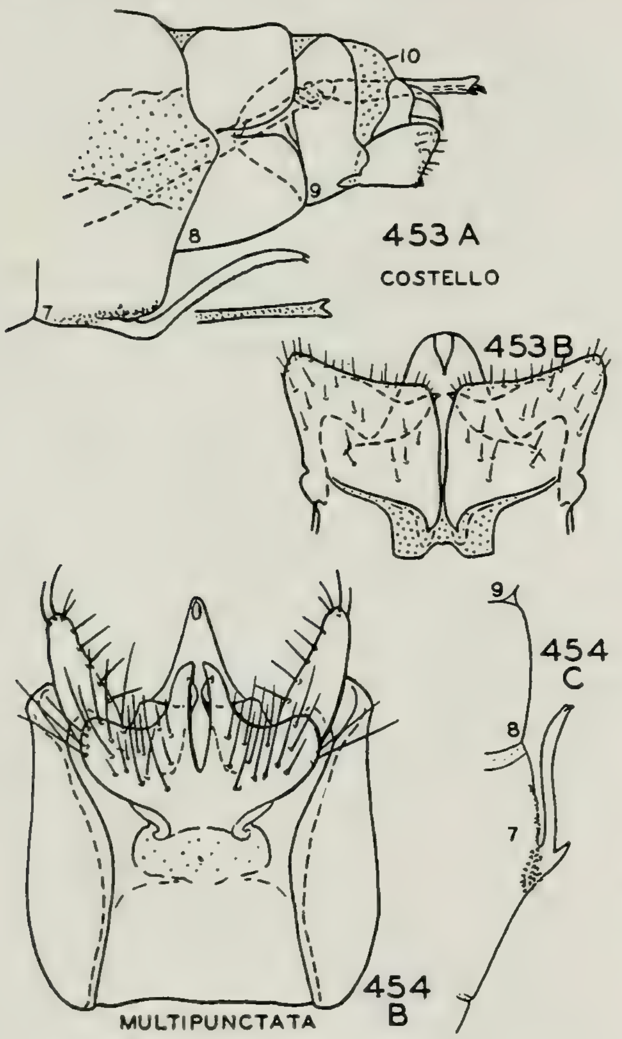
from North Carolina, it has since been collected in southeastern Oklahoma. The male genitalia and wings are illustrated in fig. 452; the female and larva are unknown.

Agraylea Curtis

Agraylea Curtis (1834, p. 217). Genotype, monobasic: *Agraylea multipunctata* Curtis.

Hydrorchestria Kolenati (1848, p. 103). Emended name.

Only one species of the genus, *multipunctata*, has been collected in Illinois. The



Figs. 453–454.—*Agraylea*, male genitalia. *A*, lateral aspect; *B*, ventral aspect; *C*, lateral process of seventh sternite.

only other eastern species, *costello*, differs markedly in the shape of the claspers, fig. 453.

Agraylea multipunctata Curtis

Agraylea multipunctata Curtis (1834, p. 217).

Allotrichia signata Banks (1904*d*, p. 215); ♂.

Agraylea fraterna Banks (1907*b*, p. 164); ♂.

Allotrichia flavida Banks (1907*b*, p. 164); ♀. New synonymy.

Larva (mature type).—Length 5 mm. Head round and robust, front legs short and stocky, middle and hind legs longer, with exceptionally long tarsal claws. Abdominal segments enlarged gradually to beyond middle and decreasing to apex, segments separated by a constriction and without dorsal armature.

Case.—Purselike, formed of two symmetrical ovate valves and with anterior and posterior slits. The case is carried erect. Construction of fibers often mottled.

Adults.—Length 4–5 mm. Color salt-and-pepper mottling to almost uniformly

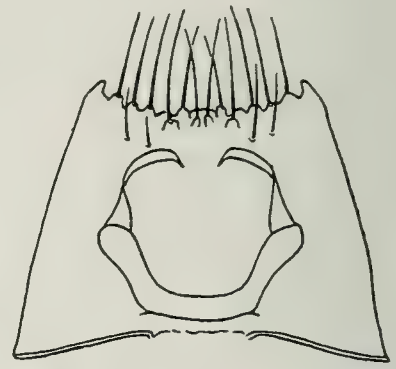


Fig. 455.—*Agraylea multipunctata*, female genitalia.

black. Venation relatively complete, much as in fig. 452. Male genitalia as in fig. 454. Female genitalia as in fig. 455.

Holarctic in distribution, this species is taken commonly throughout the northern states and Canada. In Illinois our records are most abundant in the northeastern corner. The larvae have been taken in both lakes and rivers. In addition to Illinois, we have records from British Columbia, Colorado, Maine, Manitoba, Michigan, Minnesota, New Brunswick, New York, Nova Scotia, Ontario, South Dakota, Virginia, Wisconsin.

Illinois Records.—Antioch: July 1, 1931, Frison, Betten & Ross, 2♀; July 7, 1932, at light, Frison & Metcalf, ♂♂, ♀♀. Fox Lake: July 1, 1931, Frison, Betten & Ross, 2♂, 6♀; Sept. 22, 1931, Frison & Ross, ♂♂, 6♀; Oct. 4, 1931, Ross & Mohr, ♂♂, 3♀; June 30, 1935, DeLong & Ross, ♂♂, ♀♀; May 28, 1936, in weeds, H. H. Ross, 3 larvae; June 10, 1936, Ross & Burks, 1♂. McHenry: June 30, 1931, Frison, Betten & Ross, 1♀. Palos Park, Mud Lake: Aug. 3, 1938, Ross & Burks, 1 ♂, 6 ♀. RICHMOND: June 20, 1938, Burks & Boesel, 5 ♀. SAVANNA: July 10, 1927, Frison & Glasgow, at light, 1 ♀. SPRING GROVE: Fish Hatchery, May 10, 1935, Frison & Ross, 1 ♂, 1 ♀; June 9, 1938, Burks & Mohr, 5 ♂, 5 ♀; June 17, 1938, at light, Burks & Boesel, 1 ♀; Nippersink Creek, June 17, 1938, B. D. Burks, 2 ♀; Fish Hatchery, July 11, 1938, Burks & Riegel, 4 larvae.

Ithytrichia Eaton

Ithytrichia Eaton (1873, p. 139). Genotype, monobasic: *Ithytrichia lamellaris* Eaton.

The curious hydroptilid larva described by Needham (1902) is probably of this genus. At the time Needham considered the larva (prepupa) with lateral appendages, fig. 456, to be a different phase of

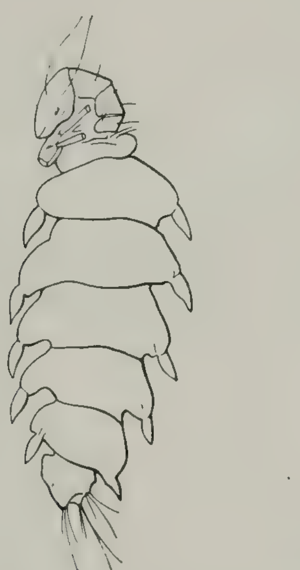


Fig. 456.—*Ithytrichia?* larva. (After Needham.)

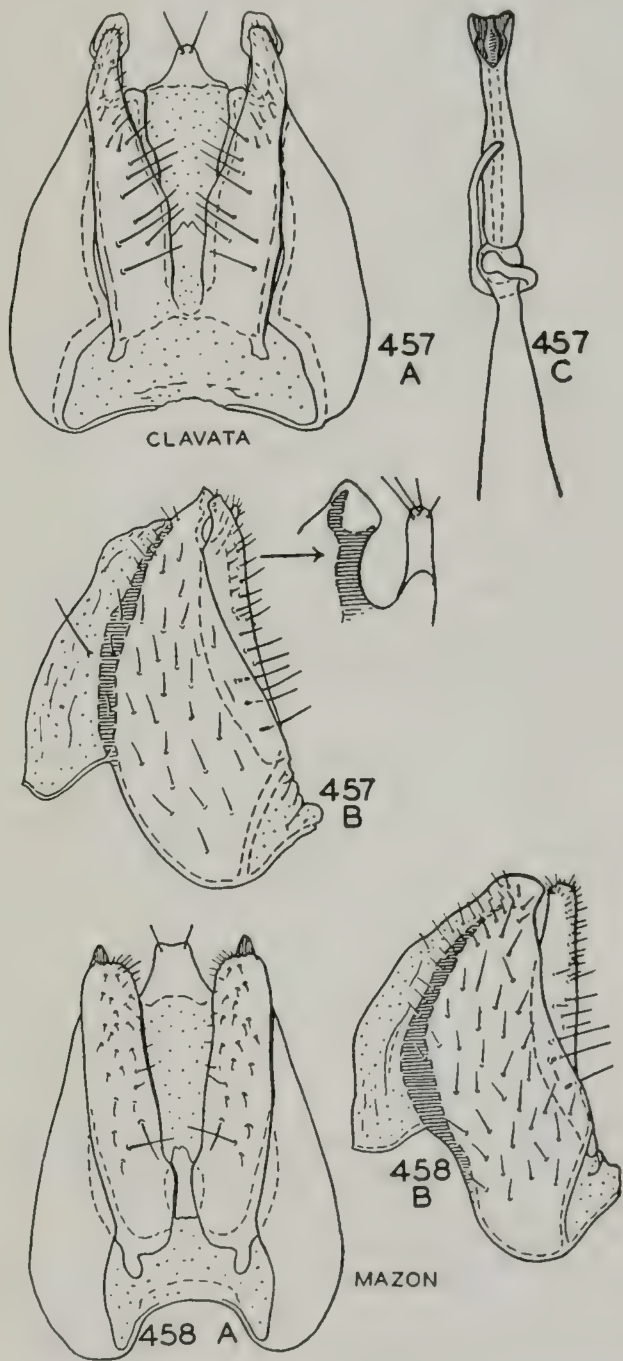
another larva without such appendages but collected with it. I have observed no such phenomenon in prepupae of other Hydroptilidae. Furthermore the larva under discussion fits descriptions of a European species of this genus (Morton 1888). I believe that two genera were involved in Needham's collecting. His larva without the lateral appendages (1902, fig. 1) may have been a species of *Oxyethira*; the one with lateral appendages (1902, figs. 2–5) was probably *Ithytrichia clavata*. Both were in cases apparently resembling fig. 465.

Both Nearctic species have been taken in Illinois. The female of one of these is unknown. The adults have the salt-and-pepper markings typical of many Hydroptilidae.

KEY TO SPECIES

Males

1. Claspers with ventral aspect narrowed to a slender apex; side plates of ninth segment with apex narrow, lateral aspect downcurved, ventral aspect flared, fig. 457 . . . . **clavata**, p. 124



Figs. 457–458.—*Ithytrichia*, male genitalia. *A*, ventral aspect; *B*, lateral aspect; *C*, aedeagus.

Claspers with ventral aspect parallel sided, apex wide and truncate; side plates of ninth segment with apex wide, without flared end, fig. 458 . . . . **mazon**, p. 124

Ithytrichia clavata Morton

Ithytrichia clavata Morton (1905, p. 67); ♂.

LARVA.—What is possibly the larva of this species was illustrated by Needham (1902, p. 377, figs. 2–5). His drawing is reproduced here in fig. 456. No additional material of this form has been found.

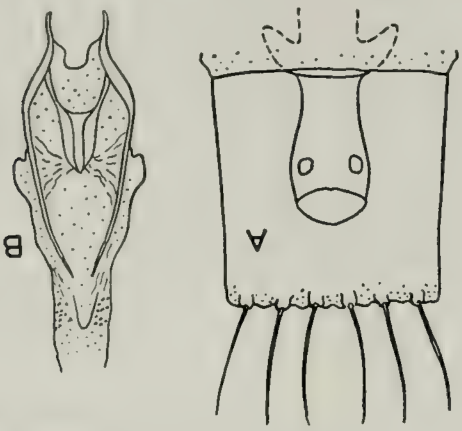


Fig. 459.—*Ithytrichia clavata*, female genitalia. *A*, ventral aspect; *B*, bursa copulatrix.

ADULTS.—Length 3 mm. Color dark brown with light mottling over body and wings. Male genitalia, fig. 457: ninth and tenth tergites entirely membranous dorsally, the lateral portion extending to apex of clasper and forming an apical portion with downcurved, truncate lateral aspect and a flared ventral aspect; below this is a thumblike protuberance from which arises a finger-like process; claspers long and slender, tapering to a narrow apex; aedeagus long, with tubular base, distinct neck with a stout spiral process and long apex flattened and flanged at end. Female genitalia, fig. 459: eighth sternite membranous with six setae at apex, each on a separate basal tubercle; near middle of segment is a curious, headlike structure having internal lobes connected with its base; bursa copulatrix with base open, fig. 459*B*.

Allotype, female.—Cultus Lake, Sardis, British Columbia: July 23, 1936, H. H. Ross.

Our only Illinois collection of this species was made at light, along the Galena River, Council Hill, June 26, 1940, Mohr & Riegel, 7♂. We have female specimens from Muncie which may be this species. Since the female of *mazon* is not known and may be similar to that of *clavata*, it seems best to leave these Muncie specimens unidentified.

The species has a very wide range, at least transcontinental and perhaps Holarctic, with records from British Columbia, California, Illinois, New York, Oklahoma, Pennsylvania. Tjeder (1930) records the species from Sweden, but there is a doubt as to the correctness of his identification.

Ithytrichia mazon new species

MALE.—Length 3 mm. Color brown with light mottling over body and wings. General structure typical for genus. Male genitalia, fig. 458: ninth and tenth tergites not separated, both membranous; lateral area of ninth segment sinuate at base, with an arcuate, sclerotized dorsal thickening, the apex wide and without flared areas or processes; claspers nearly straight, ventral aspect parallel sided and truncate at apex; aedeagus with long, tubular base, round neck, and with spiral and apex similar to, but slightly narrower than, those in fig. 457*C*.

Holotype, male.—Mazon, Illinois, along Mazon Creek, June 16, 1938, B. D. Burks.

Known only from the holotype. This species resembles *lamellaris* Eaton most closely but differs in having no sclerotized dorsal rods beneath the base of the ninth tergite and in the truncate apex of the claspers. The type was collected at light along the banks of Mazon Creek, which is a small stream laden with pollution.

Tascobia new genus

LARVA (mature type).—Head rounded, all legs short and stocky. Abdomen gradually enlarged toward middle, tapering to posterior end, with moderate constrictions between segments. Anal hooks short and not projecting on "legs."

CASE.—Purselike, of fibrous construction.

ADULTS.—Length 3 mm. Color salt-and-pepper mottling. Ocelli present, lateral pair close to eye. Wings only moderately narrowed at apex. Legs with spur count of 1-3-4. Notum, fig. 438, with mesoscutellum divided by transverse line; metascutellum wide, short and rectangular.

Genotype.—*Stactobia palmata.*

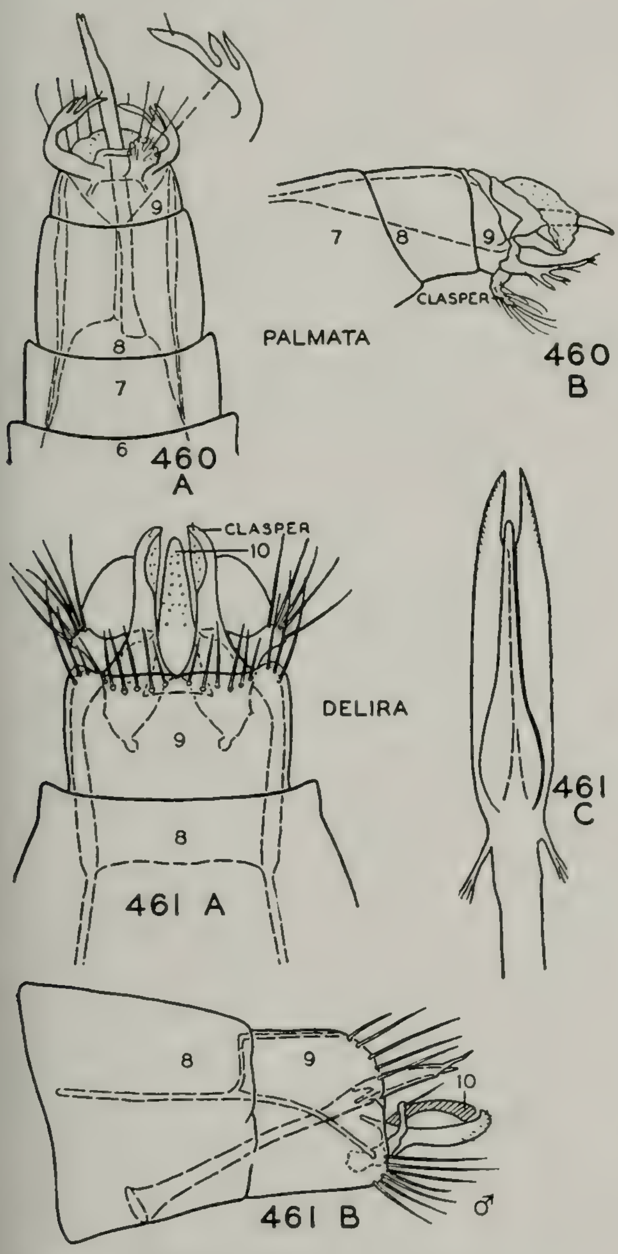
This genus includes *palmata*, *brustia* and *delira*, all placed previously in the genus *Stactobia*. *Stactobia* is apparently restricted to Europe and is quite distinct from this new genus as evidenced by differences in larvae and genitalia. Characters to separate *Tascobia* from other Nearctic Hydroptilidae are given in the key to genera.

Tascobia palmata (Ross)

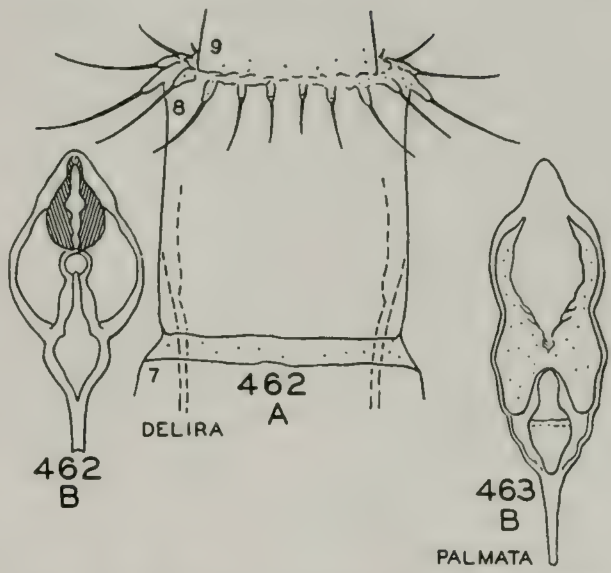
Stactobia palmata Ross (1938*a*, p. 116); ♂, ♀.

LARVA.—Length 3.5 mm. Sclerites cream to dusky, with dark lines and spots along sutures.

ADULT.—Size, color and structure as described for genus. Male genitalia, fig. 460: ninth segment forming a long internal shelf open ventrally; tenth tergite membranous; claspers short, ovate at apex; above them arise a pair of stalked processes divided at apex into three fingers; aedeagus simple and tubular. Female genitalia with a ring of spines at apex of eighth segment; bursa copulatrix as in fig. 463.



Figs. 460–461.—*Tascobia*, male genitalia. *A*, ventral aspect; *B*, lateral aspect; *C*, aedeagus.



Figs. 462–463.—*Tascobia*, female genitalia. *A*, ventral aspect; *B*, bursa copulatrix.

Of the three species known in the genus, only this one has been taken in Illinois. Another, *delira*, occurs north and east of the state and may be taken in future collecting. The two species differ radically in genitalia, figs. 460, 461.

Adults have seldom been taken, but the larvae are found in numbers in several small and fairly swift streams, notably the Sangamon and Sinsinawa rivers. The cases are found on stones in riffles, and the larvae mature in early spring. Mature pupae have been collected from several localities.

Originally described from Illinois, Kentucky, Tennessee and Wisconsin, the species has since been taken in Oklahoma.

Illinois Records.—APPLE RIVER CANYON STATE PARK: May 24, 1940, H. H. Ross, many larvae; June 6, 1940, Mohr & Burks, ♂♂, ♀♀. COUNCIL HILL, Galena River: June 5, 1940, Mohr & Burks, 2 larvae. EDDYVILLE, Lusk Creek: May 24, 1940, Mohr & Burks, 1♂ (reared), 2♂, 1♀, 6 pupae, 6 larvae; June 1, 1940, B. D. Burks, 4 larvae, many pupae. GALENA: May 23, 1940, H. H. Ross, many larvae. KANKAKEE, Kankakee River: June 6, 1935, Ross & Mohr, 2♂; May 31, 1938, Mohr & Burks, 1♂, 3♀. MAHOMET, Sangamon River: June 6, 1940, Ross & Riegel, many pupae and larvae. SUGAR GROVE: June 13, 1939, Frison & Ross, 1♀.

Ochrotrichia Mosely

Polytrichia Sibley (1926*b*, p. 102). Genotype, monobasic: *Ithytrichia confusa* Morton. Preoccupied.

Ochrotrichia Mosely (1934*b*, p. 162). Genotype, by original designation: *Ochrotrichia insularis* Mosely.

The genus *Polytrichia*, erected in 1926 for the species *Ithytrichia confusa*, is preoccupied by a genus of snails and therefore cannot be used in the caddis flies. It is necessary to resurrect the genus *Ochrotrichia*, described in 1934, with *insularis* as its type. In 1937 Mosely sank his genus *Ochrotrichia* as a synonym of *Polytrichia*, but now Mosely's name must be applied to the large assemblage of species in North, Central and South America which have previously been placed under *Polytrichia*.

Ten of the 20 described Nearctic species have been taken in Illinois and one or two more may show up with additional collecting. All the species frequent clear and rapid streams, including some which dry in summer. Many of the species appear to be local in distribution, and the few known localities for any one of these species may be widely separated.

KEY TO SPECIES

Larvae

1. Abdominal tergites, fig. 464*A*, with an ovoid sclerite having a transverse, membranous center and with lateral, sclerotized, setate spots some distance from mesal sclerite; case tortoise-like, flat on the bottom .... **riesi**, p. 132
   Abdominal tergites, fig. 464*B*, ornamented only with inconspicuous sclerotized rings; case purselike, fig. 465 2
2. Head and thoracic sclerites almost entirely yellow or light brownish yellow, sometimes with a faint reddish tone 3

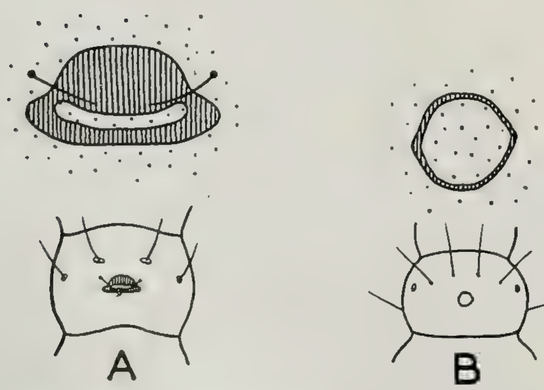


Fig. 464.—*Ochrotrichia* larvae, abdominal rings. *A*, *O. riesi*; *B*, *O. anisca*.

   Head and thoracic sclerites mostly dark brown, sometimes shading to black 4

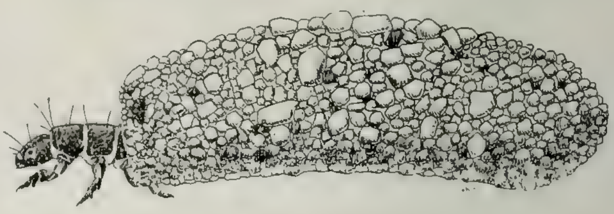


Fig. 465.—*Ochrotrichia unio*, larva and case.

3. Thoracic sclerites with distinct markings of fairly dark brown .... **tarsalis**, p. 130
   Thoracic sclerites with only indistinct suffusions of darker color; head and thorax frequently with a reddish tone .... **anisca**, p. 131
4. Head with a small, mesal pale spot or stripe .... **xena**, p. 130
   Head without a mesal pale area .... **unio**, p. 129; **eliaga**, p. 132; **spinosa**, p. 132

Adults

1. Apex of abdomen with long claspers, fig. 466 (males) 2
   Apex of abdomen tubular, fig. 478 (females) 12
2. Tenth tergite triangular or vasiform, figs. 466, 467, small, without long or hooked, sclerotized processes; both ninth segment and claspers long and narrow 3
   Tenth tergite longer, with a set of definite, heavily sclerotized hooked or straight processes, fig. 471; ninth segment and claspers shorter 4
3. Claspers with two mesal brushes of black pegs at apex, fig. 466; tenth tergite triangular .... **xena**, p. 130
   Claspers with only one mesal brush of black pegs at apex, fig. 467; tenth tergite vasiform .... **unio**, p. 129
4. Claspers shoelike, upcurved at apex, dorsal margin concave, fig. 468 5
   Claspers sinuate, fig. 475 8
5. Left side of tenth tergite with a large, conspicuous spine near middle, curved mesad, fig. 471 ... **tarsalis**, p. 130
   Left side of tenth tergite without such a spine curved mesad 6
6. Tenth tergite with spine *C* filamentous and not angled from its base, fig. 468 .... **shawnee**, p. 131
   Tenth tergite with spine *C* stout, curved away from and back to its parent sclerite, fig. 469 7
7. Tenth tergite with sclerite *A* very broad, *D* almost touching spiral of

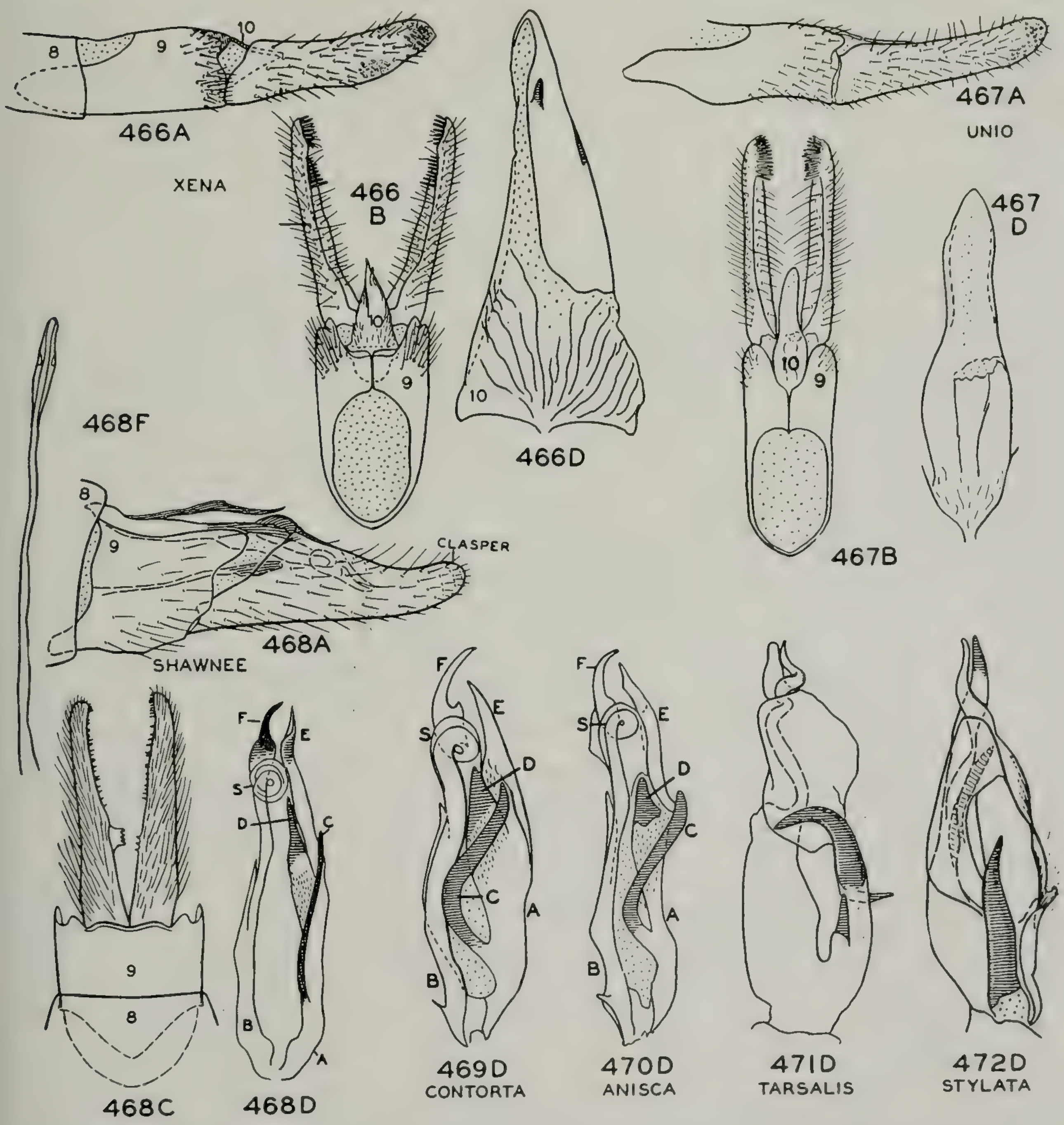
B, and *E* short, tapering evenly to pointed apex, fig. 469..**contorta**, p. 131
Sclerite *A* much narrower, *D* removed at least its own length from spiral of *B*, *E* long, obliquely truncate at apex and much closer to apex of *F*, fig. 470................**anisca**, p. 131

8. Claspers with a row of 4 or 5 long, stout, evenly spaced, black spines at middle shoulder, fig. 473....... 9
Claspers with black spines irregular or clustered at middle shoulder, figs. 475–477........................ 10

9. Hook of tenth tergite large and reaching beyond sclerite *B*; sclerites *C* and *D* both slender, fig. 473....**riesi**, p. 132
Hook of tenth tergite small, sclerite *B* extending considerably beyond it; sclerite *C* very slender, sclerite *D* shorter and stout, fig. 474................................**confusa**, p. 133

10. Right clasper with middle of ventral portion angulate; the angle bears a spine well separated from the others, fig. 475..............**spinosa**, p. 132
Right clasper with middle of ventral portion evenly sinuate, fig. 476.... 11

11. Apex of claspers with a row of 4 to 6 black, peglike spines on the mesal face of the caudo-ventral arc, fig. 476...................**eliaga**, p. 132



Figs. 466–472.—*Ochrotrichia*, male genitalia. *A*, lateral aspect; *B*, dorsal aspect; *C*, ventral aspect; *D*, tenth tergite, dorsal aspect; *F*, aedeagus.

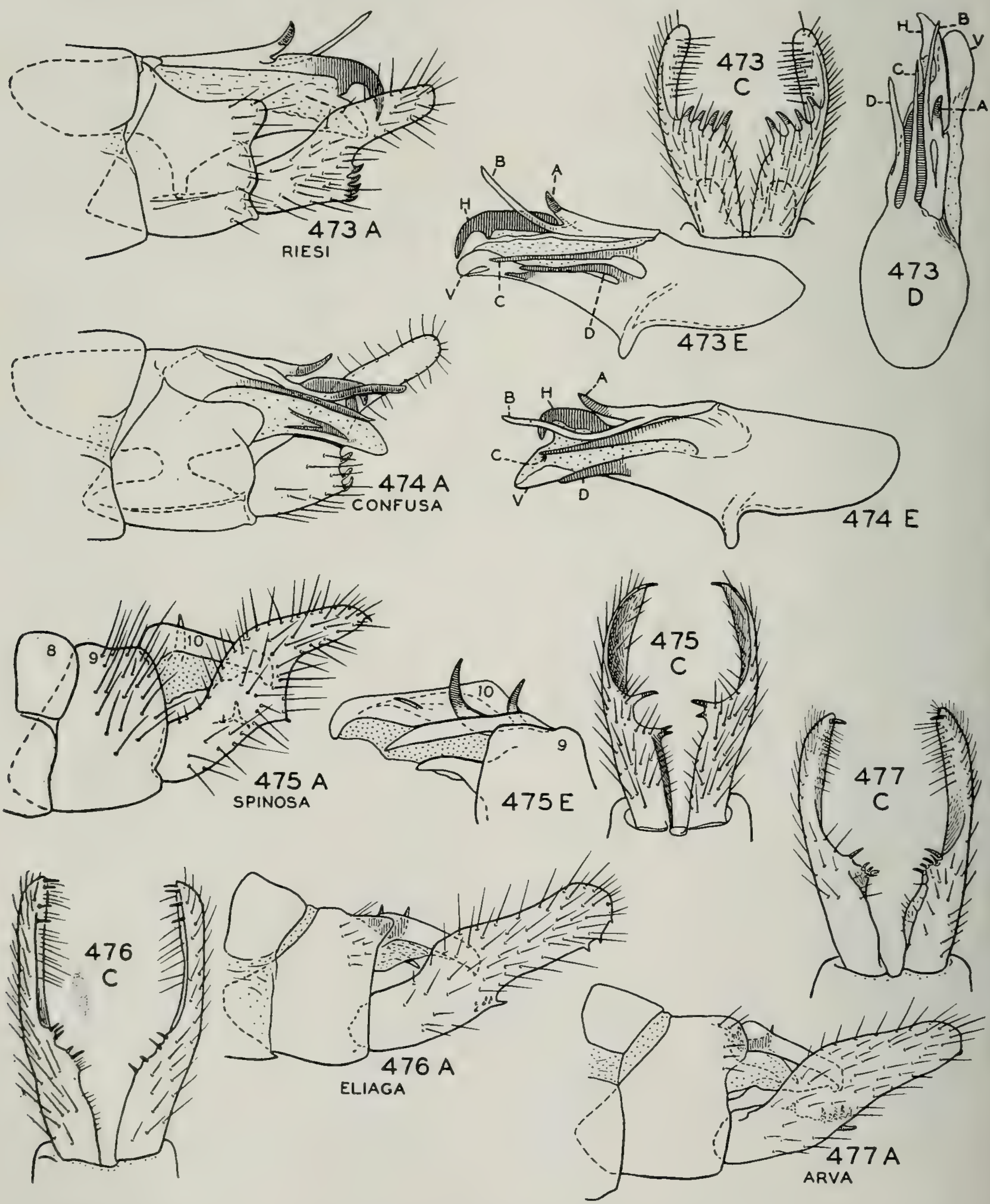
Apex of claspers with only 1 or 2 apico-mesal black spines, fig. 477 . . . . **arva**, p. 132

12. Tenth tergite heart shaped, the apex pointed, the styles arising near meson; internal structure of eighth sternite not conspicuous, fig. 478 . . . . **xena**, p. 130; **unio**, p. 129

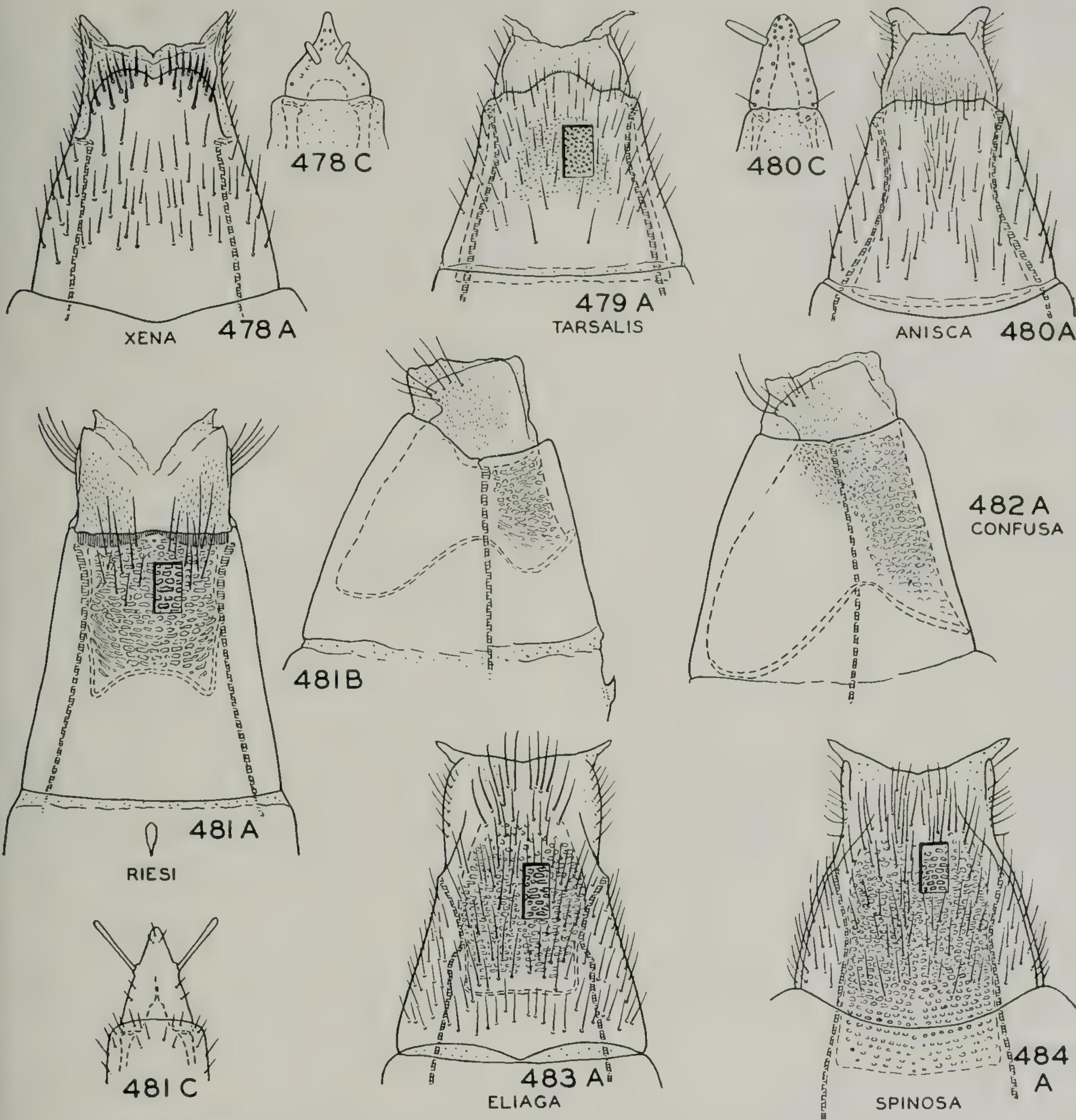
Tenth tergite triangular, apex rounded, the styles arising from lateral margin; internal structure of eighth sternite frequently sclerotized and conspicuous, figs. 479–484 13

13. Eighth sternite with apical margin produced into a low, distinct lobe; mesal area of internal structure with spicules, fig. 479 . . . **tarsalis**, p. 130

Eighth sternite with apical margin nearly straight or merged with ninth and the boundary between them in-



Figs. 473–477.—*Ochrotrichia*, male genitalia. *A*, lateral aspect; *C*, ventral aspect; *D*, tenth tergite, dorsal aspect; *E*, tenth tergite, right side.



Figs. 478–484.—*Ochrotrichia*, female genitalia. *A*, eighth sternite; *B*, eighth segment, lateral aspect; *C*, tenth segment, dorsal aspect.

distinct, figs. 480, 484 14

14. Internal structure of eighth sternite with surface membranous and indistinct, fig. 480 . . . . **shawnee**, p. 131; **anisca**, p. 131

 Internal structure of eighth sternite with surface sclerotized and reticulate, figs. 481–484 15

15. Eighth sternite with apical margin distinct, separating it from ninth, fig. 481 16

 Eighth sternite with apical margin merging with ninth sternite so that the division between the two is obliterated, fig. 483 17

16. Internal structure of eighth sternite short, reaching about middle of segment, fig. 481 . . . . **riesi**, p. 132

 Internal structure of eighth sternite long, reaching almost to base of segment, fig. 482 . . . . **confusa**, p. 133

17. Internal structure of eighth sternite short, reaching only two-thirds distance to base, fig. 483 . . . . **eliaga**, p. 132

 Internal structure of eighth sternite long, reaching well beyond base of segment, fig. 484 . . . . **spinosa**, p. 132

Ochrotrichia unio (Ross)

Polytrichia unio Ross (1941*b*, p. 56); ♂, ♀.

Larva.—Fig. 465. Length 4 mm. Head and thoracic sclerites dark brown, shading to black, with pale ring around eyes and along some sutures. Abdominal tergites with an inconspicuous sclerotized mesal ring.

ADULTS.—Length 3–4 mm. Body and appendages dark brown to black with spots of white on body and legs and a narrow white band on front wings just before middle. Male genitalia, fig. 467: ninth segment long, slender and flattened; claspers long, symmetrical and nearly straight, each with a large brush of black, peglike setae on inner face at apex; tenth tergite small, vasiform and without processes. Female genitalia as in fig. 478: eighth sternite with apex produced into a broad, emarginate lobe set with fairly stout setae; internal rods straight; endoskeleton apparently absent; tenth segment heart shaped, cerci arising near meson.

To date we have records of this species only from southern Illinois. Here it occurs in several temporary streams in the Ozarkian region. The larvae usually occur in large colonies, although adults are seldom taken. We have many collections of mature male and female pupae. There are no records for other states.

Illinois Records.—East of ALDRIDGE: May 14, 1940, Mohr & Burks, 2 larvae. ALTO PASS, Union Spring: May 25, 1940, Mohr & Burks, ♂♂, 3♀, many pupae. CARBONDALE: Clay Lick Creek, April 17, 1935, H. H. Ross, many larvae; May 11, 1935, C. O. Mohr, many larvae, 7 pupae. ELIZABETHTOWN: Hog Thief Creek, May 10, 1935, C. O. Mohr, many larvae, 8 pupae. ETHERTON, Jackson County: May 15, 1940, Mohr & Burks, many larvae. GOLCONDA: May 11, 1935, C. O. Mohr, many larvae, 2 pupae; April 30, 1940, Burks & Mohr, many larvae. HEROD: May 10, 1935, C. O. Mohr, many pupae; May 29, 1935, Ross & Mohr, many pupae; Gibbons Creek, April 19, 1937, Ross & Mohr, many larvae; April 30, 1940, Mohr & Burks, many larvae and pupae. KARBERS RIDGE: May 11, 1935, C. O. Mohr, many larvae, 3 pupae. WALTERSBURG: April 30, 1940, Mohr & Burks, many larvae. WOLF LAKE, Hutchins Creek: May 12, 1939, Burks & Riegel, 7 larvae; May 31, 1940, B. D. Burks, 1♂.

Ochrotrichia xena (Ross)

Polytrichia xena Ross (1938*a*, p. 122); ♂.

LARVA.—Length 3.5 mm. Head and thoracic sclerites dark brown, except for a pale ring around eyes and a small mesal pale spot or stripe down the front of the head. Otherwise similar to *unio*.

ADULTS.—Size and color as for *unio*. Male genitalia, fig. 466: ninth segment long, slender and flattened; claspers long, symmetrical, curved slightly dorsad, each clasper with two brushes of black, peglike setae on inner face, one brush at extreme apex, the other brush just beyond middle near ventral margin; tenth tergite triangular, the base membranous and wrinkled, the apex bearing a large sclerotized shield which bears two small peglike teeth. Female genitalia indistinguishable from *unio*, fig. 478.

Allotype, female.—Oakwood, Illinois: May 21, 1936, Mohr & Burks.

Known only from a few scattered localities in Illinois, this species is recorded chiefly from larval and pupal material. Better diagnosis of the larvae shows that most of the larvae I regarded as of this species in 1938 are in reality *unio*.

Illinois Records. — HEROD, Gibbons Creek: May 13, 1937, Frison & Ross, 4♂. MUNCIE, Stony Creek: May 1, 1935, H. H. Ross, many larvae; May 6, 1936, Ross & Mohr, many larvae. OAKWOOD: May 1, 1935, H. H. Ross, many larvae; May 21, 1936, Mohr & Burks, 3♂, 2♀.

Ochrotrichia tarsalis (Hagen)

Hydroptila tarsalis Hagen (1861, p. 275); ♂.
Polytrichia confusa Betten (1934, p. 154); *nec* Morton. Misidentification.

LARVA.—Length 4 mm. Head and thoracic sclerites almost entirely yellow or straw color, sometimes with a light brownish tint; thoracic sclerites with distinct dark brown markings along sutures; legs pale with dark brown markings along sutures. Case purselike.

ADULTS.—Size and color as for *unio*. Male genitalia: ninth segment short, claspers shoe shaped as in fig. 468, both claspers very similar, long and tapering as seen from ventral view; tenth tergite, fig. 471, with right portion produced into a long spiral process overlaid by a large plate; left process stout, with two small sclerotized points and a large sclerotized hook pointing mesad. Female genitalia, fig. 479: eighth sternite with apical margin sinuate, the mesal portion produced into a rounded lobe; internal rods sinuate; endoskeleton large, extending the full length of the segment and with the center area covered with small, sharp spicules; tenth tergite similar to that in fig. 480, long, somewhat triangular, rounded at apex, the cerci arising from the lateral margin.

Allotype, female.—Hollister, Missouri: July 14, 1938, Mrs. Vitae Kite.

The male genitalia extremely distinctive, resembling only those of *stylata*, fig. 472, which may be distinguished by the large, dark basal process of the tenth tergite. This latter species is apparently western in range (Montana to Oklahoma).

Showing a preference for clear, medium-sized streams, *tarsalis* occurs in several such streams in Illinois. We have established the identity of the larvae by collections of pupae from the Salt Fork River at Oakwood.

The range of *tarsalis* is widespread and includes Illinois, Indiana, Missouri, New York, Oklahoma, Ontario, Texas and Wisconsin.

Illinois Records.—Danville, Middle Fork River: Aug. 27, 1936, Ross & Burks, 1 ♂, 1 ♀, many larvae. Kankakee: Aug. 1, 1933, Ross & Mohr, 1 ♂; July 21, 1935, Ross & Mohr, 2 ♂. Mahomet, Sangamon River: June 6, 1940, Ross & Riegel, many larvae. Momence: Aug. 21, 1936, Ross & Burks, 8 ♂; Kankakee River, May 26, 1936, H. H. Ross, 2 larvae; May 17, 1937, Ross & Burks, many larvae; June 22, 1938, Ross & Burks, 2 ♂; June 6, 1940, Ross & Riegel, many larvae. Morris: Aug. 22, 1938, H. H. Ross, 1 ♀. Oakwood, Salt Fork River: July 18, 1933, Ross & Mohr, 1 ♂. Ottawa: July 3, 1937, at light, Werner, 1 ♀. White Pines Forest State Park: Aug. 13, 1937, Ross & Burks, 1 ♀. Wilmington: July 1, 1935, DeLong & Ross, 1 ♂.

Ochrotrichia anisca (Ross)

Polytrichia anisca Ross (1941*b*, p. 58); ♂, ♀.

Larva.—Length 4 mm. Head, thoracic sclerites, and legs light brownish yellow, frequently with a faint reddish tone; sometimes indistinct suffusions of a darker color are present but never forming distinct markings as in *tarsalis*. Abdominal tergites with only inconspicuous sclerotized rings. Case purselike.

Adults.—Size and color as for *unio*. Male genitalia with ninth segment and claspers similar to *shawnee*, fig. 468; tenth tergite, fig. 470, with process, *C*, stout, curved mesad and then abruptly laterad; *D*, short and stout, situated more than its own length from spiral, *S*; the hook, *F*, longer and close to the spiral. Female genitalia, fig. 480: eighth sternite with apical margin slightly reticulate but not produced; internal rods markedly sinuate, following the shape of the membranous, indistinct endoskeleton. Tenth tergite somewhat triangular, the apex rounded, and the cerci arising from the lateral margin.

In Illinois this species frequents several small temporary streams in the Ozarkian region. These streams are rapid and clear in early spring when the larvae of the species mature. Collections of pupae at Wolf Lake have associated the larval and adult stages. A very large colony of larvae at this locality was unique in that each case had a comparatively large "anchor" stone attached to one side.

The range of the species extends through the Ozarks and neighboring mountains, with records for Arkansas, Illinois and Oklahoma.

Illinois Records.—LaRue, McCann School: May 26, 1939, Burks & Riegel, ♂♂, ♀♀. Wolf Lake: Hutchins Creek, May 25, 1940, Mohr & Burks, many larvae; May 31, 1940, B. D. Burks, ♂♂, ♀♀.

Ochrotrichia contorta (Ross)

Polytrichia contorta Ross (1941*b*, p. 60); ♂.

This species is known from various localities in south central Missouri in the Ozarks and might be collected in Illinois.

Ochrotrichia shawnee (Ross)

Polytrichia shawnee Ross (1938*a*, p. 120); ♂, ♀.

Larva.—Unknown.

Adults.—Size and color as for *unio*. Male genitalia, fig. 468: ninth segment short, claspers shoe shaped, both appearing long, slender and similar in shape from ventral view; tenth tergite divided into many parts; the right sclerite, *B*, formed near apex into a coiled spring, *S*, and beyond that forming a bent point, *F*; left process, *A*, with a long, slender style, *C*, arising near base, beyond this a mesal process, *D*, which has a sclerotized, narrow, pointed tip and at the extreme apex a pointed process, *E*. Female genitalia similar to *anisca*.

The original type material from Herod, Illinois, May 29, 1935, Ross & Mohr, is the only known collection of this species.

Ochrotrichia eliaga (Ross)

Polytrichia eliaga Ross (1941*b*, p. 57); ♂, ♀.

LARVA.—Length 4 mm. Head and thoracic sclerites dark brown to black with pale ring around each eye and along some sutures. Abdominal tergites with only inconspicuous sclerotized rings. Case purselike.

ADULTS.—Size and color as in *unio*. Male genitalia as in fig. 476: ninth segment short and high; claspers suddenly sinuate near base, the apex slightly enlarged and spatulate; from ventral view the base appears broad, suddenly tapering to a platelike apical portion, the shoulder thus formed bearing an uneven row of four to five sclerotized teeth, the extreme apex of the clasper bearing a row of four sclerotized teeth along the apico-ventral margin; tenth tergite with long keel-like structure, and teeth in processes on right side similar to *arva*. Female genitalia, fig. 483: eighth sternite merging imperceptibly with structures of the ninth segment; internal rods sinuate, touching the endoskeleton and then curving laterad; endoskeleton distinct, reaching about two-thirds the distance to the base of the segment and with the entire ventral surface fenestrate with rectangular reticulations; tenth segment as in *anisca*, fig. 480.

This species is known from only two states, Tennessee and Illinois. The Illinois record consists of a single male collected in company with a large flight of *anisca*, along Hutchins Creek, Wolf Lake, May 31, 1940, B. D. Burks.

Ochrotrichia spinosa (Ross)

Polytrichia spinosa Ross (1938*a*, p. 121); ♂.

LARVA.—Length 4 mm. Head and thoracic sclerites dark brown to black, similar to *eliaga*, as are also the inconspicuous sclerotized rings on the abdominal tergites and the purselike case.

ADULTS.—Size and color as in *unio*. Male genitalia, fig. 475: ninth segment short and high; claspers evenly sinuate, the apex narrowed and slightly pointed, with a sclerotized tooth at the tip, and with a triangular projection near the middle of the ventral side; from ventral view the base of each clasper appears broad, narrowing suddenly beyond middle to a bladelike apex; at the shoulder thus formed there is a small group of two or three sharp, black spines on the left clasper, and on the right clasper a small group of similar spines just below the middle, and a stout spur upon this and well separated from it. Female genitalia, fig. 484: eighth sternite merging imperceptibly with structures of the ninth segment; internal rods curving to meet and follow the endoskeleton; endoskeleton distinct and long, extending well beyond the base of the segment and fenestrate over most of its surface with rectangular reticulations.

Allotype, female.—North Lake, Wisconsin: June 5, 1938, Ross & Burks.

Our Illinois records are all from a single colony at Split Rock Brook (see p. 8), a small, spring-fed brook, where we have collected larvae and mature pupae. Association of males and females is based on a large collection of adults from a creek at North Lake, Wisconsin.

Few collections of this species have been made, but these indicate a wide range: Illinois, Kentucky (Harrodsburg), Oklahoma (Turner Falls State Park) and Wisconsin (North Lake).

Illinois Records.—UTICA, Split Rock Brook: Feb. 1, 1941, Frison, Ries & Ross, many larvae; June 17, 1941, Burks & Riegel, 4♂, 7 pupae, many larvae.

Ochrotrichia arva (Ross)

Polytrichia arva Ross (1941*b*, p. 58); ♂.

Originally described from Martin Springs, Tennessee, the species has not yet been taken in Illinois.

Ochrotrichia riesi new species

LARVA (mature type).—Length 4 mm. Color of sclerites black or dark brown. Head and thorax small but rounded; legs short and stocky. Abdominal segments gradually enlarged to beyond middle and tapering to apex, segments separated by constrictions; each segment having an ovoid, dorsal sclerite with a curious, transverse, membranous center and lateral sclerotized spots bearing setae situated at some distance from the mesal sclerite.

Case.—Tortoise-shell-like with top piece ovoid, high and convex, the bottom piece forming a plate which covers all but the front and back of bottom opening. Made from fibrous material, opaque, sometimes with other matter attached.

Male.—Length 2.8 mm. Color and general structure as given for *unio*. Genitalia, fig. 473: ninth segment short and stocky, its dorsal portion cutting away nearly to base to receive the tenth tergite; tenth tergite with a rounded internal base shaped like an inverted scoop; apical portion of tergite divided into many parts, conspicuous among them being stylelike sclerites *B*, *C* and *D*, spurlike *A*, the stout, apical hook *H*, and the ventral lobe *V* which has a small preapical tooth; the entire structure is produced on each side into a sclerotized attachment stub which is anchored to the internal lateral portion of the ninth sternite; claspers sinuate, the base fairly wide, suddenly constricted near middle to form a broad shoulder bearing four dark spurs and an apical flaplike portion; aedeagus simple and filiform, typical for the genus.

Female.—Similar to male in size, color and general structure. Genitalia, fig. 481: eighth sternite set off distinctly from structures of the ninth, its apical margin fairly heavily sclerotized and almost straight; the segment has an internal bell-shaped structure whose ventral surface is fenestrate with oblong and linear reticules; bursa copulatrix typical for the genus.

Holotype, male.—Utica, Illinois, Split Rock Brook: July 11, 1941, Ross & Ries.

Allotype, female.—Same data as for holotype.

Paratypes.—Illinois: Port Byron: May 14, 1942, Ross & Burks, 2♂, 3♀.

This species is related to *confusa*, differing from it in the shorter apical process of the clasper, the much larger hook of the tenth tergite, shorter style *B*, and other details.

A colony of larvae of this peculiar species has been found, existing in a short stretch of the spring-fed brook at Split Rock, Utica, Illinois. Unique for the genus is the tortoise-shell-like case and the conspicuous, sclerotized plates on the tergites of the larvae. In genitalia the adults suggest nothing peculiar, very plainly being a derivative of the *spinosa* group. In this group the larvae and cases are very similar to those of the primitive *unio* group.

Ochrotrichia confusa (Morton)

Ithytrichia confusa Morton (1905, p. 69); ♂.

Although known only from New York and Tennessee, this species may be found in Illinois with future collecting. The larva has not been discovered. The larva accredited to this species by Lloyd (1915*a*) was misidentified; it was *Leucotrichia pictipes*.

Oxyethira Eaton

Oxyethira Eaton (1873, p. 143). Genotype, here designated: *Hydroptila costalis* Curtis.

Loxotrichia Mosely (1937, p. 165). Genotype, by original designation: *Loxotrichia azteca* Mosely. New synonymy.

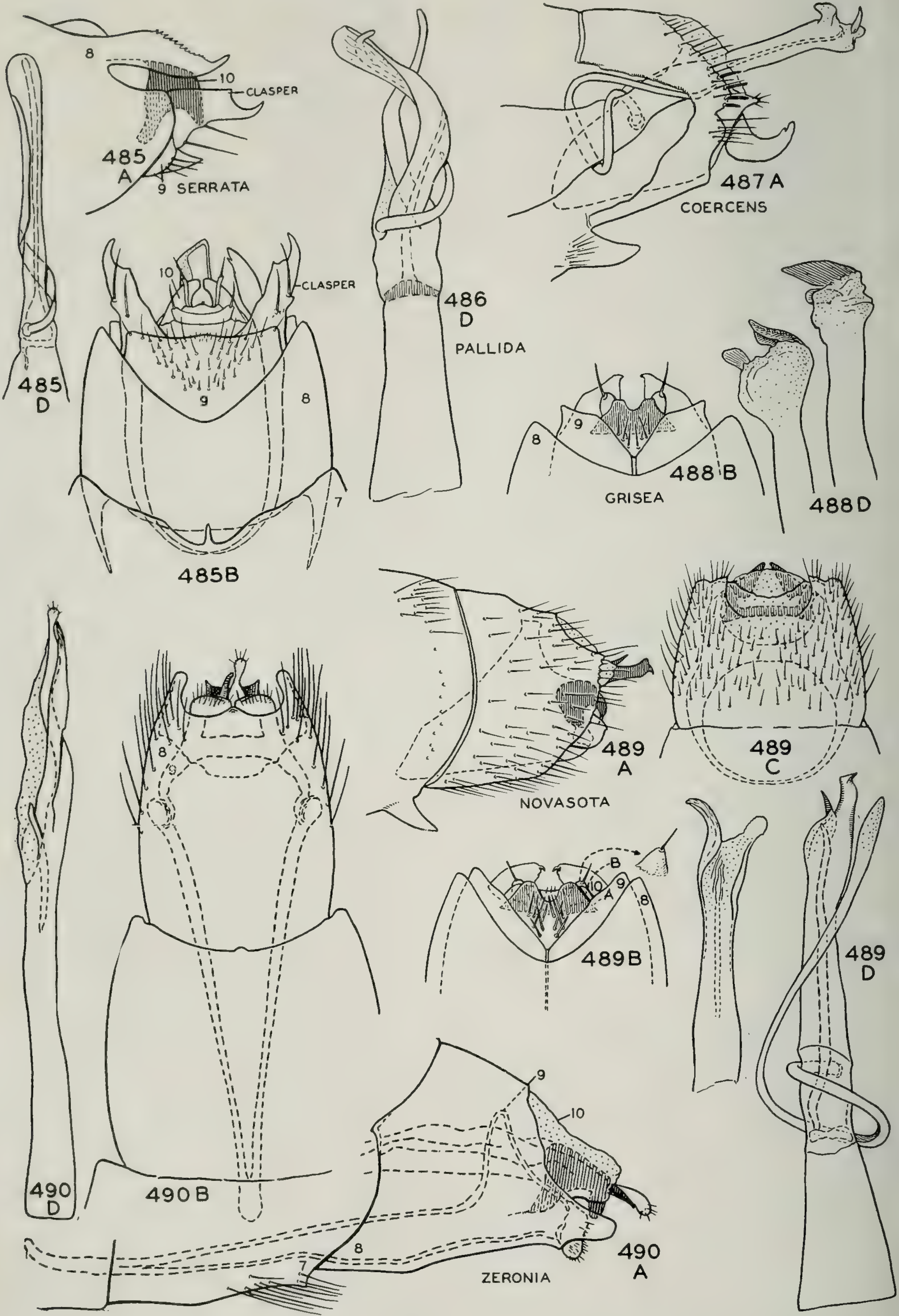
Dampfitrichia Mosely (1937, p. 169). Genotype, by original designation: *Dampfitrichia ulmeri* Mosely.

The species of this genus frequent a wide variety of situations, and many of them are very widely distributed geographically. We have taken only four species in Illinois, but it is likely that others will be found in future collecting. No characters have been found to separate the larvae to species.

KEY TO SPECIES

Adults

1. Apex of abdomen with various sclerotized rods and plates (males), fig. 485 2
   Apex of abdomen cylindrical (females), fig. 494 10
2. Eighth tergite with apico-lateral margins produced into long, serrate processes, fig. 485 .... **serrata**, p. 136
   Eighth tergite without apico-lateral processes, fig. 489 3
3. Aedeagus divided at neck into two twisted, sclerotized filaments which cross each other near apex, fig. 486 .... **pallida**, p. 137
   Aedeagus not divided into twisted filaments 4
4. Aedeagus with prominent spiral process at neck, figs. 487–489 5
   Aedeagus with spiral process inconspicuous or absent, figs. 492, 493 7
5. Apex of eighth segment toothed and serrate; claspers projecting, upturned and bootlike, fig. 487 .... **coercens**, p. 137



Figs. 485–490.—*Oxyethira*, male genitalia. *A*, lateral aspect; *B*, ventral aspect; *C*, dorsal aspect; *D*, aedeagus.

Apex of eighth segment only minutely serrate; claspers not projecting and upturned, fig. 489 6

6. Apex of aedeagus bulbous, with both apical processes smooth, the larger one short and stout; plate formed by claspers narrow, fig. 488 . . . . **grisea**, p. 138

Apex of aedeagus only slightly enlarged, with a long, smooth process and a round, platelike, serrate one; plate formed by claspers much wider, fig. 489 . . . . **novasota**, p. 138

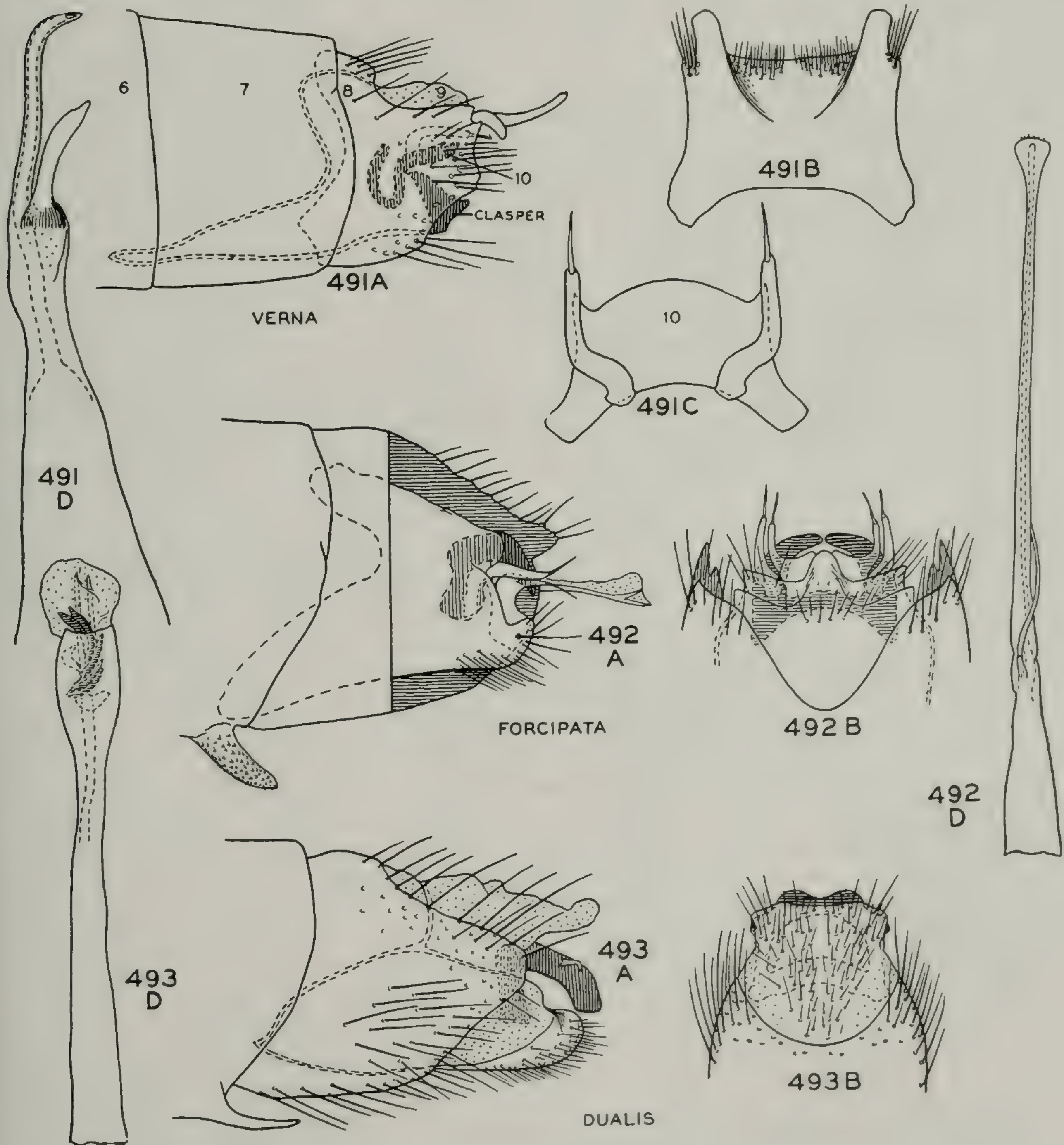
7. Ninth sternite produced to form a long, narrow, ventral internal plate which is four or five times as long as the posterior part of the segment, fig. 490 . . . . **zeronia**, p. 139

Ninth sternite not produced into such a long plate, the internal narrowed part never more than twice the length of posterior portion of segment, fig. 491 8

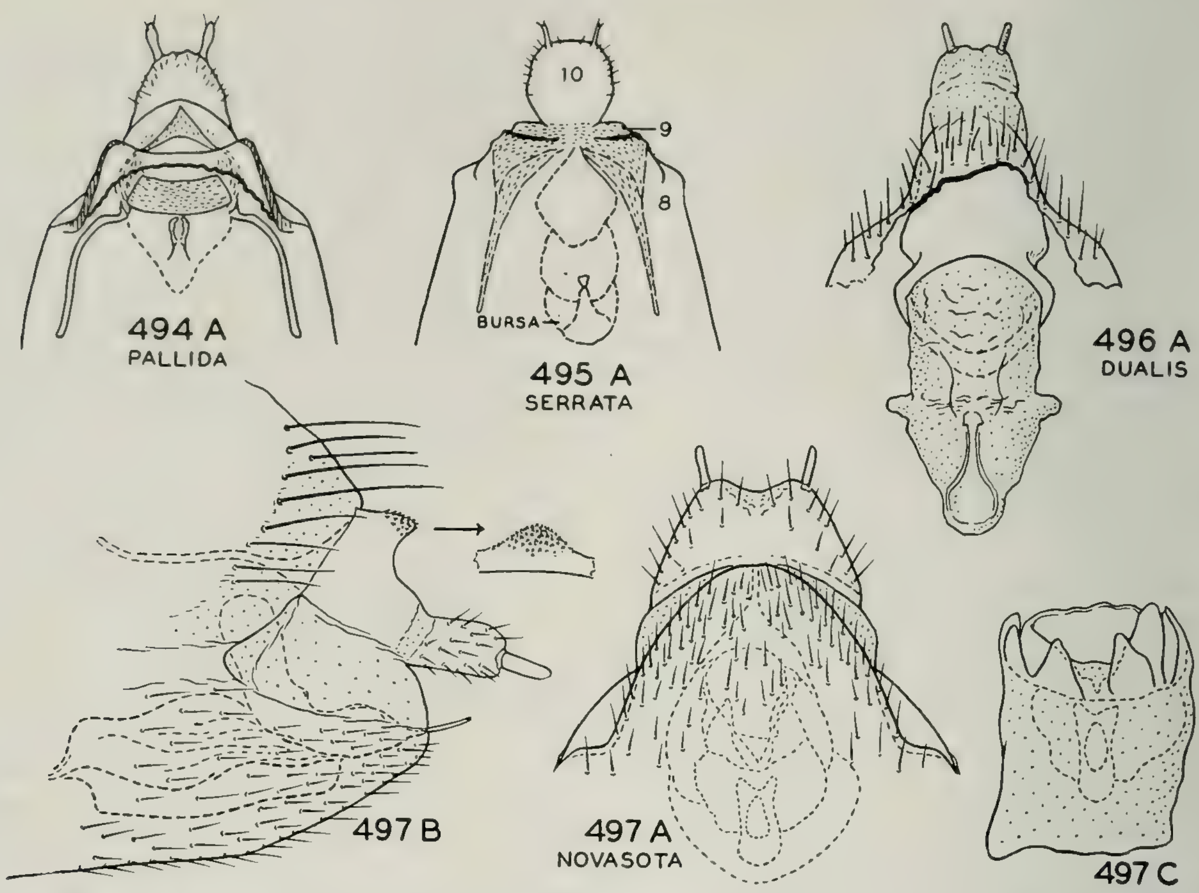
8. Aedeagus with a long, stout tooth just beyond neck, fig. 491 . . . . **verna**, p. 139

Aedeagus without a tooth; at most with a short, slender thread, fig. 492 9

9. Aedeagus with a neck, a weak, slender thread and a slender apex tipped with a small plate, fig. 492 . . . . **forcipata**, p. 139



Figs. 491–493.—*Oxyethira*, male genitalia. *A*, lateral aspect; *B*, ventral aspect; *C*, dorsal aspect; *D*, aedeagus.



Figs. 494–497.—*Oxyethira*, female genitalia. *A*, ventral aspect; *B*, lateral aspect; *C*, bursa copulatrix.

Aedeagus with neither neck nor thread, with the tip enlarged and vasiform and containing an eversible group of 5–6 sclerotized spines, fig. 493 . . . . **dualis**, p. 139

10. Eighth sternite truncate, fig. 495, or emarginate, fig. 494 11
Eighth sternite produced into a rounded apex, fig. 497 12

11. Bursa copulatrix short, with a ventral, sclerotized bridge, fig. 494 . . . . **pallida**, p. 137
Bursa copulatrix elongate, without a sclerotized ventral bridge, fig. 495 . . . . **serrata**, p. 136

12. Bursa copulatrix with a semisclerotized, large, vasiform base, fig. 496 . . . . **dualis**, p. 139
Bursa copulatrix with base membranous and not vasiform, fig. 497 . . . . **novasota**, p. 138

Oxyethira serrata Ross

Oxyethira serrata Ross (1938*a*, p. 117); ♂, ♀.

LARVA (mature type).—Length 3 mm. Head rounded. Middle and hind legs much more slender than front legs. Abdomen without dorsal sclerites and only slightly widened at middle, the segments not set off by constrictions.

CASE.—Fig. 498. Constructed of transparent, sheetlike material, without sand grains, narrow at end and tapering evenly to front, end slightly flattened.

ADULTS.—Length 2.5–3.0 mm. Color light and mottled. Wings tapered to a slender apex; hind wings slender. Tibial spur count 0-3-4. Ocelli present. Male genitalia, fig. 485: claspers elongate; tenth segment beaklike; aedeagus with a short base and elongate, cylindrical apex, with a ribbon-like spiral which apparently fuses with the apical portion; eighth segment with a pair of long, lateral processes which are serrate along the dorsal margin. Female genitalia, fig. 495: eighth sternite wide and slightly emarginate, ninth segment narrow and sclerotized, with a pair of long, internal rods; tenth segment nearly ovate; bursa copulatrix composed of three saclike lobes.

This species is apparently confined in Illinois to the glacial lakes in the northeastern corner of the state. The cases have been found in large numbers under stones in 2 or 3 feet of water along open beaches. Adult emergence seems confined to the earlier part

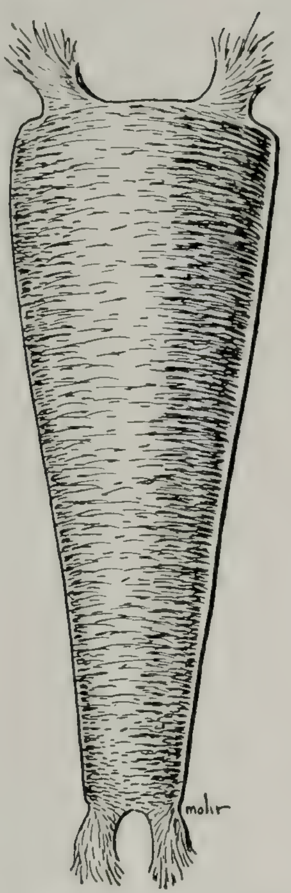


Fig. 498.—*Oxyethira serrata*, case.

of the year, from May to the middle of July; the number of generations per year has not been determined. In local areas around these lakes the species sometimes occurs in tremendous numbers, swarming around lights.

Little is known concerning the range of the species, with records available only from Illinois, New York and Wisconsin. All records, however, indicate a restriction to lakes and connecting channels.

Illinois Records.—ANTIOCH: July 7, 1932, Frison & Metcalf, 4♂, ♀♀. CHANNEL LAKE: May 27, 1936, H. H. Ross, ♂♂, 5♀. FOX LAKE: July 15, 1935, at light in town, DeLong & Ross, ♂♂, ♀♀; May 15, 1936, Ross & Mohr, ♂♂, ♀♀, many pupae, 2 larvae; May 28, 1936, H. H. Ross, ♂♂, 1♀; June 10, 1936, Ross & Burks, 1♀. JOHNSBURG, Fox River: May 28, 1936, H. H. Ross, ♂♂, ♀♀.

Oxyethira pallida (Banks)

Orthotrichia pallida Banks (1904*d*, p. 215); ♂.

Oxyethira viminalis Morton (1905, p. 71); ♂.

ADULTS.—Length 3 mm. Color a salt-and-pepper combination of cream and light brown, the general tone light. Male genitalia, fig. 486, with aedeagus split and curiously twisted. Female genitalia, fig. 494: eighth sternite produced into a wide, emarginate lobe which is sclerotized along the sides; tenth segment fairly long; ninth segment with very long and curved internal rods which extend below and to the side of the bursa copulatrix; bursa copulatrix short, with a ventral sclerotized bridge.

Allotype, female.—Wilmington, Illinois: Aug. 20, 1934, DeLong & Ross.

This species was first recorded from Illinois in the original description of *viminalis*, in which Morton recorded material from Lake Forest, collected October 15, 1902, by Professor Needham. We have since taken it in scattered localities in the northern half of the state. Adult emergence occurs throughout the warmer months of the year, from June to October. Our records indicate that the species frequents streams, lakes and artificial ponds. This is very likely the species which has been taken in large numbers as larvae by various fish in certain experimental lakes investigated by the Natural History Survey.

The distribution of the species apparently occupies most of the eastern and central part of the continent, with records available for the District of Columbia, Illinois, Nebraska, New York, Oklahoma, Texas, Virginia and Wisconsin.

Illinois Records.—COUNCIL HILL, Galena River: June 26, 1940, Mohr & Riegel, ♂♂, ♀♀. DOWNS, Kickapoo Creek: July 31, 1940, Ross & Riegel, 2♂. FOX LAKE: Sept. 22, 1931, Frison & Ross, 2♂; Oct. 4, 1931, Ross & Mohr, 1♂. KANKAKEE: July 21, 1935, Ross & Mohr, 1♂. LIVERPOOL: Oct. 7, 1931, T. H. Frison, 3♂, ♀♀. McHENRY: Oct. 4, 1931, Ross & Mohr, 1♂. MOMENCE: June 22, 1938, Ross & Burks, 1♂. PALOS PARK, Mud Lake: Aug. 3, 1938, Ross & Burks, 9♀. QUINCY, Burton Creek: June 25, 1940, Mohr & Riegel, 1♀. SPRING GROVE: Aug. 12, 1937, at light, Ross & Burks, 9♀. WHITE PINES FOREST STATE PARK: Aug. 13, 1937, Ross & Burks, ♂♂, ♀♀. WILMINGTON: Aug. 20, 1934, DeLong & Ross, 2♂, 8♀.

Oxyethira coercens Morton

Oxyethira coercens Morton (1905, p. 70); ♂.

ADULTS.—Length 3 mm. Color a salt-and-pepper mottling of cream and brown.

Male genitalia, fig. 487: eighth segment spiny at sides; claspers projecting and upturned at apex; aedeagus with a long, ribbon-like spiral and with apex knobbed and bearing a pair of sharp, short processes.

Our only records of this species in Illinois have been taken along the Kankakee River at Momence during May. Nothing is known regarding its biology.

Records of this species are very scattered but indicate an extensive range stretching from New York to Oklahoma, with records available for Indiana, New York and Oklahoma as well as Illinois.

Illinois Records.—MOMENCE, Kankakee River: May 17, 1937, Ross & Burks, 1 ♂; May 24, 1937, H. H. Ross, 1 ♂.

Oxyethira novasota new species

MALE.—Length 3 mm. In color and general structure similar to the preceding, the diagnostic characters apparently confined to the male genitalia.

Genitalia as in fig. 489. Eighth segment very simple, without sclerotized processes, both dorsal and ventral margins of the apex circularly incised, the dorsal incision bearing membranous folds; there is a distinct angle where the dorsal margin and the lateral margin join. Ninth segment short; the venter with a wide, triangular emargination, the dorsum reduced to a narrow bridge. Tenth tergite somewhat inverted U-shaped, the base large and the apex pointed; the basal portion is bridgelike and the apex is divided into a pair of lobes appearing somewhat triangular, as viewed from above, and pointed mesad, not quite touching at apex, and armed at tip with a minute spine. Below the tenth tergite is a pair of semimembranous horns, each surmounted by a long seta. Below this are two plates, a short wide one with a slightly concave posterior margin and below that a longer one divided into a pair of rounded lobes separated by a rounded mesal incision, the ventral margin armed with a cluster of long setae. Aedeagus with a wide, tapered, tubelike basal portion; a sinuate, wide "neck" from which arises a long, stout spiral encircling the structure one and one-half times, proceeding as far toward the posterior as the remaining genitalia and ending in a clavate tip; and an apical tube which tapers from the base to the middle, then expands slightly, and is divided at the extreme apex into a sclerotized point and a semisclerotized lobe which appears beaked from lateral view and ovate from dorsal view.

FEMALE.—Length 3.2 mm. Color and general structure as for male. Genitalia as in fig. 497. Eighth segment with tergite simple, bearing at apex an irregular row of long setae. Eighth sternite with its apical margin produced into a long, rounded projection which merges with the ninth sternite. Ninth tergite fairly heavily sclerotized, its baso-ventral angle produced into a long, internal rod, its baso-dorsal region produced into a rounded projection bearing a cushion of short, thick, black spines and its apex tapering to meet the tenth tergite. Tenth tergite appearing narrow from lateral view and wide and emarginate from ventral view with a pair of styles arising from each lateral hump. From the inner margin of the apex of the eighth arises a series of semimembranous folds which encircle the bursa copulatrix. This structure is irregular in shape, somewhat like a truncate cylinder, the posterior margin with a wide opening around the ventral margin from which arises a group of semisclerotized, irregular, toothlike lobes.

Holotype, male. — Marquez, Texas, along Novasota River: April 16, 1939, J. A. & H. H. Ross.

Allotype, female.—Same data as for holotype.

Paratypes.—TEXAS.—Same data as for holotype, 1 ♂.

On the basis of genitalia, this species is most closely related to *grisea* from which it differs in the two-lobed apex of the aedeagus and other characters of the genitalia.

This species has not yet been taken in Illinois. The river along which it was collected in Texas is a sluggish, silty river much like some of the rivers of southern Illinois, and there is a good possibility that it may be found in Illinois with additional collecting.

Oxyethira grisea Betten

Oxyethira grisea Betten (1934, p. 162); ♂.

ADULTS.—Length 3 mm. Color a salt-and-pepper mottling of cream and brown. Male genitalia, fig. 488, similar in general features to those of the preceding species, differing chiefly in the apex of the aedeagus and smaller cleft of the fused claspers.

The holotype of this species may be lost. There seems little doubt, however, that our material is the species described by Betten. The coiled spiral of the aedeagus and the lobes of the aedeagus head indicate this; in Betten's illustration of the side view of the genitalia (1934, pl. 14, fig. 5), the apparent hook of the eighth segment is undoubtedly a silhouette of the hooklike tenth tergite.

We have only a single male from Illinois, collected along a small creek near Momence, June 22, 1938, Ross & Burks. The only other available records for the species are from Indiana and New York. It is probable that this species, like many others in the genus, has a wide but scattered range.

Oxyethira verna Ross

Oxyethira verna Ross (1938*a*, p. 118); ♂.

Adults.—Length 2.7 mm. Color a salt-and-pepper mixture of cream and brown, predominantly light. Male genitalia, fig. 491, with ninth segment produced internally into a long, ventral lobe; claspers fused on meson, tenth tergite somewhat platelike, with a pair of styliform appendages, and aedeagus simple, with a large tooth near base of apical portion.

To date we have only two Illinois records for this species, both of them in the extreme northeastern corner of the state. Nothing is known regarding the biology or habitat preference of the species. The only record outside of Illinois is from New Brunswick, indicating a wide but probably local range.

Illinois Records.—Spring Grove: June 12, 1936, Ross & Burks, 1♂. Willow Springs: 2♂.

Oxyethira forcipata Mosely

Oxyethira forcipata Mosely (1934*b*, p. 153); ♂.

Not yet taken in Illinois. It occurs to the north and east, with records available for New York, Ontario, Virginia and Wisconsin.

Oxyethira zeronia Ross

Oxyethira zeronia Ross (1941*a*, p. 15); ♂.

Adults.—Length 2.5 mm. Color a salt-and-pepper combination of yellow and brown. Male genitalia, fig. 490: eighth segment produced into a pair of earlike apicoventral lobes; ninth segment appearing triangular from side view with a very long internal ventral projection which is narrow and pointed; claspers minute and biscuitlike; tenth tergite hooklike; aedeagus with a slender base, no distinct neck, the apical portion divided into two slender rods, one pointed, the other sinuate with a round apical knob.

Originally described from upper Michigan, this species has been identified since from only two localities in extreme northeastern Illinois. Nothing is known of its immature stages or general distribution.

Illinois Records.—Richmond: Aug. 15, 1936, Ross & Burks, 1♂. Spring Grove: Aug. 12, 1937, at light, Ross & Burks, 1♂.

Oxyethira dualis Morton

Oxyethira dualis Morton (1905, p. 71); ♂.

Not yet taken in Illinois. It is very widely distributed, occurring across the entire continent, but has not been taken many times. We have a record from Meramec Springs at St. James, Missouri, which is only a short distance from Illinois. Records are available for California, Missouri, New Mexico, New York, Texas and Virginia.

The female, which has not been described before, has the following diagnostic characters, fig. 496: eighth sternite tapering and produced at apex into a rounded lobe; tenth segment short and relatively wide; bursa copulatrix with a sclerotized, vasiform basal portion to which is attached an apical, membranous portion culminating in a somewhat lock-shaped ventral process.

Allotype, female.—Pecos River, Carlsbad, New Mexico: April 29, 1939, J. A. & H. H. Ross.

Orthotrichia Eaton

Orthotrichia Eaton (1873, p. 141). Genotype, here designated: *Hydroptila angustella* McLachlan.

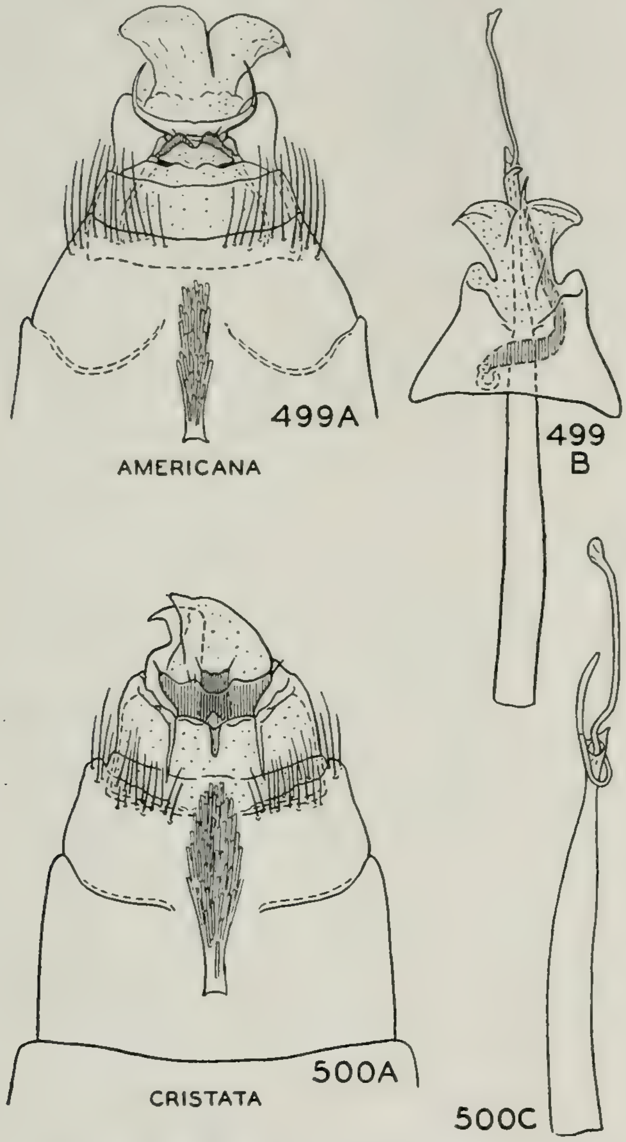
Only two Nearctic species in this genus are known; both occur in Illinois. To date I have found no characters to separate these two in the larval stages.

KEY TO SPECIES

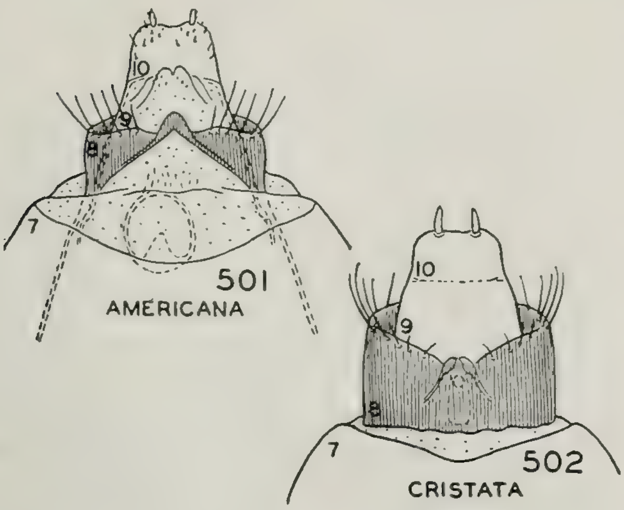
Adults

1. Apex of abdomen with platelike, conspicuous appendages, fig. 499 (males) 2

Apex of abdomen simple and tubular, without platelike or produced appendages, fig. 501 (females) 3



Figs. 499–500.—*Orthotrichia*, male genitalia. *A*, ventral aspect; *B*, dorsal aspect; *C*, aedeagus.



Figs. 501–502.—*Orthotrichia*, female genitalia.

2. Claspers wide, with a sharp, projecting, apico-lateral corner; plate back of claspers small and truncate, fig. 500 . . . . **cristata**, p. 141
   Claspers narrow, converging, together forming a trapezoidal, dark block; plate back of claspers with a pair of long hornlike arms, each tipped with a long seta, fig. 499 . . . . **americana**, p. 140
3. Eighth sternite with median process not flared out at a wide angle toward base; this mesal portion of sclerite distinctly but not heavily sclerotized, fig. 502 . . . . **cristata**, p. 141
   Eighth sternite with median process flared out at a wide angle toward base; this mesal portion membranous, fig. 501 . . . . **americana**, p. 140

Orthotrichia americana Banks

Orthotrichia americana Banks (1904*b*, p. 116); ♂, ♀.

Oxyethira dorsalis Banks (1904*d*, p. 216); ♀. New synonymy.

Orthotrichia brachiata Morton (1905, p. 70); ♂.

LARVA (mature type).—Length 4 mm. Head and thorax brown and robust. Front legs stocky, middle and hind legs very long, with tarsi elongate. Abdomen elliptical, widest near middle but not distended and with the segments not separated by constrictions.

CASE.—Modification of the purse type; composed of two equilateral halves, the case almost round in cross section, long and with the slits at each end visible from the ventral view only.

ADULTS.—Length 2.5–3.5 mm. Color mottled with a salt-and-pepper combination over the entire body, and with a pale stripe down meson when wings are folded. Seventh sternite of male with a mesal process covered with a brush of long scales. Male genitalia, fig. 499: ninth segment mostly membranous; tenth tergite forming a pair of long, wide membranous lobes; claspers small, fused to form a bifid plate; above these arise a pair of long horns, each bearing a long seta at tip; aedeagus very long, with a sclerotized, eversible penis; lying near and above aedeagus is a curved, sclerotized blade. Female genitalia, fig. 501: eighth sternite with a wide, membranous ventral area; bursa copulatrix nearly circular.

This species was recorded by Morton (types of *brachiata*) from Lake Forest, Illinois. In our recent collecting we have taken the species at various points in the northeastern part of the state and found the larvae frequenting ponds and lakes. Adult records extend from June 9 to August 15, probably indicating more than one generation per year.

Although collections are not common, the range of the species is wide, as shown by records from the District of Columbia, Illinois, Kentucky, Maryland, Minnesota, New York, Texas, Virginia.

Illinois Records.—ANTIOCH: Aug. 1, 1931, Frison, Betten & Ross, 1♂; July 7, 1932, at light in town, Frison & Metcalf, 2♂, 1♀. FOX LAKE: June 30, 1935, DeLong & Ross, 1♂, 1♀. PALOS PARK, Mud Lake: Aug. 3, 1938, Ross & Burks, ♂♂, ♀♀. RICHMOND: Aug. 15, 1938, Ross & Burks, 5♀. ROSECRANS, Des Plaines River: June 19, 1938, Ross & Burks, 2♂. SPRING GROVE: Aug. 12, 1937, at light, Ross & Burks, 3♂, 3♀; June 9, 1938, Mohr & Burks, 6♂, 6♀.

Orthotrichia cristata Morton

Orthotrichia cristata Morton (1905, p. 73); ♂.

LARVA.—Not differentiated from *americana.*

ADULTS.—Size and color as for *americana.* Seventh sternite with a mesal process bearing a large brush of long scales. Male genitalia, fig. 500: similar in general organization to *americana*; claspers larger, black and produced into lateral processes; process above, small, quadrate, with two small apical spines; no large, curved blade present. Female genitalia, fig. 502, with only a small, membranous mesal area.

Allotype, female. — Belton, Montana: July 10, 1940, at light, H. H. & J. A. Ross.

In Illinois we have taken this species in fewer numbers but in more widespread localities than *americana,* including localities along small streams, lakes and ponds. Adult emergence continues from June to August.

The range of the species is widespread, with records from British Columbia, Illinois, Michigan, Montana, Oklahoma, Tennessee, Texas.

Illinois Records.—ANTIOCH: at light in town, July 7, 1932, Frison & Metcalf, 1♀. FOX LAKE: June 30, 1935, DeLong & Ross, 1♂, 2♀. OAKWOOD, Salt Fork River: July 18, 1933, Ross & Mohr, 1♀. PALOS PARK, Mud Lake: Aug. 3, 1938, Ross & Burks, 1♂, 2♀. SPRING GROVE: at light, Aug. 12, 1937, Ross & Burks, 5♂, 5♀; June 9, 1938, Mohr & Burks, 6♂, 6♀. WHITE PINES FOREST STATE PARK: Aug. 13, 1937, Ross & Burks, 1♂.

Hydroptila Dalman

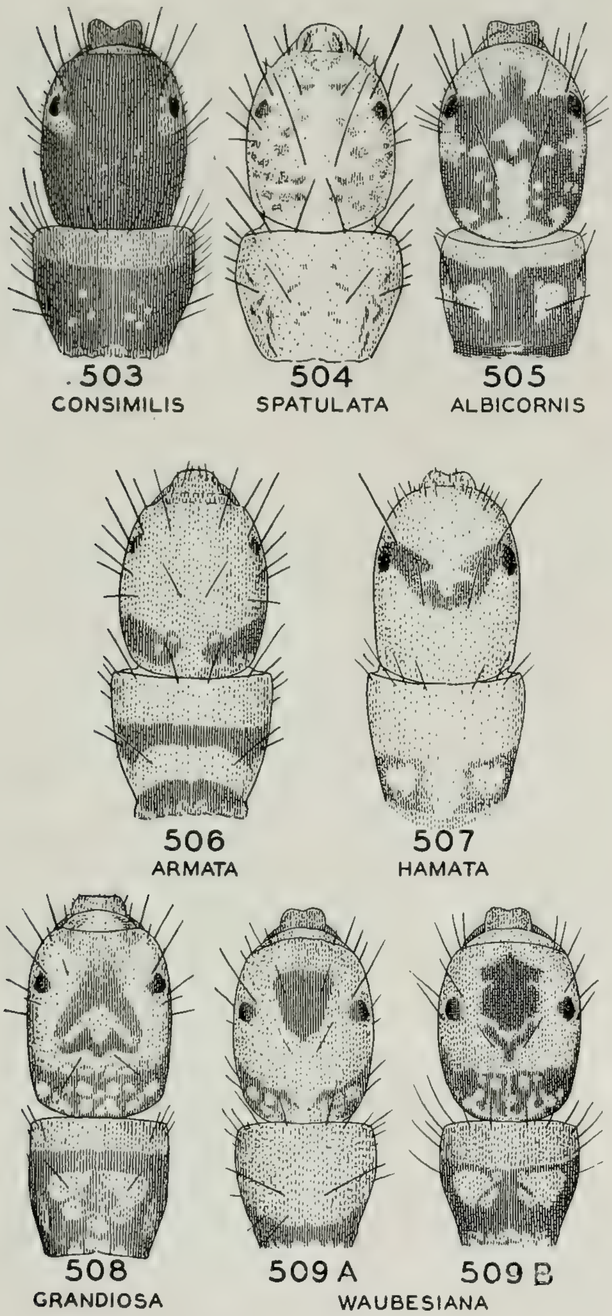
Hydroptila Dalman (1819, p. 125). Genotype, monobasic: *Hydroptila tineoides* Dalman.

Phrixocoma Eaton (1873, p. 132). Genotype, here designated: *Hydroptila sparsa* Curtis.

This genus embraces about 35 Nearctic species, comprising one-third of the Hydroptilidae. The habits of the various species are diverse. Several species have a known range covering most of the continent. Fourteen species have been taken in Illinois, nine of which we have reared. No structural differences have been found to separate the larvae to species, so that color has been the only guide to separation. This varies so much in some species, and is so similar in other species, that it seems impossible at present to make a key which would be accurate. Instead, a short diagnosis is presented drawing attention to the few characters so far discovered.

DIAGNOSIS OF LARVAE

1. Head yellowish or brown, without definite markings—paler specimens are usually **ajax,** darker specimens usually **angusta,** and nearly black specimens **consimilis,** fig. 503.
2. Head and pronotum pale yellow with scattered, small, dark spots as in fig. 504: **spatulata.**
3. Head and thoracic sclerites with a contrasting pattern as in fig. 505, the head always with a light, postero-mesal streak, the nota always with a pair of lateral, light areas: **albicornis.**
4. Head yellow, marked only with a pair of posterior dark bars, and each thoracic notum with a transverse dark bar in addition to dark posterior margin, fig. 506: **armata.**
5. Head entirely yellow except for a wide, black V across top of frons, fig. 507; pronotum variable in color: **hamata.** In darker specimens the posterior portion of the head is darker and the black V-mark enlarges anteriorly to a pentagon.
6. Head yellowish, with both a wide posterior dark band and a V-shaped dark mark above frons, fig. 508; each thoracic notum with anterior portion and two vague lateral areas pale, intervening areas brownish: **grandiosa.** In darker specimens the V-mark enlarges to form a hollow diamond.



Figs. 503–509.—*Hydroptila* larvae.

7. Head varying from yellow with dark marks arranged as in fig. 509*A* to much darker with light areas as in fig. 509*B*; each notum varies as shown: **waubesiana.**

8. Head and pronotum almost entirely black, head with at most an indistinct light area between posterior and anterior dark dorsal areas: probably dark specimens of **hamata.**

KEY TO SPECIES

Adults

1. Apex of abdomen with complicated set of appendages, figs. 510-526 (males) 2
   Apex of abdomen tubular and with simple parts, figs. 527–539 (females) 17

2. Seventh sternite with a long median process either expanded at apex, straight or sinuate, fig. 515 3
   Seventh sternite with a short, spurlike, median process, fig. 520 9

3. Tenth tergite with apex divided into a pair of long, stout, heavily sclerotized arms curved sharply mesad at apex, fig. 510 . . . . **xella,** p. 148
   Tenth tergite divided only into semimembranous lobes 4

4. Eighth sternite with an apico-mesal, heavily sclerotized projection; median process of seventh sternite sinuate and suddenly narrowed at apex, fig. 511 . . . . **virgata,** p. 148
   Eighth sternite without a mesal projection; median process of seventh sternite expanded and flanged at apex, or of even thickness, figs. 512, 515 5

5. Claspers short and beaklike, tenth tergite projecting beyond them, fig. 513 6
   Claspers long and slender, as long as tenth tergite, figs. 514–516 7

6. Aedeagus with apex divided into a pair of very slender rods, one straight and the other sharply right-angled close to end, fig. 512 . . . . **hamata,** p. 149
   Aedeagus without one apical rod so sharply angled, at most as in fig. 513 . . . . **amoena,** p. 150

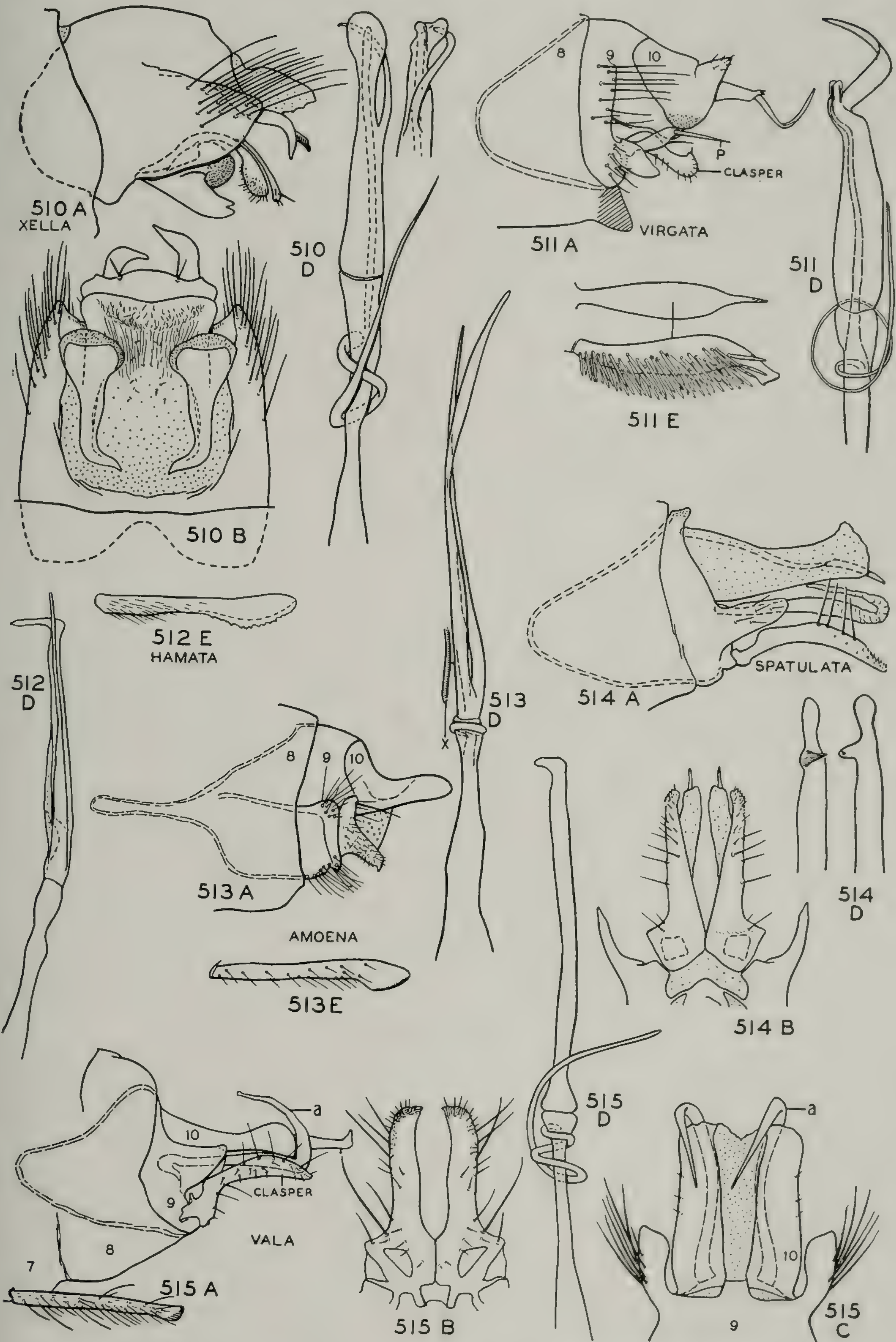
7. Apex of aedeagus with a definite knob beyond lateral spur near tip, fig. 514 . . . . **spatulata,** p. 148
   Apex of aedeagus with lateral spur at tip, figs. 515, 516 8

8. Tenth tergite with apex blunt and unexpanded, fig. 515 . . . . **vala,** p. 148
   Tenth tergite with apex divided into a pair of laterally directed, sharp points, fig. 516 . . . . **armata,** p. 147

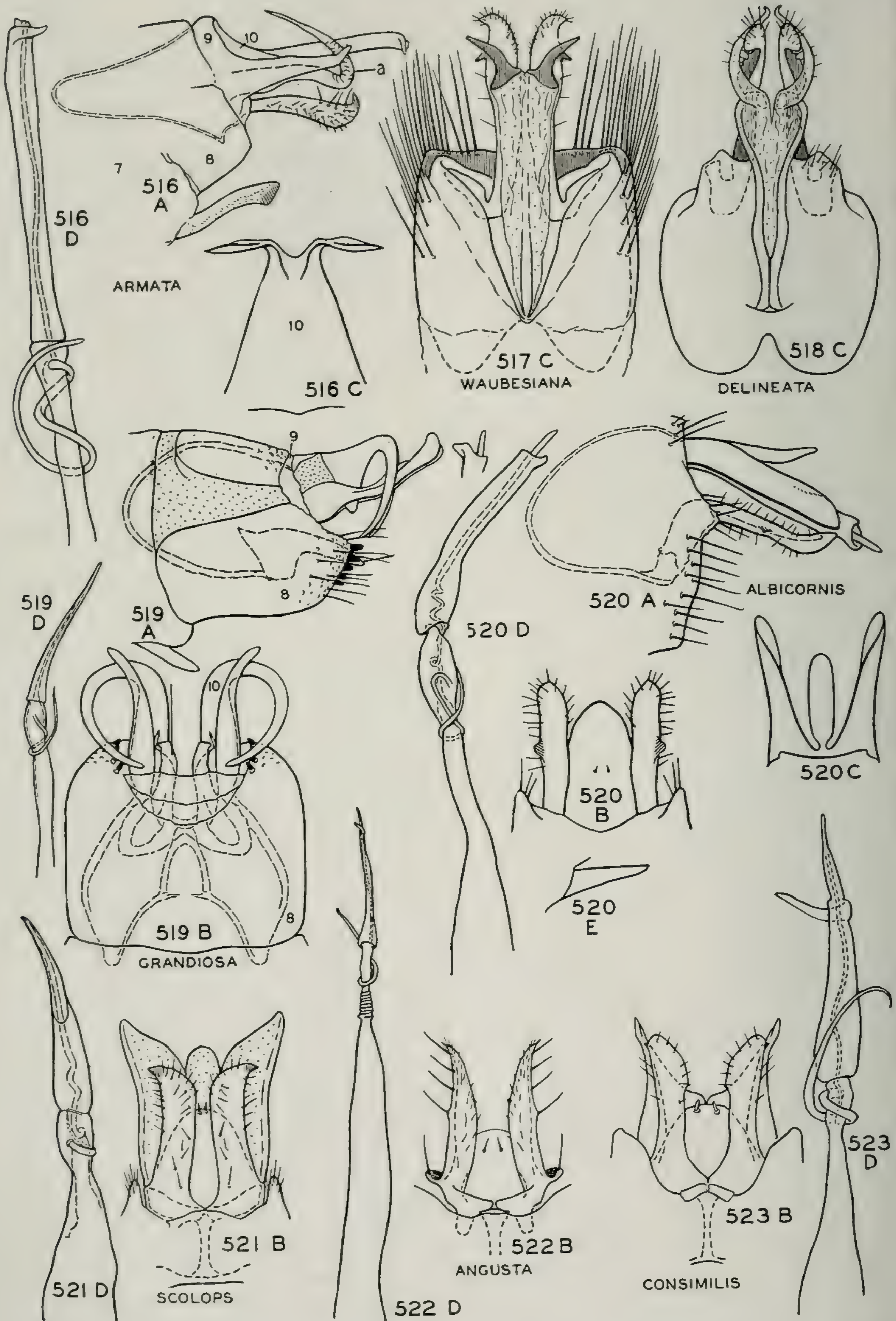
9. Tenth tergite with apex divided into a pair of hornlike spikes directed laterad, fig. 517 . . . . **waubesiana,** p. 150
   Tenth tergite without such apical structures, fig. 518 10

10. Tenth tergite with apex divided into a pair of lateral, slender, sinuate filaments curved under the apico-dorsal projections of the claspers, fig. 518 . . . . **delineata,** p. 151
    Tenth tergite without such apical structures, figs. 519–525 11

11. Eighth sternite with a row of 4 to 6 stout black spines at each apico-dorsal corner, fig. 519 . . . . **grandiosa,** p. 151
    Eighth sternite without stout black spines 12

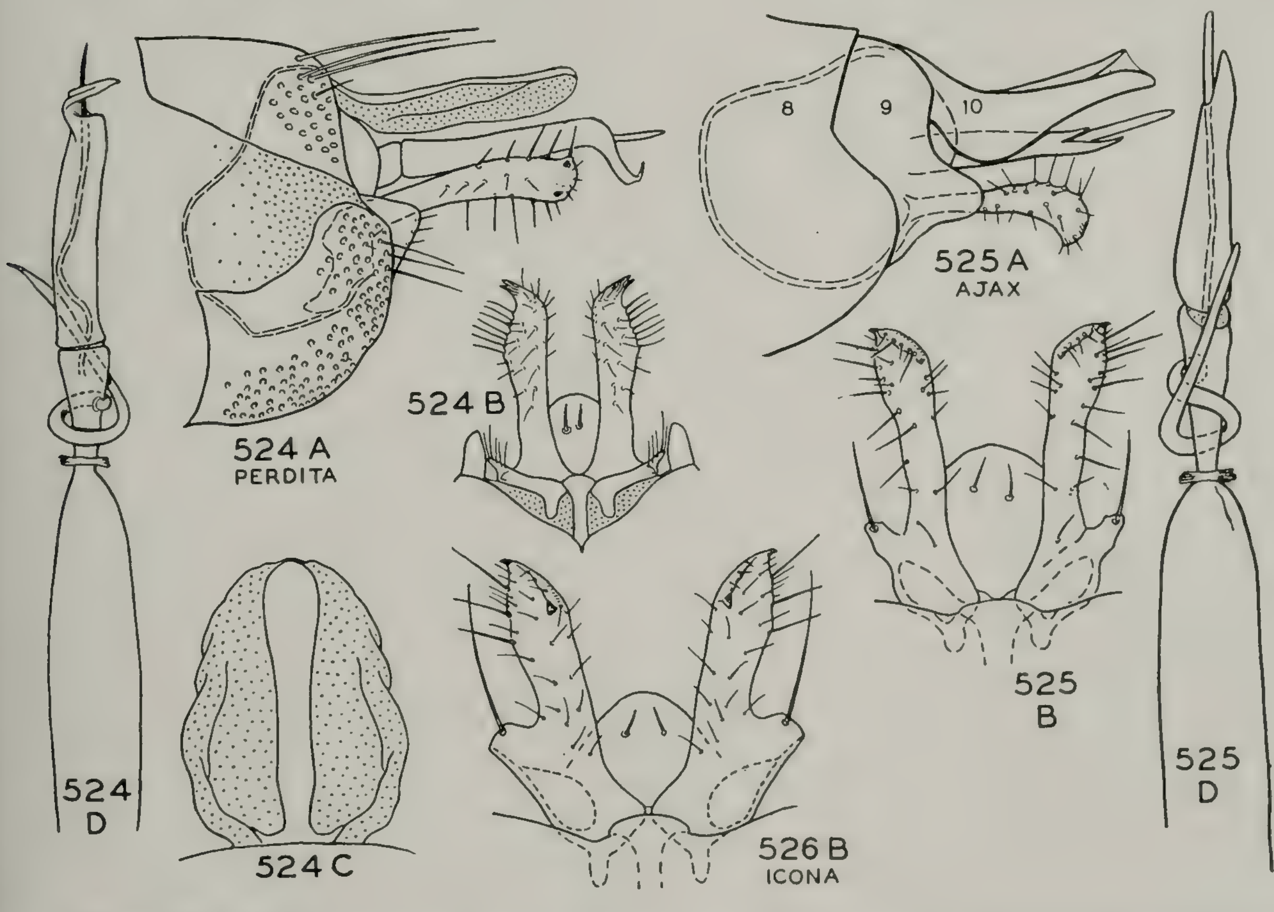


Figs. 510–515.—*Hydroptila*, male genitalia. *A*, *B*, *C*, respectively lateral, ventral and dorsal aspects; *D*, aedeagus; *E*, process of seventh sternite.

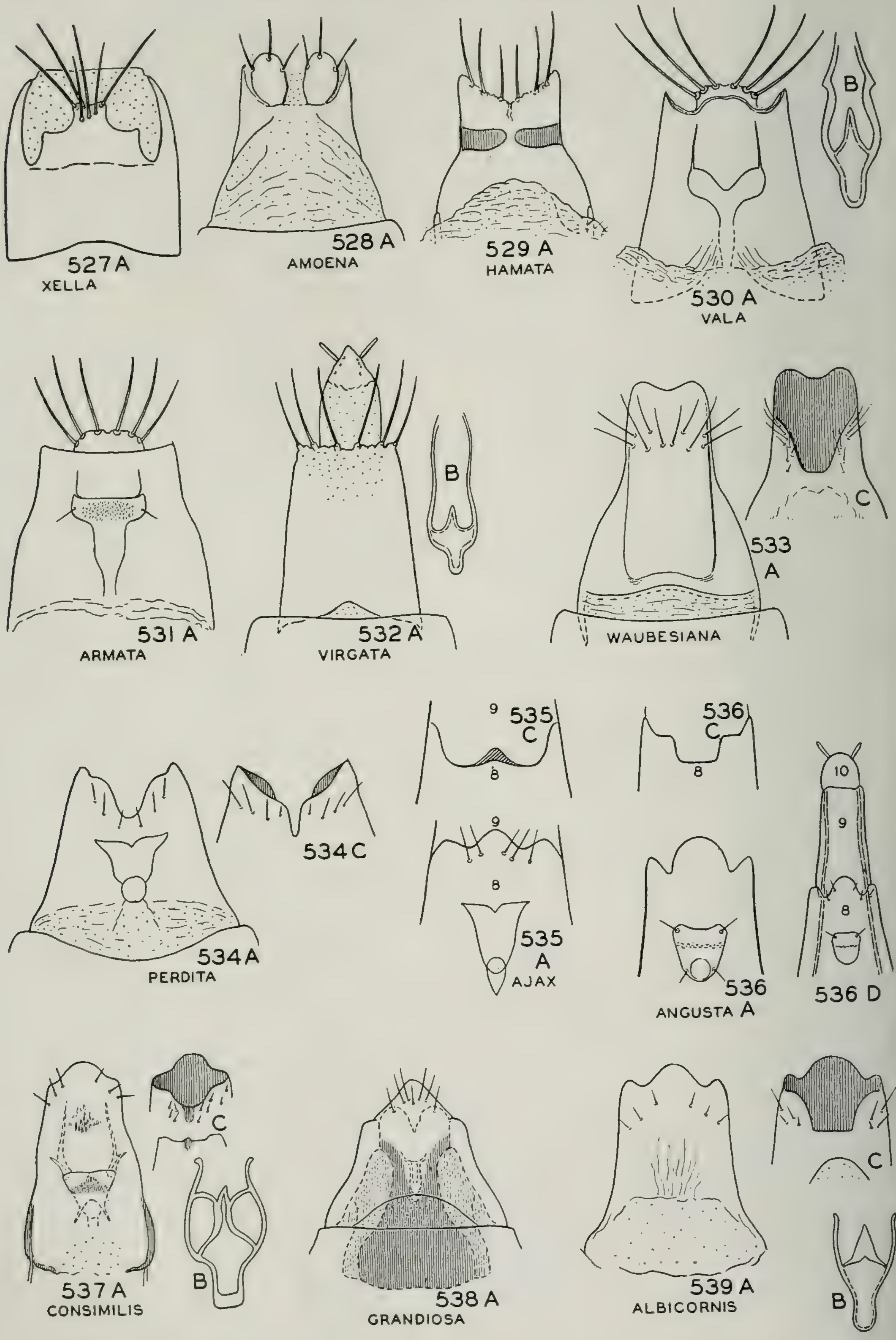


Figs. 516–523.—*Hydroptila,* male genitalia. *A, B, C,* respectively lateral, ventral and dorsal aspects; *D,* aedeagus; *E,* process of seventh sternite.

12. Claspers with dark sclerotized elevation near lateral margin midway between base and apex, fig. 520. . . . .**albicornis,** p. 151
    Claspers with dark sclerotized points only along mesal or apical margins, figs. 521–525. 13
13. Spiral process of aedeagus short and slender, fig. 521. . . . .**scolops,** p. 152
    Spiral process of aedeagus long and stout, fig. 522. 14
14. Claspers saber shaped, pointed at apex, with a dark, sclerotized point beyond middle of mesal margin, figs. 522, 523. 15
    Claspers with mesal margin concave and without sclerotized point, apex slightly curled latero-ventrad and bearing a sclerotized point at each corner, figs. 524, 525. 16
15. Apical portion of aedeagus short and slender, its extreme apex with only a short curved process, fig. 522. . . . .**angusta,** p. 152
    Apical portion of aedeagus longer and stouter, its extreme apex with a long, stout process, fig. 523. . . . .**consimilis,** p. 153
16. Extreme apex of aedeagus bent at a right angle to form a narrow, sharp process, fig. 524; tenth tergite with a sclerotized, clavate, mesal strip with the lateral areas membranous . . . .**perdita,** p. 153
    Extreme apex of aedeagus straight, fig. 525; tenth tergite divided by membranous strips into a mesal and 2 lateral sclerotized fingers. . .**ajax,** p. 153
17. Apex of eighth sternite formed as in fig. 527, with a pair of sharp corners between which arises a truncate tongue bearing about 6 long, stout setae. . . . .**xella,** p. 148
    Apex of eighth tergite not formed as in fig. 527. 18
18. Apex of eighth sternite with a pair of flat, ovate lobes, each bearing 3 long setae, fig. 528. . . . . .**amoena,** p. 150
    Apex of eighth sternite without a pair of flat, ovate lobes bearing 3 long setae. 19
19. Eighth sternite bearing a pair of transverse, sclerotized bars below apex, fig. 529. . . . .**hamata,** p. 149
    Eighth sternite not bearing such a pair of bars. 20
20. Eighth sternite with a group of 6 long radiating hairs at apex, figs. 530, 532. 21
    Eighth sternite without a group of 6 long radiating hairs at apex, figs. 533–539; hairs absent or short. . . . 24



Figs. 524–526.—*Hydroptila*, male genitalia. *A*, *B*, *C*, respectively lateral, ventral and dorsal aspects; *D*, aedeagus.



Figs. 527–539.—*Hydroptila*, female genitalia. *A*, eighth sternite; *B*, bursa copulatrix; *C*, eighth tergite; *D*, apex of abdomen.

21. Eighth sternite with a long, T- or Y-shaped area marked on middle, fig. 530 22
    Eighth sternite without central ornamentation, fig. 532 23
22. Mesal sclerite of eighth sternite Y-shaped, without imbrications, fig. 530 .... **vala**, p. 148
    Mesal sclerite of eighth sternite with posterior margin truncate and the wide portion imbricate, fig. 531 .... **armata**, p. 147
23. Eighth sternite with apical 6 setae situated on individual stalks along margin; tenth segment triangular, fig. 532 .... **virgata**, p. 148
    Eighth sternite with apical 6 setae clustered on a mesal lobe as in fig. 531; tenth segment semicircular .... **spatulata**, p. 148
24. Apex of eighth sternite produced into a long shield extending half the length of the segment beyond meson of tergite, fig. 533 .. **waubesiana**, p. 150
    Apex of eighth sternite not produced into a long shield 25
25. Surface of eighth sternite bearing a single mesal plate near middle, fig. 534 26
    Surface of eighth sternite not bearing a mesal plate, fig. 539 29
26. Apex of eighth sternite incised on meson, fig. 534 .... **perdita**, p. 153
    Apex of eighth sternite produced on meson, fig. 535 27
27. Mesal plate of eighth sternite bell shaped, long and narrow, fig. 535 .... **ajax**, p. 153
    Mesal plate of eighth sternite trapezoidal, short and wide, figs. 536, 537 .. 28
28. Apex of eighth tergite with a narrow, straight-sided, straight-bottomed incision without a mesal thickening, fig. 536 .... **angusta**, p. 152
    Apex of eighth tergite with incision shallower, wider and with a mesal thickening, fig. 537 .. **consimilis**, p. 153
29. Eighth segment with a large, spatulate, internal plate, best seen from ventral aspect, fig. 538 ... **grandiosa**, p. 151
    Eighth segment without a large internal plate, fig. 539 .... **albicornis**, p. 151

Hydroptila armata Ross

Hydroptila armata Ross (1938*a*, p. 123); ♂, ♀.

Larva (mature type).—Fig. 506. Length about 5 mm. Head yellow with an interrupted posterior band; each thoracic notum yellow with a central and a posterior dark band. Body, fig. 541, similar in shape and general appearance to that of *Ochrotrichia* except for key characters. Each segment of abdomen with a very small, inconspicuous rectangular sclerite, difficult to detect.

Case.—Shape as in fig. 465. Length about 5 mm. Purselike type, generally narrower in cross section than *Ochrotrichia*, sometimes constructed of sand grains.

Adults.—Length 2–4 mm. (generally quite variable within this genus). Color a mottled, salt-and-pepper combination of white, gray, brown and dark brown. Seventh sternite of male with a long, sinuate process. Male genitalia, fig. 516: tenth tergite wide at base, tapering toward apex, and divided at extreme apex into a pair of sharp lobes directed laterad; beneath the tenth arise a pair of long processes which proceed beyond the apex of the tenth tergite and then curve back above it; claspers long, extreme tip sclerotized and upturned; aedeagus with small neck, long spiral process, and long, slender apex which is armed at tip with a short arm at right angles to stem. Female genitalia, fig. 531: eighth segment short, semimembranous, with a T-shaped, ventral, imbricated area, and with an apical lobe bearing six long setae.

Association of males, females and larvae was established by a collection of larvae and mature pupae in Nippersink Creek at Spring Grove, Illinois. In Illinois, as in other states, the species has been taken only in riffles of clear and moderately swift streams of various sizes. The adults appear continuously from May through September. They are usually rare, but occasionally a fairly large colony is found.

The range of the species, including Illinois, Indiana, Michigan, Oklahoma and Wisconsin, seems to follow the western portion of the oak-hickory forest.

Illinois Records.—Fox Lake: July 15, 1935, DeLong & Ross, 2♂. Momence: Aug. 21, 1936, Ross & Burks, 1♂; May 17, 1937, Ross & Burks, 1♂, 6♀ (reared); May 24, 1937, H. H. Ross, 7♂; June 22, 1938, Ross & Burks, ♂♂. Oakwood, Salt Fork River: Sept. 20, 1935, DeLong & Ross, 1♂. Spring Grove: Nippersink Creek, May 14, 1936, Ross & Mohr, 1♂, 3♀ (reared), many larvae and pupae; June 12, 1936, Ross & Burks, 1♂. Wilmington: July 1, 1935, DeLong & Ross, 2♂.

Hydroptila vala Ross

Hydroptila vala Ross (1938*a*, p. 123); ♂, ♀.

Larva.—Unknown.

Adults.—In size and color similar to *armata*. Seventh sternite of male with a long, straight process. Male genitalia, fig. 515: tenth tergite divided into a pair of thick, rectangular lobes; beneath these arise a pair of long arms which curve back over the tergite; claspers with apical portion long and flattened, curved slightly mesad at tip; aedeagus with apical portion long, simple and sharply turned at tip, and with a long spiral. Female genitalia, fig. 530: eighth segment semimembranous; sternite with a central Y- or T-shaped structure without imbrications, and with an apical, detached plate bearing six long setae.

Originally described from Herod, Illinois, the species has since been collected at another locality near Herod and in the Kiamichi Mountains of Oklahoma.

Illinois Records.—Eddyville, Lusk Creek: June 19–20, 1940, Mohr & Riegel, ♂♂. Herod: May 29, 1935, Ross & Mohr, ♂♂, ♀♀.

Hydroptila xella Ross

Hydroptila xella Ross (1941*b*, p. 65); ♂, ♀.

Not yet taken in the state but perhaps to be expected in future collecting. The species is known only from south central Tennessee, where it occurred along a creek similar to several found in southern Illinois. Both sexes are readily identified by means of the genitalia; the larvae are unknown.

Hydroptila spatulata Morton

Hydroptila spatulata Morton (1905, p. 66); ♂.

Larva.—Fig. 504. Head and body sclerites tawny yellow, head and pronotum with a scattering of small, dark spots.

Adults.—Size and color as for *armata*. Seventh sternite of male with a long, straight process, oblique at apex. Male genitalia, fig. 514: tenth tergite membranous, with a pair of sinuate, sclerotized rods running through it; beneath tenth tergite arise a pair of recurved, membranous processes, frequently difficult to see due to poor refraction; claspers spatulate; aedeagus very long and slender, spiral small, tip provided with a lateral spur and beyond this spur a knob. Female genitalia without ventral ornament on eighth sternite, the apical setae of this sternite grouped on a semicircular lobe as in fig. 531.

Allotype, female.—Kankakee, Illinois: June 6, 1935, Ross & Mohr.

Our only abundant records in Illinois are along the Kankakee River. Here the larvae occur in the rapids, where we have collected mature pupae. Other records are from the Oakwood region. Adult records extend from June to late in August, indicating successive summer generations.

The range of the species extends throughout the Northeast; definite records are available for Illinois, Indiana, Michigan, New York, Quebec, Wisconsin.

Illinois Records. — Danville, Middle Fork River: Aug. 27, 1936, Ross & Burks, 3 larvae. Kankakee: Kankakee River, Aug. 1, 1933, Ross & Mohr, 4♂, 1♀, many larvae, 2 pupae; June 6, 1935, Ross & Mohr, ♂♂, 6♀. Momence: July 14, 1936, B. D. Burks, 1 larva; strip mines, Aug. 21, 1936, Ross & Burks, ♂♂, many larvae and pupae; Kankakee River, Aug. 24, 1936, Ross & Burks, 4♂; May 17, 1937, Ross & Burks, many larvae; Kankakee River, May 24, 1937, H. H. Ross, ♂♂; at light, June 24, 1939, Burks & Ayars, 1♂. Morris: Aug. 22, 1938, H. H. Ross, ♂♂, ♀♀. Oakwood: Salt Fork River, July 18, 1933, Ross & Mohr, 2♂, 3♀; Middle Fork, Vermilion River, July 18, 1933, Ross & Mohr, 1♂; May 21, 1936, Mohr & Burks, 1♂. Putnam, Lake Senachwine: July 11, 1933, C. O. Mohr, 4♂. Wilmington: July 1, 1934, DeLong & Ross, 4♂; Aug. 20, 1934, DeLong & Ross, 4♂, 16♀; Kankakee River, May 27, 1935, Ross & Mohr, 1♂, many larvae and pupae; Kankakee River, June 6, 1935, Ross & Mohr, ♂♂; July 1, 1935, DeLong & Ross, ♂♂.

Hydroptila virgata Ross

Hydroptila virgata Ross (1938*a*, p. 125); ♂, ♀.

Larva.—Unknown.

Adults.—Size and color as for *armata*. Seventh sternite of male with mesal process sinuate and abruptly narrowed at tip. Eighth sternite of male with apico-mesal portion forming a heavily sclerotized, rudder-like projection. Male genitalia, fig. 511:

tenth tergite pointed and conical; claspers short and sinuate; near base of each clasper arises a short style tipped with a long seta, *P*; aedeagus with long, slender spiral and a sickle-like hook at tip. Female genitalia, fig. 532: eighth segment cylindrical, almost membranous, without ventral ornament; its apical margin straight, the ventral margin bearing six evenly spaced setae, each situated on an individual stalk; bursa copulatrix with end short and robust. Tenth segment triangular, unique in the genus.

In Illinois this species is restricted to the Ozark Hills where it has been collected along the streams peculiar to that region (see p. 6). The seasonal appearance of the adults is distinctly vernal, as indicated by records not only for Illinois but for all other states from which the species is known. Although the adults have been taken in large numbers, no larvae have yet been discovered.

The known distribution records are scanty, including only Arkansas, Illinois and Oklahoma, but indicate a restriction to the Ozarks and nearby mountains.

Illinois Records.—EDDYVILLE, Lusk Creek: June 1, 1940, B. D. Burks, 6♂, 6♀. EICHORN, Hicks Branch: May 29, 1935, Ross & Mohr, 1♂. HEROD: May 10, 1935, C. O. Mohr, 1♂; May 29, 1935, Ross & Mohr, ♂♂, ♀♀; May 13, 1937, Frison & Ross, ♂♂.

Hydroptila hamata Morton

Hydroptila hamata Morton (1905, p. 67); ♂, ♀.

LARVA.—Fig. 507. Color variable. Light extreme has head yellow, with black V across top of frons, and pronotum mostly yellow; darker individuals have head with a dusky posterior band and a black pentagonal central area, and pronotum dark with pale anterior margin.

ADULTS.—Fig. 540. Size and color as for *armata*, except for the femora, which are dark brown or black (they are tawny in other members of the genus). Seventh sternite of male with a long mesal process expanded at apex and flared laterad, the flared edges serrate. Male genitalia, fig. 512: ninth segment with long, finger-like internal arms; tenth tergite simple; claspers short, with a beaked ventral portion and a finger-like, style-bearing, dorso-lateral portion; aedeagus very long, the apical portion divided into a long, slender filament and a long rod bent sharply at apex. Female genitalia, fig. 529: eighth sternite with six apical setae along incised apical margin, and with a pair of transverse sclerotized bands near middle.

Although we have collections of this species from many widely scattered localities in the state, it must be classed as a rarity

Fig. 540.—*Hydroptila hamata* ♂.

for Illinois. It occurs in some of our northeastern glacial lakes and in clear rivers and streams in various other localities, but is almost always collected in very small numbers. We have associated larvae and adults on the basis of mature pupae from Channel Lake and Lusk Creek. The adults appear from spring to late summer.

The species ranges throughout most of the mountainous and predominantly hilly country from southern Mexico to at least Washington in the west and to New York and Ontario in the east. It is frequently abundant in such areas as the Ozarks and hilly parts of Oklahoma. Records are available from Arizona, Arkansas, Illinois, Indiana, Kentucky, Michigan, Missouri, New Mexico, New York, North Carolina, Oklahoma, Ontario, Oregon, Pennsylvania, Texas, Virginia, Washington, Wyoming, Mexico.

Illinois Records.—CHANNEL LAKE: May

16, 1936, Ross & Mohr, 4♂, 1♀. Danville, Middle Fork River: Aug. 27, 1936, Ross & Burks, 2 larvae. Eddyville, Lusk Creek: June 19–20, 1940, Mohr & Riegel, 5♂, 5♀, 1 pupa. Elizabethtown: June 25, 1932, Ross, Dozier & Park, 1♂. Fox Lake: June 30, 1935, DeLong & Ross, 1♀. Harrisburg: June 15, 1934, DeLong & Ross, at light, 1♂. Herod: June 20, 1940, Mohr & Riegel, 1♂. Homer: Aug. 5, 1931, H. H. Ross, 1♂. Momence: Aug. 21, 1936, Ross & Burks, 1♂. Ottawa: July 3, 1937, at light, Werner, 1♂.

Hydroptila amoena Ross

Hydroptila amoena Ross (1938*a*, p. 124); ♂.

Larva.—Unknown.

Adults.—Size and color as for *armata.* Seventh sternite of male with a long mesal process which is curved ventrad and slightly indented at apex, the apical margin slightly rounded and neither flanged nor serrate. Invaginated lateral portion of ninth segment long and narrow. Male genitalia, fig. 513: tenth tergite narrow and projecting; claspers short, with a wide base and narrow apex, slightly beaked at tip; aedeagus with very short spiral wound tightly around the short neck, the apical portion long and divided almost to base to form long processes. Female genitalia, fig. 528: eighth sternite tapering and semimembranous, with a pair of ovate lobes at apex, each bearing three long setae.

Allotype, female.—Broken Bow, Oklahoma, along small creek near town: June 8, 1940, Mrs. Roy Weddle.

Our only records for this species are collections of males from Herod, Illinois, and Turner Falls State Park, Oklahoma (the type series) and a subsequent collection of both sexes from Broken Bow, Oklahoma. Presumably this species is a spring form inhabiting small streams in the Ozarks and neighboring ranges.

Illinois Records.—Herod: May 29, 1935 Ross & Mohr, 1♂; Gibbons Creek, April 19, 1937, Ross & Mohr, 1♂.

Hydroptila waubesiana Betten

Hydroptila waubesiana Betten (1934, p. 160); ♂, ♀.

Larva.—Figs. 509, 541. Color extremely variable. Light extreme has head and tho-

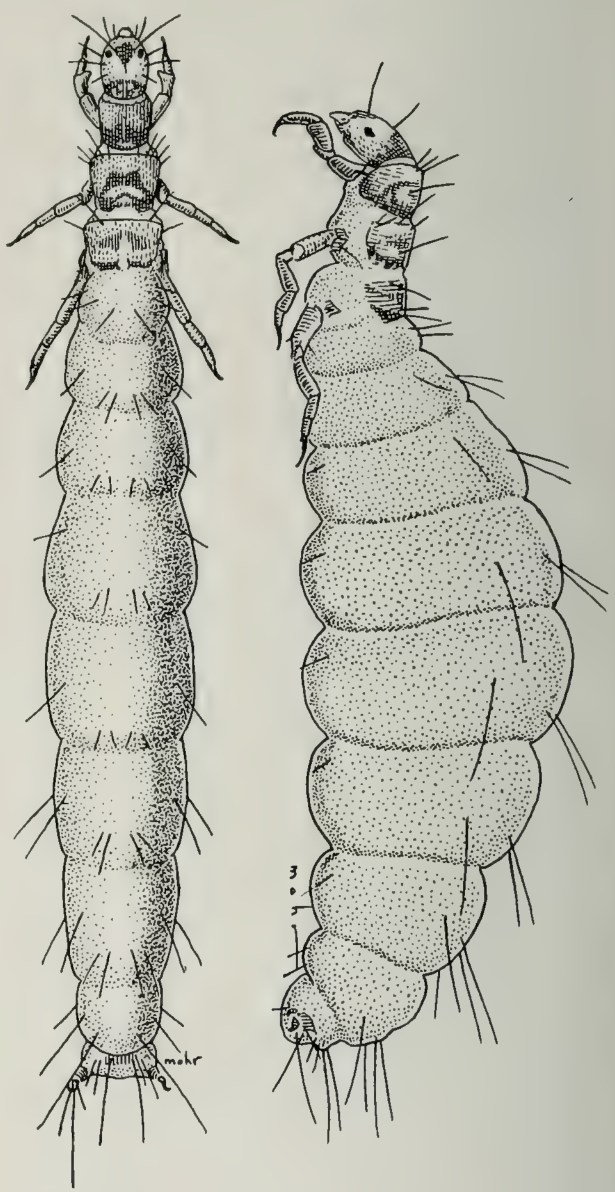


Fig. 541.—*Hydroptila waubesiana* larva. Dorsal aspect, left; lateral aspect, right.

racic terga yellow with small black marks as in fig. 509*A*; dark extreme has head mostly black with thoracic terga having large dark areas.

Adults.—Size and color as for *armata.* Male genitalia, fig. 517: ninth segment almost entirely retracted within eighth; tenth tergite divided into a pair of long processes, closely appressed and with apexes pointed laterad, truncate and sclerotized; claspers long, slender and hooked at apex, reaching beyond apex of tenth tergite; aedeagus simple, rodlike. Female genitalia, fig. 533: eighth segment sclerotized, the ventral portion produced into a long, tonguelike flap which is emarginate at tip, tergite deeply incised on meson.

Interesting among the habits of this species is its ability to thrive in both lakes and streams. In Illinois it occurs over the entire state; in the northeastern portion it inhabits the glacial lakes and over the remainder it inhabits a variety of clear streams and large rivers. We have collections of larvae and mature pupae from Fox Lake and from Quiver Creek near Havana. Adult emergence occurs from April through October.

In addition to Illinois, the species is known from Indiana, Michigan, Ohio, Ontario, Saskatchewan and Wisconsin.

Illinois Records.—Many males, females and pupae, taken April 29 to October 5, and many larvae, taken April 25 to May 29, are from Amboy, Antioch, Council Hill, Fox Lake, Galena, Grand Tower, Havana, Kankakee, La Rue, Mahomet, McHenry, Momence, Palos Park, Pere Marquette State Park, Quincy, Richmond, Spring Grove, White Pines Forest State Park, Wolf Lake.

Hydroptila delineata Morton

Hydroptila delineatus Morton (1905, p. 66); ♂.

Not yet taken in Illinois; it is known from Indiana, New York and Nova Scotia. Only the male is known, readily distinguished by the genitalia, fig. 518.

Hydroptila grandiosa Ross

Hydroptila grandiosa Ross (1938*a*, p. 126); ♂.

Larva.—Fig. 508. Head tawny yellow with dark posterior band and a dark V across top of frons, this V sometimes closed in front to form a dark, hollow diamond; each thoracic tergum with an anterior light margin and a pair of lateral light areas outlined by a darker background.

Adults.—Size and color as for *armata*. Male genitalia, fig. 519: eighth sternite large and scoop shaped, bearing four to six black, peglike setae on each lateral margin; ninth segment small and retracted within eighth; tenth tergite divided into a pair of large, sclerotized hooks broad at base and sharp at tip; below these arise a pair of long, sinuate rods around which the hooks curl; claspers small, short and truncate; aedeagus short, with a slender spiral and tapered apex. Female genitalia, fig. 538: eighth segment short, wide at base and narrowing rapidly toward apex; sternite without external plates but with apex produced into a triangle set with short setae; internal skeleton large and conspicuous, dark and expanding anteriorly.

Allotype, female. — Oakwood, Illinois, along Salt Fork River: July 18, 1933, Ross & Mohr.

To date this species has been taken only in the northern half of Illinois, in clear rivers and small, permanent streams. In only one or two cases have more than a few specimens been taken at one time. The adults emerge over the entire summer, our records including May through September. Larvae and both sexes of the adults were associated by collections of larvae and pupae from the Sinsinawa River near Galena, and from the Apple River.

Known from Illinois, Indiana, Missouri, Oklahoma and Wisconsin, the species has a range that seems to follow the better streams of the western oak-hickory forest, much as with *armata*.

Illinois Records.—Amboy, Green River: July 7, 1939, Mohr & Riegel, 2 ♀. Apple River Canyon State Park: Aug. 23, 1939, Ross & Riegel, 1 ♂; Apple River, May 24, 1940, H. H. Ross, many larvae and pupae. Danville, Middle Fork River: Aug. 27, 1936, Ross & Burks, 1 ♂, 1 pupa, 4 larvae. Galena: May 23, 1940, H. H. Ross, 2 ♂, 3 ♀, many pupae and larvae. Momence: May 17, 1937, Ross & Burks, 7 ♂; Kankakee River, May 24, 1937, H. H. Ross, 2 ♂. Muncie: June 27, 1932, H. H. Ross, 1 ♀. Oakwood: Salt Fork River, July 18, 1933, Ross & Mohr, 2 ♀; Salt Fork River, July 18, 1933, Ross & Mohr, 2 ♂, 2 ♀; Salt Fork River, Sept. 20, 1935, DeLong & Ross, 1 ♂; May 21, 1936, Mohr & Burks, 1 pupa. Richmond: Aug. 15, 1938, Ross & Burks, 1 ♀. Rock City: June 6, 1940, Mohr & Burks, 1 ♂. Sugar Grove: June 13, 1939, Frison & Ross, 1 ♂, 2 ♀.

Hydroptila albicornis Hagen

Hydroptila albicornis Hagen (1861, p. 275); ♂.

Larva.—Fig. 505. Head patterned with pale yellow and dark brown, always with a postero-mesal pale streak; each thoracic notum dark brown with anterior margin and a pair of lateral areas pale.

Adults.—Male, fig. 520: tenth tergite divided into a mesal and a pair of lateral semimembranous lobes, each narrow. Claspers as long as tenth tergite, slender, situated some distance apart; the mesal margin is nearly straight, the apex is rounded and curved slightly dorsad, and near the lateral margin is a sclerotized point midway between base and apex. Above the claspers is a round plate bearing a pair of small setae near the middle. Aedeagus with spiral slender, neck large, and tip of apical portion with a short lateral projection. Female, fig. 539: eighth segment semisclerotized, tubular, without internal plates or external ornamentation; tergite with a flat-bottomed mesal depression; sternite with meson produced into a rounded lobe.

Allotype, female.—Kankakee, Illinois: July 22, 1935, at light, DeLong & Ross.

As pointed out in the lectotype designation (Ross 1938*c*, p. 9), the type is in reality a male, although the original description notes it as a female.

Our only Illinois records for this species are from various points along the Kankakee River (see p. 6). Here it is abundant; we have taken larvae and pupae from the river at Momence and Kankakee. Records for the species are widespread but not numerous, including Illinois, Indiana, Missouri, Ontario and Wisconsin. All specimens were taken along large, swift, clear rivers, including the St. Lawrence, Kankakee, White (in Indiana), Gasconade and White (in Missouri), and Namekagon (in Wisconsin). The adults emerge throughout the warmer months (May through September).

Records given under the name *albicornis* by Betten (1934) probably refer to some other species; the illustrations indicate *hamata*.

Illinois Records.—Kankakee: Kankakee River, Aug. 1, 1933, Ross & Mohr, many larvae; July 22, 1935, DeLong & Ross, 1 ♂, 1 ♀. Momence: July 14, 1936, B. D. Burks, many pupae and larvae; Aug. 21, 1936, Ross & Burks, ♂ ♂, many pupae and larvae; Kankakee River, Aug. 24, 1936, Ross & Burks, 1 ♂; May 17, 1937, Ross & Burks, 5 ♂, many pupae and larvae; Kankakee River, May 24, 1937, H. H. Ross, ♂ ♂. Wilmington: Aug. 20, 1934, DeLong & Ross, 3 ♀; Kankakee River, May 17, 1937, Ross & Burks, 2 ♂.

Hydroptila scolops Ross

Hydroptila scolops Ross (1938*a*, p. 128); ♂.

Larva.—Unknown.

Adults.—Size and color as for *armata.* Male genitalia, fig. 521: tenth tergite membranous, divided into two large lateral lobes and a small mesal lobe; claspers fairly long and straight, with an apico-lateral sclerotized point and only small setae; aedeagus short, basal portion flared, neck distinct, spiral small and apical portion large at base, tapering gradually to a pointed tip. Female unknown.

This species is known only from the holotype, collected along the Ohio River at Shawneetown, Illinois, May 11, 1935, at light, C. O. Mohr.

Hydroptila angusta Ross

Hydroptila angusta Ross (1938*a*, p. 130); ♂, ♀.

Larva.—Head and thoracic sclerites varying from tawny yellow to fairly dark brown, the color fairly uniform over the entire area and not forming a pattern.

Adults.—Male, fig. 522: tenth tergite wide, divided down meson by a deep, angular cleft, with only lateral margins sclerotized. Claspers with a wide "foot," the upper portion bladelike; blade with a small, sclerotized point on mesal margin beyond middle, with a row of irregular setae on lateral margin and with tip pointed. The rounded plate above the claspers bears a pair of short setae near apex. Aedeagus very long, with an imbricated portion below neck, a narrow neck, a long, stout spiral and a long, slender apical portion which has a sinuate, small finger at tip. Female, fig. 536: eighth segment semimembranous, tapering; apex of tergite with a truncate incision; sternite with somewhat stocky, mesal plate near middle and with a mesal, tongue-like projection at apex.

Association of larvae and adults was established by collections of larvae and pupae from the Middle Fork River near Danville, and from other localities.

In Illinois the species has been collected from widespread localities. It prefers moderate-sized to large streams and rivers, and is frequently encountered in large numbers. The adults emerge over a wide span; we have records from May 1 to October 16.

The range of the species extends from the arid plains of western Texas and eastern New Mexico to Ohio, with records from Illinois, Indiana, Missouri, New Mexico, Ohio, Oklahoma and Texas.

Illinois Records.—Many males, females and two pupae, taken May 1 to October 16, and many larvae, taken August 1 to August 27, are from Amboy, Charleston, Danville, Galena, Homer, Kankakee, Mahomet, Milan, Momence, Morris, Mount Carroll, Muncie, Oakwood, Ottawa, Putnam, Richmond, Rock City, Rock Island, Serena, Spring Grove, Sugar Grove, Wilmington.

Hydroptila consimilis Morton

Hydroptila consimilis Morton (1905, p. 65); ♂.

LARVA.—Fig. 503. Head and thoracic nota mostly black; head sometimes with a narrow pale area between posterior and anterior dark areas; thoracic nota with anterior margin pale.

ADULTS.—Male, fig. 523: similar in most structures to the preceding species, but differing as follows: claspers wider, rounder at apex; the apex of the aedeagus robust and shorter, with a long, finger-like, lateral process at tip. Female, fig. 537: eighth segment semimembranous, tapering; tergite with a wide, shallow incision at apex, the bottom of the incision with a sclerotized, mesal thickening; sternite with a somewhat trapezoidal mesal ornament and a rounded, mesal projection.

Allotype, female.—Utica, Illinois, Split Rock Brook: July 11, 1941, Ross & Ries.

Although taken several times, this species must be classed as a rarity in Illinois. We have taken it in numbers only in two peculiar and restricted situations, at Elgin and Split Rock (Utica). Other records are from clear, permanent streams, most of them in the northern quarter of the state. All our records are in June and July, but records for other states indicate that the adults emerge from April to September.

The range of the species is extensive and seems to cover all the mountainous and much of the heavily wooded areas from Texas to British Columbia in one direction and New York in the other. Records are available from Arizona, British Columbia, Illinois, New York, Oklahoma, Oregon, Tennessee, Texas, Utah, Virginia and Wyoming.

Illinois Records.—Many males, females and eight pupae taken June 5 to August 15, and five larvae taken May 23 to June 6, are from Apple River Canyon State Park, Council Hill (Galena River), Dixon, Elgin (Rainbow Springs), Galena, Mount Carroll, Muncie, Oakwood (Middle Fork Vermilion River), Utica (Split Rock Brook), White Pines Forest State Park.

Hydroptila perdita Morton

Hydroptila perdita Morton (1905, p. 67); ♂.

LARVA.—Unknown.

ADULTS.—Male, fig. 524: tenth tergite large, somewhat hood shaped, almost entirely membranous except for a mesal, clavate sclerotized strip. Claspers with a distinct foot, the blade long, slightly out-curved at apex, and with a dark, sclerotized point at each apical angle. Aedeagus with a stout spiral and with the tip of the apical portion bent to form a sharp, right-angled process. Female, fig. 534: eighth segment wide at base and semimembranous; tergite with sloping apex and a narrow mesal incision; sternite with sinuate apical margin and a wide, rounded incision; near the center of the sternite is a bell-shaped plate.

Allotype, female.—Washington County, Arkansas: June 19, 1940, M. W. Sanderson.

To date we have only two records of this species for Illinois, from the Kankakee and Salt Fork rivers, both on the extreme eastern edge of the state. These, together with other localities, indicate a preference for large, clear, rapid streams, with adult emergence from May to October.

Available records are from Arkansas, Illinois, Michigan, New York, Ontario and Pennsylvania.

Illinois Records.—MOMENCE, Kankakee River: May 24, 1937, H. H. Ross, 1♂. OAKWOOD, Salt Fork River: July 18, 1933, Ross & Mohr, 1♀. SPRING GROVE: Aug. 12, 1937, at light, Ross & Burks, 3♂.

Hydroptila ajax Ross

Hydroptila ajax Ross (1938*a*, p. 127); ♂, ♀.

LARVA.—Head and thoracic sclerites tawny yellow, varying somewhat in exact shade but not forming a pattern.

ADULTS.—Size and color as for *armata*. Male genitalia, fig. 525: tenth tergite hoodlike, divided by membranous darts into a mesal and pair of lateral lobes; claspers having a distinct foot and a fairly long, narrow blade with the apex outcurved and a sclerotized point on each apical corner;

aedeagus large, with a large spiral and the apical portion straight at tip. Female genitalia, fig. 535: eighth tergite with apex widely and deeply emarginate and with a sclerotized nodule at base of depression; sternite with a long, bell-shaped central plate and with the apical margin undulate to form a pair of low, lateral humps and a higher mesal projection.

The species *icona*, described from Mexico and since taken in Texas and Oklahoma, might be confused with this species, but *icona* differs radically in having short claspers, fig. 526.

This is one of the more common Illinois species of the genus, having been taken in large numbers in a considerable variety of creeks and small rivers in the northern half of the state. Larvae and pupae have been collected in several localities. The adults appear throughout the warmer months, from May through September.

The range of the species extends from Oklahoma to New York, with Illinois as the apparent density center. We have records for Illinois, Indiana, New York and Oklahoma.

Illinois Records.—Many males and females and four pupae, taken May 24 to September 20, and many larvae, taken May 21 to June 6, are from Amboy (Green River), Apple River Canyon State Park, Downs (Kickapoo Creek), Howardsville, Kappa (Mackinaw River), Mount Carroll, Muncie, Oakwood (Middle Fork, Vermilion River, Salt Fork River), Quincy (stream near Cave Spring, Burton Creek), Rock City, Serena, Spring Grove, White Pines Forest State Park.

Neotrichia Morton

Cyllene Chambers (1873, p. 124); preoccupied. Genotype, monobasic: *Cyllene minutisimella* Chambers.

Neotrichia Morton (1905, p. 72). Genotype, monobasic: *Neotrichia collata* Morton.

Exitrichia Mosely (1937, p. 170). Genotype, by original designation: *Exitrichia anahua* Mosely.

Dolotrichia Mosely (1937, p. 177). Genotype, by original designation: *Dolotrichia canixa* Mosely.

Guerrotrichia Mosely (1937, p. 179). Genotype, by original designation: *Guerrotrichia caxima* Mosely.

Lorotrichia Mosely (1937, p. 181). Genotype, by original designation: *Lorotrichia hiaspa* Mosely.

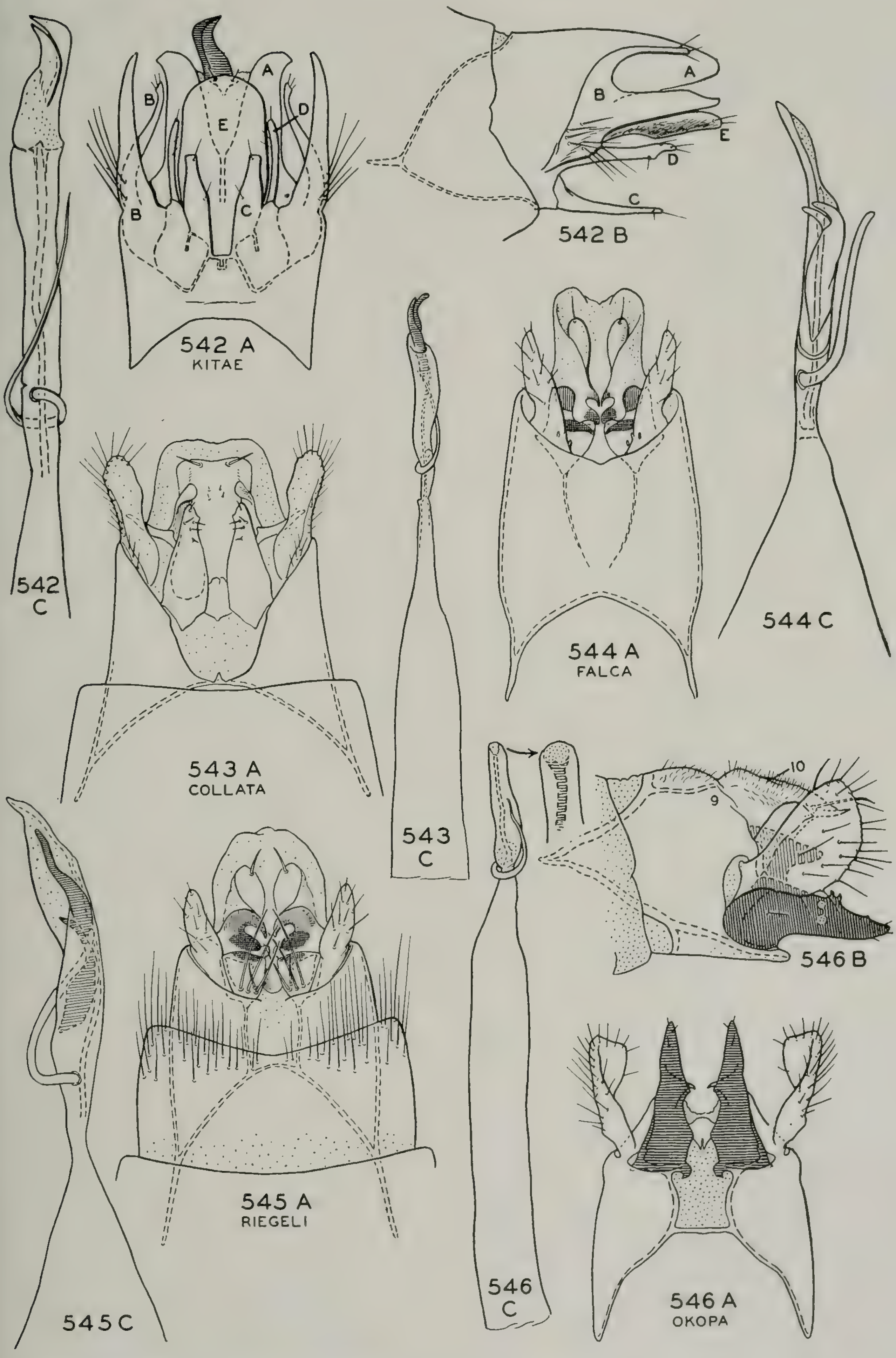
This genus contains the smallest caddis flies in North America. Of the 11 species known from the United States, 6 have been captured in Illinois. All the species frequent clear-water streams, and some of them are extremely local in their distribution. The genus has developed a large fauna in the Neotropical region, which seems to be the center of distribution for many "micros" that range from southern Mexico to Oklahoma, Illinois and New York.

Characters of the genitalia separate the species in both males and females, but, to date, reliable characters have not been found for separating the larvae. We have associated larvae and adults of *minutisimella, okopa, collata* and *riegeli.*

KEY TO SPECIES

Adults

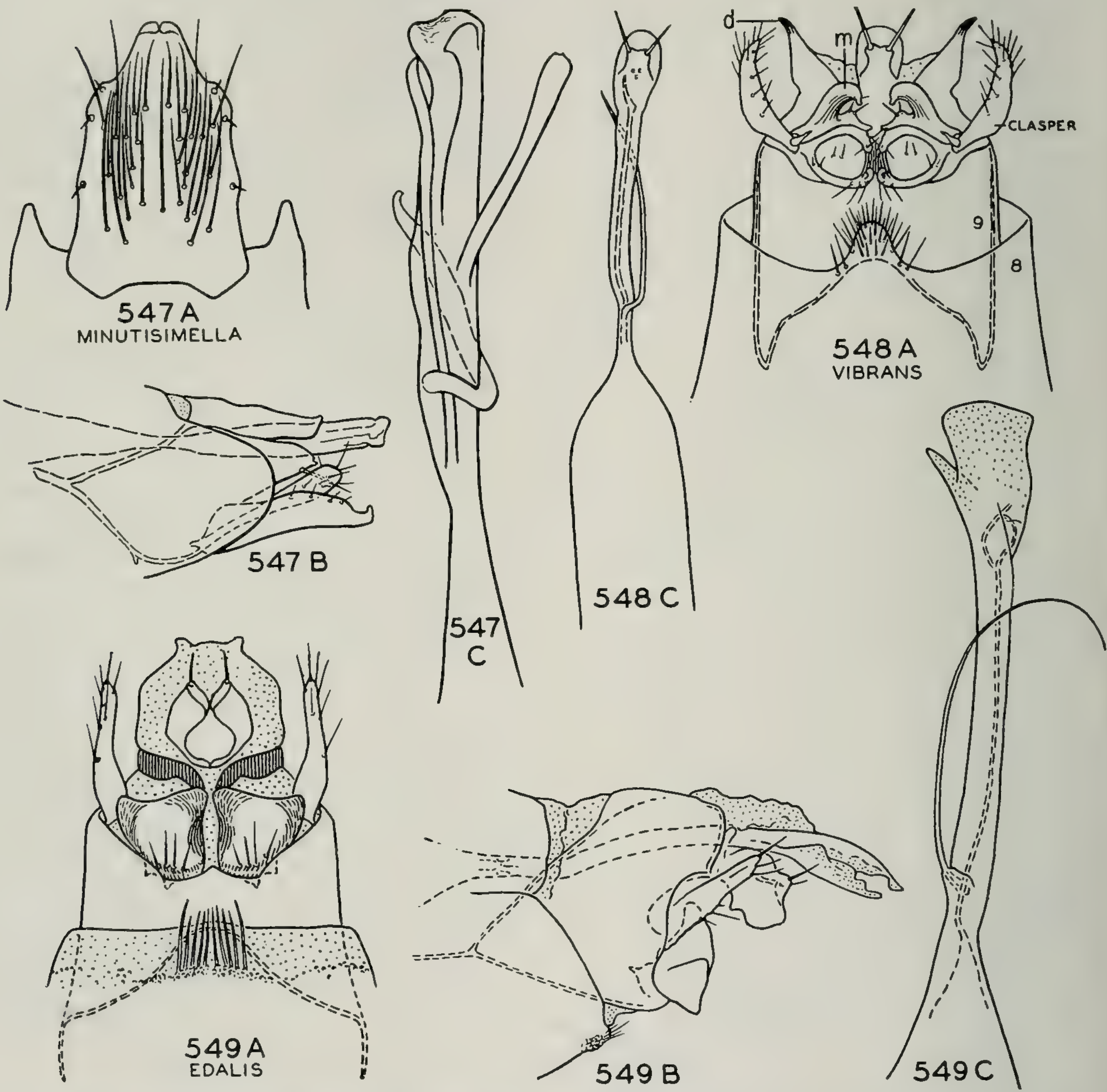
1. Apex of abdomen with several sets of plates or processes (males)........ 2
   Apex of abdomen simple and tubular (females)...................... 9
2. Ninth segment with outer lateral process *B* divided to form long dorsal and ventral fingers; plate *E* behind claspers twice as long as claspers, fig. 542..................**kitae, p. 158**
   Ninth segment with outer lateral process simple; plate behind claspers short or inconspicuous, figs. 543–549.......................... 3
3. Aedeagus with a pair of stout, sclerotized hooks, figs. 543–545.......... 4
   Aedeagus without stout, sclerotized hooks, figs. 546–549.............. 6
4. Claspers slender, almost three times longer than wide, fig. 543.........
   ....**collata, p. 159**
   Claspers almost quadrate, no longer than wide, fig. 544............... 5
5. Aedeagus with both sclerotized hooks subequal and alike; apex of claspers with a steplike break, fig. 544.....
   ....**falca, p. 159**
   Aedeagus with sclerotized hooks very dissimilar in length and shape; apex of claspers truncate, fig. 545..
   ....**riegeli, p. 159**
6. Aedeagus ending in a uniform, sclerotized cylinder; claspers heavily sclerotized and black, fig. 546.....
   ....**okopa, p. 158**
   Aedeagus not cylindrical or sclerotized at apex; claspers not as above, fig. 547........................ 7
7. Claspers fused to form a long ventral



Figs. 542-546.—*Neotrichia*, male genitalia. *A*, ventral aspect; *B*, lateral aspect; *C*, aedeagus, the basal portion omitted in 542.

plate covered with long setae and narrowed and upturned at apex, fig. 547............**minutisimella**, p. 157
Claspers not forming a plate, figs. 548, 549............................ 8

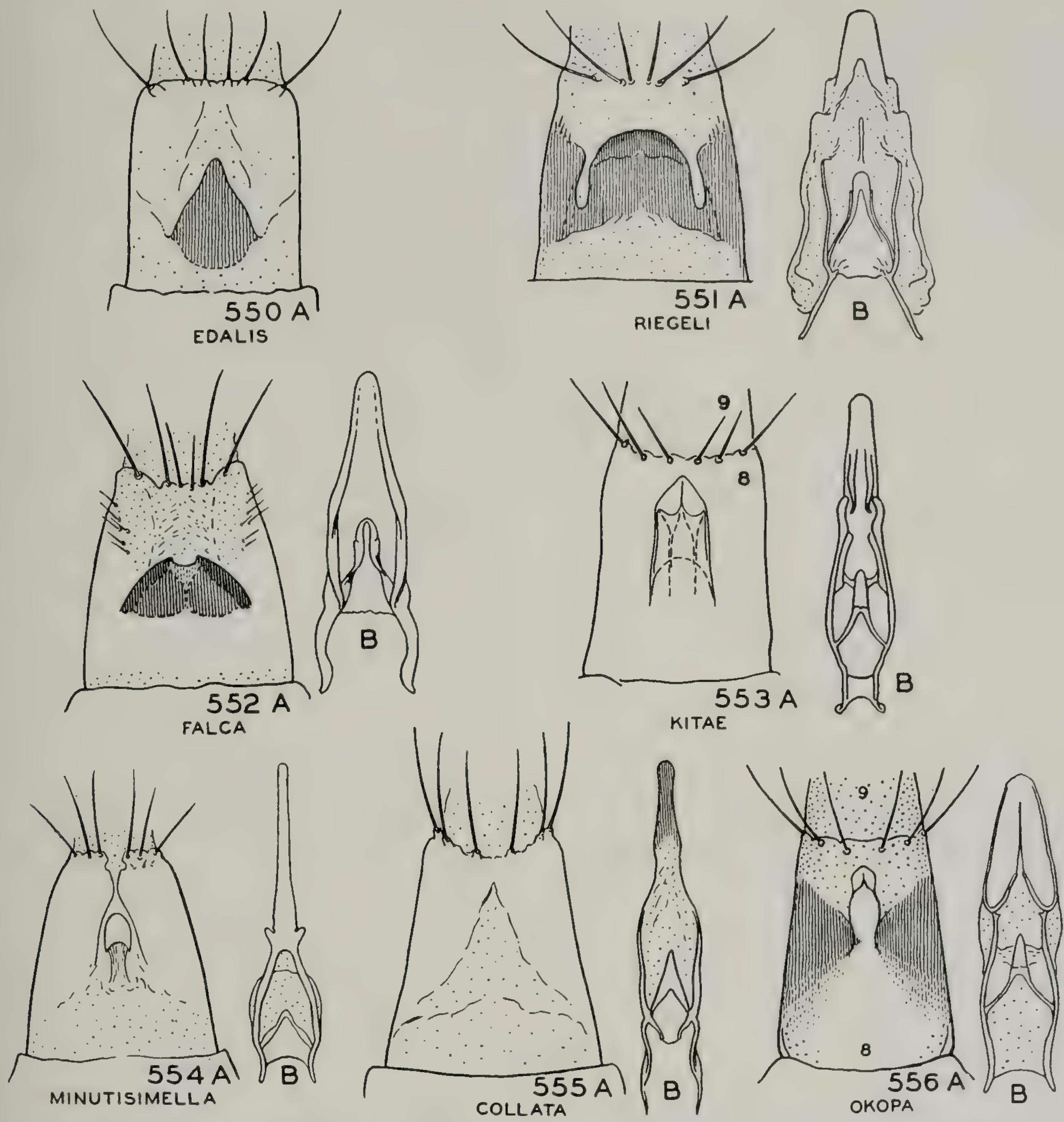
10. Sclerotized plate of eighth sternite narrow and angular, fig. 550 ....**edalis**, p. 158
Sclerotized plate of eighth sternite wide and arcuate, figs. 551, 552... 11



Figs. 547-549.—*Neotrichia*, male genitalia. *A*, ventral aspect; *B*, lateral aspect; *C*, aedeagus, the basal portion omitted in 547 and 548.

8. Apex of aedeagus flattened and elliptic, with a pair of long, apical setae; apex of tenth tergite divided into a pair of divergent, pointed, sclerotized lobes, fig. 548.....**vibrans**, p. 159
Apex of aedeagus flattened, but with a membranous "thumb" instead of setae; tenth tergite entirely membranous, fig. 549.........**edalis**, p. 158
9. Eighth sternite with a heavily sclerotized, arcuate or angular plate, figs. 550, 551........................ 10
Eighth sternite without a sclerotized plate, fig. 553..................... 12

11. Sclerotized plate of eighth sternite evenly arcuate along apical margin, fig. 551.................**riegeli**, p. 159
Sclerotized plate of eighth sternite with a mesal emargination, fig. 552 ....**falca**, p. 159
12. Eighth sternite with a large mesal body, angulate at apex, occupying a full third of the width of the segment, fig. 553............**kitae**, p. 158
Eighth sternite with mesal body either much smaller, fig. 556, or of a different shape, fig. 554; note also differences in bursa copulatrix..... 13



Figs. 550–556.—*Neotrichia*, female genitalia. *A*, eighth sternite; *B*, bursa copulatrix.

13. Apex of bursa copulatrix forming a long, narrow, tapered rod, figs. 554, 555 14
    Apex of bursa copulatrix forming a wide, bilobed structure, fig. 556... 15
14. Median portion of bursa copulatrix with a pair of sclerotized projections at base of apical rod, fig. 554...... .... **minutisimella**, p. 157
    Median portion of bursa copulatrix entirely membranous, without projections, fig. 555 .... **collata**, p. 159
15. Eighth sternite sclerotized and darkened to form a distinct V, fig. 556.. .... **okopa**, p. 158
    Eighth sternite slightly sclerotized but not darkened; without an evident V-shaped pattern....... **vibrans**, p. 159

Neotrichia minutisimella (Chambers)

Cyllene minutisimella Chambers (1873, p. 125); ♂.

LARVA (mature type).—In general shape similar to fig. 557. Length 2 mm. Head somewhat cone shaped, narrowed toward front. Legs short but slender. Abdomen abruptly enlarged at juncture of thorax, the second segment slightly the widest and the abdomen tapering almost evenly from that point to the end; lateral margins with a delicate, small fringe of hair. Anal hooks situated on short, stubby but distinct "legs."

CASE.—Short and elliptic, tapered at the base without a bottom opening; composed of sand grains woven into an even, fairly smooth surface. Top opening closed for pupation by an irregular silky layer.

ADULTS. — Length 1.5–2.0 mm. Color strawlike, wings with only indistinct markings. Male genitalia, fig. 547: tenth tergite large, bilobed and submembranous; ventral plate (probably consisting of the fused claspers) large, clothed with long setae and narrowed and upturned at apex; aedeagus with a large spiral process at neck, the apical portion submembranous with one or two accessory finger-like lobes. Female genitalia, fig. 554: eighth sternite practically colorless, divided down meson by membranous incision which flares out at the base; within this area at the base arises an ovate structure with rounded apex and membranous base; bursa copulatrix with long, slender, apical style and a pair of horns at its base.

Allotype, female.—Kankakee, Illinois: July 22, 1935, at light, DeLong & Ross.

No record of this species, the smallest known caddis fly in North America, has been published since its original description from Covington, Kentucky. It is the commonest species of the genus in Illinois, especially abundant in the upper Sangamon River, where we have reared it, and has been taken also from the Kankakee River and a few small streams.

The species is known to range through Missouri, Oklahoma, Illinois, Indiana and Kentucky.

Illinois Records.—KAMPSVILLE: July 2, 1931, Frison, Betten & Ross, 1 ♂. KANKAKEE: Kankakee River, Aug. 1, 1933, Ross & Mohr, 1 ♂ ; July 22, 1935, at light, DeLong & Ross, 2 ♂, 1 ♀. MAHOMET, Sangamon River: June 6, 1940, Ross & Riegel, 2 pupae. OAKWOOD, Middle Fork River: Sept. 7, 1936, DeLong & Ross, 1 ♀. QUINCY, Burton Creek: June 25, 1940, Mohr & Riegel, 1 ♀. URBANA: Aug. 3, 1931, light trap, W. P. Flint, 7 ♂. WHITE HEATH: Aug. 2, 1940, Ross & Riegel, 1 ♀.

Neotrichia okopa Ross

Neotrichia okopa Ross (1939*b*, p. 629); ♂, ♀.

ADULTS.—Length 2 mm. Body and appendages dark brown, the wings mottled. Male genitalia, fig. 546: tenth tergite membranous with a mesal lobe, a pair of long setae and a pair of lateral extensions; beneath it are a pair of sclerotized processes; lateral appendages spatulate; aedeagus with a very long, cylindrical, basal portion, narrow neck with a prominent spiral process and the apical portion more or less cylindrical and heavily sclerotized. Female genitalia, fig. 556: eighth sternite with sclerotized portions forming a dark V; above the base of the V is a small, rounded structure the base of which is divided into two lobes; bursa copulatrix as in fig. 556*B*.

This species, not previously recorded from Illinois, has been taken at only widely separated localities in the state. It was especially abundant in Lusk Creek in the Ozark Hills, where it was reared in company with *collata* and *riegeli*. Its known range includes scattered localities in Illinois, Ohio, Oklahoma and Pennsylvania. Our collecting in Illinois indicates its preference for small, clear streams.

Illinois Records.—APPLE RIVER CANYON STATE PARK: Aug. 23, 1939, Ross & Riegel, 1 ♂. COUNCIL HILL, Galena River: June 26, 1940, Mohr & Riegel, 1 ♂, many pupae. EDDYVILLE, Lusk Creek: June 19–20, 1940, Mohr & Riegel, ♂ ♂, ♀ ♀. MOMENCE: June 22, 1938, Ross & Burks, 8 ♂. UTICA, Split Rock Brook: June 17, 1941, Burks & Riegel, ♂ ♂, ♀ ♀. WHITE PINES FOREST STATE PARK: Aug. 13, 1937, Ross & Burks, 1 ♂, ♀ ♀. WILMINGTON: July 1, 1935, DeLong & Ross, 1 ♀.

Neotrichia kitae Ross

Neotrichia kitae Ross (1941*b*, p. 60); ♂, ♀.

To date this species has not been taken in Illinois. It is known only from Hollister, Missouri. This species resembles the others of the genus in general size and shape, but is readily distinguished on the basis of genitalia, figs. 542, 553.

Neotrichia edalis Ross

Neotrichia edalis Ross (1941*b*, p. 62); ♂, ♀.

Although not yet taken in Illinois, this species frequents streams in eastern Oklahoma which are very similar to some in southern and western Illinois and may possibly be taken in the state in the future. The genitalia of both sexes, figs. 549, 550, are diagnostic for the species; the triangular subgenital plate of the female eighth sternite is unusual in the genus and distinctive.

Neotrichia vibrans Ross

Neotrichia vibrans Ross (1938*a*, p. 119); ♂.

ADULTS.—Length 2 mm. Body and appendages mottled with black, brown and whitish. Male genitalia, fig. 548: eighth sternite with an apico-mesal lobe; genitalia with claspers small, curved and hooklike, arising from a platelike, basal sclerite; tenth tergite produced into a pair of widely divergent pointed lobes; lateral appendages long and fusiform; aedeagus with a broad base, very narrow neck bearing a long, slightly curved, spiral process, and a long, narrow apical portion which has its tip enlarged and ovate, and bears a pair of prominent setae. Female genitalia similar to those of *okopa* in structure of eighth segment and bursa copulatrix; differing in lacking dark coloration so that the sternite has no distinct pattern.

Allotype, female.—Hollister, Missouri: July 14, 1938, Mrs. Vitae Kite.

Originally described from a single male from Oakwood, Illinois, this species has since been collected in large numbers at Hollister, Missouri. The Illinois records indicate a preference for small, clear streams. Little can be said regarding the range of the species.

Illinois Records.—MUNCIE: June 27, 1932, H. H. Ross, 1♀. OAKWOOD, Middle Fork River: Sept. 7, 1936, DeLong & Ross, 1♂.

Neotrichia falca Ross

Neotrichia falca Ross (1938*a*, p. 119); ♂.

ADULTS.—Length 2.5 mm. Color a salt-and-pepper mixture of cream and brown. Male genitalia, fig. 544: tenth tergite membranous; cerci long, slightly sinuate and with sparse setae; claspers short, the apical margin steplike and with two black, sclerotized cushions; above them membranous folds end in a pair of blunt black lobes and a pair of small black hooks; above these are a pair of ovate membranous lobes tipped by a seta; aedeagus with flared base, a long finger-like lobe rising from neck and a slender, curved apical portion with two teeth which are almost superimposed one over the other. Female genitalia, fig. 552: eighth sternite with a central sclerite with arcuate apical margin and a minute incision at tip; bursa copulatrix as in fig. 552*B*.

Allotype, female.—Quincy, Illinois, stream near Cave Spring: July 6, 1939, Mohr & Riegel.

We have taken this species in scattered localities in the northern two-thirds of the state, in every case along a small and fairly clear stream. Adult emergence is continuous throughout the warmer months, with records from June through most of September. No collections are known outside Illinois.

Illinois Records.—COUNCIL HILL, Galena River: June 26, 1940, Mohr & Riegel, 1♂. MOMENCE: June 22, 1938, Ross & Burks, ♂♂, ♀♀. MUNCIE, Stony Creek: Sept. 20, 1935, Frison & Mohr, 1♂. QUINCY: stream near Cave Spring, July 6, 1939, Mohr & Riegel, ♂♂, ♀♀; Burton Creek, June 25, 1940, Mohr & Riegel, 1♀. SUGAR GROVE: June 13, 1939, Frison & Ross, 1♂. WHITE PINES FOREST STATE PARK: Aug. 13, 1937, Ross & Burks, 4♀.

Neotrichia riegeli Ross

Neotrichia riegeli Ross (1941*b*, p. 61); ♂, ♀.

ADULTS.—Length 2.0–2.5 mm. Straw colored, with irregular light brown marks on body and wings. Male genitalia, fig. 545: similar in general structure to *falca*; claspers short, nearly quadrate, with a dense black area at apex; above, the black hooks are large with a black cushion at base; aedeagus with sclerotized hooks set one beyond the other. Female genitalia, fig. 551: eighth sternite with a large, sclerotized mesal lobe with the arcuate apical margin thickened; bursa copulatrix as in fig. 551*B*.

This species is known only from the type series, containing a large collection of males and females, from Lusk Creek near Eddyville, Illinois, June 19–20, Mohr & Riegel. Mature pupae also were collected here, linking larval and adult forms. This set was taken in company with *collata* and *okopa*.

Neotrichia collata Morton

Neotrichia collata Morton (1905, p. 72); ♂, ♀.

ADULTS.—Size 2.0–2.5 mm. Color mottled brown and tawny. Male genitalia, fig. 543: tenth tergite membranous; cerci fairly long; claspers long and tapering, with a small mesal tooth at apex; above it is a rectangular plate with a pair of apical setae; aedeagus very long, neck long and narrow, spiral long, apex with a pair of appressed sclerotized hooks. Female genitalia, fig. 555: eighth sternite without central ornamentation; bursa copulatrix with an elongate, tenpin-like process.

Our only Illinois record of this species is a large collection of males, females and pupae from Lusk Creek near Eddyville, June 19–20, 1940, Mohr & Riegel. These were taken in company with *okopa* and *riegeli.* Lusk Creek is a clear, rapid stream in the Ozark Hills of southern Illinois.

The only available records are from Illinois, Kentucky and New York.

Mayatrichia Mosely

Mayatrichia Mosely (1937, p. 182). Genotype, by original designation: *Mayatrichia ayama* Mosely.

This genus contains three North American species, of which only one, *ayama,* has been taken in Illinois. The other two are known from Oklahoma and Texas. The three species are readily distinguished on the basis of male genitalia, but differences between the females have not yet been worked out. A key to the males, followed by descriptions of the out-of-state species, is given on p. 278.

Mayatrichia ayama Mosely

Mayatrichia ayama Mosely (1937, p. 182); ♂.

Larva (mature type).—Fig. 557. Length 2 mm. Head and body sclerites cream colored with only a few slightly darker lines around the edges of some sclerites; body white. Similar in general to *Neotrichia,* with cone-shaped head and slender legs. Abdomen wedge shaped, with lateral contours very even and possessing lateral fringe, similar in this respect to the Leptoceridae.

Larva (free-living young form).—Fig. 557. Similar to mature type but with abdomen small and tapering, all segments partially sclerotized and provided with stout setae. Anal legs close together at base, fig. 552, claws as in mature form.

Case.—Fig. 558. Somewhat wedge shaped, fibrous, ventral surface flat, dorsal surface convex, raised into either longitudinal ridges, transverse ridges, or sometimes a combination of both. Posterior end closed; anterior end sealed for pupation by a circular, brown, membranous cap.

Adults.—Length 2–3 mm. Color brown without conspicuous markings. Sixth segment with a long, slender spine, fig. 559. Male genitalia, fig. 929, p. 279; ninth seg-

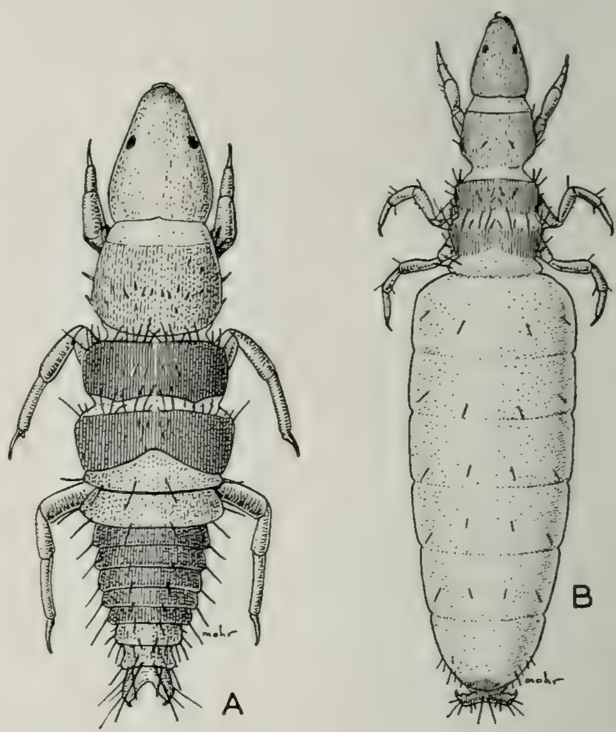


Fig. 557.—*Mayatrichia ayama. A,* free living, early instar; *B,* case making, later instar.

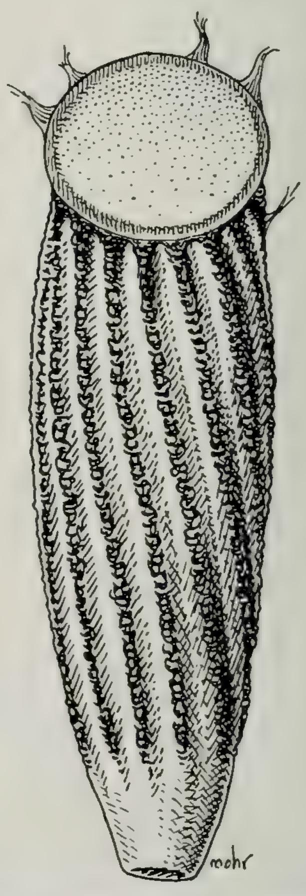


Fig. 558.—*Mayatrichia ayama,* case.

ment with a large, clasper-like lobe on the postero-lateral margin, this lobe with the apical margin rounded dorsally and tapering to a somewhat pointed ventral corner; tenth tergite membranous and somewhat hood shaped; claspers with a broad base, a small, finger-like dorso-lateral projection and a wide ventro-mesal lobe the apical margin of which is rounded and which bears four to six setae; above the claspers is a

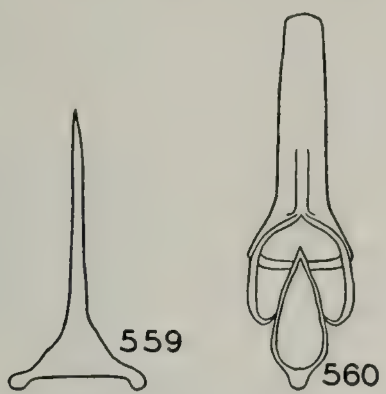


Fig. 559.—*Mayatrichia ayama* ♂, spine of sixth sternite.

Fig. 560.—*Mayatrichia ayama* ♀, bursa copulatrix.

stout, wide lobe with a long, sharp ventral beaked apex; aedeagus long, slender and simple, the extreme apex divided into a three-pronged sclerotized plate. Female genitalia simple and tubular, with bursa copulatrix large and shaped as in fig. 560.

This species is the one described by Betten (1934, p. 164) as an undetermined genus and species.

In Illinois, we have taken the species commonly in the northern fourth of the state and have, in addition, a record from southern Illinois. We have taken the larvae and pupae abundantly in the riffles of the Galena River at Council Hill, Illinois, thus associating the larvae, males and females; we have made similar collections in the Kankakee River at Momence. This species has a distinct preference for the more rapid and clear Illinois rivers and streams. Adult emergence extends from June to early September, indicating a continuous cycle of generations.

The range of the species extends from extreme southern Mexico to New York and Montana; most of the records follow fairly closely the confines of the deciduous forests, ranging through Texas into Florida and more northern eastern states; in the northwestern states our only record is from Montana. Although the records are scattered over a wide area, the species is quite rare and not commonly taken. We have records from Florida, Georgia, Illinois, Iowa, Kentucky, Missouri, Montana, New York, Oklahoma, Pennsylvania, Tennessee and Texas.

Illinois Records.—Many males, females and pupae, taken June 21 to September 10, and many larvae, taken June 6 to August 21, are from Amboy (Green River), Apple River Canyon State Park, Council Hill (Galena River), Dixon, Elizabethtown, Kankakee, Momence, Oregon, Ottawa, Rock Island, Serena.

PHRYGANEIDAE

In this family the maxillary palpi are four segmented in the male, five in the female. The larvae construct cases which in most genera are long and built in a spiral. Characteristic of the larvae are their membranous meso- and metanotum, each with a lateral tuft of long setae; in addition, the lateral gills are covered with hair, and the lateral line of the abdomen is represented by a fairly wide area of short hair.

The generic limitations in this family have previously been established on the basis of wing venation and vestiture. Both of these characters, however, vary so much in some genera that it is impractical to use these as a basis for generic differentiation in this family. The best characters for this purpose seem to be the female genitalia, which present some striking evidences of both differentiation and affinities, and the generic groupings outlined here are based on these characters.

The genus *Neuronia* Leach, used commonly in the past as a caddis fly genus of this family, apparently belongs to the Plecoptera, with *Phryganea fusca* Linnaeus as the type.

In general, the family favors marshes and lakes for its abode, but some species are taken in rivers and streams.

KEY TO GENERA

Larvae

1. Frons with a median black line, fig. 561 2
   Frons without a median black line, fig. 564 3
2. Pronotum with anterior margin black,

fig. 561, and without a diagonal black line.........**Phryganea,** p. 174

Pronotum with a diagonal black line, fig. 562, anterior margin mostly yellow........**Banksiola selina,** p. 169; **Agrypnia straminea,** p. 165

3. Mesonotum with a pair of small sclerites near anterior margin, fig. 563 4

Mesonotum without a pair of sclerites, sometimes with a very small sclerotized area around the base of 1 seta, fig. 564.................. 5

4. Mature larvae attaining length of 30 mm..............**Eubasilissa,** p. 168

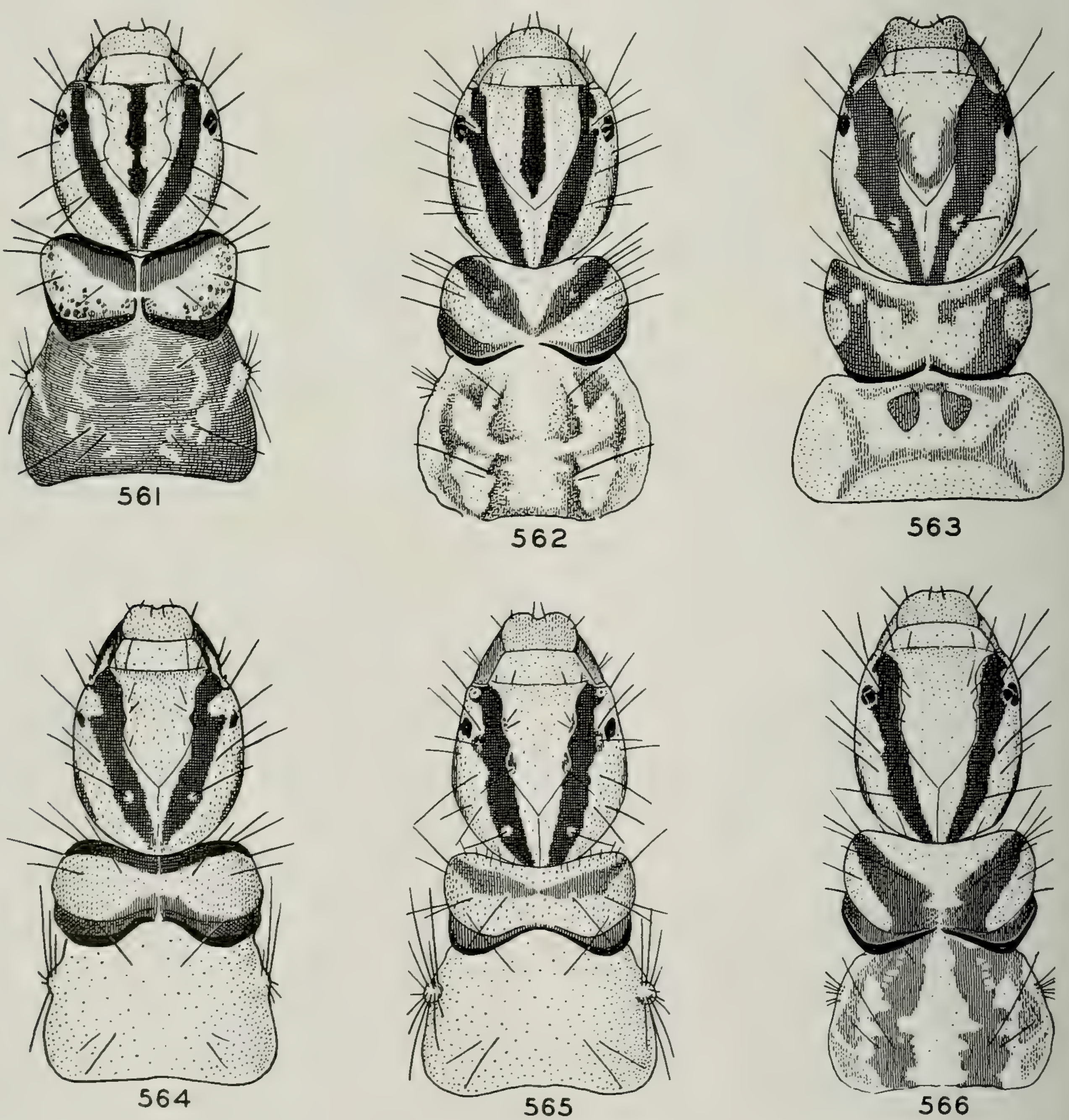
Mature larvae attaining length of only 20 mm.......**Oligostomis,** p. 167

5. Pronotum with anterior margin black, fig. 564, and without a diagonal black line.....**Agrypnia vestita,** p. 166

Pronotum with a diagonal black line, fig. 565, anterior margin mostly yellow........................ 6

6. Diagonal marks on pronotum meeting at posterior margin to form a V-mark, fig. 566...........................**Phryganeid Genus A,** p. 167

Diagonal marks on pronotum not reaching posterior margin but join-



Larvae of Phryganeidae

Fig. 561.—*Phryganea* sp.
Fig. 562.—*Banksiola selina.*
Fig. 563.—*Oligostomis ocelligera.* (After Lloyd.)
Fig. 564.—*Agrypnia vestita.*
Fig. 565.—*Ptilostomis ocellifera.*
Fig. 566.—*Phryganeid Genus A.*

ing each other on meson to form an arcuate mark, fig. 565 .... **Ptilostomis**, p. 171

Pupae

1. Mandibles short and fleshy, sometimes with a small mesal point but without an apical blade, much shorter than labrum, fig. 567 2

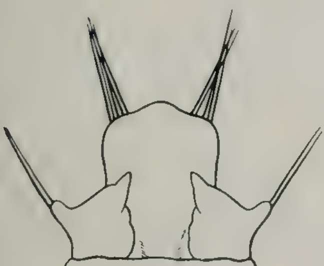
   Mandibles long, with a sclerotized apical blade, figs. 568, 569 5

2. Apical processes of abdomen long and not widely separated, fig. 570 .... **Banksiola**, p. 169

   Apical processes of abdomen short and their apical points very widely separated, fig. 571 3

3. Posterior plate of fifth tergite with 6 teeth forming one row, fig. 574; apical projection of first tergite elongate, membranous and truncate ..... **Phryganeid Genus A**, p. 167

   Posterior plate of fifth tergite with



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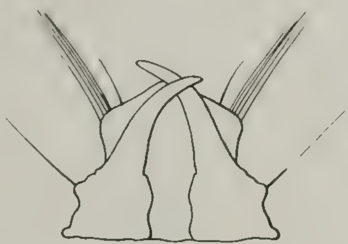

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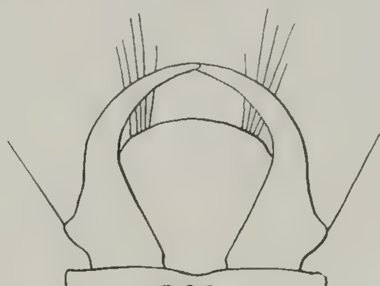

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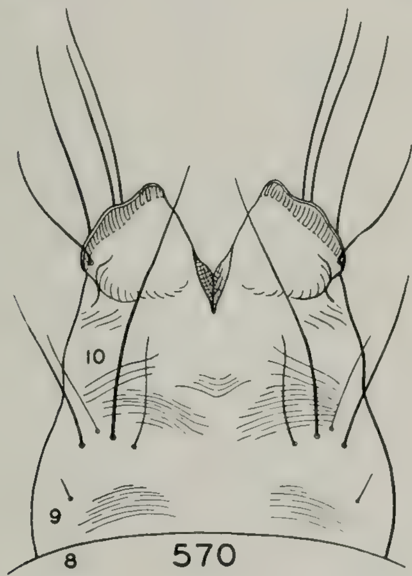

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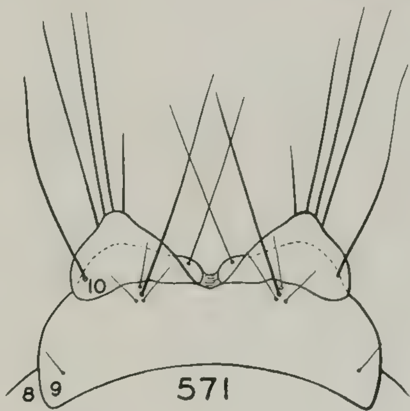

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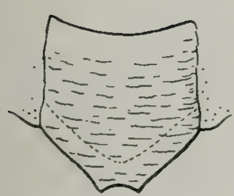

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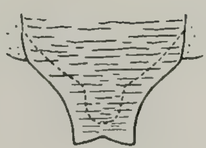

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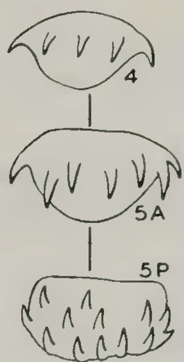

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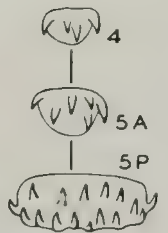

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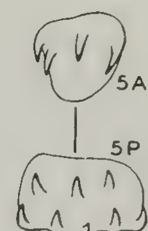

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Fig. 567.—*Banksiola selina* pupa, mandibles and labrum.

Fig. 568.—*Agrypnia vestita* pupa, mandibles and labrum.

Fig. 569.—*Phryganea sayi* pupa, mandibles and labrum.

Fig. 570.—*Banksiola selina* pupa, apex of abdomen.

Fig. 571.—*Phryganeid Genus A* pupa, apex of abdomen.

Fig. 572.—*Ptilostomis ocellifera* pupa, first tergite.

Fig. 573.—*Eubasilissa pardalis* pupa, first tergite. (After Lloyd.)

Fig. 574.—*Phryganeid Genus A* pupa, hook bearing abdominal plates.

Fig. 575.—*Ptilostomis ocellifera* pupa, hook bearing abdominal plates.

Fig. 576.—*Phryganea sayi* pupa, hook bearing abdominal plates.

Fig. 577.—*Agrypnia vestita* pupa, hook bearing abdominal plates.

10–12 teeth forming two rows, fig. 575; apical projection of first tergite bifid, figs. 572, 573 4

4. Apical projection of first tergite only moderately produced, the apex wide, fig. 572 . . . . . . **Ptilostomis,** p. 171
   Apical projection of first tergite forming a long structure with a narrow apex, fig. 573 . . . . . . **Eubasilissa,** p. 168

5. Mandibles greatly curved and sickle shaped, fig. 569; fourth tergite with a normal sized, hook-bearing, sclerotized plate, fig. 576, which nearly equals size of anterior plate on fifth tergite . . . . **Phryganea,** p. 174
   Mandibles only slightly curved, fig. 568; fourth tergite with hook-bearing plate absent or not more than half size of anterior plate on fifth tergite, fig. 577 . . . . **Agrypnia,** p. 165

Adults

1. Maxillary palpi 4-segmented, fig. 64; genitalia with an aedeagus, figs. 580, 594 (males) 2
   Maxillary palpi 5-segmented; genitalia without an aedeagus, figs. 582, 598 (females) 8

2. Ninth sternite produced as a toothed shelf beyond the bases of the claspers, fig. 594 . . . . **Ptilostomis,** p. 171
   Ninth sternite not shelflike, figs. 580, 585 3

3. Claspers produced posterad into a short, slightly upturned point, but rounded and low dorsad, appearing spoon shaped from the side and biscuit shaped from below, figs. 603, 604 . . . . **Phryganea,** p. 174
   Claspers produced dorsad into either a long process or into appendage-like blades, figs. 580, 585 4

4. Tenth tergite forming two long, black, sclerotized rods, fig. 590; ninth sternite with a pair of sharp points, fig. 590. Hind wings banded with black and dark yellow, fig. 588 . . . . **Eubasilissa,** p. 168
   Tenth tergite not rodlike; ninth sternite sometimes with 1 mesal point but not 2. Hind wings not so banded 5

5. Hind wings almost entirely black, fig. 587 . . . . **Oligostomis,** p. 167
   Hind wings with only black spots or markings on a gray or clear ground color 6

6. Ninth tergite forming a transverse, somewhat hood-shaped area arising above base of tenth tergite and bearing a brush or pair of brushes of long setae, figs. 580, 581 . . . . **Agrypnia,** p. 165
   Ninth tergite continuous with outline of tenth tergite and usually not bearing a brush of long setae 7

7. Middle tibiae thorny, the black spines sticking out prominently and about as long as the tibia is thick; wings shiny with a conspicuous pattern of black markings, fig. 591 . . . . **Banksiola,** p. 169

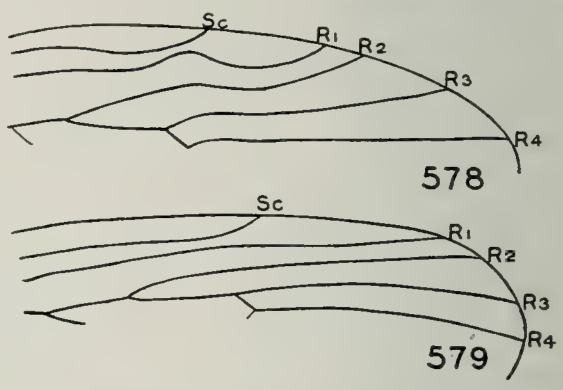


Fig. 578.—*Banksiola selina,* front wing.
Fig. 579.—*Ptilostomis semifasciata,* front wing.

   Middle tibiae not appearing thorny, the black spines not sticking out prominently, shorter than the tibia is thick; wings dull, tawny brown and with only a faint, fine, irrorate pattern . . . . **Fabria,** p. 166

8. Ninth sternite divided at apex into three long processes, which are stout and close together, figs. 589, 605 9
   Ninth sternite either not divided into three points or these very short, figs. 586, 601 10

9. Both wings checkered with black and orange, the hind wings black at base with two bands at apex, fig. 588; ninth sternite with apical processes shorter and converging, fig. 589 . . . . **Eubasilissa,** p. 168
   Neither pair of wings with orange, the hind wings pale at least at base; ninth sternite with apical processes longer and divergent, fig. 605 . . . . **Phryganea,** p. 174

10. Ninth sternite forming an extremely wide, flat, emarginate plate, fig. 584*C* . . . . **Fabria,** p. 166
    Ninth sternite not forming such a plate, figs. 582, 593 11

11. Ninth sternite with a semimembranous apical lobe set off by a constricted neck, fig. 582 . . **Agrypnia,** p. 165
    Ninth sternite not produced into such a lobe, figs. 586, 593 12

12. Ninth sternite almost triangular, tapering evenly to a narrow apex, fig. 586 .... **Oligostomis**, p. 167
    Ninth sternite wide at apex, figs. 593, 601 13
13. R_1 markedly sinuate in both front and hind wings, fig. 578 .... **Banksiola**, p. 169
    R_1 nearly straight in both front and hind wings, fig. 579 .... **Ptilostomis**, p. 171

Agrypnia Curtis

Agrypnia Curtis (1835*a*, p. 540). Genotype, monobasic: *Agrypnia pagetana* Curtis.

Agrypnetes McLachlan (1876, p. ii). Genotype, monobasic: *Agrypnetes crassicornis* McLachlan.

Dasystegia Wallengren (1880, p. 73). Genotype, by subsequent designation of Milne (1934, p. 7): *Phryganea obsoleta* Hagen.

Phryganomyia Banks (1907*a*, p. 122). Genotype, by original designation: *Asynarchus alascensis* Banks.

Prophryganea Martynov (1924, p. 210). Genotype, by original designation: *Prophryganea principalis* Martynov.

Jyrvia Milne (1934, p. 3). Genotype, by original designation: *Neuronia vestita* Walker.

The size, color, wing venation and vestiture all vary through a wide range in this genus, but the curious ninth sternite of the female, fig. 582, and the structure of the male genitalia leave no doubt but that this forms a compact generic unit well differentiated from the rest of the family.

Only two species of the genus have been taken in Illinois. A third occurs in Wisconsin, and the remaining seven or eight occur to the north. Several of these occur through the subarctic regions of Alaska and Canada.

KEY TO SPECIES

1. Wings almost uniformly tawny, at most with a few brownish streaks in the forewing .... **straminea**, p. 165
   Front wings with a definite pattern of brown and gray; hind wings clear with an apical band of dark brown .... **vestita**, p. 166

Agrypnia straminea Hagen

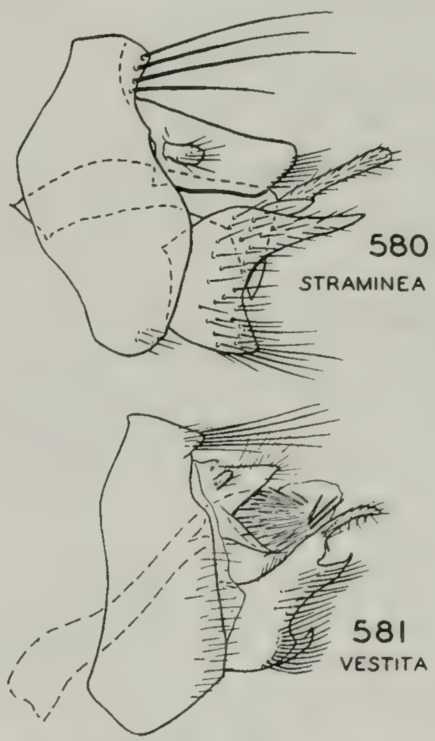
Agrypnia straminea Hagen (1873, p. 425); ♂.

Agrypnetes curvata Banks (1900*a*, p. 252); ♂.

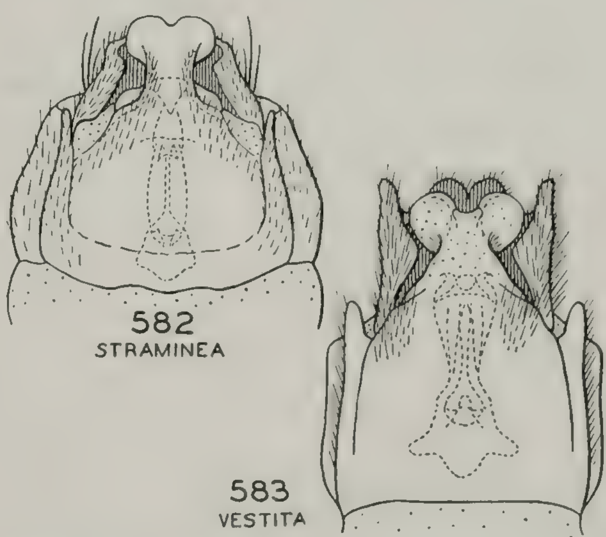
Phryganomyia obscura Banks (1907*a*, p. 122); ♂.

LARVA.—Not reared in Illinois. A specimen determined as this species by Elkins, loaned through the courtesy of Professor C. E. Mickel, University of Minnesota, appears identical with our specimens of *Banksiola selina* (see p. 169).

ADULTS.—Length 14 mm. Head, body and appendages almost uniformly yellowish brown, the front wings with a few slightly darker streaks and with a very fine and faint pattern of irrorations. Legs with only a scattering of short, tawny spines. Male genitalia, fig. 580: ninth segment with a pair of slightly projecting lateral areas, each bearing a brush of long setae; tenth tergite almost hemicylindrical; claspers with a large



Figs. 580–581.—*Agrypnia*, male genitalia.



Figs. 582–583.—*Agrypnia*, female genitalia.

base, tapering dorsally to a narrow apex divided into two sharp points and bearing a bladelike apical segment which extends between and beyond these two points. Female genitalia, fig. 582, with ninth sternite constricted at apex and then expanded into a wide, semimembranous orbicular lobe.

Dr. Betten (1934) has recorded this species in an insect drift along Lake Michigan at Lake Forest, Illinois. This catch was made by Professor Needham on August 12, and constitutes the only known record for the state. The species was reared by Elkins (1936) from Minnesota.

The range of the species is widespread through the northern states and Canada from Alaska to Quebec, with records available for Alaska, Colorado, Illinois, Manitoba, Michigan, Minnesota, Quebec, Saskatchewan and Wisconsin.

Agrypnia vestita (Walker)

Neuronia vestita Walker (1852, p. 10); ♂, ♀.
Neuronia commixta Walker (1852, p. 10); ♂.

Larva.—Fig. 564. Length 25 mm. Head, pronotum and legs yellow; head with a pair of black lines following the boundaries of the frons and with another short, black line on the lateral margin; pronotum with anterior and posterior margins black, without diagonal marks.

Case.—About 45 mm. long, slender and of spiral construction.

Adults.—Length 18–22 mm. Color brown with dense, matted hair on most of the body; front wings variegated brown, the posterior and apical margins with grayish cream-colored areas which form a sinuate pattern when the wings are folded; hind wings clear with an apical dark brown margin. Tibiae with long, pale spines which stand out conspicuously and give the legs a tawny appearance. Male genitalia, fig. 581, similar in general structure to *straminea*, differing chiefly in the long, sharp, mesal projection of the base of the clasper. Female genitalia, fig. 583, with the orbicular lobe of the ninth sternite larger and stouter than in *straminea*.

This species has frequently been placed in *Phryganea* or *Dasystegia*.

In our recent collections we have found this species confined in Illinois to the lakes and marshes of the northeastern corner of the state. We have, however, a single early record (1894) from Havana, near the center of the state. The species was recorded from Lake Forest and Diamond Lake, Illinois, by Betten (1934). We have reared the larvae from the Dead River at Zion, Illinois, where the cases were found in abundance in mats of aquatic smartweed and other plants. Adult records extend from May to mid August and indicate the possibility of more than one generation per year; our own records are confined chiefly to May and June, so that undoubtedly the greatest wave of adult emergence occurs at this time.

The range of the species includes most of the Northeast and East; records are known for the District of Columbia, Georgia, Illinois, Indiana, Massachusetts, New York and Ohio.

Illinois Records.—Algonquin: June 9, 1909, 1 ♂; June 11, 1910, at light, 1 ♀; June 20, 1910, at light, 1 ♀. Chicago: June 17, W. J. Gerhard, 1 ♂, fm. Havana: 1894, 1 ♀. Northern Illinois: 1 ♀; Aug. 13, 1898, 1 ♀. Palos Park: July 4, 1905, W. J. Gerhard, 1 ♀, fm. Pistakee Lake: May 28, 1936, H. H. Ross, 1 ♀. Sand Lake: June 15, 1892, Hart & Shiga, 1 ♀. Willow Springs: June 26, 1910, W. J. Gerhard, 1 ♀, fm. Zion, Dead River: May 28, 1938, Mohr & Burks, 1 ♂, 1 reared pupa and larval parts; May 20, 1940, Mohr & Burks, 9 larvae; June 6, 1940, Mohr & Burks, 2 ♀, 4 pupae, 2 larvae; June 16, 1940, Mohr & Burks, 1 ♂, 1 ♀, 7 larvae (reared).

Fabria Milne

Fabria Milne (1934, p. 9). Genotype, by original designation: *Neuronia inornata* Banks.

This genus is readily distinguished in the female by the extremely broad ninth sternite. The male is distinguished by the combination of drab color and genitalia, as outlined in the key.

One of the two North American species has been taken in Illinois.

Fabria inornata (Banks)

Neuronia inornata Banks (1907*a*, p. 117); ♂.

Larva.—See following genus.

Adults.—Length 20–24 mm. Color light brown, the wings with a very fine reticulation of slightly darker brown marks. Front wings with R_1 very sinuate at apex, hind wings with R_1 also sinuate. Male genitalia, fig. 584: tenth tergite stocky and somewhat hood shaped; claspers with a large, broad basal segment bearing a short, sharp tooth at apex which is nearly as long as the short, sinuate second segment. Female genitalia very wide, the ninth sternite as in fig. 584*C*.

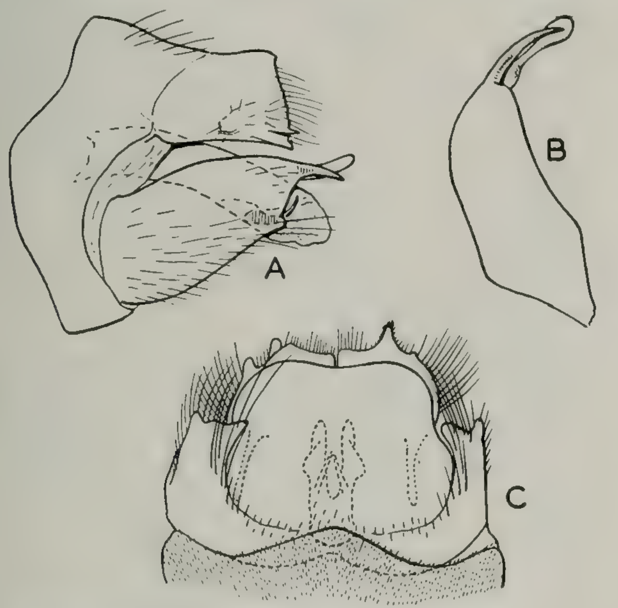


Fig. 584.—*Fabria inornata*, genitalia. *A*, male, lateral aspect; *B*, clasper, caudal aspect; *C*, female, ventral aspect.

In Illinois we have taken this species only at Zion, where adults have been collected at lights beside the Dead River. In this locality we reared all the species of larvae that we found except one, described below as *Genus A*. Similarly, all the Phryganeidae adults which we collected there were reared except one, *Fabria*. There is a very good possibility, therefore, that *Genus A* is the larva of this species. Little is known regarding the range of the species. It was described from Minnesota, and this is only the second state record for it.

Illinois Records.—ZION, Dead River: July 7, 1937, Frison & Ross, 2♀; May 28, 1938, Mohr & Burks, 1♂; June 3, 1938, Mohr & Burks, 2♂; June 4, 1938, Ross & Burks, 2♂, 1♀; June 6, 1940, Mohr & Burks, 5♂.

Phryganeid Genus A

LARVA.—Fig. 566. Length 22 mm. Head, pronotum and legs yellow; head with no mesal line but with two pairs of dark lines, one outside the frons, the other on the lateral margin; pronotum with posterior margin black, and each half with a diagonal black line, the two not meeting posterad on the meson. Meso- and metanotum without any sclerites near the meson and with a dark purple line on each side of the meson.

Of the many phryganeid larvae collected in the Dead River at Zion, Illinois, this species alone was not reared. As explained in the discussion of the preceding species, circumstantial evidence indicates that this might be the larva of *Fabria inornata*. This larva has been taken only in the Dead River, where it was quite common in the smartweed beds (see p. 11). We found that it differed from others inhabiting the same location in being unable to withstand our rearing conditions, which were accompanied, unfortunately, by rather high, unseasonable temperatures.

Illinois Records.—ZION, Dead River: May 18, 1940, Mohr & Burks, 1 larva; May 20, 1940, Mohr & Burks, 2 pupae, many larvae; June 6, 1940, Mohr & Burks, 4 larvae; June 16, 1940, Mohr & Burks, 3 larvae; June 28, 1940, Mohr & Riegel, 2 larvae.

Oligostomis Kolenati

Oligostomis Kolenati (1848, p. 80). Genotype, by subsequent designation of Milne (1934, p. 8): *Phryganea reticulata* Linnaeus.

We have only one species of this genus in North America, *ocelligera*, which has not been taken in Illinois. This species is very striking in coloration, fig. 587, having reticulate black front wings and black hind wings

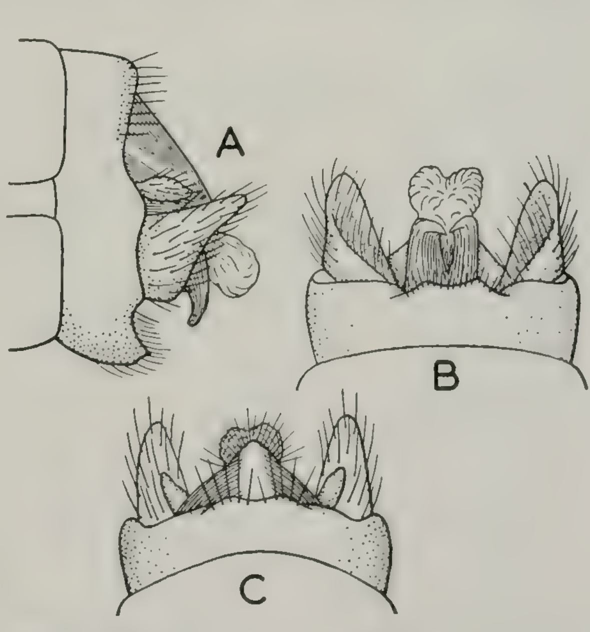


Fig. 585.—*Oligostomis ocelligera*, male genitalia. *A*, lateral aspect; *B*, ventral aspect; *C*, dorsal aspect. (After Betten & Mosely.)

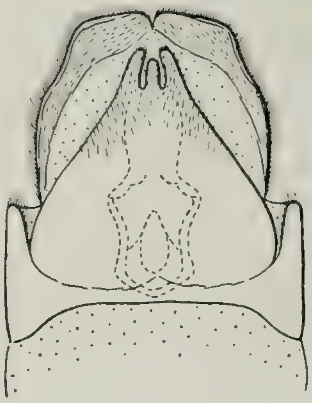


Fig. 586.—*Oligostomis ocelligera*, female genitalia.

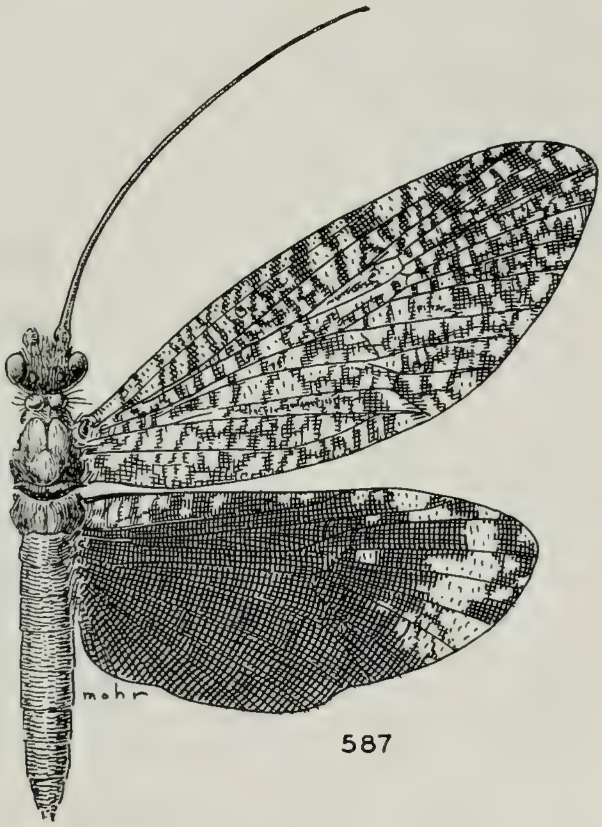


Fig. 587.—*Oligostomis ocelligera* ♂.

with a bandlike group of yellow reticulations near apex. It has been reared by Lloyd (1921, p. 26), who described the larva under the name *Neuronia stygipes*, which is a synonym of *ocelligera*. The genitalia of both sexes are distinctive, figs. 585, 586.

Eubasilissa Martynov

Regina Martynov (1924, p. 215); preoccupied. Genotype, by original designation: *Neuronia regina* McLachlan.
Eubasilissa Martynov (1930, p. 88). New name for *Regina*.

This genus is represented in North America by only the brightly colored *pardalis*,

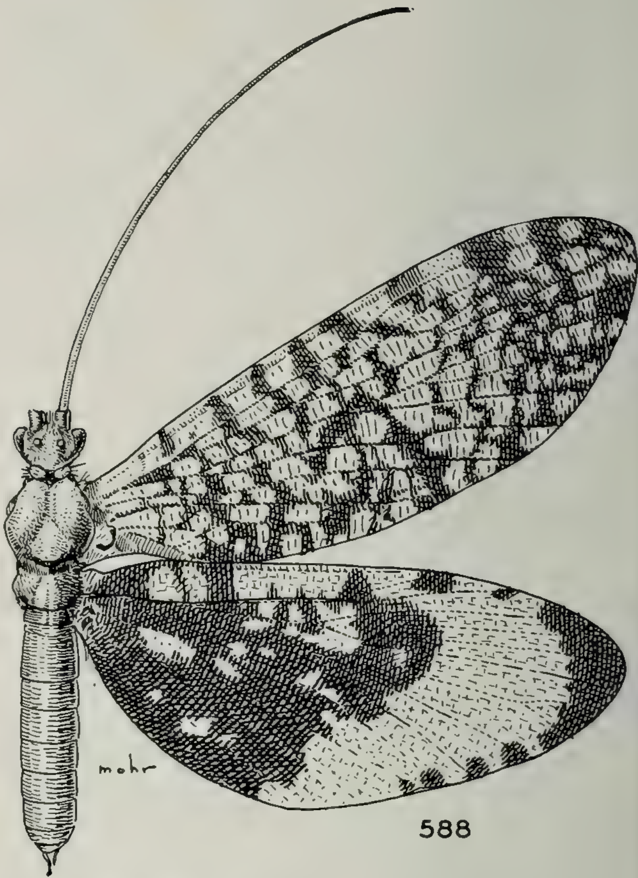


Fig. 588.—*Eubasilissa pardalis* ♀.

which has not been taken in Illinois. This species, fig. 588, is so brightly colored with orange and black that it could be confused with many of the brighter Lepidoptera. The genitalia are distinctive for both sexes, figs. 589, 590. The species is known only from the Northeast, including New Hampshire, New York, Nova Scotia and Quebec. Lloyd (1921, p. 21) has described the immature stages and case under the name *Neuronia pardalis*. This is the most colorful North American caddis fly. In Europe, however,

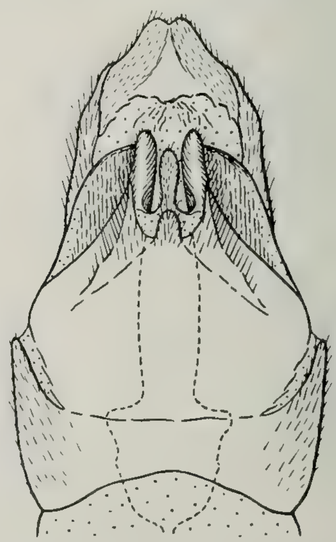


Fig. 589.—*Eubasilissa pardalis*, female genitalia.

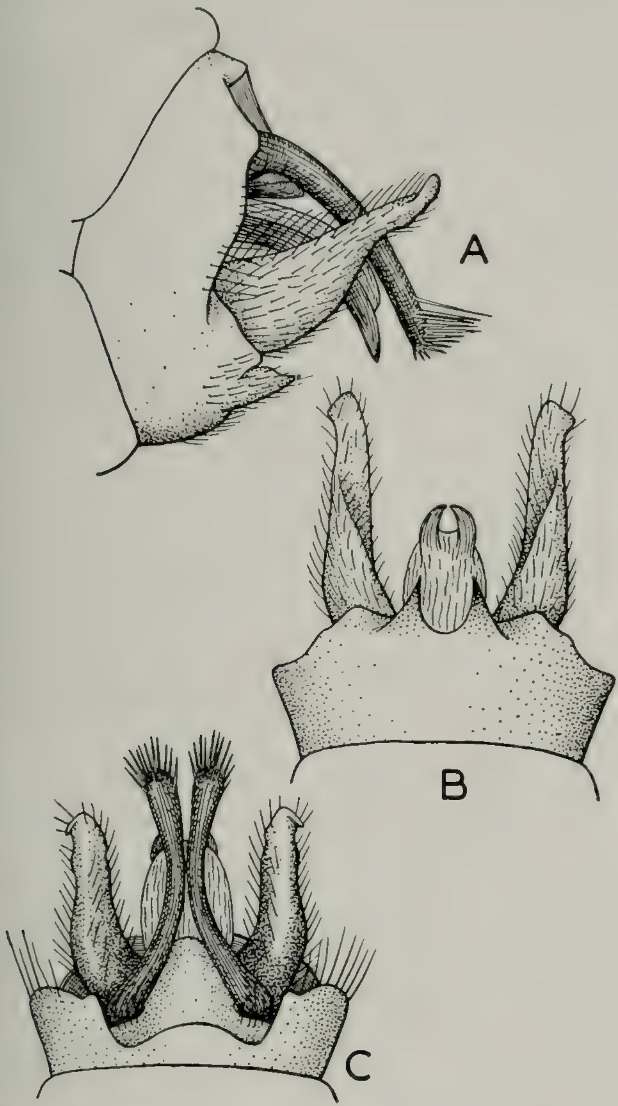


Fig. 590.—*Eubasilissa pardalis*, male genitalia. *A*, lateral aspect; *B*, ventral aspect; *C*, dorsal aspect. (After Betten & Mosely.)

there are several closely related species which are larger and more strikingly colored.

Banksiola Martynov

Banksiola Martynov (1924, p. 216). Genotype, by original designation: *Neuronia concatenata* Walker.

This genus is distinguished by the sinuate apex of R_1 in both wings, the spiny tibiae, the reticulate and spotted wings, and in particular the quadrate brown spots on the otherwise clear hind wings. At the present time five species are recognized in the Nearctic region. One of these, *canadensis*, was placed in *Oligostomis* by Milne (1934); it seems better placed in *Banksiola* on the basis of the venation and spiny legs. The genitalia, however, are extremely aberrent. Unquestionably a review of the world fauna will necessitate changes in some of these generic groupings.

Only one species has been taken in Illinois.

Banksiola selina Betten, new species

LARVA.—Fig. 562. Length 20 mm. Head, pronotum and legs yellow; head with a mesal and two lateral lines, the latter converging toward the back of the head but not actually meeting; pronotum with posterior margin black, and with the disk having a pair of black lines which usually touch on the meson. Mesonotum and metanotum entirely membranous, with irregular purplish blotches.

ADULTS.—Fig. 591. Length of male 12–15 mm.; of female 16–20 mm. Head mostly yellow; ocelli yellow, sometimes greenish yellow, with their bases dark brown, the area between lateral ocelli with some round, dark brown spots each with a stout bristle; posterior warts brown, covered with yellowish bristles; in some specimens the brown color of the head predominant; antennae with alternate dark brown and yellowish bands, the basal part of each segment dark; palpi brownish yellow and covered with darker bristles. Thorax various shades of brown, the bristles yellowish. Legs brownish yellow, the spurs brown, the spines black. Forewings with pale, cream-colored background, covered with a close reticulation of dark brown; larger dark brown spots at base and tip of subcosta, at tips of anals, and often between anal veins; the dark spot at tips of anals and one beyond on Cu_{1a} are generally noticeable in the mid-dorsal line when wings are roofed over abdomen. Hind wings clear at base, a dark brown area on the line of anastomosis and brown reticulations from there out to the wing tip; M_3 and M_4 fused in the males, separate for some distance in the females. Abdomen yellowish brown, darker above; a transverse sclerotized line on sternites 4–7 in the male, 3–6 in the female; a blunt sclerotized tooth projects from meson on the sixth sternite of the female, a smaller tooth appears on the seventh and, rarely, one on the fifth; these are usually absent on the male abdomen.

MALE GENITALIA.—Fig. 592. Ninth segment sclerotized and ringlike, the anterior margin curved and telescoped into the eighth segment, the posterior margin nearly straight and bearing dorsally many long

Fig. 591.—*Banksiola selina* ♀.

bristles. Tenth tergite forming a dorsal roof which narrows from its base and is notched at the posterior margin; on each side near the base is a lateral projection. Aedeagus with a blunt membranous stalk beneath which extends a dark brown, heavily sclerotized flat strap; arising from the base of the aedeagus is a membranous appendage which has on the upper margin of its tip a large number of stout, reddish bristles; this appendage curves down along the side of the aedeagus, generally on the left side. Claspers very heavy, each terminating in a strong dorsal hook and with strong teeth along the posterior margin; seen from below the bases of the claspers meet in a straight line.

Female Genitalia.—Fig. 593. Terminal dorsal segment of abdomen rooflike, not unlike that of the male; near its base is a transverse line of bristles and two bunches of these are located toward the tip. Embedded in the ventral wall of the eighth ventral segment is a dark brown, corneous structure, thin in the middle and with inflated lobes at the sides; at the posterior end of this structure there are two spinose arms and between these a shorter, generally broad and rounded projection also covered with spines. These parts vary greatly.

Holotype, male.—Zion, Illinois, along Dead River: June 3, 1938, Mohr & Burks.

Allotype, female.—Zion, Illinois: larva from Dead River, emerged June 12, 1940, Mohr & Burks.

Paratypes.—Illinois.—Zion: Same data as for holotype, 4♀; July 7, 1937, Frison & Ross, 1♂, 1♀; same data as for allotype, 2♀. Four paratypes are deposited in the collection of Dr. Betten.

Additional specimens have been examined from Illinois, Massachusetts, Michigan, Minnesota, New York and Ontario.

This species has heretofore always been identified as *concatenata.* The type of the latter (described by Betten & Mosely 1940) is a female in which M_3 and M_4 are separate nearly to the line of anastomosis, much farther than is ordinarily the case in *selina*; the genitalia of *concatenata* resemble those of *dossuaria* more than those of *selina.*

The above description was kindly sent to us by Dr. Betten for inclusion in this report.

In Illinois, with the exception of a single male taken at lights in Champaign, all our records are from the extreme northeastern corner. We have found the species breeding abundantly in the Dead River near Zion, and apparently its main range in the state is in the region containing similar marsh

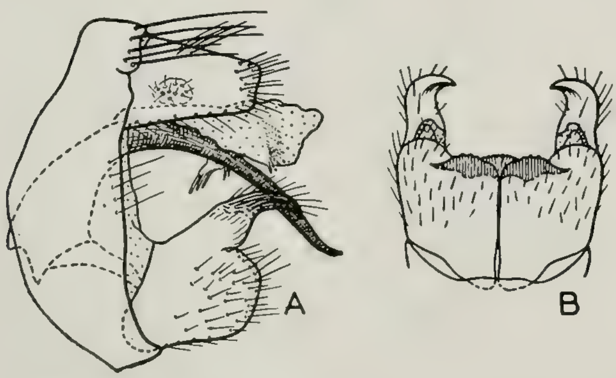


Fig. 592.—*Banksiola selina*, male genitalia. *A*, lateral aspect; *B*, claspers, ventral aspect.

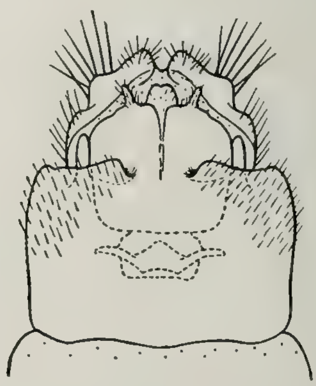


Fig. 593.—*Banksiola selina*, female genitalia, ventral aspect.

areas. There is only a single generation per year, the adults being present in June and early July.

Illinois Records. — ALGONQUIN: June 30, 1906, 1 ♀; May 25, 1908, 1 ♀; July 9, 1909, 1 ♀; July 12, 1910, 1 ♀, all by W. A. Nason. CEDAR LAKE: June 19, 1892, H. S. Shiga, 1 ♀. CHAMPAIGN: at electric light, June 17, 1886, Hart, 1 ♂. ZION: many larvae, pupae and adults (including the type series) taken in or near Dead River from May 15 to July 7.

Ptilostomis Kolenati

Ptilostomis Kolenati (1859*b*, p. 198). Genotype, monobasic: *Ptilostomis kovalevskii* Kolenati.

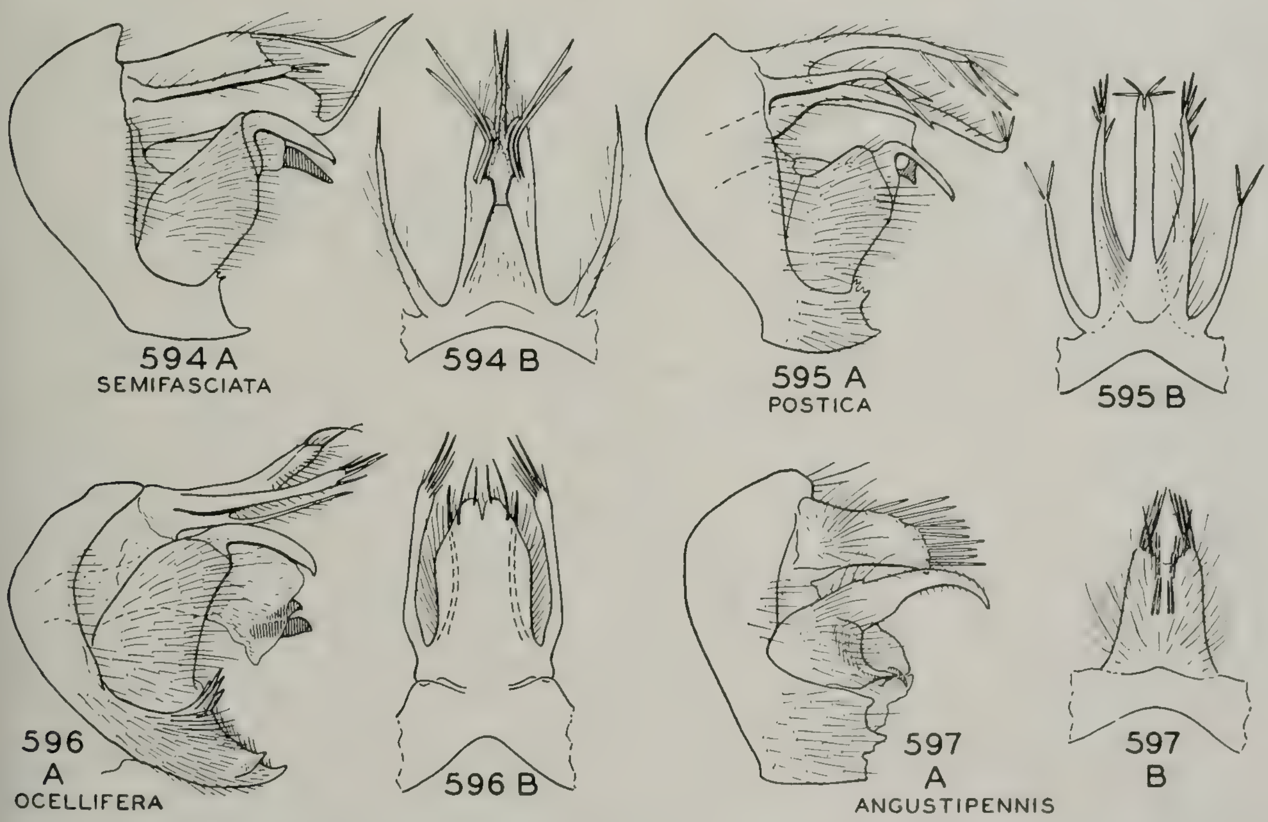
All the species of this genus are brown, frequently with an angulate dark brown mark in the hind wings. The shelflike projection of the male ninth sternite and the broad ninth sternite of the female, with its two lateral finger-like processes and mesal triangular process, are diagnostic. The larvae have no mesal dark line down the frons and have the diagonal marks on the pronotum forming an arcuate mark, fig. 565. To date no characters have been found to separate the larvae to species. They make a long cylindrical case of spiral formation similar to that of other members of the family.

Four species of the genus are recognized, three of which occur in Illinois. The genotype, *kovalevskii*, described from Alaska, has never been identified definitely, and we do not know whether it constitutes a fifth Nearctic species of the genus or whether it is the same as one of the four treated below.

KEY TO SPECIES

Adults

1. Maxillary palpi 4-segmented (males) ... 2
   Maxillary palpi 5-segmented (females) ... 5
2. Apex of tenth tergite with a pair of long, curved, filiform blades, fig. 594 ... **semifasciata,** p. 173
   Apex of tenth tergite at most with long setae, fig. 595 ... 3
3. Base of tenth tergite with two pairs of processes which arise from it, then angle suddenly and run parallel with the segment; the dorsal pair is very long, the lateral pair short, fig. 595 ... **postica,** p. 173
   Base of tenth tergite at most with a lateral pair of processes, figs. 596, 597 ... 4
4. Tenth tergite flat and rectangular, with



Figs. 594–597.—*Ptilostomis*, male genitalia. *A*, lateral aspect; *B*, tenth tergite, dorsal aspect.

a tuft of long setae at apex and long, lateral processes, fig. 596. . . . .**ocellifera**, p. 172

Tenth tergite convex, with a pair of dorsal rows of setae and without lateral processes, fig. 597. . . . .**angustipennis**, p. 174

5. Bursa copulatrix with a high, triangular ventral keel, fig. 598. . . . .**semifasciata**, p. 173

   Bursa copulatrix with a short ventral process which forms a transverse fork or short plate, figs. 599–601. . . 6

6. Ventral process of bursa forming a short fork which is narrow and small, fig. 599. . . . .**postica**, p. 173

   Ventral process of bursa transverse and platelike, its tip emarginate and sometimes forming a very broad V, figs. 600, 601. 7

7. Ventral process of bursa with the anterior face forming a short mesal keel, fig. 600. . . .**angustipennis**, p. 174

   Ventral process of bursa with the anterior face slightly carinate at each lateral margin where it joins with base, fig. 601, but without a mesal keel. . . . .**ocellifera**, p. 172

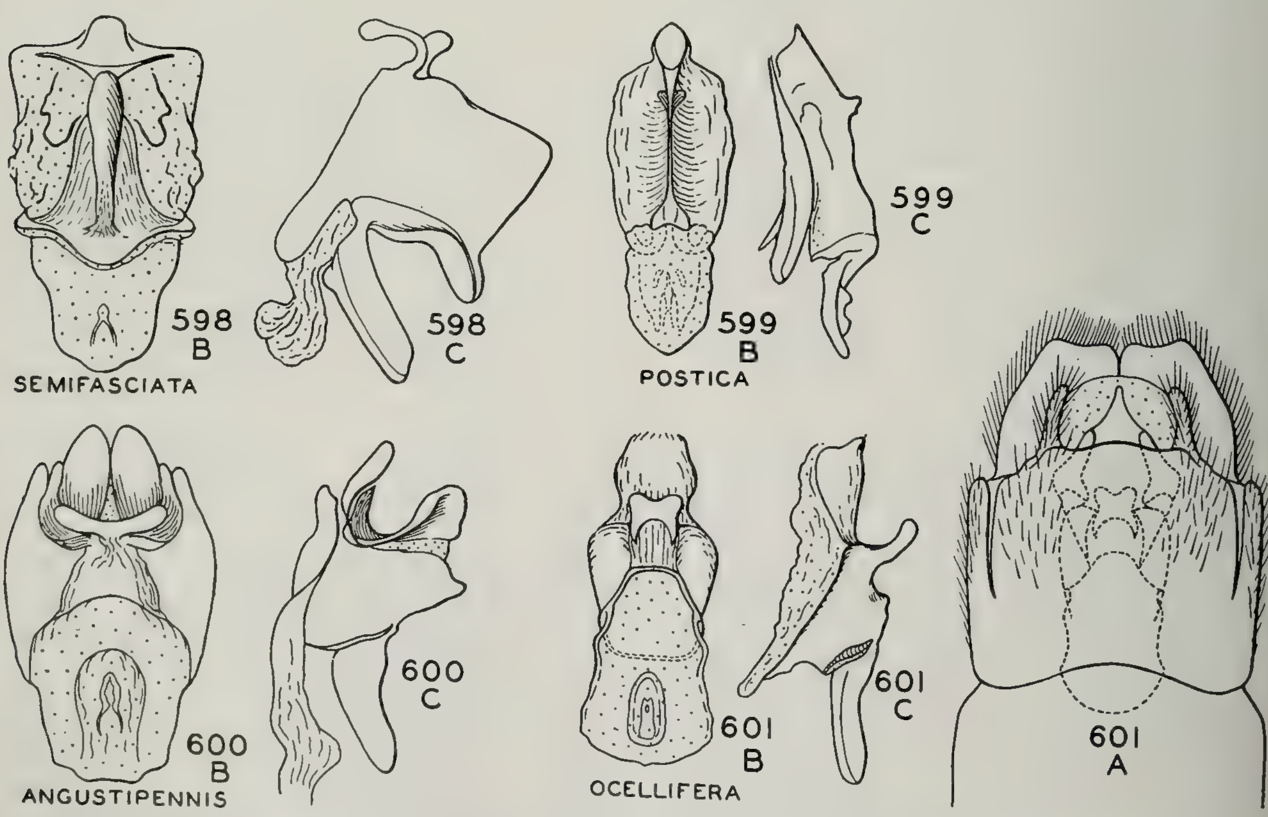
Ptilostomis ocellifera (Walker)

Neuronia ocellifera Walker (1852, p. 8); ♂. *Neuronia simulans* Betten & Mosely (1940, p. 107); ♀. New synonymy.

LARVA.—Length 27 mm. Head, pronotum and legs yellow; head with two pairs of black lines, one on each side of the frons and one on the lateral margin; pronotum with posterior margin black and with an arcuate dark brown line starting at each antero-lateral corner and running to about the middle of the mesal margin.

CASE.—Very long, usually about 50 mm.

ADULTS.—Length 21–24 mm. Color yellowish brown, the front wings minutely speckled with darker brown, hind wings sometimes with a V-shaped dark brown mark which is small or even completely absent in some specimens. Male genitalia, fig. 596: tenth tergite long and somewhat rectangular with a pair of long, stout lateral arms arising from base, and a pair of spiny processes arising from ventral margin near middle; the apex of the tergite bears a pair of long, curved setae; ninth sternite produced beneath and beyond base of claspers, the apex of the ventral margin forming two stout teeth, the dorsal margin with a row of irregular teeth. Female genitalia, fig. 601: bursa copulatrix with a relatively short body bearing a ventral transverse projection which extends platelike at right angles to the surface and is usually emarginate at apex; this projection is anchored at its base with a short carinate brace at each lateral



Figs. 598–601.—*Ptilostomis*, female genitalia. *A*, ventral aspect; *B* and *C*, bursa copulatrix, ventral and lateral aspects.

margin; posterior to this projection is a fairly wide and long, heavily sclerotized piece.

This species has been collected at scattered points in the central and northern portions of Illinois. At Oakwood we reared it from larvae collected in the back waters of a small stream. At other localities we have taken unreared larvae of this genus in similar situations. Our adult records extend from April to late June, indicating that we may have only a single early summer emergence of adults in Illinois. In more northern states, the species emerges later.

This species is widespread through the Northeast; records are known from Illinois, Indiana, Michigan, New Jersey, New York, Nova Scotia, Ohio, Ontario, Pennsylvania, Quebec and Wisconsin.

Illinois Records. — Algonquin: June 17, 1907, W. A. Nason, 1 ♀; June 16, 1908, 1 ♀; June 29, 1909, at light, Nason, 2 ♂; June 20, 1910, at light, Nason, 3 ♂. Chicago: June 28, 1908, 1 ♀; June 4, W. J. Gerhard, 1 ♂, 1 ♀, FM. Harvard: Chas. Faust, 1 ♂. Havana: Chas. Faust, 1 ♂. Northern Illinois: 1 ♂; May, Peabody Collection, 1 ♂. Oakwood: April 10, 1936, Ross & Mohr, 1 ♀, 2 larvae, 1 larva (reared); May 27, 1936, Ross & Mohr, 2 ♂, 5 ♀; June 1, 1936, Ross & Mohr, 1 ♀; June 13, 1936, Ross & Mohr, 1 ♀. Palos Park: June 20, 1908, W. J. Gerhard, 1 ♂, FM. Urbana: June 12, 1886, Hart, 1 ♂.

Ptilostomis semifasciata (Say)

Phryganea semifasciata Say (1828, pl. 44).
Neuronia fusca Walker (1852, p. 9); ♂.
Neuronia dubitans Betten & Mosely (1940, p. 105); ♀. New synonymy.

Adults.—In size and color similar to the preceding species. Male genitalia, fig. 594: tenth tergite, very complex, having a pair of long, widely separated dorso-lateral appendages arising from extreme base, a pair of setal tufts arising from central portion, and with the lateral margins modified at apex into a pair of sclerotized plates which end in a long, narrow upturned blade; ninth segment with apex of shelflike portion bearing four teeth on the emarginate ventral margin and an irregular group of teeth on the dorsal margin. Female genitalia, fig. 598, with bursa copulatrix bearing a large, long keel on the venter, this keel being the most prominent part of the entire structure.

Neotype, male. — Momence, Illinois: June 4, 1932, Frison & Mohr.

The traditional identification of this species has been quite uniform for many years, and in order to avoid any ambiguity I have selected the above neotype since Say's type is lost.

This species, like the preceding, has been taken at scattered localities in the northern half of Illinois. Our adult records are entirely from June and July, indicating a single adult brood. Specimens have been taken in the proximity of both lakes and streams, with a preponderance of records from localities near streams.

The range of the species is apparently widespread through the Northeast; records are available from Illinois, Kentucky, Ohio, Quebec, South Dakota and Wisconsin.

Illinois Records. — Algonquin: June 10, 1905, W. A. Nason, 1 ♂; June 13, 1905, W. A. Nason, 1 ♂; July 10, 1905, W. A. Nason, 1 ♂; July 13, 1905, W. A. Nason, 1 ♂; June 13, 1910, W. A. Nason, 1 ♀; June 20, 1910, at light, W. A. Nason, 1 ♂. Channel Lake: June 15, 1928, T. H. Frison, 1 ♀. Charleston: June 11, 1931, at light, H. H. Ross, 1 ♀. Elgin, Botanical Gardens: June 6, 1939, Burks & Riegel, 1 ♀. Fithian: June 18, 1919, at light, 1 ♀. Homer: June 30, 1927, at light, Frison & Glasgow, 1 ♀. Momence: June 4, 1932, Frison & Mohr, 1 ♂, 1 ♀; 3 miles east, June 22, 1938, Ross & Burks, 1 ♀. Oregon: June, 1930, Sauer, 1 ♀. Palos Park: July 2, 1910, W. J. Gerhard, 1 ♀, FM. Richmond: June 4, 1938, Ross & Burks, 1 ♂. St. Joseph: July 30, 1929, T. H. Frison, 1 ♂. Urbana: July 18, 1885, 1 ♀. Wadsworth, Des Plaines River: July 7, 1937, Frison & Ross, 1 ♀.

Ptilostomis postica (Walker)

Neuronia postica Walker (1852, p. 9); ♀.

Adults.—Length 19–20 mm. Color as in *ocellifera*. Male genitalia, fig. 595: tenth tergite with central portion long and styliform, with two pairs of processes which arise from it, then angle suddenly and run parallel with the segment; the dorsal pair is very long, the lateral pair short; apical shelflike projection of ninth sternite with a pair of ventral, low teeth and an arcuate row of smaller, irregular teeth. Female genitalia, fig. 599, with bursa copulatrix having a long, ventral blade which bears near its middle a short fork which is narrow and small.

The male of this species was described by Betten & Mosely (1940, p. 108) as the male of their new species *simulans* (the female type of *simulans* is *ocellifera*).

In Illinois we have only three scattered collections for this species, all of them along fairly large rivers, including the Kankakee, Rock and Kaskaskia. Our few records extend from May until late September.

The range of the species is poorly known but apparently is extensive through much of the Northeast; records include Georgia, Illinois, Michigan, New Jersey and New York.

Illinois Records.—Momence: June 4, 1932, Frison & Mohr, 1 ♂. New Memphis, Kaskaskia River: Sept. 25, 1939, Frison & Ross, 2 ♀. Olive Branch: Oct. 4, 1909, W. J. Gerhard, 1 ♀, fm. Oregon: May, 1929, Sauer, 1 ♀.

Ptilostomis angustipennis (Hagen)

Neuronia angustipennis Hagen (1873, p. 400); ♂, ♀.

This species has not yet been taken in the state but may be found with subsequent collecting. We have records from Massachusetts, Michigan and New Jersey.

Phryganea Linnaeus

Phryganea Linnaeus (1758, p. 547). Genotype, by subsequent designation of Westwood (1840, p. 49): *Phryganea grandis* Linnaeus.

The adults of this genus are all large, with a conspicuous pattern of brown and gray, most noticeable in repose, fig. 602. The female ninth sternite, fig. 605, and the short, biscuit-shaped claspers of the male, fig. 603, are diagnostic for the genus.

Only three species are recognized in North America, and two of these have been taken in Illinois. Larvae of these two species have been reared, but no characters have yet been found to distinguish them.

KEY TO SPECIES

1. Hind wings with basal two-thirds smoky, apical third dark brown or blackish gray.............**sayi,** p. 176

   Hind wings uniformly gray or brownish, marked at apex only with a few slightly darker darts along the veins,

Fig. 602.—*Phryganea cinerea* ♂. This species may attain a length of nearly an inch. Its mottled pattern mimics the dead rushes on which it rests.

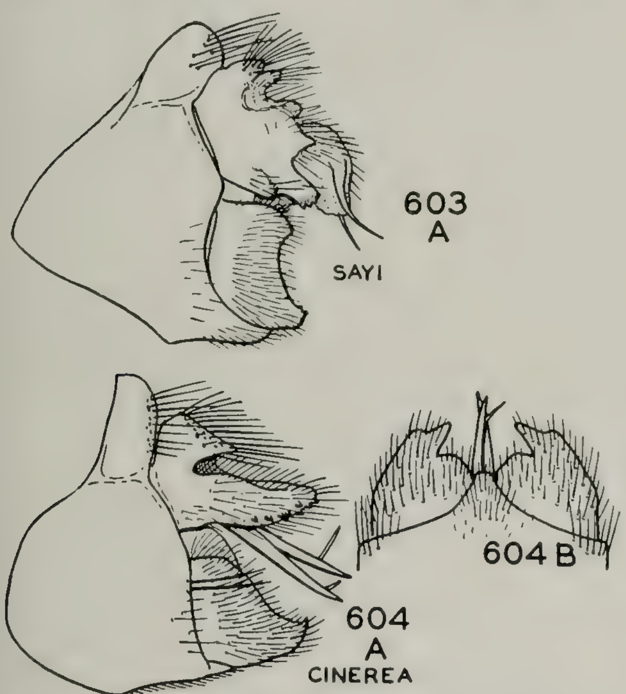
but with no suggestion of an apical band.................. **cinerea**, p. 175

Phryganea cinerea Walker

Phryganea cinerea Walker (1852, p. 4); ♂, ♀.

Larva.—Fig. 561. Length 35 mm. Head, pronotum and legs yellow; head with a mesal dark line down the frons, a pair of oblique dark lines, one on each side of the frons; and a second pair of dark lines, one along each lateral margin of the head. Pronotum with anterior and posterior margins black, the two lines frequently meeting on meson.

Case.—Very long, usually 65–70 mm., and of the usual spiral type of construction.



Figs. 603–604.—*Phryganea*, male genitalia. *A*, lateral aspect; *B*, claspers, ventral aspect.

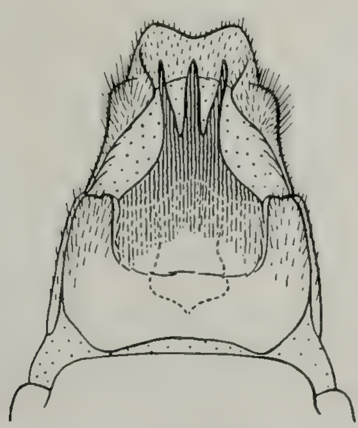


Fig. 605.—*Phryganea cinerea*, female genitalia.

Adults.—Length 21–25 mm. Color predominantly gray or brown, the front wings with an irregular pattern of various shades of brown with light gray patches along the posterior margin, these forming triangular marks when the wings are folded; hind wings uniformly gray, with a few slightly darker darts along the extreme tips of the veins. Male genitalia, fig. 604: tenth tergite divided into a pair of cercus-like organs with a short but broad dorsal spur and a group of stout, black spines at apex; claspers short, somewhat spoon shaped as seen from lateral view, rounded and biscuit shaped as seen from ventral view. Female genitalia, fig. 605, characterized by the tridentate apex.

In Illinois we have taken this species only in the northeastern part of the state where it is apparently confined to glacial lakes and marshes. We reared the species from the Dead River at Zion, where the larvae were taken in aquatic smartweed beds in company with *sayi* (see p. 11). Our adult records are chiefly from June and July, indicating a heavy early summer emergence with stragglers beyond that time.

The adults are crepuscular, flying chiefly in the first hours after dark. During the day they rest on rushes and sedges around lakes or marshes. When at rest, with wings folded, they blend into their surroundings.

The species is widely distributed through the northern states and Canada, extending as far west as the Rocky Mountains; our Illinois records represent apparently the most southern points at which the species has been taken. Records are available for Alberta, Colorado, Illinois, Maine, Manitoba, Massachusetts, Michigan, Minnesota, Montana, New York, Ontario, Saskatchewan, South Dakota, Wisconsin and Wyoming.

Illinois Records.—Antioch: July 1, 1931, Frison, Betten & Ross, 1♂, 1♀. Channel Lake: Aug. 13, 1906, 1♂. Chicago: Wescott, 1♂. Fox Lake: July 1, 1931, Frison, Betten & Ross, 1♂; June 30, 1935, DeLong & Ross, 3♂. Grass Lake: July 1, 1926, Frison & Hayes, 1♂, 1♀. Northern Illinois: July 28, 1898, 1♀. Zion, Dead River: July 7, 1937, Frison & Ross, 4♂, 1♀; June 12, 1940, Mohr & Burks, 1♀ (reared); June 28, 1940, Mohr & Riegel, 3♂, 2♀; June 16, 1940, Mohr & Burks, 4♂, 3♀, 1♂ (reared); July 1, 1940, Mohr & Burks, 1♀.

Phryganea sayi Milne

Phryganea interrupta Say (1828, pl. 44); preoccupied.

Phryganea sayi Milne (1931, p. 228). New name.

LARVA AND CASE.—Indistinguishable from those of *cinerea.*

ADULTS.—Length 20–25 mm. In color similar to *cinerea,* differing chiefly in the hind wings, which are grayish yellow with the apical third dark brown and forming a distinct band. Male genitalia, fig. 603, with the tenth tergite much broader and shorter than in *cinerea.* Female genitalia very similar to those of *cinerea* in regard to both external and internal parts.

We have scattered records of this species from the northern half of Illinois. Larvae were collected and reared from the Dead River at Zion, in company with those of *cinerea.* Our adult records extend from June 6 to August 27. Indications are that this species has a longer adult life than many caddis fly species. The larva illustrated for this species by Lloyd (1921) is apparently a misidentification; his larva, described under the old name *interrupta,* has diagonal marks on the pronotum, whereas Vorhies (1909) found (and we did, also) that the marks followed the margin as in *cinerea.* I do not know what species Lloyd actually had.

The range of the species is apparently confined principally to the Northeast. Records are available from the District of Columbia, Illinois, Massachusetts, Michigan, Missouri, New Jersey, New York, Pennsylvania and Wisconsin.

Illinois Records.—ALGONQUIN: Aug. 27, 1908, 1 ♀. HAVANA: June 12, 1894, C. A. Hart, 1 ♂; June 14, 1894, C. A. Hart, 1 ♀; June 23, 1894, C. A. Hart, 1 ♂. OAKWOOD, Salt Fork River: July 18, 1933, Ross & Mohr, 1 ♀. SPRINGFIELD: July 2, 1885, at light, C. A. Hart, 1 ♀. URBANA: Aug. 2, 1886, at light, C. A. Hart, 1 ♀; Aug. 18, 1886, at light, C. A. Hart, 1 ♀; Aug. 23, 1886, at light, C. A. Hart, 1 ♂; Aug. 22, 1938, G. T. Riegel, light trap, 1 ♀. ZION, Dead River: June 6, 1940, Mohr & Burks, 1 ♂, 1 ♀; June 12, 1940, Mohr & Burks, 1 ♂ (reared); June 16, 1940, Mohr & Burks, 1 ♂ (reared), 1 ♀ (reared), 2 ♂, 2 ♀; June 28, 1940, Mohr & Burks, 1 ♂; July 1, 1940, Mohr & Burks, 1 ♀; July 15, 1940, Mohr & Burks, 1 ♂.

LIMNEPHILIDAE

This is one of the largest families of caddis flies in North America, represented by over 20 genera and nearly 200 species. It is characterized by having the maxillary palpi of the male three segmented, by distinct ocelli in both sexes, and other structural characters as outlined in the key. The larvae are quite variable in many characters, but in all of them the antennae are situated midway between the eye and the base of the mandible. All species are case makers, many of which are illustrated by Lloyd (1921).

Discovery of its larva shows that the genus *Neothremma,* previously placed in the Sericostomatidae, belongs definitely in the Limnephilidae. The genus *Farula* also was placed in the Sericostomatidae, but since it possesses distinct ocelli, I am removing it tentatively to the Limnephilidae.

Most of the genera and species of the Limnephilidae are western or northern in distribution, and Illinois occurs on the southern fringe of the main range of the family. Only a small proportion of the species have been taken in Illinois, and many of these are rare or locally distributed.

In many cases the genera are only imperfectly defined, and we are awaiting information on females or larvae, which are as yet unknown for many genera and species.

KEY TO GENERA

Larvae

1. Anterior margin of mesonotum with a mesal, rectangular emargination, fig. 606; at this point it is connected to pronotum by a short, sclerotized strap; head with malar space nearly twice height of head above eye, fig. 609................**Neophylax,** p. 202

   Anterior margin of mesonotum evenly rounded and not emarginate, fig. 607; head with malar space no longer than height of head above eye, fig. 610......................... 2

2. Front femora slender, the apical margin short, fig. 611; pronotum slightly incised along anterior margin; always with sclerotized portions of head and body black or nearly so.. ....**Dicosmoecus,** p. 181

   Front femora somewhat chelicerate, widened, with the apical margin very oblique and nearly as long as the lower margin, fig. 612........ 3

3. Gills arising singly, fig. 613 4
   Gills arising in groups of two or more 5
4. Seventh abdominal tergite with an antero-mesal gill; postero-lateral corner of mesonotum with a linear black mark ...... **Astenophylax**, p. 183
   Seventh abdominal tergite with no antero-mesal gill; postero-lateral corner of mesonotum with either a spot or no black mark, as in fig. 20 .... **Pycnopsyche**, p. 193
5. Pronotum with dense, short black spines, especially anterior margin, fig. 608; legs banded with red and black, fig. 612 ... **Glyphopsyche**, p. 200
   Pronotum without dense black spines, clothed primarily with long setae, fig. 607; legs not so banded 6
6. Anal legs with a group of about 10 setae on the bulbous ventral portion .... **Frenesia**, p. 199
   Anal legs with no setae on bulbous ventral portion 7
7. Dorsal gills of first few abdominal segments with 6–12 branches forming a fanshaped spread, figs. 615, 616 8

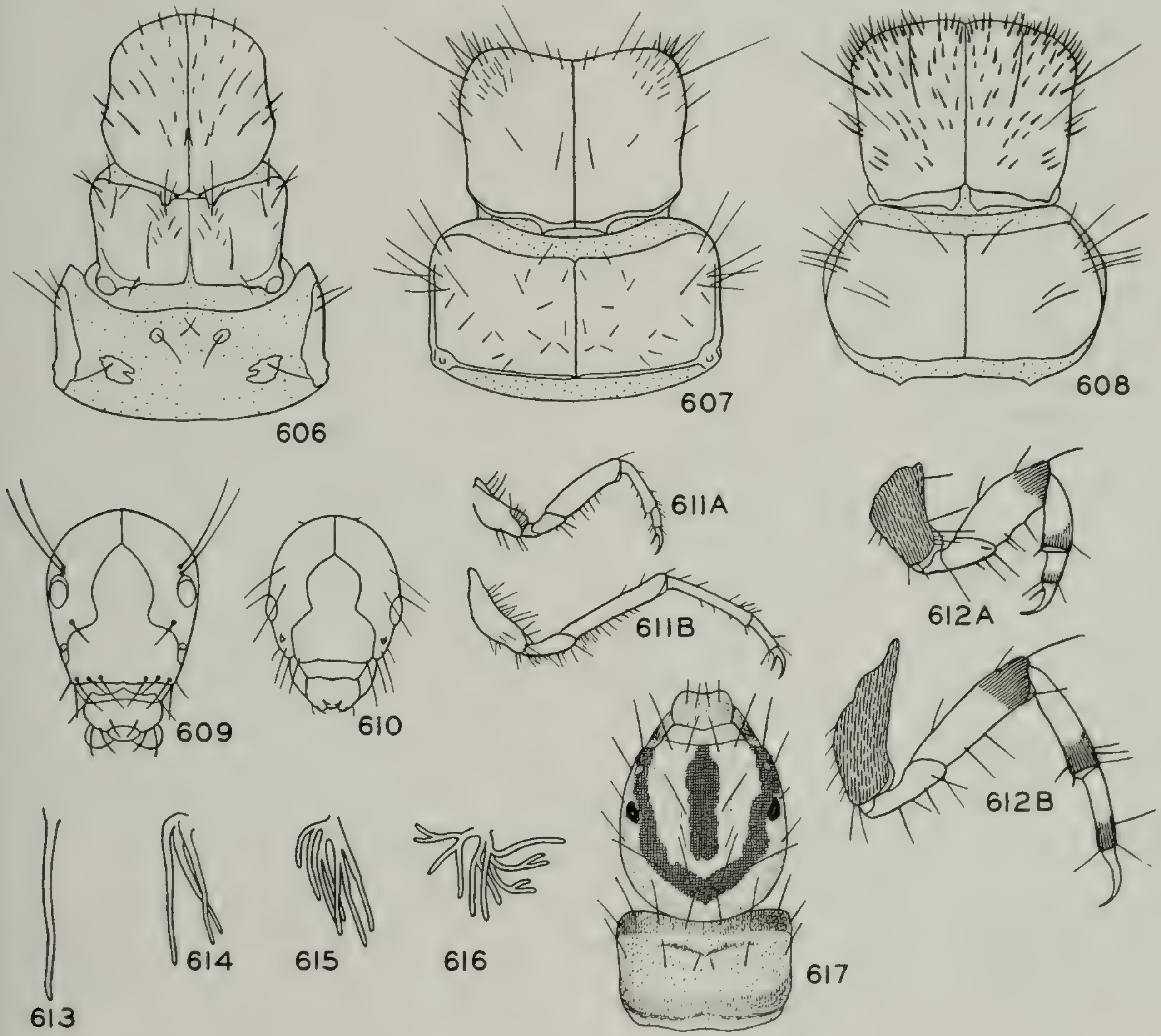


Fig. 606.—*Neophylax autumnus* larva, thorax.
Fig. 607.—*Frenesia missa* larva, thorax.
Fig. 608.—*Glyphopsyche missouri* larva, thorax.
Fig. 609.—*Neophylax autumnus* larva, head.
Fig. 610.—*Frenesia missa* larva, head.
Fig. 611.—*Dicosmoecus* sp. larva, legs. *A*, front leg; *B*, hind leg.
Fig. 612.—*Glyphopsyche missouri* larva, legs. *A*, front leg; *B*, hind leg.
Fig. 613.—*Pycnopsyche subfasciata* larva, abdominal gill.
Fig. 614.—*Limnephilus submonilifer* larva, abdominal gill.
Fig. 615.—*Hesperophylax designatus* larva, abdominal gill.
Fig. 616.—*Caborius* sp. larva, abdominal gill.
Fig. 617.—*Glyphotaelius* sp. larva, head and pronotum.

Dorsal gills of first few abdominal segments with 2 or 3 branches at the most, not spreading fanlike, fig. 614 9

8. Dorsal gills at base of abdomen with about 12 branches each, fig. 616. . . . . **Caborius**, p. 196

Dorsal gills at base of abdomen with about 6 branches each, fig. 615. **Hesperophylax**, p. 183

9. Head with a narrow, dark line along meson of frons and with a dark, U-shaped line running through eyes and above frons, fig. 617. . . . . **Glyphotaelius**, p. 183

Head either with wider dark areas, fig. 648, or without indication of dark lines, fig. 646. 10

10. Prosternal horn short, not projecting beyond apexes of front coxae. . . . . **Limnephilus**, p. 185

Prosternal horn projecting distinctly beyond apexes of front coxae. **Platycentropus**, p. 181

Pupae

1. Dorsal plates *5P* transverse, narrow and with two rows of about 24 teeth each, fig. 618. . . . . . . **Neophylax**, p. 202

Dorsal plates *5P* much more ovate or nearer square, fig. 620, with rows of not more than 12 teeth each, fig. 619 2

2. Dorsal abdominal gills arising in groups of 5 or 6 or threadlike, usually crushed into a small, shapeless bundle. . . . . **Hesperophylax**, p. 183; probably **Caborius** also, p. 196

Dorsal abdominal gills finger-like and distinct, figs. 622, 623, never with more than 3 or 4 gills in a group. . . 3

3. Dorsal abdominal gills stout, very long, and arising singly. 4

Dorsal abdominal gills more slender, arising in bunches of two or more. . 5

4. Dorsal plates *5P*, 6 and 7 with about 17, 5 and 4 teeth, respectively, fig. 619. . . . . **Astenophylax**, p. 183

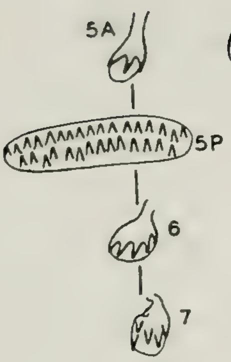
Dorsal plates *5P*, 6 and 7 with about 7 and 2 teeth and 1 tooth, respectively, fig. 621. . . . **Pycnopsyche**, p. 193

5. Second antennal segment with a tuft of long, black hair, fig. 624. . . . . **Dicosmoecus**, p. 181

Second antennal segment with at most a tuft of very short setae, fig. 625. . 6

6. Postero-dorsal gills of second abdominal segment and antero-dorsal gills of third segment with some filaments reaching fifth segment and a few others nearly as long, fig. 622. **Platycentropus**, p. 181

Postero-dorsal gills of second abdominal segment and antero-dorsal gills of third never reaching more than a short distance on fourth segment, fig. 623. . . . . . **Limnephilus**, p. 185; **Glyphopsyche**, p. 200; **Frenesia**, p. 199



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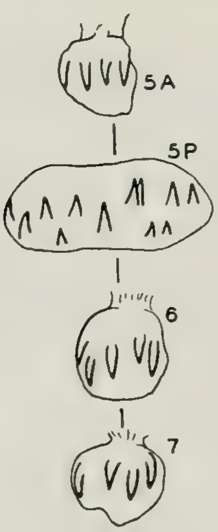

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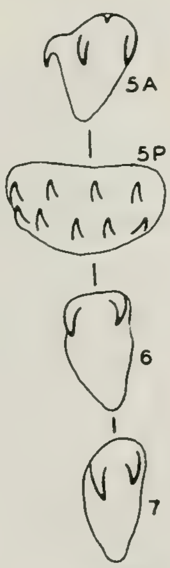

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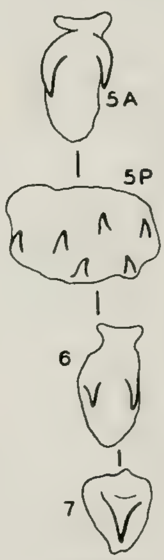

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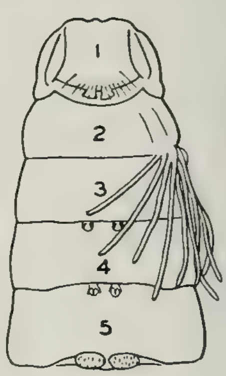

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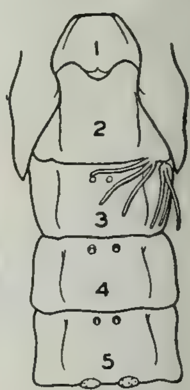

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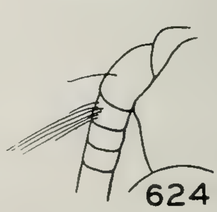
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Fig. 618.—*Neophylax autumnus* pupa, hook-bearing plates.

Fig. 619.—*Astenophylax argus* pupa, hook-bearing plates.

Fig. 620.—*Limnephilus submonilifer* pupa, hook-bearing plates.

Fig. 621.—*Pycnopsyche subfasciata* pupa, hook-bearing plates.

Fig. 622.—*Platycentropus radiatus* pupa, portion of abdomen.

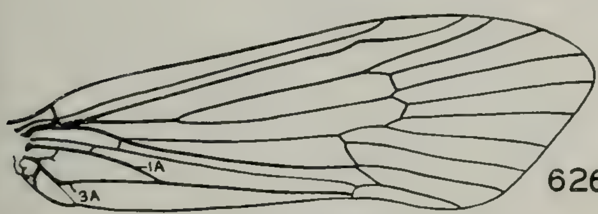
Fig. 623.—*Glyphopsyche missouri* pupa, portion of abdomen.

Fig. 624.—*Dicosmoecus* sp. pupa, base of antenna.

Fig. 625.—*Platycentropus radiatus* pupa, base of antenna.

Adults

1. Front wings with apical abscissa of vein 2*A* atrophied, fig. 626 .... **Platycentropus**, p. 181
   Front wings with vein 2*A* complete, fig. 628 2
2. Front wings with Sc ending in a short, straight, oblique crossvein, fig. 627 .... **Radema**, p. 181
   Front wings with Sc not ending in an oblique crossvein, figs. 628, 629... 3
3. Hind wings with M_{1+2} undivided, fig. 637; head with a small pair of warts between lateral ocelli and posterior warts.............. **Neophylax**, p. 202
   Hind wings with M_{1+2} divided into M_1 and M_2, fig. 638; head without warts between lateral ocelli and posterior warts.............. 4
4. Apex of front wings scalloped and posterior corner sharp, fig. 628.... .... **Glyphotaelius**, p. 183



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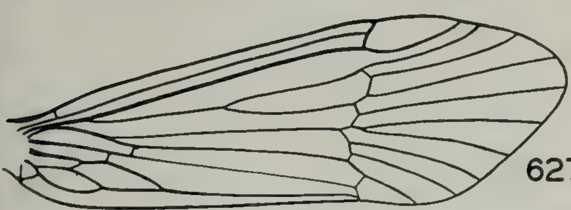
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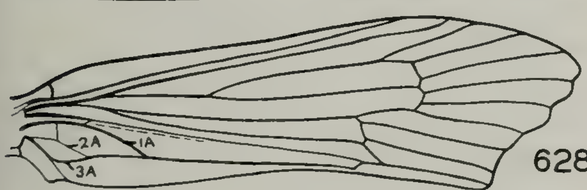

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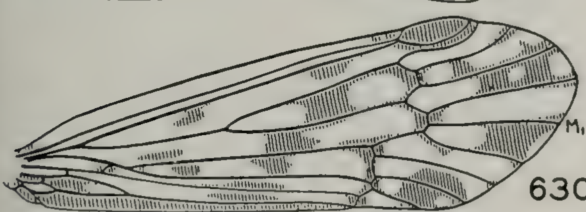

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Limnephilidae Front Wings

Fig. 626.—*Platycentropus radiatus.*
Fig. 627.—*Radema stigmatella.*
Fig. 628.—*Glyphotaelius hostilis.*
Fig. 629.—*Phanocelia canadensis.*
Fig. 630.—*Chilostigma areolatum.*

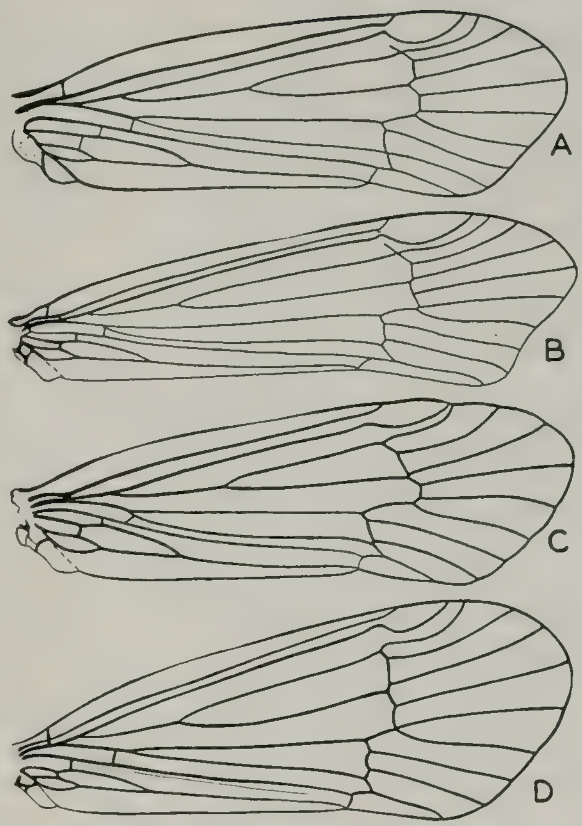


Fig. 631.—Limnephilidae front wings. *A*, *Glyphopsyche missouri*; *B*, *Glyphopsyche irrorata*; *C*, *Grensia praeteritum*; *D*, *Frenesia missa.*

   Apex of front wings either evenly rounded or incised without scalloped condition, figs. 629, 631*B*......... 5
5. Dorsum of head and pronotum greatly lengthened, with a deep, narrow groove running their entire length, fig. 644........... **Leptophylax**, p. 184
   Dorsum of either head or pronotum, or both, much shorter, and head without mesal groove............ 6
6. Front wings with fork of M_{1+2} considerably beyond crossvein *r-m*, fig. 629............... **Phanocelia**, p. 201
   Front wings with fork of M_{1+2} at or near crossvein *r-m*, fig. 630........ 7
7. Dorsum of head bright yellow, highly polished and with only a few short, black setae...... **Astenophylax**, p. 183
   Dorsum of head either dark, dull or with long or abundant setae...... 8
8. Vertex and anal portion of front wings covered with close, appressed, silky hair........... **Hesperophylax**, p. 183
   Vertex without close, appressed hair 9
9. Front wings with a short, rounded stigma (bordered below by R_1) and with R_2 also curved parallel with it or even more curved, figs. 630, 631; never with a longitudinal silvery line........................... 10
   Front wings either with a longitudinal silvery line, fig. 633, or with stigma

longer if well marked, and with R_2 less sharply curved or straight, figs. 633, 636 14

10. Wings transparent, colorless and glassy with definite solid brown markings, fig. 630; veins and membrane with very short, sparse hair; cord following a zigzag course .... **Chilostigma**, p. 199

    Wings either mostly brown, or with abundant hair on veins or membrane; cord more regular, as in fig. 631 11

11. Apical margin of front wings deeply incised and with cell Cu_{1b} very narrow, long and parallel-sided, fig. 631*B* .... **Glyphopsyche**, p. 200

    Apical margin not incised; cell Cu_{1b} narrowing gradually for most of its length, fig. 631*A*, *C* 12

12. Front wings with cord aligned with base of stigmatic area, fig. 631*D* .... **Frenesia**, p. 199

    Front wings with cord not forming a line with base of stigma, fig. 631*A*, *C* 13

13. Front wings with apex of R_2 almost fusing with apex of stigma, fig. 631*C* .... **Grensia**, p. 201

    Front wings with R_2 paralleling stigma and definitely not approaching it, fig. 631*A* .... **Glyphopsyche**, p. 200

14. Front wings with fork of R_{2+3} much basad of fork of R_{4+5}, at least as much as in fig. 632, and last tarsal segment of all legs without black spines 15

    Either front wings with fork of R_{2+3} more nearly on a level with fork of R_{4+5}, fig. 636, or last tarsal segment of at least 1 or 2 legs with 1 or more short black ventral spines 16

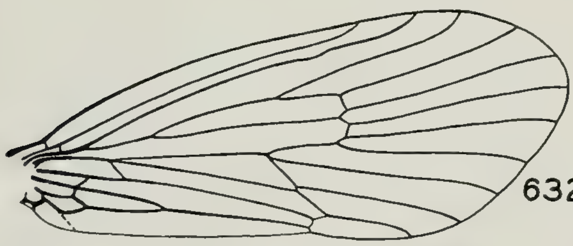
15. Hind tibiae with 2 spurs; small, slender species about 10 mm. long .... **Ironoquia**, p. 184

    Hind tibiae with 4 spurs; large, robust species about 15 mm. long .... **Caborius**, p. 196

16. Front wings as in fig. 633, with R_1 sinuate and upcurved at apex to delimit a stigmatic area, and R_2 close to and parallel with R_1 from base of stigma; wing very long and narrow; last tarsal segments never with black spines ..... **Psychoglypha**, p. 201

    Front wings either very wide or with R_2 following R_1 no closer than in fig. 636; note that R_2 does not follow R_1 at base of stigma; last tarsal segments sometimes with 1 or 2 black spines 17

17. Hind wings with R_5 bordered with a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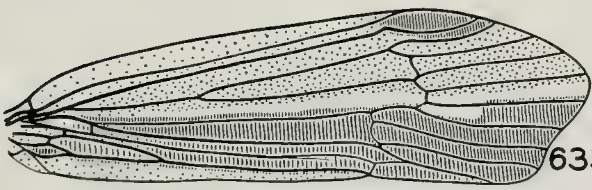
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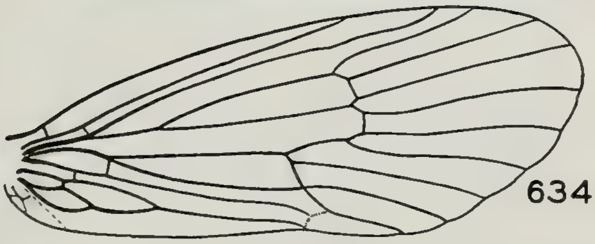
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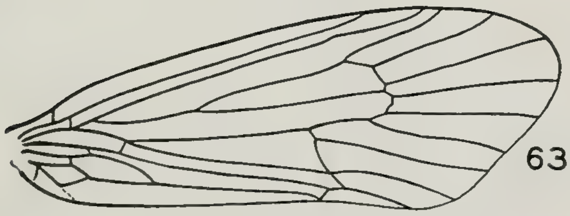
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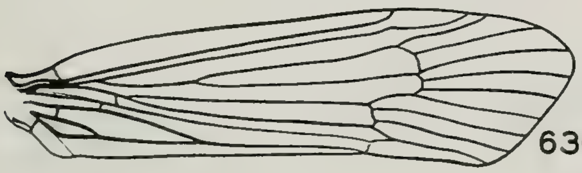
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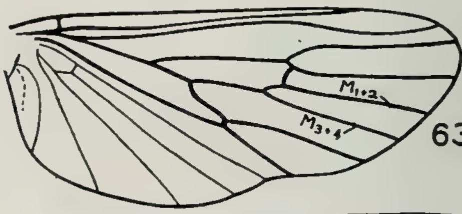

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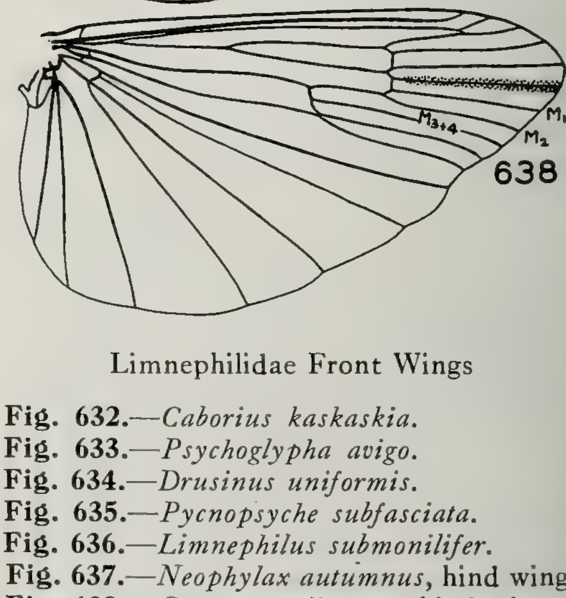


638

Limnephilidae Front Wings

Fig. 632.—*Caborius kaskaskia.*
Fig. 633.—*Psychoglypha avigo.*
Fig. 634.—*Drusinus uniformis.*
Fig. 635.—*Pycnopsyche subfasciata.*
Fig. 636.—*Limnephilus submonilifer.*
Fig. 637.—*Neophylax autumnus*, hind wing.
Fig. 638.—*Grammotaulius* sp., hind wing.

black streak, fig. 638............. ....**Grammotaulius**, p. 185
Hind wings with R_5 not bordered with a dark streak.................... 18

18. Front wings with first cell 1*A* much more than half as long as second cell 1*A*, fig. 634.................. 19
Front wings with first cell 1*A* at most only half as long as second cell 1*A*, fig. 636......................... 20

19. Front wings with post-apical margin rounded, fig. 634, and last tarsal segment of all legs without black spines...............**Drusinus**, p. 202
Front wings with post-apical margin oblique, fig. 635, and last tarsal segment of 1 or more legs with 1 or more short, black ventral spines... ....**Pycnopsyche**, p. 193

20. Mesonotum with mesoscutal warts represented by a poorly defined, linear area of setae, some of them stout, fig. 639; head either with 1 or 2 pairs of long, stout macrochaetae in postocellar area or with only a few, stout setae on posterior warts, fig. 639....**Limnephilus**, p. 185
Mesonotum with mesoscutal warts ovate, well delimited and with long, silky hair, fig. 640; head with scattered hair over postocellar area and with long, silky hair on posterior warts, fig. 640.................. 21

21. Last tarsal segments without black ventral spines; male claspers distinctly 2-segmented; female genitalia of eastern species with tenth segment vasiform....**Dicosmoecus**, p. 181
Last tarsal segment of at least 1 or 2 legs with 1 or more short, black ventral spines; male claspers with only 1 segment, figs. 673–678; female genitalia with apical portion not vasiform, fig. 680................ ....**Pycnopsyche**, p. 193

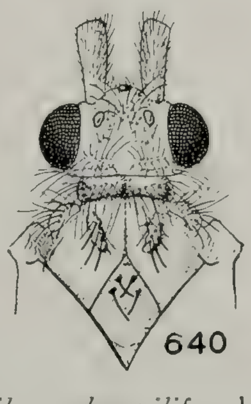


Fig. 639.—*Limnephilus submonilifer*, head and thorax.

Fig. 640.—*Pycnopsyche subfasciata*, head and thorax.

Radema Hagen

Radema Hagen (1864, p. 799). Genotype, monobasic: *Radema infernale* Hagen.

Apatidea McLachlan (1874, p. 33). Genotype, here designated: *Apatidea copiosa* McLachlan.

Apatelia Wallengren (1886, p. 78). Genotype, here designated: *Apatania* (*Apatelia*) *inornata* Wallengren.

Apatania of authors, not Kolenati.

No Illinois species of this genus have yet been reported, but several are known in the northeastern states. In general, the group is Arctic and Subarctic, occurring as far south as New York and Connecticut.

This group was formerly called *Apatania*. The genus *Apatania*, however, has as its only included species one which belongs to the genus *Molanna*; *Apatania*, therefore, must be considered a synonym of *Molanna*.

Dicosmoecus McLachlan

Dicosmoecus McLachlan (1875, p. 122). Genotype, here designated: *Stenophylax palatus* McLachlan.

No species of this genus is known to occur in Illinois, but *quadrinotatus* occurs in the Northeast.

Platycentropus Ulmer

Platycentropus Ulmer (1905*a*, p. 13). Genotype, by original designation: *Halesus maculipennis* Kolenati.

Hylepsyche Banks (1916, p. 121). Genotype, by original designation: *Halesus indistinctus* (Walker).

Of the three species described in the genus only one is known from Illinois.

Platycentropus radiatus (Say)

Phryganea radiata Say (1824, p. 308).

Limnephilus indicans Walker (1852, p. 23); ♀. New synonymy.

Halesus maculipennis Kolenati (1859*b*, p. 176); ♂. New synonymy.

Hallesus hostis Hagen (1861, p. 266); ♂. New synonymy.

Larva.—Length 24 mm. Head and pronotum with ground color yellowish brown, nearly orange, irregularly speckled with small black dots which are arranged to form a small design on the frons. Mesonotum

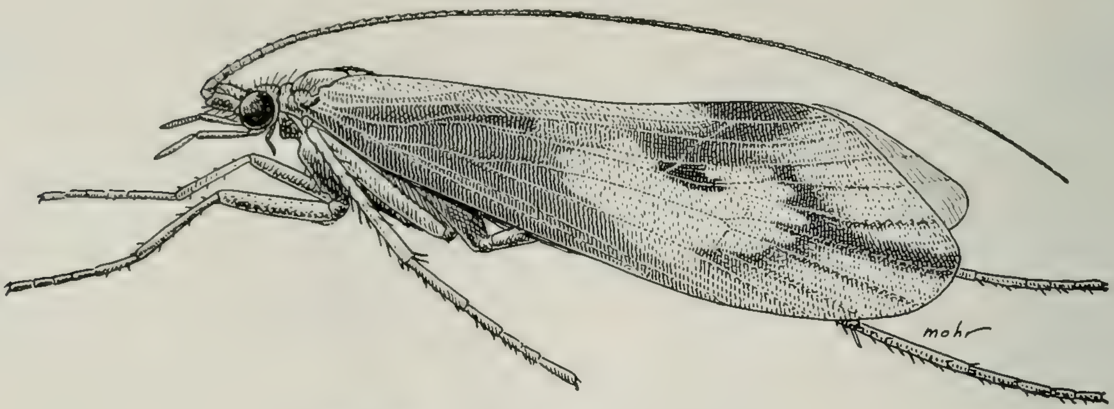


Fig. 641.—*Platycentropus radiatus* ♂.

and legs brownish yellow with irregular darker markings. Pronotum with a transverse depression. Abdominal gills long and single beyond base, arising in groups of one to three. Lateral line conspicuous.

CASE.—Length 23 mm., constructed of fiber and wood fragments to form a round and very thick case of log-cabin construction and usually very fuzzy in appearance.

ADULTS.—Fig. 641. Length 20–23 mm. General color a medium shade of brown, the wings with a very distinct pattern of various shades of brown ranging from almost cream color to chocolate, as in fig. 641. Fifth, sixth and seventh sternites in both sexes with a row of projecting sclerotized teeth. Male genitalia, fig. 642: cerci small and cushion shaped, bearing a black mesal area; tenth tergite forming a pair of long, pointed processes which are black and striate on the dorsal surface; claspers small and inconspicuous. Aedeagus as in fig. 642. Female genitalia, fig. 642, simple, without long or complicated processes.

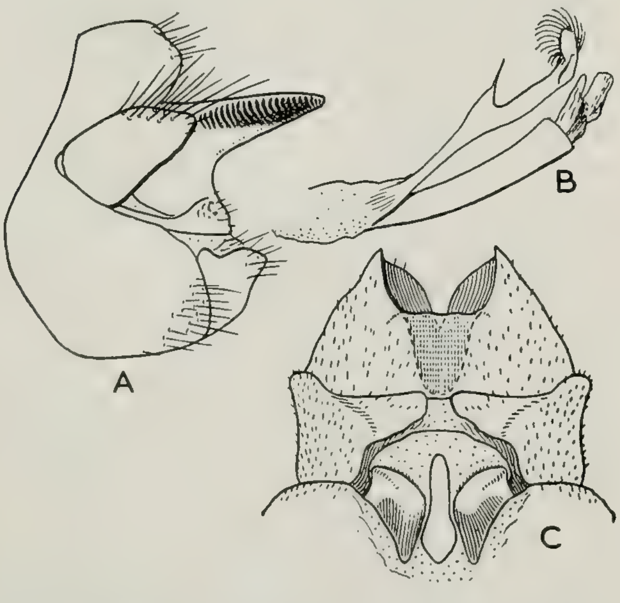


Fig. 642.—*Platycentropus radiatus*, genitalia. *A*, male; *B*, aedeagus; *C*, female.

Neotype, male.—Northern Illinois, Peabody Collection.

The neotype fits Say's description well, and records indicate that the species occurs throughout the bounds of the old "Northwest Territory," which included Illinois, Michigan, Minnesota and Wisconsin.

The occurrence of specimens of this species in old collections, such as Peabody's, may indicate that *radiatus* was more abundant in earlier years. This circumstance is undoubtedly true of some of Say's other species.

In Illinois this species has been taken at Palos Park (near Chicago) and along the Kankakee River at Momence (see p. 5). At this locality one female was taken at lights; in addition to this we took moderate numbers of the larvae on drift along the river bank after a very heavy flood. We have taken larvae of this species in abundance in some of the small streams in northwestern Indiana which are the headwaters of the Kankakee River, but we have taken the larvae at Momence only after a flood stage of water. We think it highly probable that this species does not normally live in the river at Momence but is periodically washed down from small streams. Larvae from Momence were reared.

The range of the species extends through the East and Northeast; records are known from Georgia, Illinois, Indiana, Manitoba, Massachusetts, Michigan, Minnesota, Newfoundland, New York, Ontario and Wisconsin.

Illinois Records.—MOMENCE, Kankakee River: June 4, 1932, Frison & Mohr, 1 ♀; May 19, 1937, Ross & Burks, many larvae, 1 ♂ pupa (reared). PALOS PARK: June 19, 1909, W. J. Gerhard, 1 ♂, FM; June 24, 1922, W. J. Gerhard, 1 ♀, FM.

Glyphotaelius Stephens

Glyphotaelius Stephens (1837, p. 211). Genotype, monobasic: *Limnephilus pellucidus* De Geer (spelled *pellucidulus* by Stephens).

Glyphidotaulius Kolenati (1848, p. 36). Emended name.

Only one species has been recorded from North America, *hostilis*. This species has not been taken in Illinois but is distributed throughout the Northeast.

Astenophylax Ulmer

Astenophylax Ulmer (1907*b*, p. 51). Genotype, monobasic: *Phryganea arga* Harris.

The genus contains only one species, *argus*, which has not yet been taken in Illinois.

This large and very showy caddis fly has been taken throughout the northeastern states from Maine to Wisconsin. The wings are medium brown with large areoles which are almost transparent, and the apical third of the wing is almost entirely transparent except for the brown veins.

Hesperophylax Banks

Hesperophylax Banks (1916, p. 118). Genotype, by original designation: *Platyphylax occidentalis* Banks.

The adults of this genus usually have a longitudinal silvery mark on the front wings; this is very prominent in the larger western species. The genitalia of both sexes, fig. 935, are uniform in general structure throughout the entire genus.

Of the described North American species only one occurs in Illinois.

Hesperophylax designatus (Walker)

Limnephilus designatus Walker (1852, p. 24); ♂, ♀.

LARVA.—Length 15 mm. Head, thoracic sclerites and legs yellowish brown; head and pronotum speckled with irregular small brown spots; legs with an orange tinge. Pronotum with a transverse crease. Abdominal gills mostly branched, the dorsal gills and meso-ventral gills of the first few segments with five or six branches and forming a fan, fig. 615. First abdominal sternite with many black, conspicuous setae.

CASE.—Length 18 mm., constructed chiefly of small stones and sand grains; in very young forms the case is strongly tapered and almost horn shaped; in mature specimens it is nearly cylindrical but slightly curved.

ADULTS.—Fig. 643. Length 20 mm. Color brown, the wings with a definite pattern of light and dark brown, and in addition a silver stripe through cell first R_5. Male genitalia, fig. 935: claspers appearing somewhat triangular from lateral view; tenth tergite produced into a dorso-mesal knob; claspers elongate, tapering from base to a narrow apex; aedeagus with a pair of bunches of sclerotized, serrate and appressed spurs. Female genitalia, fig. 938, without conspicuous or complicated processes.

Structurally this species is closely related to others in the genus. In the past there has been considerable confusion as to whether or not certain forms were varieties or species, but differences in the cerci and tenth tergite appear to separate these clearly. A key to the Nearctic species is given on page 281.

Our Illinois records are all from the spring-fed brooks in the Botanical Gardens at Elgin. The species is very abundant in this set of streams (see p. 7), and larvae, pupae and adults have been collected there. Our adult emergence was apparently confined to May.

The species is widely distributed through the Northeast; records are known from Illinois, Michigan, New Hampshire, New York, Nova Scotia, Ontario and Wisconsin.

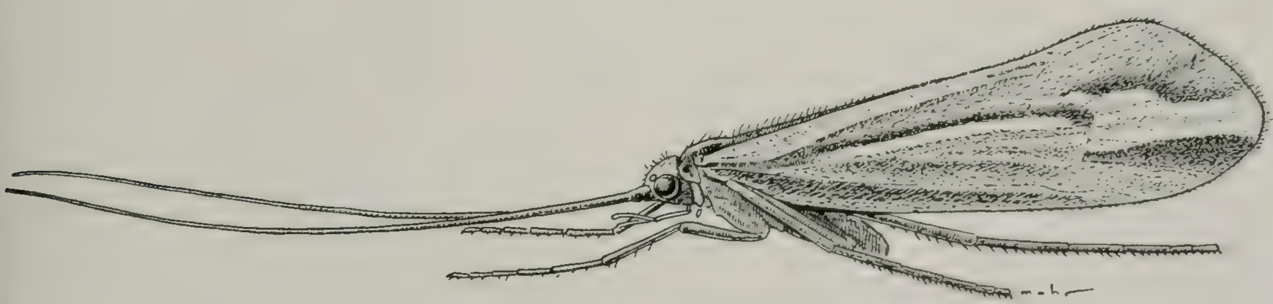


Fig. 643.—*Hesperophylax designatus* ♂.

Illinois Records.—Elgin: April 19, 1939, Burks & Riegel, 3 pupae; May 9, 1939, Ross & Burks, 2 ♂, 2 pupae, 3 larvae; May 14, 1939, Ross & Burks, 1 ♂, 3 ♀; May 20, 1939, 33 cases, 1 ♂ pupa, 3 ♀ pupae; June 13, 1939, Frison & Ross, many larvae; May 7, 1941, Mohr & Burks, 1 ♂, 1 ♀; preceding Elgin records from Botanical Gardens; Rainbow Springs, April 19, 1939, Burks & Riegel, 7 pupae; Trout Spring, March 7, 1940, Burks & Mohr, 8 larvae.

Ironoquia Banks

Ironoquia Banks (1916, p. 121). Genotype, by original designation: *Chaetopterygopsis parvula* Banks.

This genus contains only one species, the genotype, described from New Brunswick, New Jersey. It has not been taken in Illinois.

Leptophylax Banks

Leptophylax Banks (1900*a*, p. 252). Genotype, monobasic: *Leptophylax gracilis* Banks.

Only one species is known for the genus, and this has been taken in Illinois.

Leptophylax gracilis Banks

Leptophylax gracilis Banks (1900*a*, p. 252); ♀.

Larva.—Unknown.

Adults.—Fig. 644. Length 14–16 mm. Color tawny, the antennae and anal portion of the wings darker brown. Form elongate, the head and pronotum long, fig. 644. Male genitalia, fig. 645: cerci large, the apical margin sclerotized and the apico-dorsal corner forming a sclerotized point; tenth tergite forming two long, narrow blades; claspers narrow, long and pointed, the apex tipped with black. Female genitalia with apical segments large, and the lateral lobes of the tenth tergite long and pointed.

We have no recent record of this species from Illinois, but it has been collected in earlier years from Chicago and Algonquin. Nothing is known of the biology of the species. It is widespread through the Northeast; records are known from Illinois, Michigan, Minnesota, New York and South Dakota.

Illinois Records.—Algonquin: July 3,

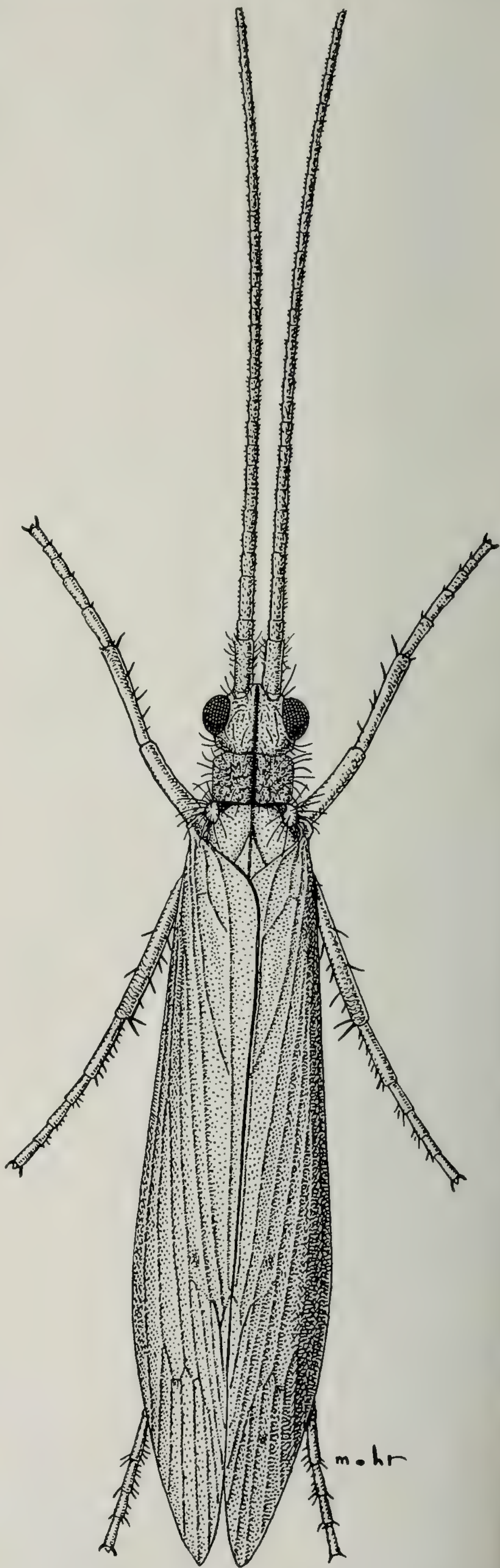


Fig. 644.—*Leptophylax gracilis* ♀. Now a rarity, but apparently abundant in Illinois at one time.

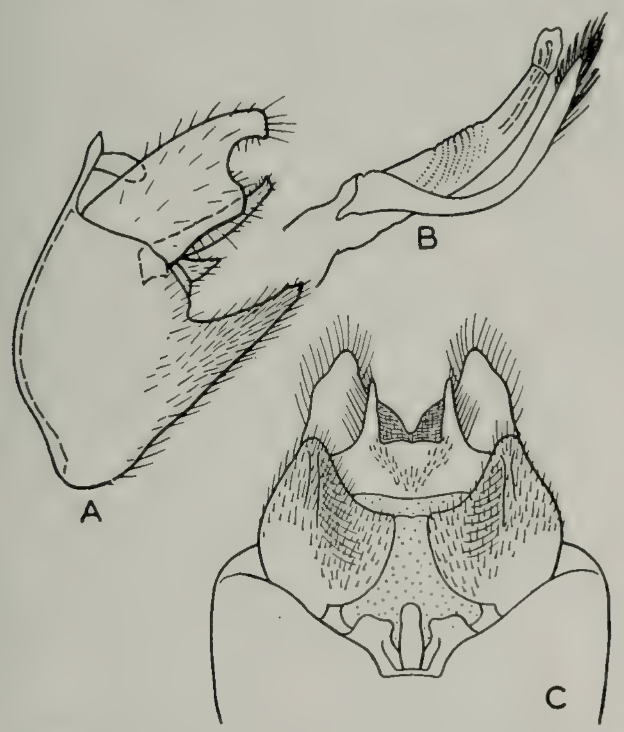


Fig. 645.—*Leptophylax gracilis*, genitalia. *A*, male; *B*, aedeagus; *C*, female.

1909, 1 ♀; July 10, 1909, 3 ♀; July 3, 1910, 4 ♂, 1 ♀; July 7, 1910, 1 ♀; July 28, 1910, 1 ♀; all W. A. Nason. Chicago: June 23, 1907, Lincoln Park, 1 ♂; June 11, W. J. Gerhard, 1 ♀, FM; June 17, W. J. Gerhard, 1 ♂.

Grammotaulius Kolenati

Grammotaulius Kolenati (1848, p. 38). Genotype, by subsequent designation of Milne (1935, p. 50): *Phryganea interrogationis* Zetterstedt.

No representatives of this genus have been taken in Illinois. The species are all large and Arctic or Subarctic in distribution. The genotype is known as far south as Minnesota. The genus was revised by Denning (1941*b*).

Limnephilus Leach

Limnephilus Leach (1815, p. 136). Genotype, monobasic: *Phryganea rhombica* Linnaeus.

Anabolina Banks (1903*a*, p. 244). Genotype, by original designation: *Anabolina diversa* Banks.

Apolopsyche Banks (1916, p. 121). Genotype, by original designation: *Stenophylax minusculus* Banks.

Algonquina Banks (1916, p. 121). Genotype, by original designation: *Stenophylax? parvula* Banks.

Rheophylax Sibley (1926*b*, p. 107). Genotype, by original designation: *Limnephilus submonilifer* Walker.

The species treated under this genus include those placed by previous writers not only in *Limnephilus* but in *Anabolia*, *Anabolina*, *Arctoecia* and *Colpotaulius*. I have been unable to find characters which will key out either the males or the females to these groups; available characters intergrade to such an extent that they cannot be used for accurate separation. I have not listed certain of these genera as synonyms because the genotypes involve European species which cannot be placed quite definitely in relation to the North American forms.

The characteristics of the genus are varied, and the only diagnostic characters which I have found are included in the key. This is probably one of the largest genera in North America, containing 60 or 70 species. Of these we have taken only 9 in Illinois, one of which is very common and widespread, the others locally distributed and rare.

KEY TO SPECIES

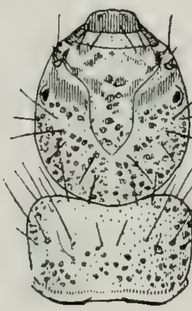
Larvae

1. Head yellow, with scattered brown dots, without dark areas or lines, fig. 646............. **consocius**, p. 190
   Head with dark areas at least as extensive as in fig. 647............. 2
2. First abdominal tergite with only a few setae beside dorsal hump and above lateral swellings, fig. 650.... .... **submonilifer**, p. 192
   First abdominal tergite with many setae in each of these areas, fig. 651 3
3. Mesal and lateral dark areas of head separated by a wide pale area, fig. 648............... **rhombicus**, p. 190
   Mesal and lateral dark areas of head separated by a narrow pale area, fig. 649................ **indivisus**, p. 191

Adults

1. Antennae 3-segmented (males)....... 2
   Antennae 5-segmented (females)..... 11
2. Front basitarsus only half length of second tarsal segment and with a black, curved apical spur......... .... **submonilifer**, p. 192
   Front basitarsus longer than second tarsal segment and with a straight, yellow apical spur................ 3

3. Cerci with a deep lateral incision dividing them into long dorsal and ventral lobes, fig. 653 . . . **ornatus,** p. 189
   Cerci with posterior margin slightly or not at all incised 4
4. Cerci very large, long and wide, dwarfing the other parts of the genitalia, especially the minute tenth tergite, fig. 654 . . . . **rhombicus,** p. 190
   Cerci either small, fig. 655, or less than twice length of tenth tergite, fig. 659 5
5. Cerci short, either widened at apex and spatulate, or with apical margin incised, figs. 655–658 6
   Cerci long and rounded or pointed at apex, figs. 659–661 9
6. Claspers reduced to a small, sharp triangle; processes of tenth tergite narrow and sharp, projecting below level of cerci, fig. 655 . . . **sericeus,** p. 192
   Claspers large, fig. 656, or projecting as finger-like processes, fig. 657; processes of tenth tergite projecting between cerci and at least partially hidden by them in lateral view 7
7. Cerci with apical margin uniformly black and heavily sclerotized, emarginate, forming a produced dorsal lobe, fig. 656; mesal face of cerci without row of teeth near base . . . . **consocius,** p. 190
   Cerci with apical margin not black but with mesal, sclerotized teeth black; apical margin nearly straight, with the dorsal corner rounded, figs. 657, 658; mesal face of cerci with a row of black, sclerotized teeth near base, fig. 658 8
8. Claspers broad, nearly as broad as cerci; lateral arms of aedeagus ending in a membranous, diamond-shaped lobe with a dense brush of spines, fig. 657 . . . . **hyalinus,** p. 191
   Claspers finger-like, much narrower than cerci; lateral arms of aedeagus bladelike and with a dorsal angulation, bearing a definite dorsal row of setae, fig. 658 . . . . **indivisus,** p. 191
9. Claspers small and platelike, without any projecting parts, fig. 659 . . . . **moestus,** p. 191
   Claspers with a long, pointed apical portion, fig. 660 10
10. Cerci longer, more slender at tip and curved slightly ventrad, fig. 660 . . . . **sordidus,** p. 189
    Cerci shorter and stouter, straight and tapered at tip to a point, fig. 661 . . . . **bimaculatus,** p. 189
11. Cerci represented only as slight swellings at base of tenth tergite, which forms a simple tube, fig. 662 . . . . **submonilifer,** p. 192
    Cerci present as distinct processes above or beside tenth tergite, figs. 663–671 12
12. Tenth segment very short and broad, cerci long; ninth tergite broad and bandlike, fig. 663 . . . . . . **ornatus,** p. 189
    Tenth segment more than half length of cerci, fig. 665, usually as long as or longer than cerci, fig. 666 13
13. Dorsal portion of tenth segment produced into a long, thin spatula



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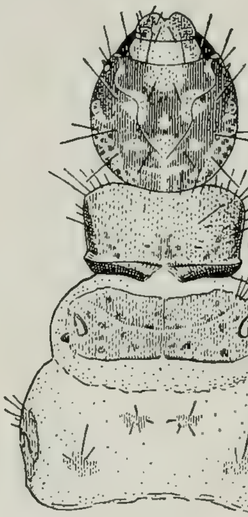

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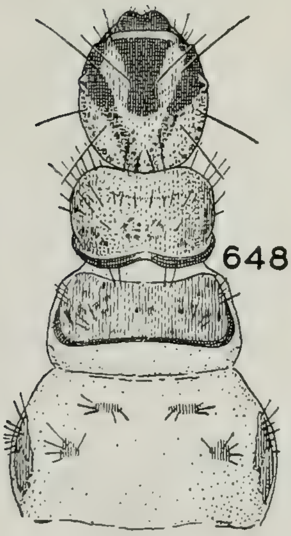

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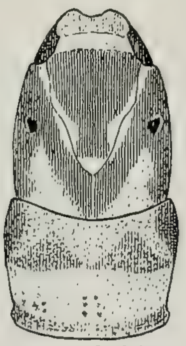

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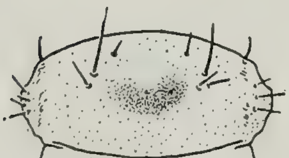

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Fig. 646.—*Limnephilus consocius* larva, head and thorax.

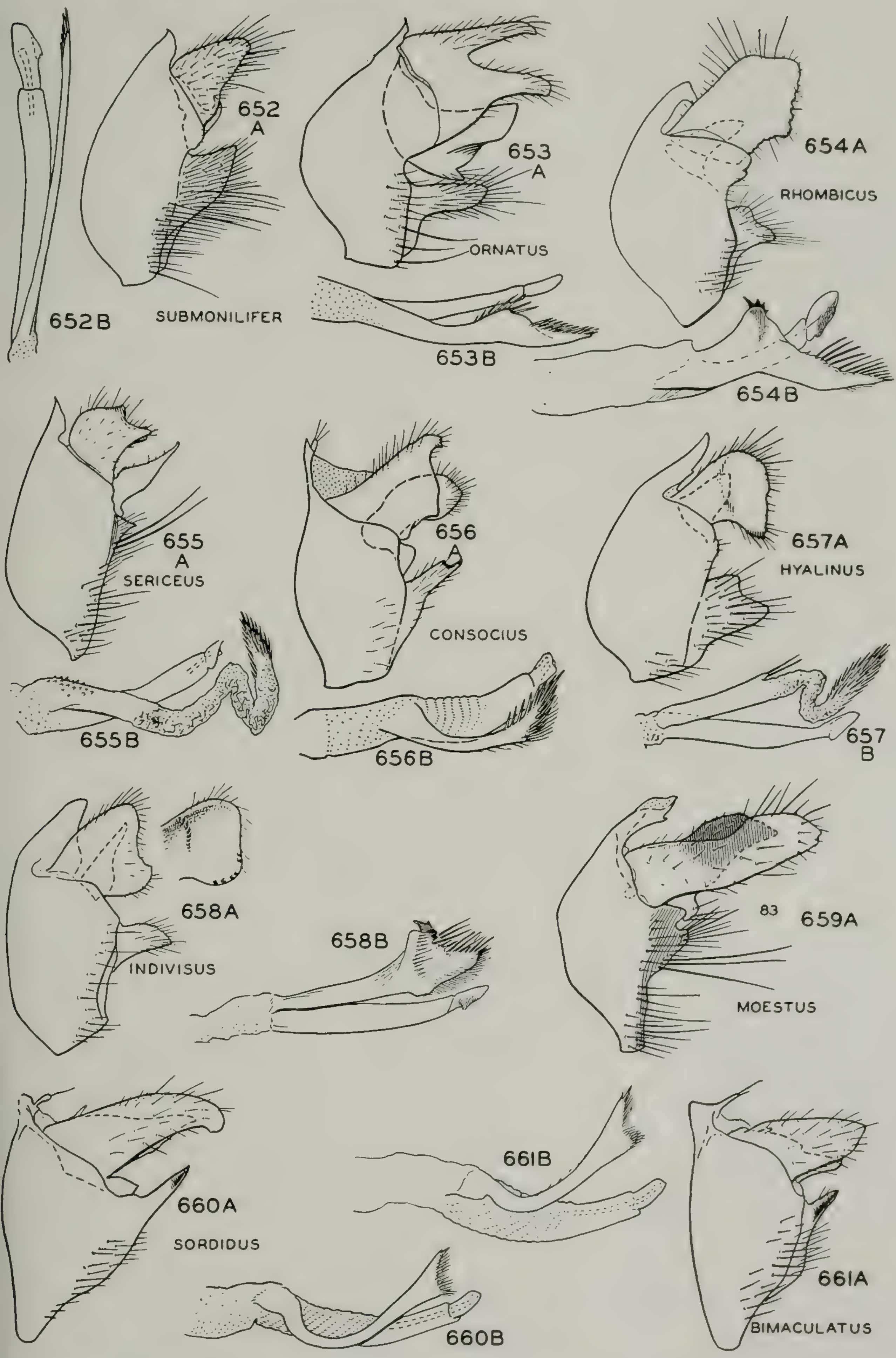
Fig. 647.—*Limnephilus submonilifer* larva, head and thorax.

Fig. 648.—*Limnephilus rhombicus* larva, head and thorax.

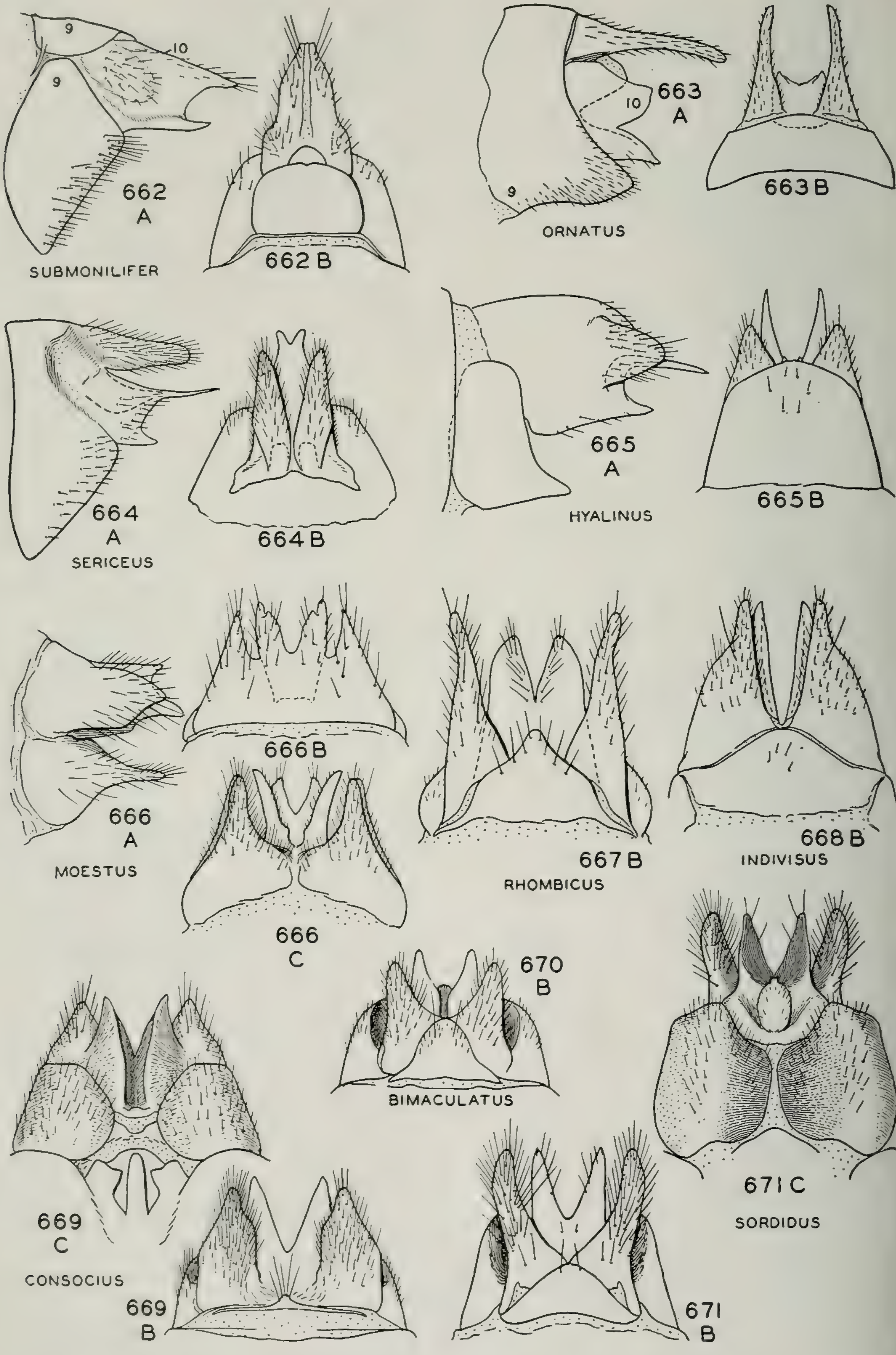
Fig. 649.—*Limnephilus indivisus* larva, head and thorax.

Fig. 650.—*Limnephilus submonilifer* larva, first abdominal tergite.

Fig. 651.—*Limnephilus rhombicus* larva, first abdominal tergite.



Figs. 652–661.—*Limnephilus*, male genitalia. *A*, lateral aspect; *B*, aedeagus, lateral aspect, showing one of the lateral arms.



Figs. 662–671.—*Limnephilus*, female genitalia. *A*, lateral aspect; *B*, dorsal aspect; *C*, ventral aspect.

slightly emarginate at apex, fig. 664 .... **sericeus**, p. 192
Dorsal portion of tenth tergite either divided at least half way to base, fig. 665, or not much produced beyond ventral margin.............. 14

14. Dorsal portion of tenth segment modified into a pair of narrow, needlelike blades, fig. 665.... **hyalinus**, p. 191
Dorsal portion of tenth segment with wide blades, fig. 666.............. 15

15. Ninth sternite prolonged into long, finger-like processes, the apices of which are separated by half the width of the segment, as in fig. 666 .... **moestus**, p. 191
Ninth sternite forming a pair of short, stocky processes, figs. 667–671.... 16

16. Cerci long, slender, spindly, and widely separated to base, tenth tergite very much stouter, its halves appressed, fig. 667..... **rhombicus**, p. 190
Cerci stout, shorter and wider, fig. 668, tenth tergite not stouter than cerci.......................... 17

17. Cerci close together at base and apex, forming with the tenth segment a definitely conical structure, fig. 668 .... **indivisus**, p. 191
Cerci either diverging, fig. 671, or wide apart at base, fig. 669............ 18

18. Ninth tergite with only a small sclerotized button, cerci wide apart at base; ninth sternite with lobes rounded ventrad, tenth tergite with lateral halves solid and pyramidal, fig. 669............ **consocius**, p. 190
Ninth tergite with a fairly large, triangular sclerite, cerci fairly close together at base; ninth sternite with lobes angular ventrad, tenth tergite with lateral halves thin and curved, fig. 671........................ 19

19. Cerci with a large, nearly bulbous basal portion which narrows to a small, short apex, fig. 670......... .... **bimaculatus**, p. 189
Cerci with a small basal portion and a long, thin apex, fig. 671......... .... **sordidus**, p. 189

Limnephilus sordidus (Hagen)

Anabolia sordida Hagen (1861, p. 264); ♂.
Anabolia longicercus Denning (1941*a*, p. 195); ♂, ♀.

LARVA.—Unknown.

ADULTS.—Length 16–18 mm. Color dark reddish brown, the dorsum and antennae almost black, the front wings very dark brown with irregular light dots scattered over the entire surface of the wing, giving it a salt-and-pepper appearance. Head and thorax with black dorsal macrochaetae, those on head sparse. Front basitarsus of male much longer than succeeding segment. Male genitalia, fig. 660, with long cerci which are narrowed at apex and have a few small sclerotized teeth along the apico-mesal margin; lobes of tenth tergite also long and reaching nearly to apex of cerci; claspers smooth, long and sharp; lateral arms of aedeagus sclerotized, curved, widened and obliquely truncate at apex. Female genitalia, fig. 671, with ninth tergite triangular, cerci long and diverging, lateral halves of tenth segment thin and long, ninth sternite produced into large angulate protuberances.

Our only Illinois record of this species is a female collected at Galena, Illinois, bearing the number 1062; this specimen was recorded by Hagen and is probably part of the Kennicott Collection.

The range of this species is poorly understood. It was originally described from the Red River valley (North Dakota–Minnesota), but undoubtedly specimens of this species had been recorded under the name *bimaculatus*, and few definite locality records can be given until this material is restudied.

Limnephilus bimaculatus Walker

Limnephilus bimaculatus Walker (1852, p. 30); ♂.

This species occurs throughout the northern states from Colorado to the Atlantic Coast. Betten mentions a record from northern Illinois in Hagen's specimens, but these specimens are the preceding species, *sordidus*. We have no definite Illinois records of this species, although it might be taken in future collections.

Limnephilus ornatus Banks

Limnephilus ornatus Banks (1897, p. 27); ♀.
Limnephilus elegans Mosely (1929, p. 504); ♂.

LARVA.—Unknown.

ADULTS.—Length 17–18 mm. Color yellowish brown, the front wings with longitudinal silvery stripes which contrast with the chocolate brown ground color. Dorsum of head and thorax with a mixture of tawny and silvery setae. Front basitarsus of male longer than second segment. Male genitalia, fig. 653, with cerci deeply incised to form long dorsal and ventral lobes; tenth tergite large and stocky; claspers with wide base and fairly long apical portion; lateral arms of aedeagus with a wide foliaceous apex bearing rows of spines. Female genitalia, fig. 663, with cerci long and slender, tenth segment short and forming a wide tube.

Dr. Betten (1934) reports this species from Lake Forest, Illinois, in June. In addition to this record, we have a single female bearing the data "Northern Illinois," a male collected at Zion, Illinois, June 26, 1936, Frison & DeLong, and a female collected at Chicago, Illinois, May 17, W. J. Gerhard, FM.

The species has been recorded from scattered localities over a very wide range from Greenland, across America, to Japan; on the North American continent records are available for Alaska, Illinois, Maine, Massachusetts, Newfoundland, New Hampshire, New York and Ontario.

Limnephilus rhombicus (Linnaeus)

Phryganea rhombica Linnaeus (1758, p. 548).
Limnephilus combinatus Walker (1852, p. 28); ♂.

LARVA.—Length 20 mm. Head, thoracic sclerites and legs yellowish brown with scattered brown dots; head with a distinct brown area down the center of the frons, a pair of brown lines on each side of the frons, and an irregular brown area occupying much of the lateral and ventral portions of the head; pronotum sometimes with anterior half dark.

CASE.—Fig. 672. Length 20 mm., stout and round, constructed of short wood fragments woven together in an irregular pattern.

ADULTS. — Length 19–20 mm. Color brownish yellow, the wings with a distinct pattern of cream color and chocolate brown arranged in somewhat oblique stripes. Head and thorax armed with silvery or tawny macrochaetae. Front basitarsus of male longer than succeeding segment. Male genitalia, fig. 654, with very long, wide cerci which have a row of ventro-mesal sclerotized teeth; tenth tergite very small, claspers small. Female genitalia, fig. 667, with minute ninth tergite, long and spindly cerci and stout tenth segment.

We have taken this species in Illinois only in the spring-fed brooks in the Botanical Gardens at Elgin (see p. 7). To date we have actually captured only three larvae and one female of this species there, so that it is a rarity with us.

This species is widely distributed throughout the Northeast. All stages were described

Fig. 672.—*Limnephilus rhombicus*, case.

by Vorhies (1909) and Lloyd (1921), and records are available from Greenland, Illinois, Maine, Newfoundland, New York, Saskatchewan and Wisconsin, in addition to records from Eurasia.

Illinois Records. — ELGIN: Botanical Gardens, June 19, 1939, H. H. Ross, 1 ♀; Trout Spring, March 7, 1940, Burks & Mohr, 3 larvae.

Limnephilus consocius Walker

Limnephilus consocius Walker (1852, p. 33); ♂.
Colpotaulius medialis Banks (1905*b*, p. 8); ♂.

LARVA.—Length 20 mm. Head and pronotum yellow, with small brown spots scattered over the entire surface, fig. 646. Other sclerites yellow with variable brown spots.

CASE.—Length 20 mm. Constructed chiefly of wood and leaf fragments, irregular in outline, but fairly stoutly constructed.

ADULTS.—Length 14–16 mm. Color almost entirely a rich reddish brown, the front wings finely marbled with a darker shade of brown but without a definite pattern. Setae of head and thorax reddish brown. Front basitarsus longer than the succeeding segment. Male genitalia, fig. 656, with cerci short and broad at apex, the posterior margin heavily sclerotized along the mesal edge; claspers narrow, with a pair of sclerotized points at apex; tenth tergite projecting beyond cerci; aedeagus with stout, curved, spinose, lateral arms. Female genitalia, fig. 669, with cerci stout and tenth tergite with the lateral halves thick and pyramidal; ninth sternite developed into large rounded protuberances.

This species has been taken at various points in the northeastern quarter of the state. Dr. Betten found it abundant in the ravines at Lake Forest, Illinois, but in our recent collections we have taken adults only in small numbers at various localities. Lloyd (1921) has described the immature stages. Our adult records for Illinois are scattered from early June to late August.

The range of the species occupies most of the Northeast; records are available from Illinois, Maine, Michigan, New Hampshire, New York, Ontario and Wisconsin.

Illinois Records.—Chicago: Aug. 3–12, W. J. Gerhard, 1 ♂, 2 ♀, FM. Kankakee: June 17, 1939, B. D. Burks, 1 ♂. Palos Park: June 19, 1933, Ross & Mohr, 2 ♀; Sept. 11, 1910, W. J. Gerhard, 1 ♀, FM. Seymour: June 13, 1929, Frison & Hottes, 1 ♂, 1 ♀. Urbana: Aug. 24, 1896, at light, C. A. Hart, 1 ♂. Waukegan: July 6, 1932, Frison *et al.*, 2 ♂.

Limnephilus indivisus Walker

Limnephilus indivisus Walker (1852, p. 34).
Limnephilus subguttatus Walker (1852, p. 34).

Larva.—Length 20 mm. Head and pronotum with a pattern of light and dark markings as in fig. 649. Legs and other sclerites yellow with indefinite brown marks.

Case.—Length 20 mm. Constructed in log-cabin style, as in fig. 833, of small twigs, grass stems and other short and narrow pieces.

Adults.—Length 15–16 mm. Color in general tawny to straw color, the front wings with scattered irregular brown marks which give a slightly banded impression. Setae of head and thorax tawny. Front basitarsus longer than the succeeding segment. Male genitalia, fig. 658: cerci short and triangular, narrow at base, the posterior margin bearing sclerotized teeth, the mesal face with a row of sclerotized teeth near base; tenth tergite with lobes long and narrow; claspers short, lateral arms of aedeagus sclerotized, with a sharp dorsal fin. Female genitalia, fig. 668, with the parts compactly arranged to give the general impression of a tube.

Our only Illinois record of this species is a single male collected at Antioch, August 1, 1930, Frison, Knight & Ross. The species is widely distributed through the Northeast with about the same range as that for the preceding. Lloyd (1921) has described the immature stages.

Limnephilus hyalinus Hagen

Limnephilus hyalinus Hagen (1861, p. 258); ♂.

Larva.—Unknown.

Adults.—Length 13–14 mm. Entire insect straw colored except for the black spines on the middle and hind legs; front wings usually without any pattern, hyaline; with very sparse, short hair; sometimes with faint brownish markings along the posterior margin. Front basitarsus longer than succeeding segment. Male genitalia, fig. 657, with cerci short, narrow at base, and with a mesal ridge of sclerotized teeth near base, this ridge, continuing faintly near ventral margin to postero-ventral corner; lobes of tenth tergite fairly wide but short, claspers wide and short, the apex emarginate; aedeagus with lateral arms terminating in an extensile membranous organ tipped with a diamond-shaped brush of spines. Female genitalia, fig. 665, with ninth tergite and cerci short and broad, tenth segment developed into a pair of long and needle-like processes.

The only Illinois record for this species is a single female in the Field Museum Collection taken at Chicago, August 29, W. J. Gerhard. The species has a very widespread range extending across the entire northern portion of the continent, with records from British Columbia, Colorado, Illinois, New York, the Northwest Territory (Canada) and Ontario.

Limnephilus moestus Banks

Limnephilus moestus Banks (1908*a*, p. 62); ♂, ♀.
Limnephilus hingstoni Mosely (1929, p. 504); ♂.

Larva.—Unknown.

Adults.—Length 12–13 mm. Color dark brown; front wings with cubital and anal areas tawny, remainder of wing chocolate brown with cream-colored spots, some of these spots forming a fairly large, light area around the cord. Front basitarsus of male longer than succeeding segment. Male genitalia, fig. 659, with very long and slightly sinuate cerci, long and pointed tenth tergite, and claspers reduced to a small plate bearing numerous short setae and a few long ones. Female genitalia similar to those in fig. 666, with cerci and tenth segment long, and ninth sternite developed into a pair of long, finger-like processes.

We have only one record of this species in Illinois, a male collected at Dixon, at lights along the Rock River, June 27, 1935, DeLong & Ross. The species is widespread through the northern part of the continent from Greenland to Colorado, with records from Colorado, Greenland, Illinois, Newfoundland, Nova Scotia, Ontario, Quebec and Wisconsin.

Limnephilus sericeus (Say)

Phryganea sericeus Say (1824, p. 309).
Limnephilus despectus Walker (1852, p. 31); ♂, ♀. New synonymy.
Limnephilus multifarius Walker (1852, p. 32); ♀. New synonymy.
Limnephilus perforatus Walker (1852, p. 33); ♀. New synonymy.
Limnephilus eminens Betten (1934, p. 323); ♂. New synonymy.

This species has not been taken in Illinois but occurs to the north from Alaska to New York. Records are available for Alaska, Minnesota, New York, Northwest Territory (Canada), Ontario, Pennsylvania and Quebec.

I am designating as a neotype a female from Duluth, Minnesota, well differentiated on the basis of its genitalia, fig. 664, and characters given in the preceding key. The species was originally described from the old Northwest Territory, which included Minnesota. Of the various species known from that general region, this particular one fits Say's description quite well, especially in the unusual black mark on the forewing.

Neotype, female.—Duluth, Minnesota.

Limnephilus submonilifer Walker

Limnephilus submonilifer Walker (1852, p. 33); ♀.
Limnephilus pudicus Hagen (1861, p. 262); ♂.

LARVA.—Length 16–17 mm. Head, thoracic sclerites and legs fairly dark brown; head with frons almost entirely brown and with small light patches at apex and sides, dorso-lateral portions variegated with yellowish brown; legs lighter yellowish brown than the head. See fig. 20, page 20.

CASE.—Length 16-20 mm., made of leaf and grass stem fragments neatly arranged in linear order to form a fairly loosely constructed straight and almost cylindrical case.

ADULTS.—Length 13–16 mm., slender. Color brown, the dorsum darker and the wings variegated with irregular lighter and darker spots; leg spines black. Head and thorax armed dorsad with long, stout macrochaetae. Front legs with a linear brush of stout, black spines on underside of femur and tibia; basitarsus only one-half length of next segment. Male genitalia, fig. 652, with cerci and claspers triangular, tenth tergite short and hooked dorsad, aedeagus with lateral arms sclerotized, filiform, very long and tipped with a small row of short spurs. Female genitalia, fig. 662, with ninth and tenth segments and cerci fused to form a single tubular structure.

This is our common temporary pond and marsh species in Illinois. We have taken it at scattered localities throughout the state, especially in the temporary ponds along railroad rights-of-way and in shallow spring marsh ponds in the northeastern corner of the state. In these situations the larvae are difficult to see since they build their cases from the dead grass stems and leaves in the bottom of the ponds, and, although they frequently practically cover the bottom, it is scarcely possible to detect them until they move.

This species has two very definite generations, at least in the general region of Illinois. The first matures early in spring, in the vicinity of Urbana the adults emerging about the first of May. Soon after this date the ponds invariably dry up, filling up again with the late summer rains. When this occurs, a second generation is developed which matures into the adults in late August and September. This same phenomenon has been noticed by previous writers. Vorhies gave evidence of this two-brooded habit from Wisconsin material, and Betten observed the same phenomenon in his studies with the species in the vicinity of Lake Forest, Illinois.

The range of the species is extensive to the north and east of Illinois; records include the District of Columbia, Illinois, Indiana, Maine, Maryland, Massachusetts, Michigan, Newfoundland, New Hampshire, New York, Ohio, Ontario, Quebec, Rhode Island, South Dakota and Wisconsin.

Illinois Records.—Many males, females and pupae, taken April 30 to October 17, and many larvae and cases, taken March 3 to May 7, are from Arcola, Cary, Champaign, Chicago, Grayslake, Leslie, Neoga, Oakwood, Rantoul, Rosecrans (Des Plaines River), Savoy; Seymour, Spring Grove, Urbana, Volo, Watson, Waukegan, West Pullman, Zion.

Pycnopsyche Banks

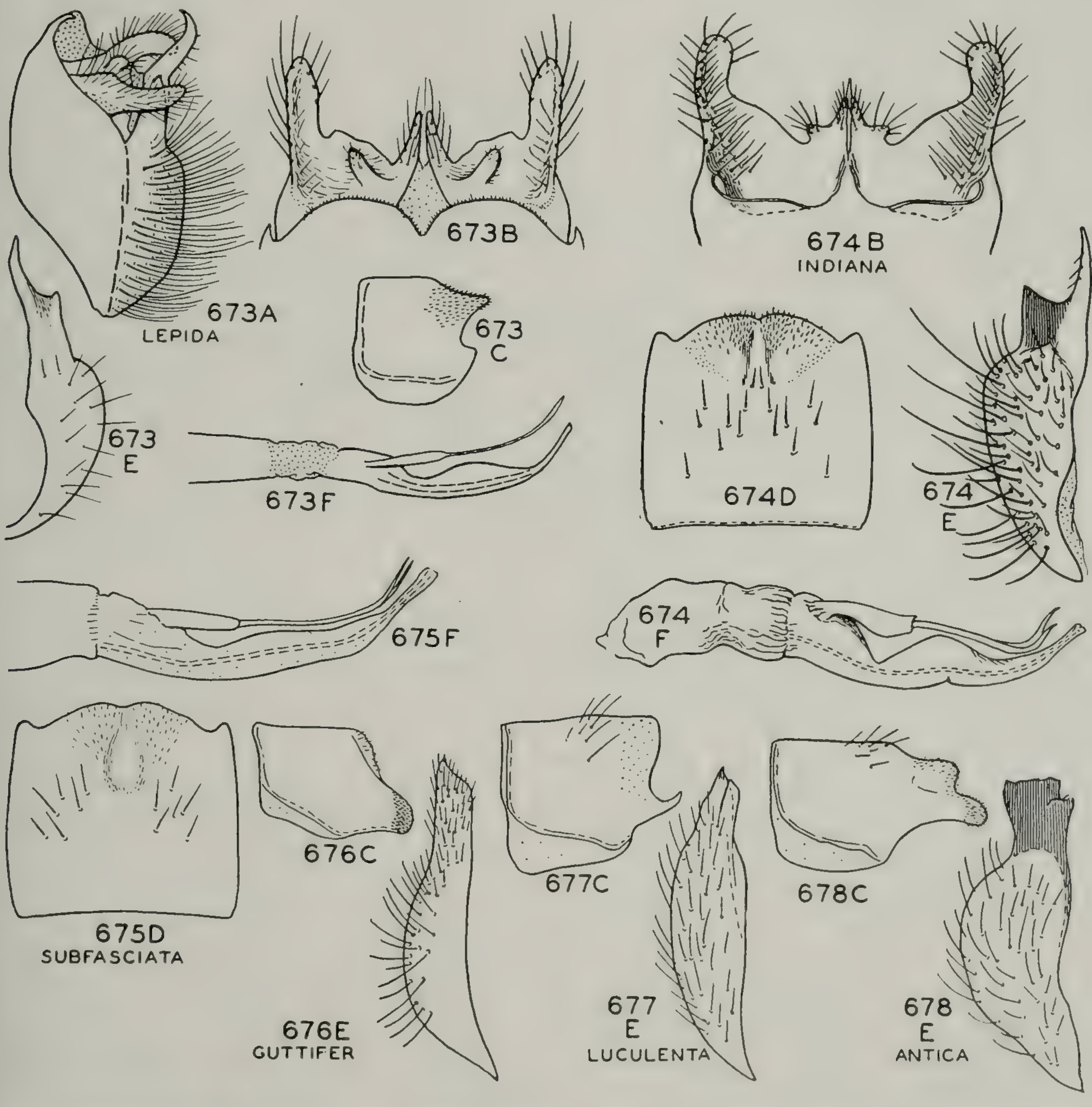
Pycnopsyche Banks (1905*b*, p. 9). Genotype, by original designation: *Limnephilus scabripennis* Rambur.

Allegophylax Banks (1916, p. 118). Genotype, by original designation: *Phryganea subfasciata* Say. New synonymy.

Eustenace Banks (1916, p. 118). Genotype, by original designation: *Stenophylax limbatus* McLachlan. New synonymy.

The general shape and color of the wings, the heart-shaped subgenital plate of the female and the structure of the male genitalia, especially the aedeagus, indicate that the species grouped under this genus form a very compact and homogenous unit. There is considerable variation in particular points of the venation and to an even greater degree in the spur count, but these differences are not substantiated by any indications of phylogenetic importance.

Many species occur in the eastern states, but to date only three have been taken in



Figs. 673–678.—*Pycnopsyche*, male genitalia. *A* and *B*, lateral and dorsal aspect respectively; *C* and *D*, eighth tergite, lateral and dorsal aspect respectively; *E*, clasper, caudal aspect; *F*, aedeagus.

Illinois. Three others, however, have been taken within a few miles of Illinois and are to be expected here in future collecting.

The larvae of several species of this genus have been reared, but to date no characters have been found to separate them to species.

KEY TO SPECIES

Adults

1. Front wings irregularly speckled over entire surface with small, dark brown spots............**antica,** p. 196

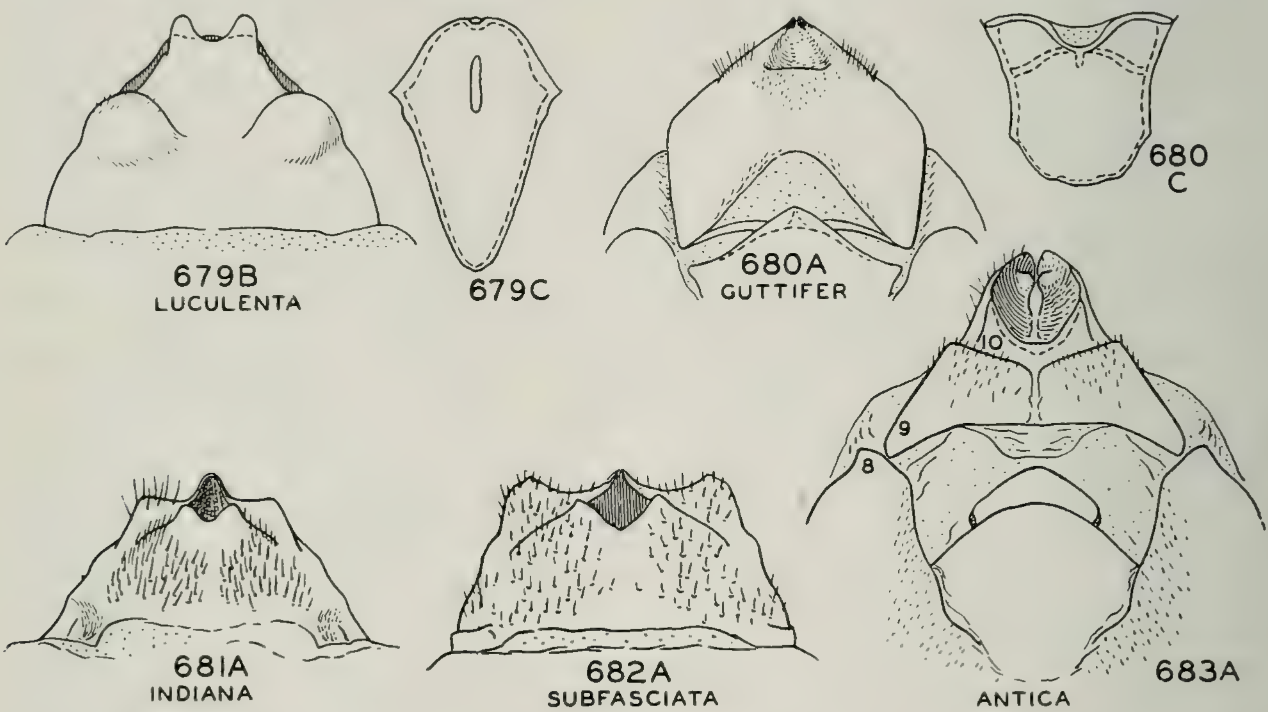
Aedeagus long, narrow, dorsal spines thrice length of their base; mesal area of eighth tergite with a depression, fig. 675...**subfasciata,** p. 194

6. Lateral lobes of eighth tergite widely separated, enlarged and covered with dense, black spines, fig. 676.. ....**guttifer,** p. 196

Lateral lobes of eighth tergite small and bare, fig. 677.....**luculenta,** p. 196

7. Tenth segment with dorsal portion tapering gradually to apex, without lateral expansions, fig. 680........ 8

Tenth segment with lateral, flangelike



Figs. 679–683.—*Pycnopsyche*, female genitalia. *A*, ventral aspect; *B*, dorsal aspect; *C*, bursa copulatrix.

Front wings at most with dark brown marks near center and along apical margin......................... 2

2. Maxillary palpi 3-segmented (males) 3

Maxillary palpi 5-segmented (females) 7

3. Apico-mesal angle of clasper projecting dorsad as a long, sharp point, fig. 673......................... 4

Apico-mesal angle of claspers not produced into a long point, fig. 676.... 6

4. Eighth tergite with an abrupt, quadrate mesal notch and with an apical brush of short, black spines, fig. 673 ....**lepida,** p. 195

Eighth tergite not abruptly notched and with triangular patches of spines instead of an apical brush... 5

5. Aedeagus short, stocky, dorsal spines only twice as long as their base; mesal area of eighth tergite not excavated, fig. 674........**indiana,** p. 196

expansions on dorsal portion, fig. 681............................ 9

8. Bursa copulatrix long and triangular; ventral margin of tenth segment bilobed and extending beyond dorsum, fig. 679.............**luculenta,** p. 196

Bursa copulatrix shorter and ovate; ventral margin of tenth segment slightly emarginate but not extending beyond dorsum, fig. 680....... ....**guttifer,** p. 196

9. Ventral portion of tenth segment narrowed to a very small, apical opening, fig. 681...........**indiana,** p. 196

Ventral portion of tenth segment narrowed, but with the apical opening wide, fig. 682.......**subfasciata,** p. 194

Pycnopsyche subfasciata (Say)

Phryganea subfasciata Say (1828, pl. 44).

Larva.—Length 18–20 mm. Head, thoracic sclerites and legs shades of reddish brown; head and pronotum with abundant small dark brown dots; legs with tibiae and tarsi darker and redder than preceding segments. Gills very long and single. First abdominal segment with a pair of very small sclerites near meson of venter and with only a few scattered setae on the rest of the venter and on the dorsum. Pronotum with distinct and fairly deep transverse furrow.

Case.—Length 20 mm. Constructed of stones, sand and wood fragments; robust and straight, frequently with a long twig or a group of small twigs cemented to the sides so that they trail behind the case; the variety of materials used varies from place to place, sometimes the stone material predominating, sometimes the wood fragment material, so that there is great variation in the general appearance of the case.

Adults. — Length 19–20 mm. Color brown, front wings usually with two dark brown marks, a transverse one which ends just in front of *m-cu*, and a more or less angulate mark along the cord; in addition the apex of the wing and a narrow border along the tips of the veins are darkened. Male with eighth tergite rounded at apex and bearing a pair of triangular areas covered with short, brown spines, fig. 675. Male genitalia, fig. 675, with claspers produced into a long dorsal process which usually has a low lateral shoulder at its base; tenth tergite with mesal processes fairly long; aedeagus elongate with a pair of long, needle-like dorsal styles, each of which has a long, tubular base. Female genitalia, fig. 682: tenth segment with lateral flangelike expansions on dorsal portion, ventral portion wide and emarginate on meson, the apical opening wide; subgenital plate and bursa copulatrix as in fig. 682.

Neotype, male. — McHenry, Illinois: Oct. 4, 1931, Ross & Mohr.

This species is very abundant in scattered localities in the state, especially in the northern and eastern parts. It occurs in such rivers as the Salt Fork and Kankakee and also in the glacial lakes in the northeastern corner. There is only a single generation per year. In this state the larvae become full grown not later than June, then aestivate until September, when the adults emerge. In localities to the north, adult emergence may take place in August, as in *Neophylax*.

This species is widespread through the Northeast; records are available for Illinois, Michigan, Minnesota, New York, Pennsylvania, South Dakota and Wisconsin.

Illinois Records. — Channel Lake: May 16, 1936, Ross & Mohr, many larvae; May 27, 1936, H. H. Ross, 2 larvae. Fox Lake: Sept. 22, 1931, Frison & Ross, ♂♂. Golconda: April 17, 1930, Frison & Ross, 1 larva. Havana: June 16, 1894, C. A. Hart, 4 larvae; Sept. 21, 1894, C. A. Hart, 2 pupae; April 9, 1895, 2 larvae; Quiver Creek, April 29, 1937, Ross & Mohr, 1♂, 1♀, 2 larvae. Homer: Sept. 24, 1927, T. H. Frison, 1♀. Kankakee: June 6, 1935, Ross & Mohr, 1 larva. Kankakee County, Kankakee River: June 1, 1901, Laske & Wright, 4 larvae. McHenry: Oct. 4, 1931, Ross & Mohr, ♂♂. Momence: Sept. 19, 1937, Ross & Burks, many larvae and pupae, ♂♂, ♀♀ (all reared), 1♂; Kankakee River, May 26, 1936, H. H. Ross, 3 larvae; July 14, 1936, B. D. Burks, 1 larva; Aug. 21, 1936, Ross & Burks, 2 larvae; Sept. 17, 1937, B. D. Burks, 7 larvae, many pupae, 1♀; Sept. 20, 1937, Ross & Burks, 3 larvae; Kankakee River, Oct. 4, 1937, Ross & Burks, 2♀. Wilmington, Kankakee River: May 17, 1935, H. H. Ross, 1 larva.

Pycnopsyche lepida (Hagen)

Enoicyla lepida Hagen (1861, p. 269); ♂.

Larva and Case.—Similar to those of *subfasciata.*

Adults.—In size and color similar to *subfasciata.* Eighth tergite of male with posterior margin sharply incised and with a brush of black setae along entire margin. Male genitalia, fig. 673, differing from those of *subfasciata* chiefly in always having a large, sharp, concave shoulder at the base of the apical process of the claspers. Female unknown; the specimen so labeled by Betten & Mosely (1940, p. 156) is only a provisional assignment as stated by the authors, and we have no well-associated females for the species.

We have only a single record of this species from Illinois, a male collected along the Kankakee River at Momence, September 7, 1937, Frison & Ross. Apparently its life cycle is the same as for *subfasciata.*

The range of the species is very similar to that of *subfasciata*: through the Northeast; records are available from Illinois, Michigan, New York, Pennsylvania, Virginia, West Virginia and Wisconsin.

Pycnopsyche guttifer (Walker)

Halesus guttifer Walker (1852, p. 16); ♂, ♀.
Pycnopsyche similis Banks (1907*a*, p. 122); ♂.

LARVA AND CASE.—Similar to those of *subfasciata*.

ADULTS.—In size and color similar to *subfasciata*; the dark marks of the front wing quite variable in size, shape and degree of darkness. Eighth tergite of male with postero-lateral corners produced into long lobes which bear a dense cushion of black spines along the apex. Male genitalia, fig. 676, with tenth tergite produced into narrow sclerotized hooks, claspers with apex long, flattened and oblique at tip, aedeagus very similar to that of *subfasciata*. Female genitalia with tenth segment narrowed toward apex, the dorsum forming a pair of narrow flanges, the ventral margin incised.

Dr. Betten has collected this species from Lake Forest, Illinois, but we have not taken it in our recent survey. The streams around Lake Forest have changed greatly since Dr. Betten collected there in about 1905-06, and it is entirely possible that the colony of *guttifer* which he located has become extinct in that area.

The species is widely distributed through the Northeast; records are available for Georgia, Illinois, Michigan, New Hampshire, New York, Nova Scotia, Ontario, Saskatchewan, South Dakota and Tennessee.

Pycnopsyche antica (Walker)

Neuronia antica Walker (1852, p. 9); ♀.

This species has not yet been taken in Illinois, but J. S. Ayars has taken it in the extreme southwestern corner of Michigan at Almena, not far from Illinois.

As pointed out by Betten & Mosely (1940, p. 144), there is some question regarding the identity of Rambur's species *scabripennis*, under which name the present species has usually been listed in North American literature. Collections from North Carolina indicate that the male here illustrated is the one associated with the type of *antica*. Its range extends through some of the eastern states; records are available from Georgia, Michigan, North Carolina and West Virginia.

Pycnopsyche indiana (Ross)

Stenophylax indiana Ross (1938*d*, p. 121); ♂, ♀.

This species has not yet been taken in Illinois, although it occurs nearby in southern Indiana. It is possible that some of the unidentified *Pycnopsyche* larvae which we have obtained from southern Illinois streams may belong to this species, but we have not yet been able to differentiate the larvae of *indiana* from other related species in the genus.

Records for the species, which are very limited, include only Rogers, Indiana, and Athens, Ohio; this may indicate that the range of the species is south and west of the main range of *subfasciata*, to which it is most closely allied.

Pycnopsyche luculenta (Betten)

Stenophylax luculentus Betten (1934, p. 345); ♂, ♀.

Although we have not yet taken this species in Illinois, we have reared it in southern Indiana close to Illinois, so that it may be found in this state with future collecting. The larvae are apparently indistinguishable from others in the genus. It is widespread in distribution, although apparently local, and seldom collected. Records are available for Indiana, New York and North Carolina.

Caborius Navás

Allophylax Banks (1907*a*, p. 119); preoccupied. Genotype, by original designation: *Halesus punctatissimus* Walker.

Caborius Navás (1918, p. 362). New name for *Allophylax* Banks.

Carborius used by Betten (1934), Milne (1935) and Ross (1938*a*); misspelling.

Both previously described species of this genus have been taken in Illinois, and a third form, until now undescribed, has also been captured. All of them are short and stocky and have broad wings.

No North American species have yet been reared. We have located many colonies of larvae in Illinois, but all efforts to rear them have failed. The larvae are about 15 mm. long, the head and pronotum are yellowish brown with brown spots, and the gills at the base of the abdomen are short and very bushy, each forming a compact fan with 10 to 12 filaments, fig. 616. These agree perfectly with the description of the European species of this genus, the peculiar gills being diagnostic. The case is usually slightly curved and made of wood fragments.

We have taken these larvae in temporary ponds and in small streams, most of which became dry in summer. In each collection we made, the larvae were full grown late in April or early in May. They appear to aestivate under roots and other objects close to or under the bank of the stream or pond. We never were able to locate the larvae after the stream or pond dried up, and the cultures which we had in cages in various streams were all killed by a fungus growth. Our adult records are all late in the season, ranging from September into October, although in other states adult records are earlier. It is very likely that this genus has essentially the same habits as *Neophylax* (see p. 202).

As it is impossible to be sure of the association of any of the larvae with definite species, the records of the larvae for the entire genus are grouped together as follows.

Illinois Records of *Caborius* Larvae: DES PLAINES, Fox River: May 26, 1936, H. H. Ross, 1 larva. FOX RIDGE STATE PARK: April 12, 1941, B. D. Burks, 1 larva. HURD, small stream: April 15, 1936, Ross & Mohr, many larvae. OAKWOOD: April 10, 1936, Ross & Mohr, 1 larva; May 6, 1936, Ross & Mohr, 2 larvae; May 7, 1936, Ross & Mohr, 1 larva. RANTOUL, temporary pond: April 10, 1936, Ross & Mohr, 1 larva. RED BUD: March 23, 1939, Ross & Burks, 2 larvae. SEYMOUR: March 20, 1929, H. H. Ross, 1 larva. WATSON: April 15, 1936, Ross & Mohr, 2 larvae; April 16, 1936, Ross & Mohr, 1 larva.

KEY TO SPECIES

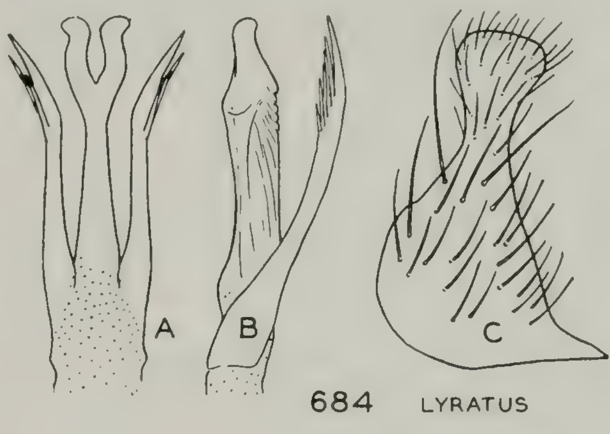
Adults

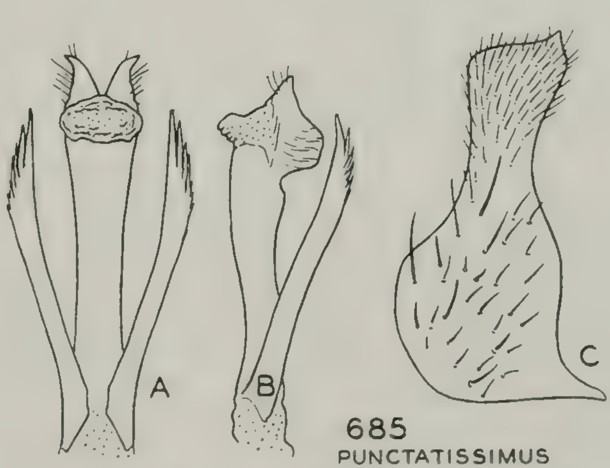
1. Maxillary palpi 3-segmented (males) 2
   Maxillary palpi 5-segmented (females) 3
2. Apex of aedeagus cleft and lyre shaped at apex, claspers rounded at apex, fig. 684 . . . . **lyratus**, p. 198
   Apex of aedeagus divided into a pair of bulging, sharp plates with a membranous dorsal pocket, claspers bluntly pointed at apex, fig. 685 . . . . **punctatissimus**, p. 197
3. Ninth and tenth tergites separated by a distinct, suture-like groove; ninth sternite without an internal plate ventrad of bursa copulatrix, fig. 686 . . . . **kaskaskia**, p. 198
   Ninth and tenth tergites fused and scarcely separable, fig. 687; ninth sternite with a round or rectangular internal plate ventrad of bursa, figs. 687, 688 4
4. Ninth sternite with an internal rectangular plate ventrad of bursa copulatrix, fig. 688 . . . . **punctatissimus**, p. 197
   Ninth sternite with internal plate much smaller and semicircular, fig. 687 . . . . **lyratus**, p. 198

Caborius punctatissimus (Walker)

Halesus punctatissimus Walker (1852, p. 17); ♂.

ADULTS.—Length 16–18 mm. Color almost uniformly yellowish brown, the front





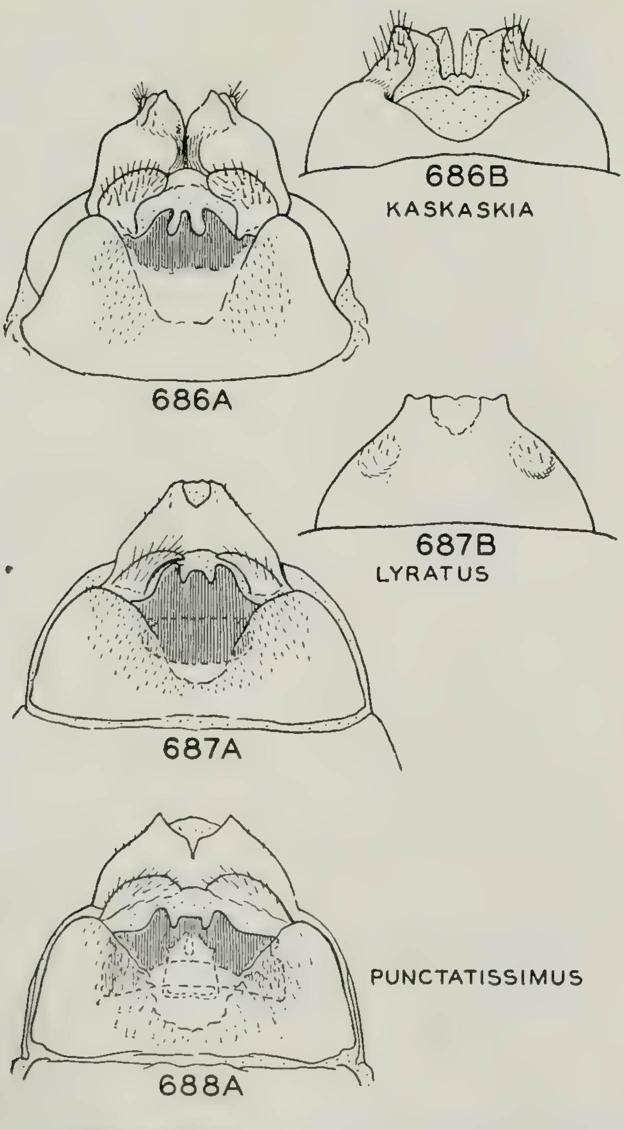
Figs. 684–685.—*Caborius*, male genitalia. *A*, aedeagus, ventral aspect; *B*, aedeagus, lateral aspect; *C*, clasper.

wings a darker bown with small, light dots scattered over the entire surface to give it a peppered look. Face with genae produced into sharp points. Male genitalia, fig. 685, with the claspers pointed at apex, the aedeagus with its extreme tip forming a pair of somewhat triangular lobes having a dorsal membranous fold. Female genitalia, fig. 688, with ninth and tenth tergites fused and with the ninth sternite bearing an internal, rectangular, sclerotized plate ventrad of the bursa copulatrix.

Allotype, female. — Columbia Crossroads, Pennsylvania: July 7, 1931, R. M. Leonard.

Our only Illinois record of this species is a female collected at Champaign, October 6, 1938, C. O. Mohr. Dr. Mohr captured this specimen in the grass and weeds at the edge of a small stream which forms the headwaters of the Embarrass River.

The species is widespread through the Northeast; definite records are available from Illinois, Indiana, Maryland, Michigan, New York, Nova Scotia and Ohio.



Figs. 686–688.—*Caborius*, female genitalia. *A*, ventral aspect; *B*, dorsal aspect.

Caborius lyratus Ross

Carborius lyratus Ross (1938*a*, p. 163); ♂.

ADULTS.—Length 16–18 mm. In color similar to *punctatissimus*, yellowish brown, the front wings darker brown with small light dots scattered over the entire surface. Face with genae not unusually produced. Male genitalia, fig. 684, with the claspers rounded at apex, the aedeagus with its extreme tip forming a divided, lyre-shaped fork without any dorsal membranous fold. Female genitalia, fig. 687, with ninth and tenth tergites fused and with the ninth sternite bearing an internal, semicircular, semisclerotized plate ventrad of the bursa copulatrix.

Allotype, female. — Oakwood, Illinois: Sept. 20, 1935, DeLong & Ross (this is the same data as for the holotype).

In Illinois this species has been taken only at Oakwood, the collection comprising the holotype and allotype, both bearing the data given above. *Caborius* larvae were collected in a small tributary of the Salt Fork near the point at which the adults were taken at lights. These larvae were not relocated in the fall after they had gone into aestivation and the stream had dried up. The range of the species is very poorly known, the only available records being from Illinois, Pennsylvania and Wisconsin.

Caborius kaskaskia new species

FEMALE.—Length 16 mm. Color light brown, the front wing slightly darker brown with small light dots scattered over the entire surface of the wing. General structure typical for the genus. Genitalia, fig. 686: subgenital plate with three processes, the lateral ones wide at base and tapering to a rounded apex; ninth and tenth segments separated on the dorsum by a sharp declivity; ninth segment with the apical portion divided from the base by a furrow; bursa copulatrix without a plate ventrad of it.

Holotype, female.—New Memphis, Illinois, along Kaskaskia River: Sept. 25, 1939, Frison & Ross.

Paratype.—Same data as for holotype, 1♀.

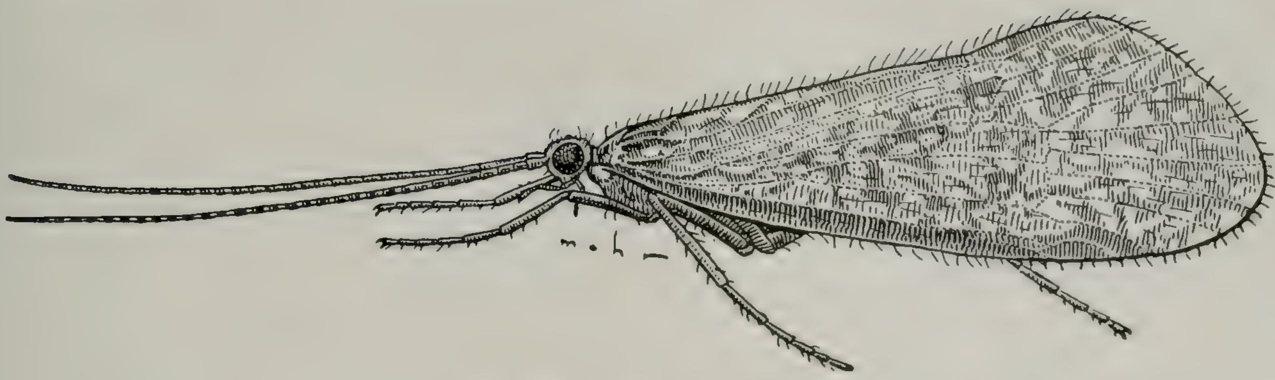


Fig. 689.—*Frenesia missa* ♀.

This species is distinguished from the others in the genus by characters given in the preceding key. It is represented only by the single collection of the type series. Considering the frequency with which the larvae are found, and the few records of the adults, there is every indication that we may have in this genus a more extensive fauna than has hitherto been considered. All our records for Illinois and Indiana were taken in September and October, a time when little general collecting is done for this order.

Chilostigma McLachlan

Chilostigma McLachlan (1876, p. 187). Genotype, monobasic: *Chilostigma sieboldi* McLachlan.

There is only one North American species in the genus, *areolatum*, described from "Arctic America," with records from Ontario and Labrador. It has never been taken in Illinois.

Frenesia Betten & Mosely

Frenesia Betten & Mosely (1940, p. 165). Genotype, by original designation: *Limnephilus difficilis* Walker.

Of the two North American species, only *missa* has been found in Illinois. The other species, *difficilis*, is eastern in distribution.

Frenesia missa (Milne)

Chilostigma missum Milne (1935, p. 35); ♂, ♀.

LARVA.—Length 11 mm. Head, thoracic sclerites and legs reddish brown, the head with only very indistinct lighter spots, the legs slightly lighter than the head. Pronotum with only a very indistinct transverse groove.

CASE.—Length 12 mm., constructed of small stones; slender, cylindrical and fairly rigid.

ADULTS.—Fig. 689. Length 13–14 mm. Head and body varying from almost black to various shades of brown; legs beyond coxae yellowish brown; wings with a ground color of brown with small, translucent dots scattered uniformly and abundantly over the entire surface, giving it a salt-and-pepper

Fig. 690.—*Frenesia missa*, male genitalia.

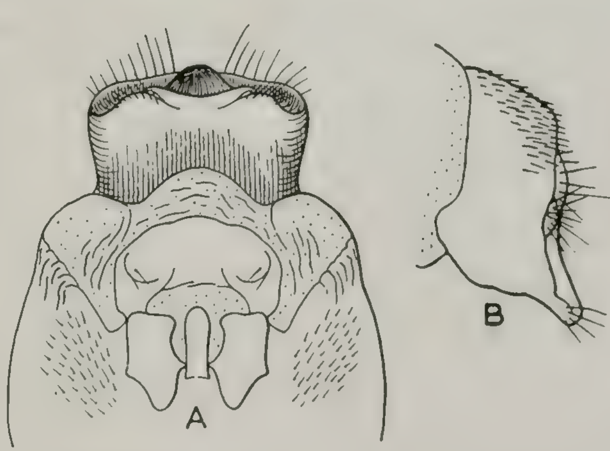


Fig. 691.—*Frenesia missa*, female genitalia. *A*, ventral aspect; *B*, lateral aspect.

appearance. Male genitalia, fig. 690, with tenth tergite forming a pair of appressed, heavily sclerotized, narrow plates angled sharply dorsad; cerci short and clavate; claspers small and padlike. Female genitalia, fig. 691, with the ninth segment appearing as a thick collar almost completely surrounding the tubular tenth, the cerci reduced to indistinct small cushions on the posterior margin of the "collar."

The eastern species, *difficilis*, is illustrated by Betten & Mosely (1940).

For years we were puzzled by two females of this species in the Illinois Natural History Survey collection labeled "Havana, Ill., November 8, 1912." Diligent search in the vicinity of Havana did not produce any caddis flies still on the wing at this date. Finally, however, a large series of the species was taken along a small, clear, springfed brook just south of Havana at Matanzas. At this time only a few cases were found in the stream. Continuing the search the next year, it was discovered that the larvae were congregated in a little seepage area near the bank and were thriving in water scarcely deep enough to cover their cases. Many of the individuals were feeding on leaves and twigs so that most of the insect and its case was actually out of water. Later we found that odd specimens would live in the stream itself; and, since the seepage areas frequently dried up, it is possible that this reservoir in the stream is chiefly responsible for the preservation of the species in this area.

The habits of this species certainly represent an intermediate stage between the typical caddis fly and one or two humus inhabiting species reported from Europe.

We have taken the species nowhere else in Illinois. The center of its range is apparently in the Northeast; records are available from the District of Columbia, Maryland, Massachusetts, Michigan, Minnesota, New Hampshire, New York, Pennsylvania and Virginia.

Illinois Records.—HAVANA, Matanzas Lake: Nov. 15, 1939, Ross & Burks, 5♂, 4♀, 5 mating pairs, many larvae; June 2, 1940, H. H. Ross *et al.*, many larvae; Sept. 30, 1940, Mohr & Burks, many larvae.

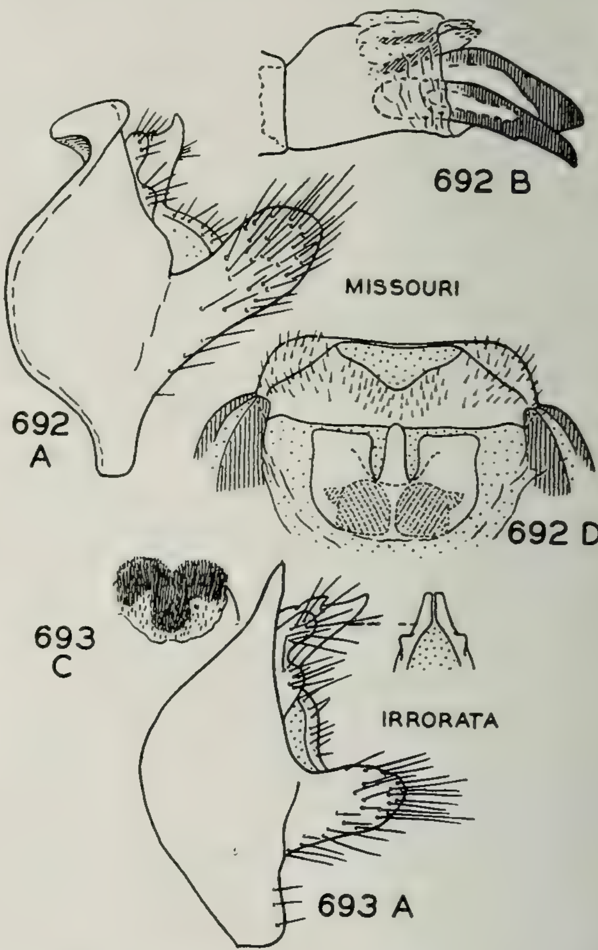
Glyphopsyche Banks

Glyphopsyche Banks (1904*c*, p. 141). Genotype, by original designation: *Glyphopsyche bryanti* Banks.

Contains only two species: *irrorata*, known from Arctic America, British Columbia and Ontario; and *missouri*.

Glyphopsyche missouri new species

LARVA.—Length 14 mm. Head, thoracic plates and coxae mostly black, with a few reddish blotches; trochanters dark red;



Figs. 692–693.—*Glyphopsyche*, genitalia. *A*, male, lateral aspect; *B*, aedeagus; *C*, spiny area of male eighth tergite; *D*, female, ventral aspect.

femora, tibiae and tarsi red with apical black band. Pronotum with short, stout black spines.

CASE.—Irregular and cylindrical, constructed of a mixture of stones and pieces of twigs.

MALE.—Length 11 mm. Color mottled shades of brown, without distinct pattern. General structure typical for the genus. Eighth tergite with a black cushion of short setae, the cushion divided into a mesal and two lateral lobes. Male genitalia, fig. 692, remarkably similar to *irrorata*, fig. 693. Tenth tergite short and sharp. Cerci bilobed and small. Claspers long and stout, with the apex slightly concave on mesal side.

Aedeagus short, with a ventral, bifid, sclerotized scoop and a pair of short, dorsal sclerotized spurs.

Female.—Similar to male in color and general structure. Genitalia, fig. 692, with small subgenital plate, the lateral lobes relatively narrow, the mesal tongue long; ninth and tenth segments fused to form a wide, very short, compressed tube with dorso-lateral expansions.

Holotype, male.—Meramec Springs, St. James, Missouri: Oct. 8, 1938, Ross & Burks.

Allotype, male.—Same data as for holotype.

Paratypes.—Same data as for holotype, 257♂, 44♀.

Known only from a single large colony at Meramec Springs, which are more in the nature of an underground river. This colony was located on September 29, 1938, by Frison & Yeager, who collected larvae and pupae and reported them literally paving spring and stream. Ross & Burks visited the spot a few days later and collected large numbers of all stages. The adults were found in floating beds of water cress; when the water cress was pushed under water the caddis fly adults came to the surface and were collected in large numbers.

The short wings of this species, fig. 631*A*, are very dissimilar to those of the genotype, fig. 631*B*, and suggest immediately that a new genus should be erected for this new species. The male genitalia, however, are so similar in the two forms that there is no doubt that *irrorata* and *missouri* are practically sister species.

Grensia new genus

Adults.—General structure typical for family. Head and mesonotum without unusually large macrochaetae. Mesoscutum with elongate oval warts. Tibial spur count 1-2-2. Front wings, fig. 631*C*, with stigma very wide and short, R_2 curving with stigma, gradually becoming closer to it, the two nearly or distinctly touching at apex; cord irregular, distinctly not in line with base of stigma; R_3 curving markedly. Hind wings typical for group.

Genotype.—*Limnephilus praeteritus.*

The only known representative is the genotype, recorded from Arctic portions of North America. It has not been taken in Illinois.

Phanocelia Banks

Phanocelia Banks (1943, p. 354). Genotype, by original designation: *Apatania canadensis* Banks.

The genotype, described from Manitoba, is the only known North American species in this genus, and has never been taken in Illinois. The female is not known, but the male is readily distinguished by the genitalia, fig. 694.

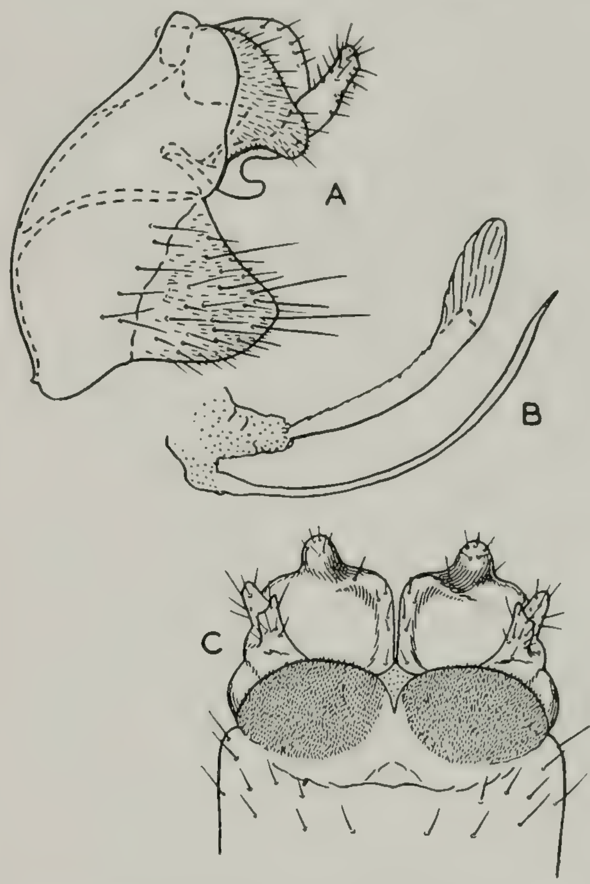


Fig. 694.—*Phanocelia canadensis*, male genitalia. *A*, lateral aspect; *B*, aedeagus; *C*, dorsal aspect.

Psychoglypha new genus

Adults.—General structure typical for family. Male palpi long and slender. Last tarsal segment of all legs without black spines. Dorsal macrochaetae of head not conspicuously longer or stouter than surrounding setae; area between and behind lateral ocelli bare except for a group of five or six silvery setae near each ocellus. Mesonotum with a pair of well-defined and ovate scutal warts; meso-scutellum with a pair of rows of five or six well-separated setae. Front wings as in fig. 633, with a distinct stigma which is usually colored red, the red extending past R_1 almost to R_2; the lower portion of the stigma is defined by R_1, which is abruptly sinuate at base of stigma and then curves evenly to the front margin of the wing; R_2 curves sharply toward R_1 and follows parallel to it to the front margin of the wing; the wing is very long and narrow and characterized by a silvery streak which runs through the first and second R_5 cells, usually with a short spur into cell M_1.

Genotype.—*Glyphopscyche avigo.*

This genus contains most of the species which have previously been placed in *Glyphopsyche,* the genotype of which does not belong here.

Most of the species are western or Subarctic in distribution. None have been taken in Illinois. One, *subborealis,* occurs in the eastern states and has been taken as far south as central Michigan.

Drusinus Betten

Drusinus Betten (1934, p. 359). Genotype, by original designation: *Drusinus uniformis* Betten.

In this genus the front wings are broad and anal cells large. The genotype is the only species so far collected in Illinois. The larva of the genus is unknown.

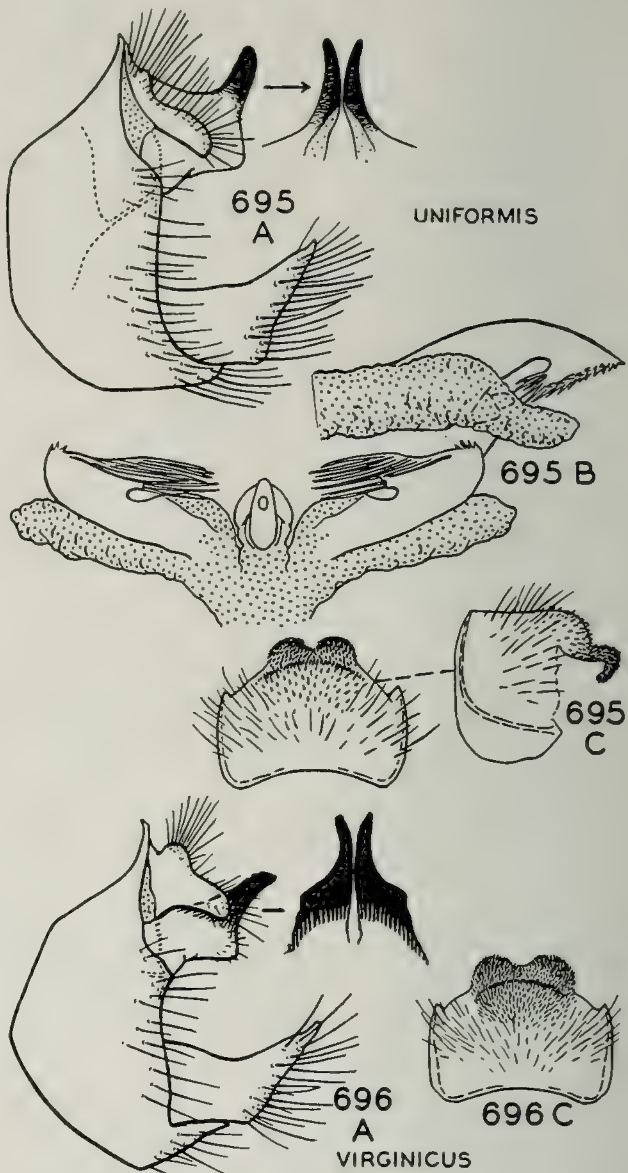
Drusinus uniformis Betten

Drusinus uniformis Betten (1934, p. 360); ♂, ♀.

ADULTS.—Length 14–16 mm. Color brown, dorsum darker, front wings with a distinctly purplish cast over the brown. Tibiae and tarsi with numerous black spines. Eighth tergite of male with a bilobed cushion of black, peglike setae. Male genitalia, fig. 695, with elongate cerci and stocky tenth tergite which is divided and upturned to form a pair of black, narrow, sclerotized processes. Female genitalia simple, with no long processes.

The male genitalia are very similar in general structure to those of *virginicus*; in this latter species, however, the cerci are larger, and the lateral apical processes of the tenth tergite are developed into a distinct shoulder at base, fig. 696.

Our only Illinois collection of this species was made at Elgin, along one of the small spring-fed brooks in the Botanical Gardens, June 6, 1939, Burks & Riegel, 1 ♂, 1 ♀. To date we have not found the larva of this species.



Figs. 695–696.—*Drusinus,* male genitalia. *A,* lateral aspect; *B,* aedeagus; *C,* eighth tergite.

Little is known regarding the range of the species. It is apparently widespread but local, as evidenced by the scattered available records from Illinois, New York and Tennessee.

Neophylax McLachlan

Neophylax McLachlan (1871, p. 111). Genotype, monobasic: *Neophylax concinnus* McLachlan.

Acronopsyche Banks (1930*b*, p. 227). Genotype, by original designation: *Acronopsyche pilosa* Banks.

In addition to characters mentioned in the key, the short, triangular front wings are characteristic of the adults. The larva has a unique long head and usually lacks the prosternal horn.

The genus is represented in the eastern states by many species, but we have taken only one in Illinois. Two others occur in nearby states and have been included in the key.

The biology of the genus in this latitude is unique in having a long aestivation period, the larvae usually maturing early in the spring, and the adults emerging late in autumn. All three species treated here have been reared, but no satisfactory key characters have been found to separate the larvae.

KEY TO SPECIES

Adults

1. Maxillary palpi 3-segmented (males) 2
   Maxillary palpi 5-segmented (females) 4
2. Claspers with a long, curved, heavily sclerotized mesal arm, fig. 697.......................... **autumnus**, p. 203
   Claspers without a heavily sclerotized arm, at most with a mesal flange as in fig. 698....................... 3
3. Claspers long, wide apart at base, with a mesal flange, fig. 698; ninth sternite slightly incised on meson............................ **ayanus**, p. 205
   Claspers short, close together, without a mesal flange, fig. 699; ninth sternite with a short, truncate mesal projection.............. **fuscus**, p. 205
4. Subgenital plate with 2 pairs of prominent lobes, fig. 700... **autumnus**, p. 203
   Subgenital plate with a mesal, spatulate style and a pair of low, lateral lobes, fig. 701........................... **fuscus**, p. 205; **ayanus**, p. 205

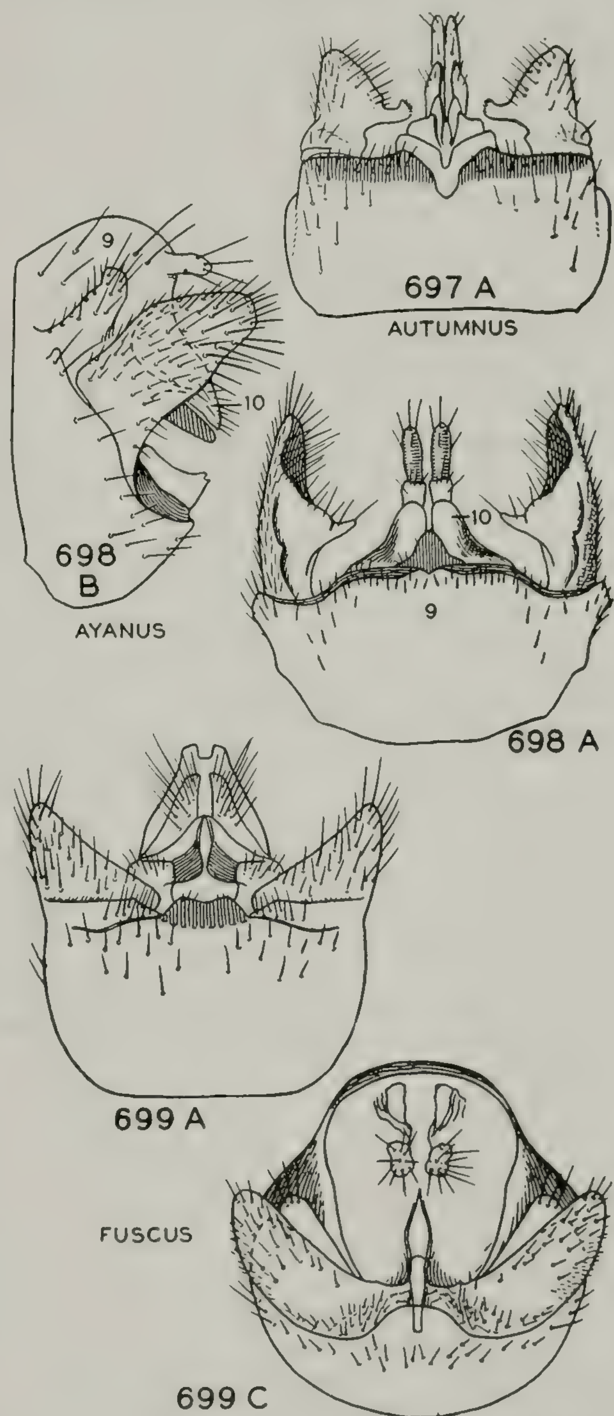
Neophylax autumnus Vorhies

Neophylax autumnus Vorhies (1909, p. 669); ♂, ♀, larva.

Larva.—Length 8–9 mm. Head varying from reddish brown to blackish brown, sometimes with a paler mesal stripe and always with round pale spots on dorsal portion. Thoracic sclerites and legs brownish yellow with narrow black areas along some sutures. Head long, malar space twice as long as distance from eye to top of head; upper portion of frons produced into a low but definite hump; antennae situated on a slight protuberance. All legs the same shape, the front ones only slightly modified for grasping. Pronotum velvety and produced into a rounded anterior portion under which the head may be retracted. Gills single and short. Sternites 3, 4 and 5 with an oval sclerotized ring.

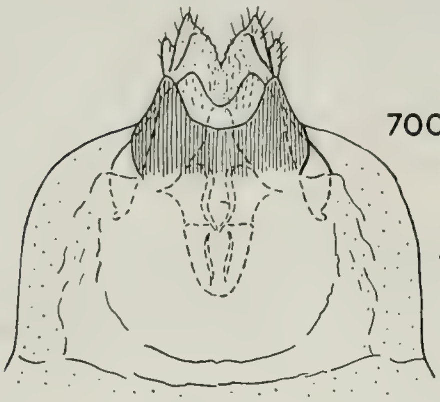
Case.—Length 8–10 mm. Constructed of stones, slightly curved, nearly cylindrical, with larger stones situated along each side to give it a broadened appearance. Before aestivation, the anterior portion of the case is capped with a single flat stone, around the edge of which are small vents.

Adults.—Fig. 702. Length 9-12 mm. Head and body brownish yellow; front wings fairly dark brown with irregular, small, lighter areas scattered over most of



Figs. 697–699.—*Neophylax*, male genitalia. *A*, *B* and *C*, respectively ventral, lateral and caudal aspects.

the surface and with a pair of large, yellow marks along the posterior margin; in repose these two yellow marks form a double, diamond-shaped, mesal pattern. Male genitalia, fig. 697, with ninth and tenth tergites both narrow and beaked, ninth sternite nearly truncate, and claspers short with a long, sclerotized, constricted mesal arm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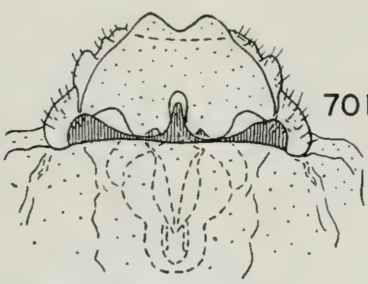
AUTUMNUS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FUSCUS

Figs. 700–701.—*Neophylax*, female genitalia.

which is enlarged at tip; aedeagus simple and tubular. Female genitalia, fig. 700, with ninth and tenth segments narrow and small, subgenital plate wide and with two pairs of fairly long projections.

This species has been found in the northern portion of Illinois and also in the Ozark Hills streams of southern Illinois. In both areas it is confined to small, clear and rapid streams with predominantly rock bottoms. In all areas but one, adults and pupae have been taken only late in the year, from September into October. The one exception was a large colony in Split Rock Brook at Utica, where the adults emerged in large numbers in April. The reason for this deviation from the usual seasonal cycle we do not know, but it is the only record of adults in the spring for the entire genus anywhere on the continent.

Of unique interest is the adaptation of this species to streams which become dry in summer, such as those in the Ozark Hills. In these situations the larvae mature at least by April, fasten their cases under stones and aestivate until autumn; in September the larvae change to the pupae, and shortly thereafter the adults emerge. When the stream becomes dry, a very high proportion of the aestivating larvae die from desiccation, but those which are situated under a rock which remains even slightly damp are able to survive and mature. We have observed successful emergence of the adults at Herod when the stream was still dry, the pupae leaving the moist cases with no mishaps. After a stream has been dry for a spring and summer, it is startling to find that the next spring, when it is again a rapid stream, the rocks are almost covered with the larvae of this species.

The species has not been taken very frequently, but the records are scattered through most of the Northeast; records include Illinois, Michigan, New York, Ontario and Wisconsin.

It has been suggested by Betten and others that this species might be the same as the genotype, which was described from New York. It certainly is closely related to the genotype, *concinnus*, but until information is available regarding the type, it seems advisable to treat the two as distinct.

Illinois Records.—Alto Pass, Union Spring: Oct. 18, 1938, Ross & Burks, many pupae and larvae; March 23, 1939, Ross & Burks, many larvae; May 26, 1940, Mohr & Burks, many larvae; May 31, 1940, B. D. Burks, many larvae; May 12, 1939, Burks & Riegel, many larvae. Belvidere, Kishwaukee Creek: June 18, 1938, B. D. Burks, 1 larva. Dundee: May 23, 1939, Burks & Riegel, many larvae. Elgin: April 19, 1939, Burks & Riegel, 1 larva; May 9, 1939, Ross & Burks, 6 larvae; Sept. 19, 1939, Ross & Mohr, 1 ♂, 1 ♀; preceding Elgin records are from Botanical Gardens; Trout Spring, March 7, 1940, Burks & Mohr, 5 larvae. Herod, Gibbons Creek: March 28, 1935, Ross & Mohr, 2 larvae; May 29, 1935, Ross & Mohr, many larvae; Aug., 1936, Ross & Burks, many larvae; April 19, 1937, 4 larvae; Sept. 11, 1937, H. H. Ross, 4 larvae; Oct. 3, 1937, Ross & Burks, many larvae, pupae and pupal skins; and the following specimens which were reared, emerging on the dates shown: Oct. 8, 1937, Ross & Burks, 5 pupae; Oct. 18, 1937, 1 ♂, 1 ♀; Oct. 21, 1937, 3 ♂; Oct. 25, 1937, 1 ♀; Oct. 29, 1937, 6 ♀; Nov. 1, 1937, 1 ♂; Nov. 2, 1937, 2 ♂; Nov. 3, 1937, 1 ♀; Nov. 5, 1937, 2 ♂. LaRue, McCann Spring:

Oct. 17, 1938, Ross & Burks, 8 larvae; March 23, 1939, Ross & Burks, many larvae and pupae. Spring Grove: May 14, 1936, Ross & Mohr, many larvae; June 12, 1936, Ross & Burks, many larvae. Starved Rock State Park: April 25, 1933, Frison & Mohr, 1 larva. Utica, Split Rock Brook: Feb. 1, 1941, Frison, Ries & Ross, many larvae, 1 pupa; April 25, 1941, T. H. Frison, 1 ♂, many larvae and pupae.

Neophylax fuscus Banks

Neophylax fuscus Banks (1903*b*, p. 242); ♂, ♀.

Not yet taken in Illinois, but found in the Meramec River near Steelville, Missouri, which is west of St. Louis and not far from Illinois. In addition to Missouri, the species is known from Michigan, New Hampshire and Virginia. The species recorded as *fuscus* by Betten (1934) is not *fuscus* but a species identical with or closely related to *stolus*.

Neophylax ayanus Ross

Neophylax ayanus Ross (1938*a*, p. 168); ♂, ♀.

Not yet taken in Illinois. The only records for this species are from Louisville, Kentucky, and Cataract, Indiana; the latter is only about 40 miles from the Illinois line, near Terre Haute.

MOLANNIDAE

This family is represented in the Illinois fauna by only one genus, *Molanna*. The genus *Beraea* has frequently been placed in the family Molannidae but is treated as a separate family in this paper.

Molanna Curtis

Molanna Curtis (1834, p. 214). Genotype, monobasic: *Molanna angustata* Curtis.

Apatania Kolenati (1848, p. 75). Genotype, monobasic: *Phryganea vestita* Zetterstedt.

The larva of this genus, fig. 709, is characterized by the long frons, antennae of medium length situated above base of mandibles, and the curious, reduced hind tibia and claw. The curious, flanged case, fig. 710, is also characteristic of the genus, although a similar case is made by some species of *Athripsodes* (see p. 228). The adults have the maxillary palpi five segmented in both sexes. When at rest the adults sit with the wings curled around the body and with the body held at an angle to the surface upon which the insect rests, its mottled gray color giving the insect in this position a remarkable resemblance to a rusty nail head or a very small twig.

Five North American species are known, of which three have been taken in Illinois, and it is quite possible that stray specimens of the other two may eventually turn up from this state.

No characters have yet been discovered to give certain identification of the females and larvae. For this reason it is necessary to disregard for the present the species *cinerea*, represented by the female type of which only fragments remain.

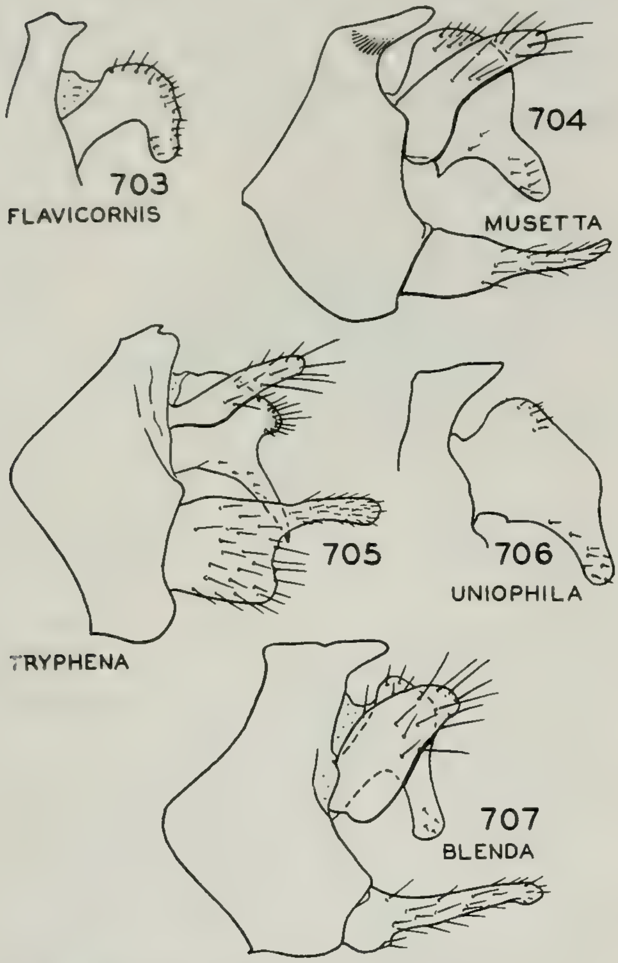
Fig. 702.—*Neophylax autumnus* ♂.

KEY TO SPECIES

Males

1. Femora and tibiae yellow, except for indefinite areas on femora, contrasting sharply with coxae; tenth tergite forming a simple hook, fig. 703 .... **flavicornis**, p. 208
   Coxae and femora the same color, dark

brown or gray; tenth tergite with dorsal or beaklike expansions, figs. 704–707 2



Figs. 703–707.—*Molanna*, male genitalia.

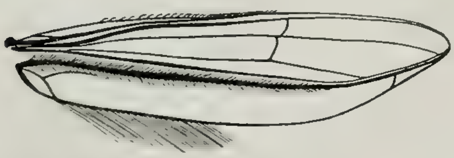


Fig. 708.—*Molanna musetta*, hind wing.

2. A long furrow of black scales in hind wings, fig. 708. . . . . **musetta**, p. 207
   No furrow of scales in hind wings 3
3. Lateral aspect of tenth tergite with a long, pointed, ventral process, fig. 705, and with a small dorsal lobe. . . . . **tryphena**, p. 207
   Lateral aspect of tenth tergite rounded at apex and with a larger or less definite dorsal lobe, figs. 706, 707. . 4
4. Tenth tergite with large dorsal lobe and small ventral lobe, fig. 706. . . . . **uniophila**, p. 206
   Tenth tergite with small dorsal lobe and very long, truncate ventral lobe, fig. 707, shaped like a duck's bill. . . . . **blenda**, p. 208

Molanna uniophila Vorhies

Molanna uniophila Vorhies (1909, p. 705); larva, pupa, ♂, ♀.

LARVA.—Fig. 709. Length 18 mm. Head, pronotum and legs yellow, head with a Y-shaped black mark, posterior portion of pronotum black; mesonotum brown, subdivided by an irregular line into an anterior and posterior portion. Head long, frons also long, the anterior portion not expanded. Mandibles short and stocky with three teeth along apical margin. Gula almost rectangular, longer than wide. Mesonotum with a semicircular, small antero-mesal plate, the remaining membranes with a lateral tuft of long setae. Gills long and filiform, most of them triple, those on the second and third abdominal tergites with five branches. Lateral line forming a fringe on segments 3–7, eighth segment with a sinuate lateral line

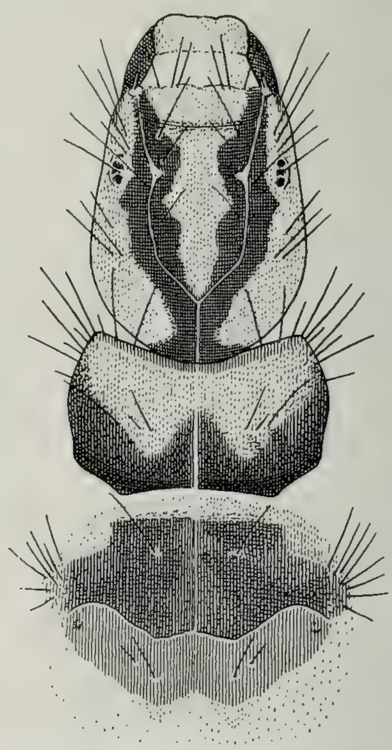


Fig. 709.—*Molanna uniophila* larva.

divided into an anterior portion of branched, short, appressed hairs and a posterior portion of about eight very long double hairs. Anal hooks large with one or two dorsal teeth.

CASE.—Fig. 710. Length 25 mm. Width 11–13 mm., the lateral margins built out into wide flanges so that the entire dorsal surface is uniformly convex and formed of sand and gravel; the ventral aspect has the middle tube made of fine grains.

ADULTS.—Length 16 mm. Body and appendages various shades of brown and gray, the wings with light areas in the middle forming a more or less checkered pattern. Male genitalia, fig. 706: tenth tergite somewhat hood shaped, produced into a short, rounded beak at apex; claspers with a small basal portion which merges gradually into a long, apical blade; at the extreme base of

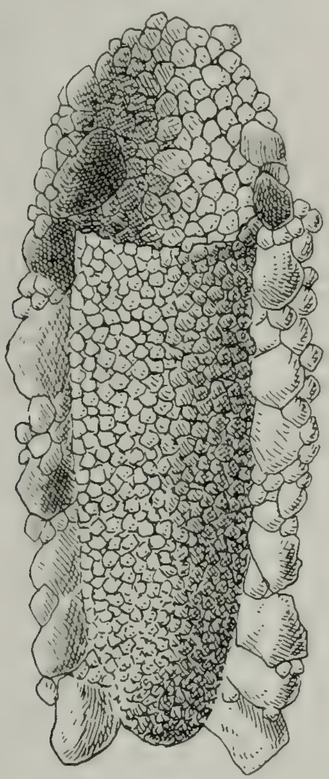


Fig. 710.—*Molanna uniophila*, case.

the clasper there arises a short, mesal, flat process bearing short setae at its apex; aedeagus tubular and slightly curved, containing an eversible group of long spines. Female genitalia very simple, bursa copulatrix small and without complicated structures.

In Illinois this species has been collected only in the glacial lakes and connecting streams in the northeastern part of the state. In these localities the larvae are found on gravel bars where they may occur in large local colonies. Our adult records are all for May and June, indicating a single generation per year.

The curious case of this insect has been the cause of frequent remarks by students of aquatic insects. Vorhies reared this species from Wisconsin, and we have reared it from Channel Lake, Illinois.

The range of the species is extensive through the Northeast. Records are available for Michigan, Minnesota, New Brunswick, New York, Ohio, Pennsylvania, Quebec and Wisconsin.

Illinois Records.—ANTIOCH: July 1, 1931, Frison, Betten & Ross, 1 ♂; July 6, 1932, Frison *et al.*, 6 ♂; June 11, 1936, Ross & Burks, ♂ ♂, ♀ ♀; June 12, 1936, Ross & Burks, 2 ♂, 1 ♀. CHANNEL LAKE: May 16, 1936, Ross & Mohr, many pupae which were reared, adults emerging June 1–3, 1936, Urbana; May 27, 1936, H. H. Ross, ♂ ♂, ♀ ♀, many pupae, larvae and cases; May 31, 1938, Mohr & Burks, 1 larva. FOURTH LAKE, Lake County: Aug. 2, 1887, C. A. Hart, 1 ♂. FOX LAKE: June 30, 1935, DeLong & Ross, ♂ ♂, ♀ ♀; May 28, 1936, H. H. Ross, 3 ♂; June 10, 1936, Ross & Burks, 1 ♂, 1 ♀. GRASS LAKE: July 14, 1926, Frison & Hayes, 1 ♂. JOHNSBURG, Fox River: May 28, 1936, H. H. Ross, ♂ ♂, 3 ♀. ROUND LAKE: June 26, 1936, at light, Frison & DeLong, ♂ ♂, ♀ ♀. SAND LAKE: June 17, 1893, Hart & Shiga, 1 ♂. SOUTH CHICAGO: June 9, 1880, 1 ♂. ZION, Dead River: May 20, 1940, Mohr & Burks, 2 larvae.

Molanna musetta Betten

Molanna musetta Betten (1934, p. 248); ♂.

LARVA.—Unknown.

ADULTS.—In size, color and general structure similar to *uniophila.* Hind wing with a long, arcuate, conspicuous furrow of scales running from the apical corner down below the middle and to the base of the wing, fig. 708. Male genitalia almost identical with *uniophila*, the tenth tergite with the dorsal portion larger, fig. 704.

We have only one record of this species for Illinois, a male collected along the Kankakee River at Wilmington, August 20, 1934, DeLong and Ross. This species apparently has a scattered range through the Northeast with a southwestward extension through the Ozarks into Oklahoma. We have records from Illinois, New York, Oklahoma and Ontario.

Molanna tryphena Betten

Molanna tryphena Betten (1934, p. 248); ♂, ♀.

Not yet taken in Illinois. This species occurs in Michigan, New York and Wisconsin. Dr. Betten (1902) has reared it in New York, recording it as *cinerea.*

Molanna blenda Sibley

Molanna blenda Sibley (1926*b*, p. 105); larva.
Molanna blenda Betten (1934, p. 245); ♂, ♀.

LARVA.—Very similar to that of *uniophila.* Sibley's illustrations indicate that the pronotum is darker, but since there is some variation of this character in *uniophila,* it is doubtful whether this is a safe criterion for identification.

ADULTS.—Length 10–11 mm. Similar in general appearance to those of *uniophila.* Front wings of male with a wide furrow running through the length of the wing, the furrow filled with scales. Male genitalia, fig. 707, similar in general structure to those of *uniophila* but with the tenth tergite shaped more like a duck's head and bill, the apico-ventral projection long and almost truncate.

We have only one Illinois record for this species, a male collected along one of the spring-fed brooks in the Botanical Gardens at Elgin, June 13, 1939, Frison & Ross. Aside from Illinois, records are available only for New York and Wisconsin.

Molanna flavicornis Banks

Molanna flavicornis Banks (1914, p. 261); ♂, ♀.

This species has not yet been taken in Illinois but has been recorded only a few miles away at Madison, Wisconsin. This species is common through the northern part of the continent with a distinct preference for lakes. Records are available for Colorado, Manitoba, Michigan, Minnesota, New York, Quebec, Saskatchewan, South Dakota and Wisconsin.

BERAEIDAE

Contains only the genus *Beraea.* No larvae of this family have been recognized from North America, the key characters used here being taken from Ulmer (1909).

Beraea Stephens

Thya Curtis (1834, p. 216); preoccupied.
Beraea Stephens (1836, p. 158). Genotype, by present designation: *Beraea marshamella* Stephens = *pullata* (Curtis).

Only two species of the genus have been found in North America, and neither of these in Illinois. Banks described the first, *nigritta,* from Long Island, New York.

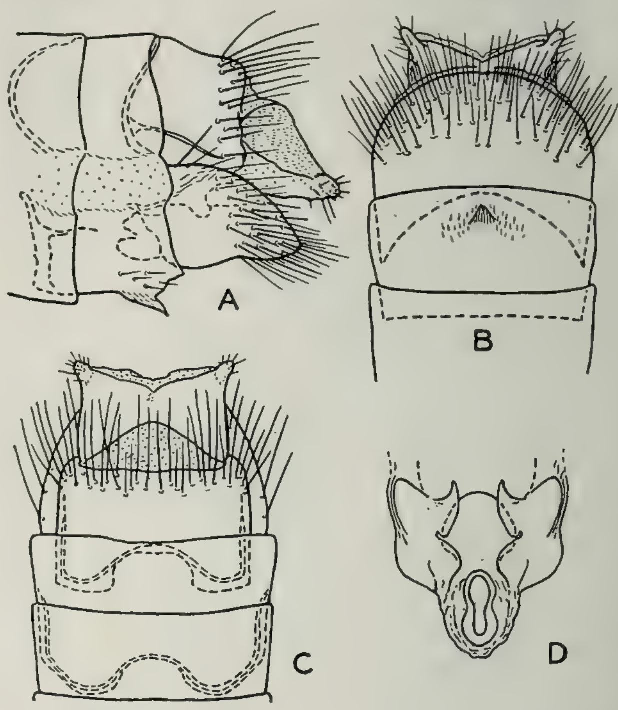


Fig. 711.—*Beraea nigritta,* female genitalia. *A, B* and *C,* respectively lateral, ventral and dorsal aspects; *D,* bursa copulatrix.

The original collection consisted of females, and no other specimens have been found from that vicinity. The female genitalia, fig. 711, resemble those of the Molannidae and Odontoceridae in general structure. Recently a male of this genus was received from Georgia, and, since it cannot be associated definitely with *nigritta,* it is described as new.

Beraea gorteba new species

MALE.—Length 5 mm. Head and thorax brown; appendages yellowish or paler, covered with brown hair, the legs with black spines; wings hyaline with brown hair. General structure typical for family; maxillary palpi cylindrical and very hairy, five segmented, the first half as long as the second, the remainder subequal; tibial spur formula

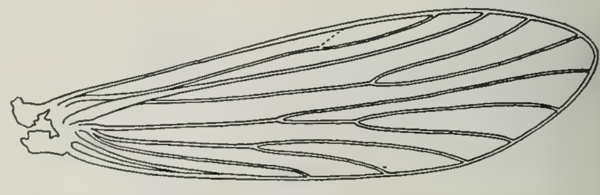


Fig. 712.—*Beraea gorteba,* front wing.

2-2-4, leg spines as in fig. 69; wing venation reduced, front wing, fig. 712, with radial sector only two branched, hind wing narrow with a wide, curved band of black scales extending above cubitus along the basal two-thirds of the wing; seventh sternite of abdomen with a mesal, sclerotized process, eighth sternite with a band of hair along apex.

Male genitalia, fig. 713: tenth tergite divided down meson to form a pair of long,

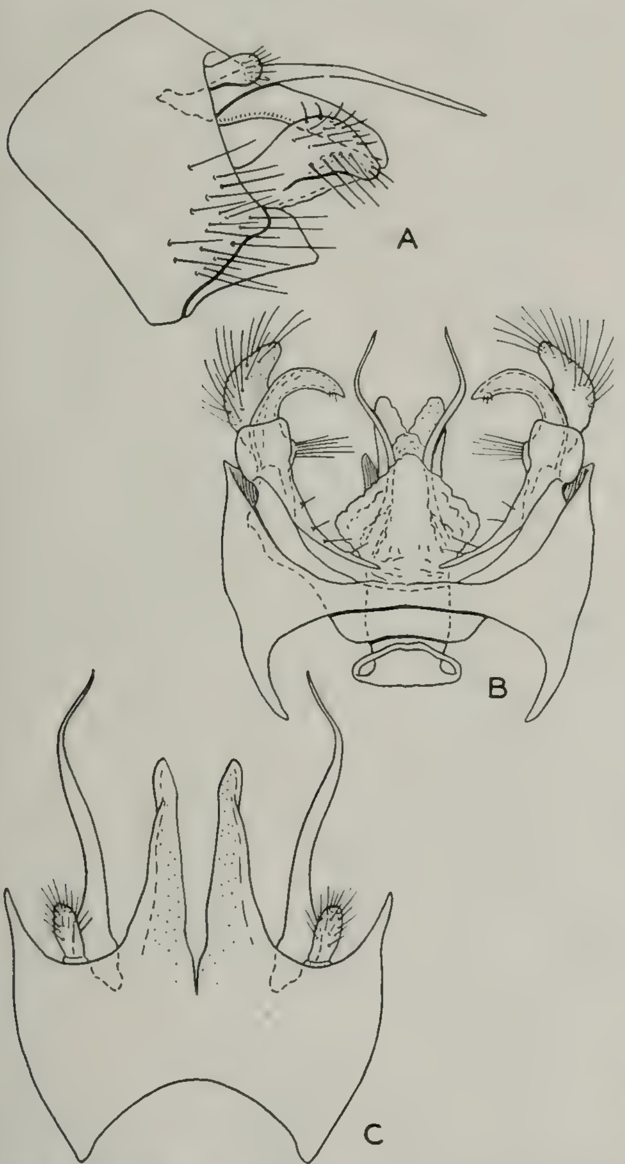


Fig. 713.—*Beraea gorteba*, male genitalia. *A*, lateral aspect; *B*, ventral aspect; *C*, dorsal aspect.

pointed, semimembranous lobes; arising near its base are a pair of long, sclerotized, sinuate rods and a pair of short, ovate cerci; claspers complex, their base fused on meson, apex comprised of (1) a quadrate ventral plate which is produced into a long, curved basal filament, (2) a stout hook which bears a small cushion of setae on the mesal margin near base and (3) a curved, membranous dorsal lobe which bears long setae; aedeagus short, its extreme base vasiform, the apical portion forming a wide, convoluted ventral area with a pair of slender sclerotized styles, a pair of short membranous lobes and a pair of sclerotized dorsal lobes.

Holotype, male.—Five miles southeast of Roberta, Georgia: May 8, 1939, P. W. Fattig.

This species is similar in general structure to *nigritta*, differing in having smaller anterior warts on the head, only a very short epicranial stem on the head, and the anterodorsal angle of the head much less produced than in *nigritta*. Additional material may show these characters to be only antigenetic.

ODONTOCERIDAE

The genus *Psilotreta* is the only representative of this family in the eastern states. It contains a number of species which are treated on page 285 and following.

CALAMOCERATIDAE

The family is represented in the eastern states by two species: *Ganonema americanum*, a brown to black species with five-segmented maxillary palpi, known from the eastern and northeastern states; and *Anisocentropus pyraloides*, an orange-brown species with six-segmented maxillary palpi, known only from Georgia. The larvae of *Ganonema* make a case by hollowing out a solid piece of twig (Lloyd 1915*b*).

LEPTOCERIDAE

All the larvae in this family make cases, using a variety of materials and constructing cases of various shapes. The adults are slender, frequently exceedingly so, and have long, slender antennae. The maxillary palpi are similar and five segmented in both sexes.

This family is well represented in Illinois, and various genera and species occur in a wide variety of streams, ponds and lakes. At times large swarms of *Oecetis* and *Athripsodes* occur along large rivers, such as the Ohio and Illinois. Their most conspicuous numbers, however, occur in the glacial lakes of the northeastern part of the state (see p. 10). Here they form the dominant part of the caddis fly fauna.

Representatives of all seven Nearctic genera occur in Illinois. A large number of the species are widespread, some of them Holarctic. It is certain that a study of the Holarctic fauna of this family will show a good many more of the names based on North American material to be synonyms of European or Asiatic names.

In the entire family the pupal chamber has a slit and not a mesh in the closing cap at both ends. Through these slits the pupa pushes out all the larval sclerites, so that it is impossible to get associations of adult structures and larval sclerites in the same case. For this reason it is necessary to rear larvae in cages in order to associate immature and adult stages.

KEY TO GENERA

Larvae

1. Middle legs with claw stout and hook shaped, tarsus bent, fig. 714; case transparent........**Leptocerus**, p. 212
   Middle legs with claw slender, slightly curved, tarsus straight, fig. 715; case seldom transparent.......... 2
2. Maxillary palpi nearly as long as stipes, fig. 717; mandibles long, sharp at apex, the teeth considerably below apex..................**Oecetis**, p. 236
   Maxillary palpi short, about half length of stipes, fig. 718; mandibles shorter, blunt at apex, the teeth near or at apex.................. 3
3. Head with a suture-like line paralleling the epicranial arms, fig. 764.... ....**Athripsodes**, p. 221
   Head without a suture-like line in addition to the epicranial arms, fig. 811 4
4. Mesonotum membranous with a pair of sclerotized, narrow, curved or angled bars, figs. 764, 769........ ....**Athripsodes**, p. 221
   Mesonotum without such a pair of sclerotized bars, fig. 836........... 5
5. Anal segment developed into a pair of sclerotized, concave plates, with spinose dorso-lateral and mesal carinae, and an overhanging ventral flap, fig. 719..........**?Setodes**, p. 256
   Anal segment convex and without carinae between anal hooks, fig. 720.. 6
6. Hind tibiae entirely sclerotized, without a fracture in middle, fig. 716; abdomen without gills............ ....**Leptocella**, p. 213
   Hind tibiae with a fracture near middle which appears to divide tibiae into two segments, fig. 715; abdomen with at least a few gills........... 7

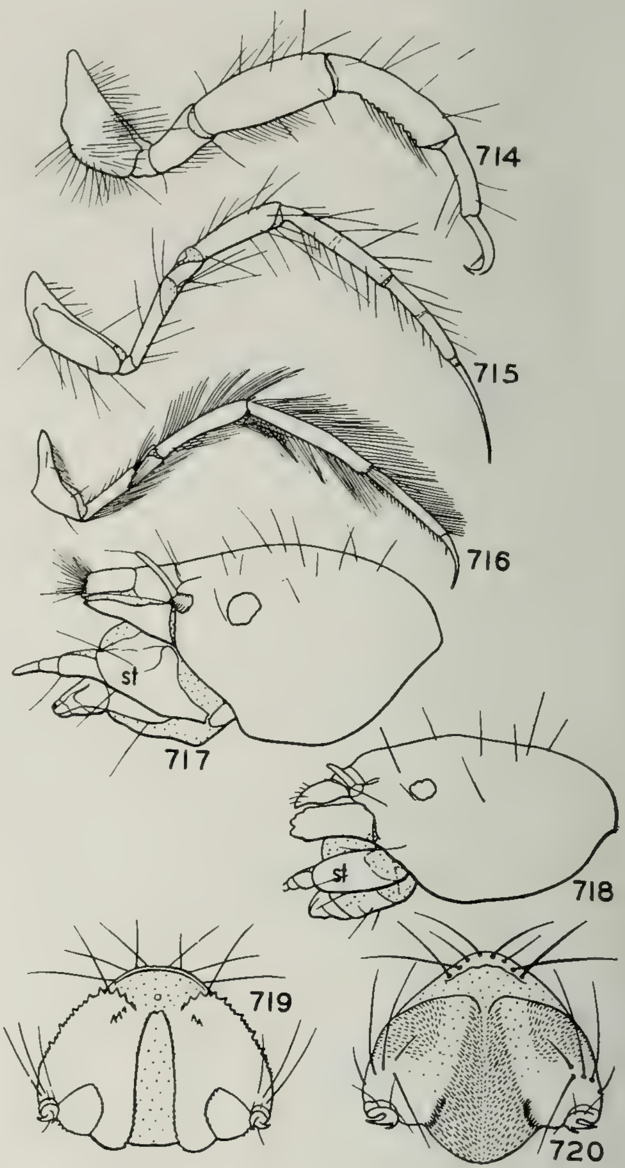
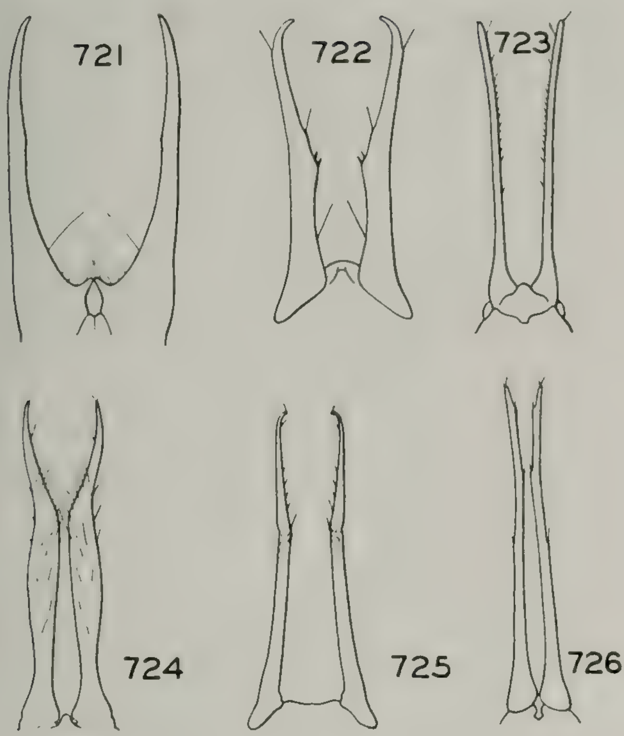


Fig. 714.—*Leptocerus americanus* larva, middle leg.
Fig. 715.—*Mystacides sepulchralis* larva, hind leg.
Fig. 716.—*Leptocella candida* larva, hind leg.
Fig. 717.—*Oecetis cinerascens* larva, head; *st*, stipes.
Fig. 718.—*Leptocella candida* larva, head; *st*, stipes.
Fig. 719.—*Setodes* sp. larva, anal segment.
Fig. 720.—*Mystacides sepulchralis* larva, anal segment.

7. Hind tibiae with a regular fringe of long hair, as in fig. 716........... ....**Triaenodes**, p. 244
   Hind tibiae with only irregularly placed hairs, fig. 715............ ....**Mystacides**, p. 253

Pupae

1. Anal appendages wide at base with a sharp mesal corner, the apex tapering gradually to a sharp point, fig. 721................**Leptocerus**, p. 212



Anal Appendages of Pupae

Fig. 721.—*Leptocerus americanus.*
Fig. 722.—*Athripsodes tarsi-punctatus.*
Fig. 723.—*Oecetis inconspicua.*
Fig. 724.—*Triaenodes tarda.*
Fig. 725.—*Mystacides sepulchralis.*
Fig. 726.—*Leptocella* sp.

Mandibles of Pupae

Fig. 727.—*Leptocerus americanus.*
Fig. 728.—*Triaenodes tarda.*
Fig. 729.—*Oecetis inconspicua.*
Fig. 730.—*Athripsodes tarsi-punctatus.*
Fig. 731.—*Mystacides sepulchralis.*
Fig. 732.—*Leptocella* sp.

Anal appendages with the base narrow; shoulder, if present, situated at the middle, fig. 722. 2

2. Mandibles with a definite area of teeth below the apical point, fig. 730; frequently stocky and triangular. 3
   Mandibles without teeth, sometimes with the apex minutely serrate, fig. 731; always with blade very narrow 5
3. Anal appendages slender, straight and of uniform thickness throughout, fig. 723. . . . . **Oecetis**, p. 236
   Anal appendages with a distinct shoulder at or near middle, beyond which the apex tapers evenly to a sharp point, fig. 722. 4
4. Mandibles with apex long and slightly twisted, teeth small and situated on a slight convex bulge, fig. 728. . . . . **Triaenodes**, p. 244
   Mandibles with apex shorter and straight, either the teeth situated within an angulation or curve, fig. 730, or mandible short and triangular. . . . . **Athripsodes**, p. 221
5. Mandibles with a large, bulbous base, the apical blade minutely serrate and little longer than base, fig. 731. . . . . **Mystacides**, p. 253
   Mandibles with base small, blade long and slender, not serrate, fig. 732. . . . . **Leptocella**, p. 213

Adults

1. Front wings with stem of M atrophied, leaving only two main veins between convex R_1 and convex Cu_1, fig. 733 . . . . **Triaenodes**, p. 244
   Front wings with stem of M present, so that three main veins are present

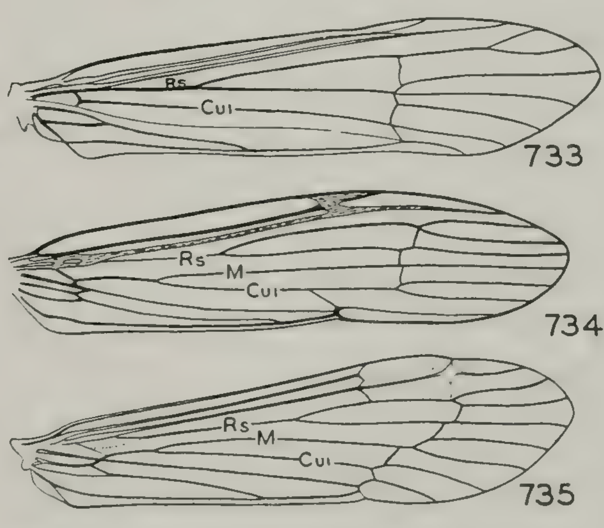


Fig. 733.—*Triaenodes injusta*, front wing.
Fig. 734.—*Oecetis inconspicua*, front wing.
Fig. 735.—*Mystacides sepulchralis*, front wing.

between convex R_1 and convex Cu_1, fig. 734 2

2. M apparently not branched, fig. 734 . . . . **Oecetis**, p. 236

M obviously branched, fig. 735 3

3. Epicranial stem distinct, lateral sutures absent or indistinct, fig. 736; katepisternum constricted at apex, fig. 739 4

Epicranial stem absent or indistinct, lateral sutures well marked, fig. 738; katepisternum truncate at apex, fig. 740 5

4. Dorsal triangle of head small, epicranial stem long, fig. 737; color whitish, straw yellow or light brown . . . . **Setodes**, p. 256

Dorsal triangle of head large, epicranial stem short, fig. 736; color very dark brown or bluish black, including wings . . . . **Mystacides**, p. 253

5. Meso-epimeron membranous nearly to ventral margin, fig. 740; hind wings with most of R_s and its branches atrophied; ground color white . . . . **Leptocella**, p. 213

Meso-epimeron with a wide sclerotized bridge between membranous area and ventral margin, fig. 741; hind wings with R_s and its branches present; ground color not white . . . 6

6. Front tibiae with 2 apical spurs . . . . **Athripsodes**, p. 221

Front tibiae without apical spurs . . . . **Leptocerus**, p. 212

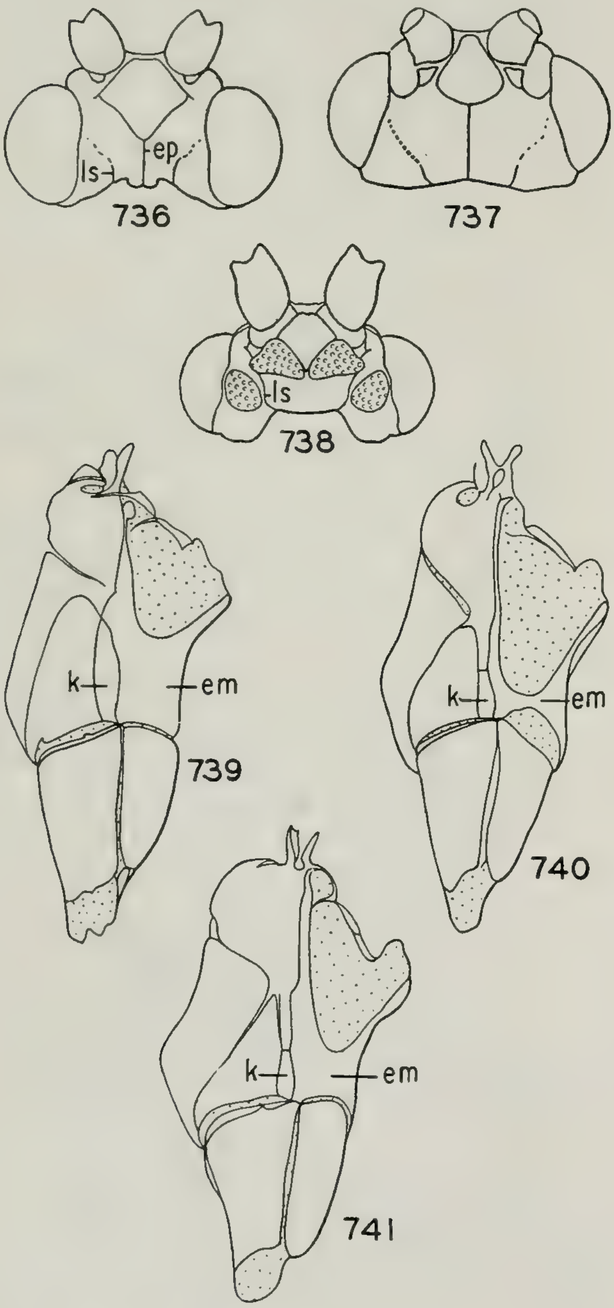


Fig. 736.—*Mystacides sepulchralis*, head.
Fig. 737.—*Setodes vernalis*, head.
Fig. 738.—*Athripsodes tarsi-punctatus*, head.
Fig. 739.—*Mystacides sepulchralis*, mesopleuron.
Fig. 740.—*Leptocella albida*.
Fig. 741.—*Athripsodes transversus*.
em, mesoepimeron; *ep*, epicranial stem; *k*, katepisternum; *ls*, lateral suture.

Leptocerus Leach

Leptocerus Leach (1815, p. 136). Genotype, monobasic: *Phryganea interrupta* Fabricius.
Ymymia Milne (1934, p. 16). Genotype, monobasic: *Setodes americana* Banks.

The curious translucent case, the hooked middle leg and anal tufts of the larvae, and the genitalia of the adults readily distinguish the only North American species of this genus.

The type of case, structure of larva and adult venation leave no doubt but that *americanus* is congeneric with the genotype, which is European. This necessitates reducing *Ymymia* to synonymy and resurrecting *Setodes* for the group of species for which Milne used the name *Leptocerus*. It is interesting to note that within both these groups the male genitalia vary greatly in shape.

Leptocerus americanus (Banks)

Setodes americana Banks (1899, p. 215); ♂, ♀.

Setodes grandis Banks (1907*a*, p. 128); ♂.

LARVA.—Fig. 742. Length 6–7 mm. Head, pronotum and legs straw color, the head and pronotum with many black spots. Gula somewhat heart shaped. Mandibles short, truncate at end. Middle leg with claw hooked, tibiae with rounded mesal teeth.

Abdominal gills absent. Anal segment incised on meson, with brushes of black setae along the sides of the incision.

CASE.—Length 7–8 mm.; slender, slightly curved and made entirely of secretion; pale green to straw color.

Fig. 742.—*Leptocerus americanus* larva.

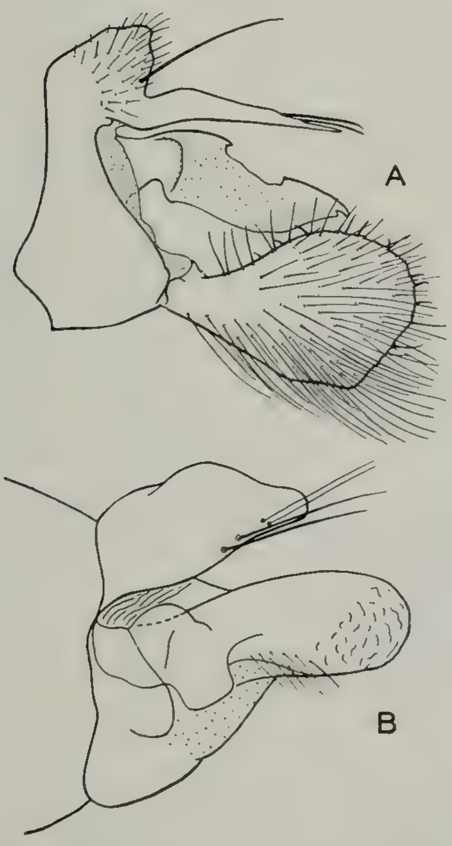


Fig. 743.—*Leptocerus americanus*, genitalia. *A*, male; *B*, female.

ADULTS.—Length 8 mm. Body very slender, dark brown in color. Both wings narrow and pointed. Male genitalia, fig. 743, with tenth tergite long and bladelike, aedeagus irregular; claspers short, narrow at base and expanding rapidly into a large, spatulate structure. Female genitalia, fig. 743, with tenth tergite large and semimembranous, lobes of the ninth tergite large and clasper-like, and bursa copulatrix small and somewhat circular.

This species is distributed over all parts of Illinois but has been taken in large numbers around only the glacial lakes and in the slow streams connecting them. In these places the larvae are almost invariably found in water horsetail.

Illinois Records.—Many males, females and pupae, taken May 6 to August 2, and many larvae, taken May 15 to June 12, are from Antioch, Carbondale, Channel Lake, Effingham, Eichorn (Hicks Branch), Fox Lake (Pistakee Bay), Fulton, Grand Tower, Grass Lake, Havana (Devil's Hole), Herod, McHenry, Momence, Olive Branch (Horse Shoe Lake), Ottawa, Pistakee Lake, Putnam (Lake Senachwine), Richmond, Savanna, Springfield, Wadsworth (Des Plaines River), West Havana, Zion (Dead River).

Leptocella Banks

Leptocella Banks (1899, p. 214). Genotype, by original designation: *Mystacides uwarowii* Kolenati.

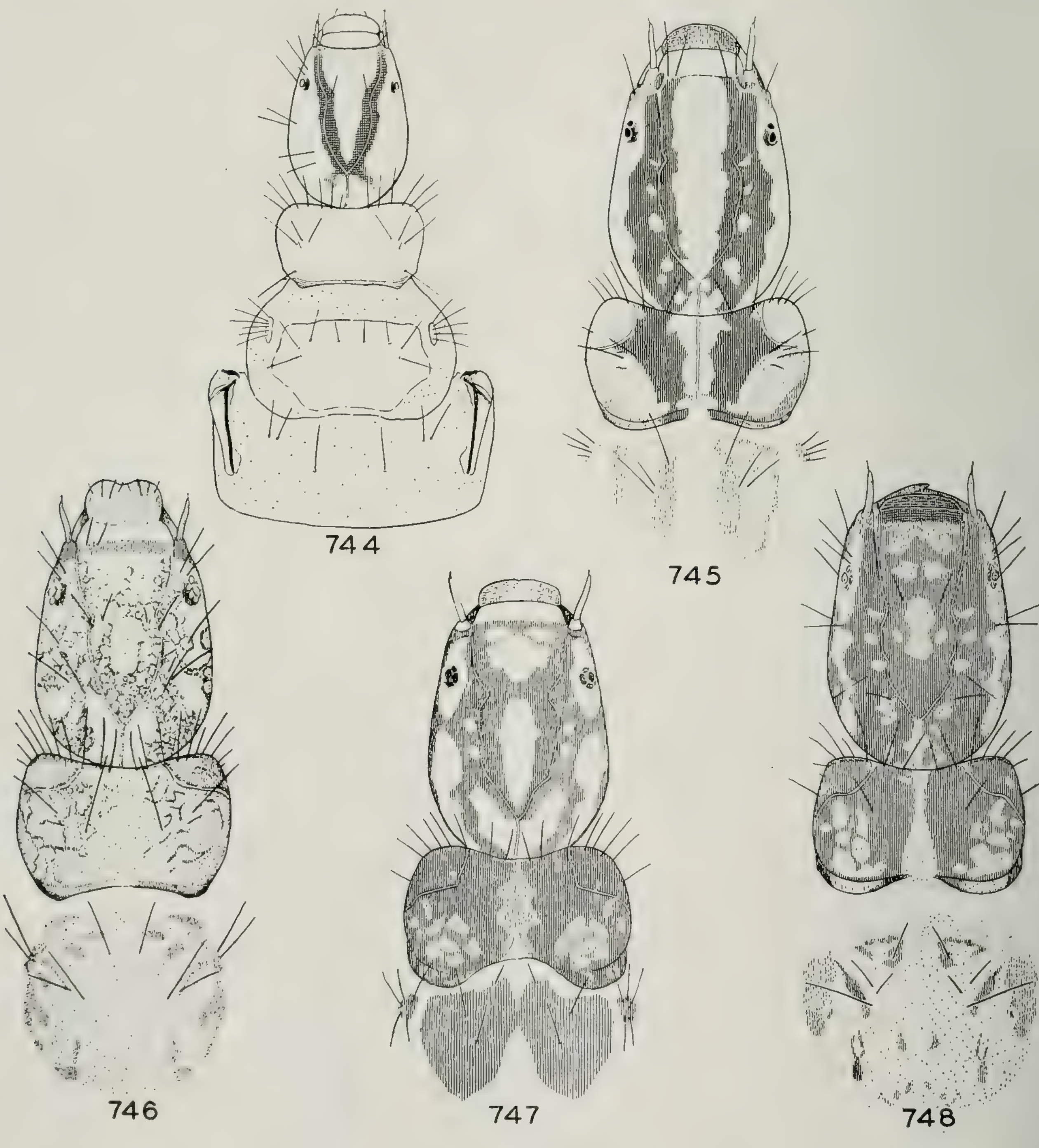
In this genus the case and larva are always very long and narrow. The larva has a long, triangular gula, short mandibles with a broad apex divided into three or four teeth, and undivided tibiae. Hind legs with or without swimming brush.

The adults are very long and slender, chiefly white or gray, frequently with conspicuous patterns. They include some of our most beautiful caddis flies. This is the only genus in which it is essential to have material pinned instead of preserved in liquid. For satisfactory results the specimens must be handled extremely carefully. To obtain good study material, it is necessary to kill them a few at a time in a strong cyanide bottle, remove them to a temporary container where they will not rub, and then pin them up very carefully at the first opportunity, taking pains at all times to avoid rubbing off the hairs on the wings. These hairs form the color pattern, which is frequently essential for adult diagnosis.

No caddis fly genus has been subject to more conjecture regarding the differentiation and limits of its species than has *Leptocella*. In the past, some 14 species have been described from America north of Mexico. Most of these have been synonymized by Milne (1934, p. 13), who reduced the genus to two species with one species subdivided into 10 forms.

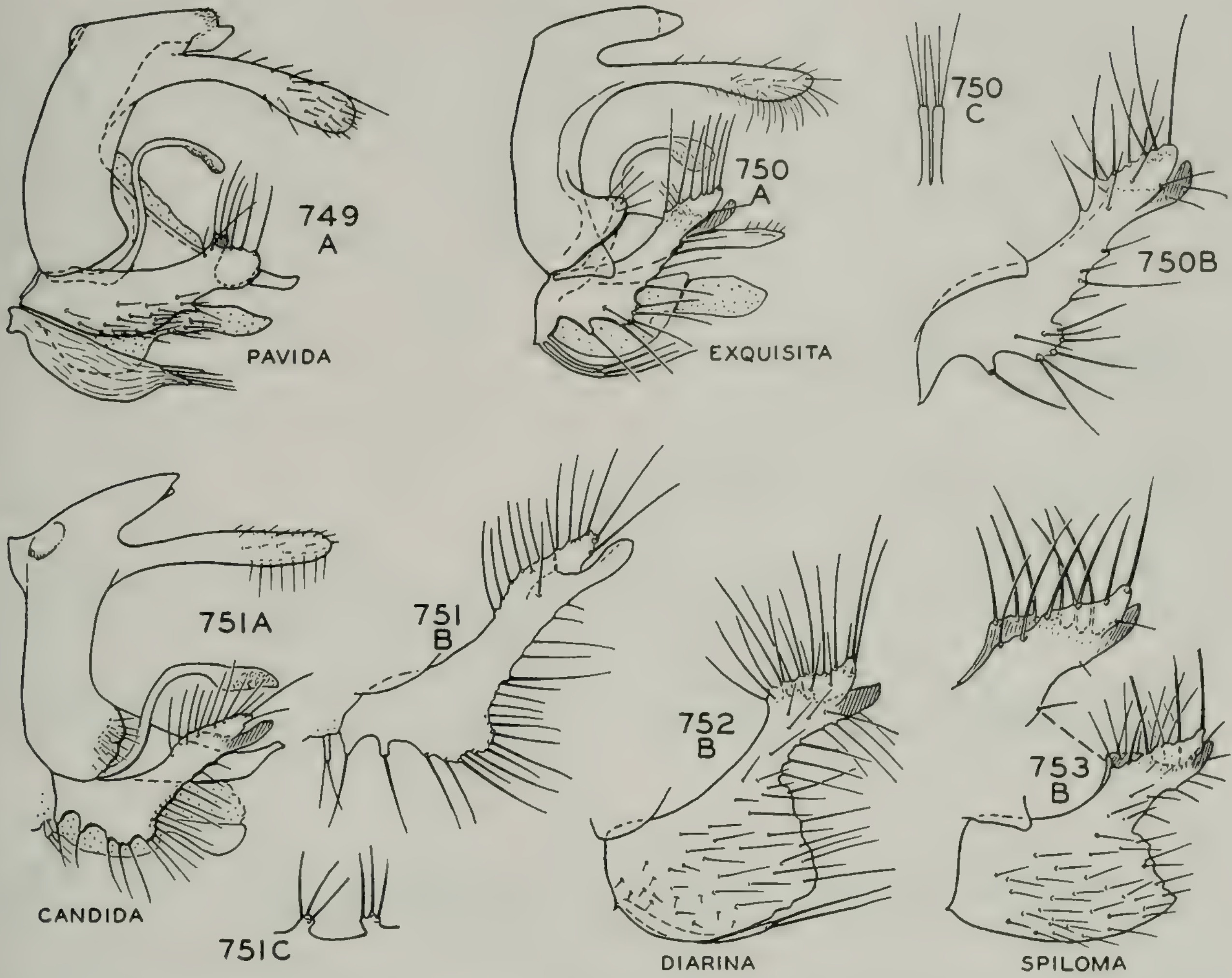
Early in our work on the Illinois caddis flies, we discovered that several species belonging to *Leptocella* occurred in Illinois with conspicuous and constant differences in the larval forms. We have not as yet succeeded in rearing all of them but have reared three in controversial groups. This rearing led to a more detailed study of the adults in our search for specific characters and resulted in the discovery that size of eyes and certain differences in male genitalia could be used to supplement color pattern in the definite diagnosis of at least some species. Most of these adult characters are presented in the descriptions which follow.

I wish to emphasize that there are many



Larvae of *Leptocella*

Fig. 744.—*L. albida.* **Fig. 745.**—*L. diarina.*
Fig. 746.—*L. exquisita.* **Fig. 747.**—*L. pavida.* **Fig. 748.**—*L. candida.*



Figs. 749–753.—*Leptocella*, male genitalia. *A*, lateral aspect; *B*, claspers; *C*, styles at base of claspers.

species which have not yet been investigated sufficiently to determine their status. Such forms as *coloradensis*, *intervena* and *minuta* have not been satisfactorily diagnosed. I have been unable to find any appreciable difference in the male genitalia of these. Experience with the Illinois fauna leads me to believe that until cultures of these other species are reared, or until additional adult characters are found, it will be unwise to attempt definite placement of these names. There is a very good possibility that many of them represent distinct species. Not until we know how many species exist and what are their limits can we satisfactorily diagnose them.

KEY TO SPECIES

Larvae

1. Hind legs with only scattered hair. Head yellow with a definite V mark, as in fig. 744 . . . . **albida**, p. 220
   Hind legs with a definite swimming brush of long hair, fig. 716. Head with either large, irregular brown areas or with parallel dark lines, figs. 745–748 2
2. Head with parallel dark lines which are carried back on the pronotum, fig. 745 . . . . **diarina**, p. 218
   Head with irregular dark areas or a dark network, fig. 746 3
3. Middle and hind legs almost entirely black beyond coxae; dorsum of head with fine reticulations, fig. 746 . . . . **?exquisita**, p. 217
   Middle and hind legs mostly yellow, at most with small dark areas; dorsum of head with solid lines or areas of brown or black, figs. 747, 748 . . . 4
4. Legs pale, banded with dark brown or black . . . . **sp. a**, p. 221
   Legs almost uniformly light colored . . 5
5. Head with an open network of dark brown or black lines, fig. 747 . . . . **pavida**, p. 218
   Head with more extensive dark areas as in fig. 748 . . . . **candida**, p. 217

Adults

1. Genitalia with claspers and aedeagus, fig. 749 (males) 2

Genitalia without such structures (females) 7

2. Apex of ninth sternite produced into a spoon-shaped lobe situated beneath aedeagus, fig. 749 . . . . **pavida**, p. 218

Apex of ninth sternite with a pair of long, or short, narrow processes . . . 3

3. Claspers with basal portion not produced into a wide flap, figs. 750, 751 4

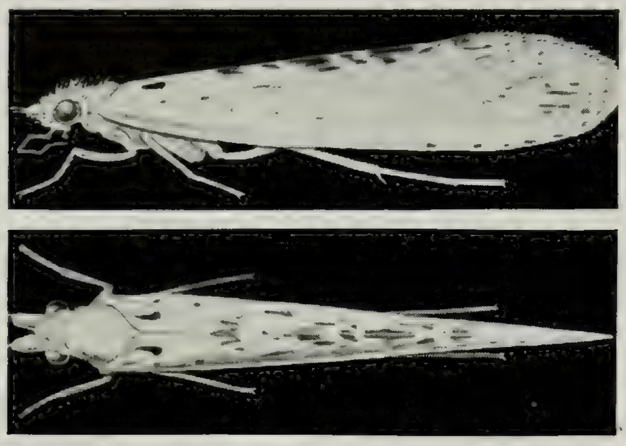


Fig. 754.—*Leptocella spiloma*, wing pattern.

Fig. 755.—*Leptocella exquisita*, wing pattern.

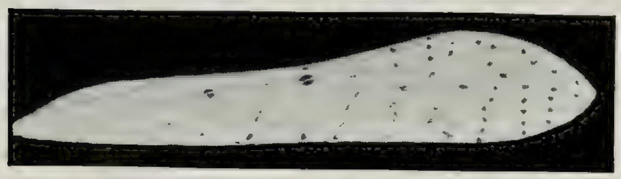


Fig. 756.—*Leptocella pavida*, wing pattern.

Claspers with basal portion produced into a wide flap, fig. 752 5

4. Wings with transverse yellowish bars in the membrane, fig. 755 . . . . **exquisita**, p. 217

Wings without transverse yellowish bars in the membrane, fig. 757 . . . . **candida**, p. 217

5. Ventral aspect of head with eye width equal to distance between eyes, fig. 761 . . . . **spiloma**, p. 219

Ventral aspect of head with eye width less than distance between eyes, figs. 759, 760 6

6. Wings in repose forming a distinct dorsal pattern of V-marks, as in fig. 754 . . . . **diarina**, p. 218

No dorsal pattern formed by marks on wings, which have either indistinct apical rows of spots or the spots absent and the veins quite prominent, fig. 758 . . . . **albida**, p. 220

7. Wings with transverse yellowish bars in the membrane, and with four black areas in membrane near apex of posterior margin, fig. 755 . . . . **exquisita**, p. 217

Wings without transverse yellowish bars, sometimes with four black areas of hairs but never black areas in the membrane 8

8. Wings with four patches of black hair near apex of posterior margin, fig. 757 . . . . **candida**, p. 217

Fig. 757.—*Leptocella candida*, wing pattern.

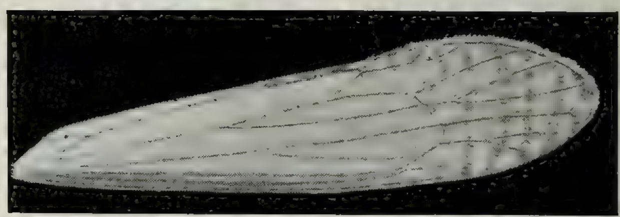
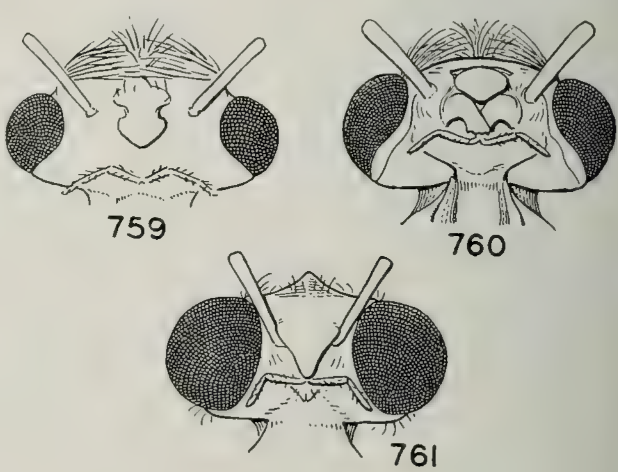


Fig. 758.—*Leptocella albida*, wing pattern.

Wings without patches of black hair in this region 9

9. Wings yellowish with small, well delineated, scattered black spots, fig. 756 . . . . **pavida**, p. 218



Heads, Ventral Aspect

Fig. 759.—*Leptocella albida.*
Fig. 760.—*Leptocella diarina.*
Fig. 761.—*Leptocella spiloma.*

Wings either with spots larger or less contrasting, figs. 754, 758........ 10

10. Wings with a dorsal pattern of V-marks, fig. 754, formed by dark areas along the posterior margin of the wings.......................... 11

Wings without conspicuous dark marks on posterior margin, therefore without dorsal V-marks when the wings are folded in repose, fig. 758...... ....**albida,** p. 220

11. Wings chalky white, with conspicuous shoulder marks, spots contrasting and eyes occupying most of lateral aspect of head........**spiloma,** p. 219

Ground color of wings slightly tawny, shoulder mark usually absent and spots not as dark; eyes smaller, not occupying most of lateral aspect of head..................**diarina,** p. 218

Leptocella candida (Hagen)

Setodes candida Hagen (1861, p. 280); ♂.

LARVA.—Length 12 mm. Head and thoracic sclerites mottled with yellow and brown, as in fig. 748, the frons always with the upper portion almost entirely brown; legs entirely yellow, sometimes with very narrow dark lines at the joints. Hind legs with a long swimming brush of fine hair.

CASE.—About 20 mm. long, constructed of wood and leaf fragments molded into a fairly smooth exterior, frequently with one to several long twigs cemented to side; before pupation the case is reduced in length.

ADULTS.—Length 15 mm. Head and sclerites tawny, covered with white hair. Wing membrane transparent, with a definite pattern from a covering of hair; front wings white with rows of gray and black marks, and having four conspicuous tufts of black hair along the hind margin at apex, as in fig. 757. Male genitalia, fig. 751: ninth segment more or less cylindrical, produced into a meso-dorsal hood, below which arise a pair of long fingers; tenth tergite almost ventral in position, broad at base and tapering to a slightly upturned and narrow apex; at the base of the tenth tergite arise a pair of filaments curved like a swan's neck and expanded at apex into a reticulate plate; claspers narrow at base, with a slight projection of the ventral margin, this entire margin bearing rows of long setae; at apex the clasper is divided into a subapical, spoonlike, sclerotized mesal lobe and a lateral apical lobe with a very oblique margin clothed with very long setae; between the bases of the claspers arise a pair of very short lobes bearing two or three setae at apex; aedeagus membranous with a spoon-shaped ventral sclerite. Female genitalia very simple, consisting of one or two inconspicuous pairs of lobes.

Allotype, female.—Momence, Illinois: Aug. 16, 1938, Ross & Burks.

This species is widely distributed over the state. It frequents a wide variety of streams and rivers, ranging from Quiver Creek to the Mississippi River and has been found also in marshes adjoining these streams. Adult emergence continues from early June to late August, indicating more than one generation per year. Both adults and larvae are frequently taken in large numbers. Reared collections of larvae from Quiver Creek have established the association of larval and adult forms.

This species ranges through the central and southern states, with records from Florida, Illinois, Indiana, Iowa, Kentucky and Ohio.

Illinois Records.—Many males and females and three pupae, taken May 28 to September 20, and many larvae and four cases, taken May 14 to August 21, are from Council Hill (Galena River), Deer Grove (Green River), Dixon, East Dubuque, Elizabethtown, Erie (Rock Creek), Freeport, Hamilton, Havana (Quiver Creek), Henry, Hillsdale, Homer, Jackson Island (in Mississippi River opposite Hannibal, Missouri), Kampsville, Kankakee, Keithsburg, Milan, Momence (Kankakee River), Mount Carmel, Oakwood, Pontiac, Quincy, Rockford, Rock Island, Rosiclare, St. Joseph, Savanna, Shawneetown, Shelbyville, Vandalia, and Wilmington.

Leptocella exquisita (Walker)

Leptocerus exquisita Walker (1852, p. 72); ♀.

LARVA (not reared, see below).—Length 12 mm. Head and thoracic sclerites mottled with yellow and light brown to form pattern as in fig. 746; front legs and all coxae yellow, middle and hind legs mostly black beyond coxae.

CASE.—Length 20 mm., made of wood fragments and similar in general to that of *candida*.

ADULTS.—Length 17 mm., the female usually not over 11 mm. Head and thorax tawny, covered with white hair. Front wings with a very conspicuous pattern, composed of cross bands of brownish yellow and a series of four quadrate black spots on posterior margin near apex, as in fig. 755; the bands are actually pigmented areas in the wing membrane with hair which follows this pattern closely. Male genitalia, fig. 750, with structures typical for genus, the claspers with only a small basal projection and with a pair of long styles tipped with long setae arising between bases of claspers.

Our Illinois records are confined to the eastern and northern portions of the state, and the species has been taken in large numbers only around the glacial lakes in the northeast corner. The larva which is described above as belonging to this species was found abundantly in Channel Lake, from which our largest collections of adults were taken; it is the only *Leptocella* larva in this entire lake region which was not reared; so we feel fairly confident in identifying it as *exquisita*. Collection data indicate a single generation per year, the Illinois emergence ranging from late June to mid July.

This species is widely distributed through the East, with an extension westward through the Ozarks to Oklahoma. We have records from Arkansas, Florida, Georgia, Illinois, Indiana, Kentucky, Maine, Michigan, Minnesota, Missouri, New York, North Carolina, Ohio, Oklahoma, Ontario, Pennsylvania, Quebec, South Carolina, Tennessee, Vermont and Wisconsin.

Illinois Records.—ALGONQUIN: July 16, 1910, Nason, 1 ♂. ANTIOCH: July 7, 1932, Frison & Metcalf, ♂ ♂. RICHMOND: June 28, 1938, Ross & Burks, 3 ♂ ; June 29, 1938, Ross & Burks, 4 ♂. WILMINGTON: July 1, 1935, DeLong & Ross, 1 ♂, 4 ♀. YORKVILLE, Fox River: June 25, 1936, at light, Frison & DeLong, 5 ♂, 8 ♀.

Leptocella pavida (Hagen)

Setodes pavida Hagen (1861, p. 282); ♀.

LARVA.—Length 7 mm. Head with a definite pattern of brownish yellow and dark brown, pronotum mostly brown with yellowish marks, as in fig. 747; legs yellowish with a few dark marks near the joints.

CASE.—Length 9 mm. Constructed of leaf fragments and forming a slightly flattened capsule.

ADULTS.—Length 10 mm. Color very pale yellow, including both the front wing membrane and the hairs on the wing; front wing, in addition, with a scattering of small and very black dots over most of the surface, many of the dots arranged in rows but all of them well separated, fig. 756. Male genitalia, fig. 749: general structure typical for genus as regards most of the structures; diagnostic are the claspers, which have a basal flap, and the large scoop-shaped sclerite beneath the base of the claspers and extending to the end of the basal lobe of the claspers.

In Illinois this species is a rarity. We have taken only four specimens, three of them in the center of the state, and one in the southern tip. We have not found any larvae. A collection of larvae and pupae made at Poe Springs, Alachua County, Florida, April 15, 1935, J. S. Rogers, has given us the association of larvae and adults.

The range of the species includes the eastern states with extensions westward through the Ozarks into Oklahoma. Records are available from Arkansas, District of Columbia, Florida, Georgia, Illinois, Kentucky, Maryland, Massachusetts, Michigan, Missouri, New York, Oklahoma, Tennessee and Wisconsin.

Illinois Records. — HEROD: Aug. 16, 1937, at light, Ross & Ritcher, 1 ♀. MAHOMET: Aug. 3, 1937, Ross & Burks, 2 ♀. MONTICELLO: June, 1932, T. H. Frison, 1 ♂.

Leptocella diarina new species

LARVA.—Length 11 mm. Head and thoracic sclerites yellow with a pair of black lines running the full length of head and pronotum and frequently indicated on the mesonotum, fig. 745. Legs various shades of brown, hind legs with a swimming brush of long hair.

CASE.—Length 20 mm. Made from wood fragments or sand grains, usually with a long stick attached to the side and with wood fragments predominating in the construction.

MALE.—Length 14 mm. Head and body straw colored, the legs whitish, all covered with white hair. Antennae banded with black and white hair. Wings with membrane transparent, color pattern formed entirely of hair; color nearly white with light brown spots arranged in rows across the apical third of the wing and scattered indefinitely over the anterior two-thirds; along the dorsum the wings usually form three large V-marks with small ones between. Sometimes these V-marks are reduced in size, in which case the intermediate small ones disappear, leaving only widely spaced dots. The general appearance is much as in fig. 754; the chief difference is that the central part of the wing has a few more spots, and the apical portion does not have such black bars; frequently, also, the shoulder spot is present near the base of the wing (well shown in fig. 754), but usually it is absent. General structure typical for genus. Eyes moderately large, separated on venter by twice their width as seen from this view, fig. 760. Genitalia typical for the *albida* group; ninth segment with dorsal process finger-like, the tenth tergite in the "swan's neck" processes typical for the genus; claspers, fig. 752, with a large basal flap, short narrow neck, the apex divided into a mesal spoon-shaped mesal lobe and a lateral, truncate, apical lobe bearing long setae; on the mesal face of the clasper there is a seta-bearing ridge which runs from the base of the mesal, subapical lobe to the anterior corner of the apex, with considerable variation as to the exact detail of this region.

FEMALE.—Slightly shorter and a little stouter than the male but similar to it in color and general structure; the color pattern is almost always reduced in contrast as compared to that of males. Abdomen bright green.

Holotype, male.—Havana, Illinois: June 29, 1936, Mohr & Burks.

Allotype, female. — Havana, Illinois: June 27, 1936, Mohr & Burks (reared from same lot as holotype).

Paratypes.—ILLINOIS.—Same data as for holotype, including June 24 to June 29, 3♂, ♀♀. ALGONQUIN: Sept. 16, 1904, W. A. Nason, 1♂; July 2, 1905, W. A. Nason, 1; same but June 28, 1♂; same but July 26, 1♂; same but Aug. 14, 1♀. AURORA: July 17, 1927, at light, Frison & Glasgow, 1♀. RICHMOND: June 24, 1938, Ross & Burks, 1♂, 6♀; same but June 28, 1♀; same but June 29, 2♂, 1♀.

INDIANA.—CRAWFORDSVILLE, Honey Creek: Aug. 10, 1938, Ross & Burks, 1♀. NOBLESVILLE: Aug. 10, 1938, Ross & Burks, 2♂.

MICHIGAN.—NILES: July 13, 1914, at light, 1♂.

SOUTH DAKOTA.—BROOKINGS: July 11, 1919, H. C. Severin, 1♂, 1♀.

In characters of the genitalia this species belongs to the *albida* group and is most closely related to the *intervena-texana* complex. It differs from this latter, however, in lacking close, definite rows of brown marks near the base of the wings, and in having the V-marks on the dorsum (when the wings are folded) or in having three large V-marks separated by small dots. Subsequent rearing of Texas material may show that this species is just a variant of *texana*, but in the material at hand there seems to be a clear-cut line between the two.

In Illinois we have taken this species at only scattered places. The larvae have always been found in fairly swift, cool streams such as Quiver Creek and Nippersink Creek. Larvae from both of these localities were reared. Little data are available on adult emergence, but the few records are sufficiently scattered from June to September to indicate the possibility of two generations per year.

The larvae of this species have been taken in company with *candida* but quite evidently are much rarer than *candida*.

Available records are from Illinois, Indiana, Michigan and South Dakota. So little material has been seen, however, that these records may give little indication of the true range of *diarina*.

Illinois Larval Records.—EAST PEORIA, Farm Creek: Aug. 29, 1940, 5 larvae. HAVANA, Quiver Creek: Aug. 7, 1895, C. A. Hart, many larvae; June 11, 1896, E. B. Forbes, 1 larva; May 28, 1936, Mohr & Burks, many larvae; May 29, 1936, Mohr & Burks, 6 larvae; June 5, 1936, Mohr & Burks, many larvae; June 20, 1936, Mohr & Burks, 2 larvae, 1♂, 2♀. SPRING GROVE, Nippersink Creek: June 12, 1936, Ross & Burks, 1 larva; June 8, 1938, Mohr & Burks, 5 larvae (reared); June 20, 1938, B. D. Burks, 2 larvae, 5 cases, 1 pupa (reared).

Leptocella spiloma new species

LARVAE.—Unknown.

MALE.—Length 12 mm. Head and body straw colored, the legs whitish, all covered with white hair; antennae banded white and black; wings transparent, covered with hair to form a white and brown pattern, fig. 754. In this species the black shoulder mark is always present, and the spotting on the anterior three-fourths of the wing is always sparse, with heavy dorsal V-marks. General structure typical for genus. Eyes very large, occupying most of the lateral aspect of the head and, as seen from ventral view, as wide as the distance between them. Male genitalia almost identical with the preceding species; claspers, fig. 753, with a very wide basal flap and with the mesal ridge, which continues from the base of the short apical lobe, extending above the dorsal margin of the lateral lobe. There is considerable variation in the details of these parts.

Female.—Length 11 mm. Slightly more robust than male and with the spots usually a little smaller but just as contrasting as in the male; abdomen bright green. The eyes are much smaller than in the male but considerably larger than the eyes of females of *diarina*. Genitalia typical for genus.

Holotype, male.—Junction City, Kansas: July 29, 1938, J. A. & H. H. Ross.

Allotype, female.—Douglas County, Kansas: July, at light.

Paratypes.—Kansas.—Same data as for allotype, 10♂, 22♀.

Texas.—Brownsville: Feb. 3, George Dorner, 2♂; Feb. 4, George Dorner, 1♀.

This species is most closely related to the preceding, differing from it slightly in the pattern but chiefly in the large eyes which, as seen from ventral view, are as wide as the distance between them, fig. 761. The only other described species with large eyes is *stigmatica*, which is much darker than this species.

In all the specimens we have seen, the females of this species appear to have a ground color of almost snowy white, with the green of the abdomen showing through, whereas the females of *diarina* have a ground color which is closer to a straw color or a very pale tawny shade, with the green of the abdomen showing through.

We have taken only one specimen of this species in Illinois, a female collected at Quincy, July 6, 1937, Mohr & Riegel. Little is known regarding the habits of the species, but it appears to have a range centering around Texas and Kansas, extending northeastward with records in Missouri and Illinois. As with the preceding species, records are too few to give an adequate picture of the range.

Leptocella albida (Walker)

Leptocerus albidus Walker (1852, p. 71); ♂.
Setodes nivea Hagen (1861, p. 281); ♂.
?*Mystacides uwarowii* Kolenati (1859*b*, p. 249).

Larva.—Fig. 744. Length 11 mm. Head, thoracic sclerites and front legs brownish yellow; the head with a V-shaped dark brown mark along frons, and with ventral portion dark brown; middle and hind legs dark brown to black with lighter areas at the joints, legs without swimming brushes.

Case.—Length 20 mm., slender and tapering, constructed of sand grains and minute fragments of clam shells, smooth in outline and sometimes with a slender twig fastened to one side. Before pupation the lower portion is cut off, leaving a case about 15 mm. long which is cylindrical and truncate at both ends. The case for this species is illustrated in fig. 762.

Adults.—Length 16 mm. Head and thorax almost black, covered with white hair. Front wings nearly white with rows of small gray marks beyond the cord; after the adult has been flying for some time some of the wing hairs come off, after which the veins stand out fairly boldly as in fig. 758. Male genitalia similar to those of *diarina*, having the same type of clasper with a wide basal flap.

Until the fauna of Alaska is better known, it is impossible to place Kolenati's *uwarowii* with certainty, but his illustration of the insect seems to fit this species fairly well.

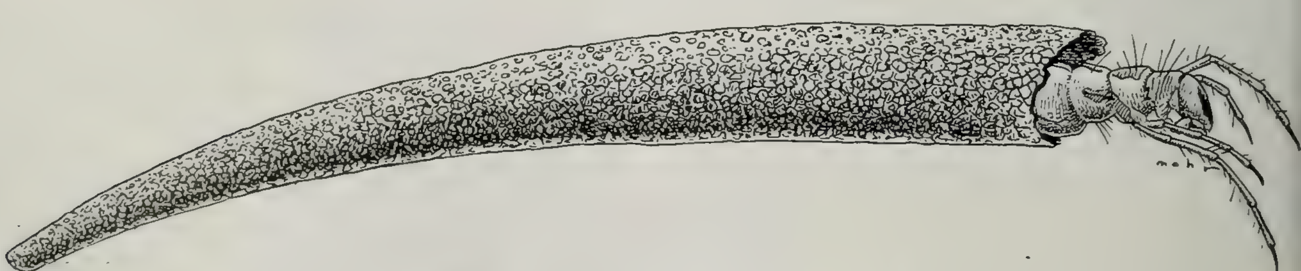


Fig. 762.—*Leptocella albida*, case.

Vorhies (1909) described all stages of this insect under the name *uwarowii.*

In Illinois the species centers around the glacial lakes in the northeastern part of the state. In these it is very abundant, being found under stones and among weeds near the shore. Our adult emergence records, including those from other states, extend from June to September, indicating more than one generation per year.

The species ranges widely through the North and Northeast; records are available from Illinois, Michigan, New Brunswick, New York, Ontario, Pennsylvania, Saskatchewan and Wisconsin. The range may be more extensive southward, but I have restricted identifications of this species to specimens about which there seems no doubt.

Illinois Records.—Many males, females and pupae, taken May 18 to August 14, and many larvae and cases, taken May 15 to June 11, are from Algonquin, Antioch, Aurora, Channel Lake, Chicago, Fox Lake, Grass Lake, Havana, Ottawa, Pistakee Lake, Richmond, Round Lake, Sand Lake, Spring Grove (Nippersink Creek), Volo, Zion (Dead River).

Leptocella species a

Larva.—Length 12 mm. Head and pronotum with a mottling of brown and yellow very similar to that in *diarina.* Mesonotum yellow with brownish marks as in the same species. Legs yellow, the middle and hind pair with narrow black bands at apex. Hind legs with swimming brush of long hairs.

This larva has not been reared, nor have we any evidence which would link it with species known only from the adults. We have one larva from Illinois, from the Spoon River near Havana, October 2, 1938, B. D. Burks; in addition, material has been taken in Wisconsin and Michigan.

Athripsodes Billberg

Athripsodes Billberg (1820, p. 94). Genotype, by subsequent designation of Milne (1934, p. 18): *Phryganea albifrons* Linnaeus.

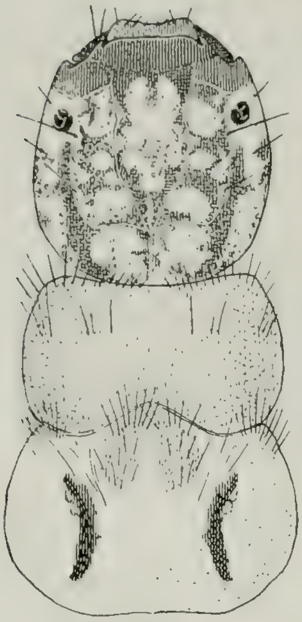
The larva is short and builds either a tapering, horn-shaped case, fig. 810, or one with lateral flanges, figs. 808, 809; gills are usually abundant and tufted, although difficult to distinguish and reduced in number in some forms; the mouthparts are short, the mandibles with a blunt, toothed apex. The adults are brown or black, with wide hind wings.

A large number of species have been described from North America, of which 14 have been collected in Illinois. Eight species are known from the larval stage, and three additional unassociated forms have been recognized; characters have been found for separating these to species and also for separating the females for all the Illinois species in which this sex is known.

KEY TO SPECIES

Larvae

1. Mesonotum with many hairs, fig. 763; parafrontal areas originating at apex of frons............**mentieus,** p. 232
   Mesonotum with only two or three pairs of scattered hairs, fig. 765; parafrontal areas, if present, originating below apex of frons, fig. 764 ... 2
2. Parafrontal areas absent, head pale without distinct markings........ ....**sp. a,** p. 235
   Parafrontal areas outlined distinctly at least somewhere along their boundary, fig. 764................ 3
3. Head dark brown except for distinct pale lines on "false frons" and side, fig. 766; case with extended lateral margin, fig. 808.................. 4
   Head either yellowish, or brown with many pale spots, fig. 764; case usually without extended lateral margin, fig. 810..................... 5
4. Case twice as long as wide, fig. 808; frons nearly black......**ancylus,** p. 227
   Case broader, only one and one-half times as long as wide, fig. 809; frons reddish brown..........?**flavus,** p. 228
5. Sclerotized bars of mesonotum wide, with a mesal spur and a thickened area down the center, fig. 769; pronotum chocolate brown.......... ....**sp. c,** p. 236
   Sclerotized bars of mesonotum linear, without a mesal spur or thickened central area, fig. 764; pronotum yellowish brown to colorless....... 6
6. Ninth segment with only weak, short setae, variable in number, fig. 771.. 7
   Ninth segment with two dorsal pairs of long, black setae, fig. 770....... 8
7. Head with parafrontal areas nearly as wide as frons, fig. 772......**sp. b,** p. 235
   Head with parafrontal areas much narrower than frons, fig. 773 ....**dilutus,** p. 231



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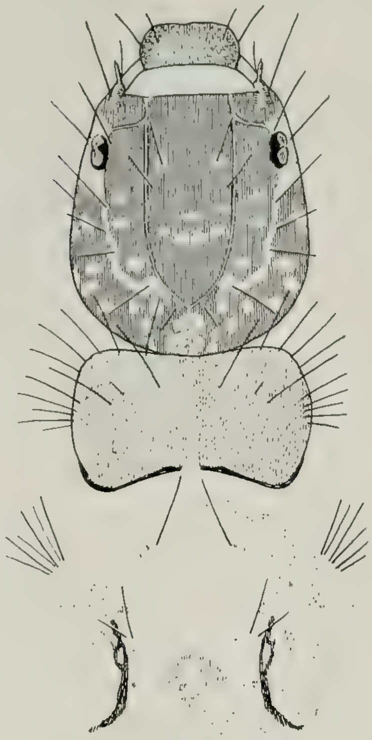

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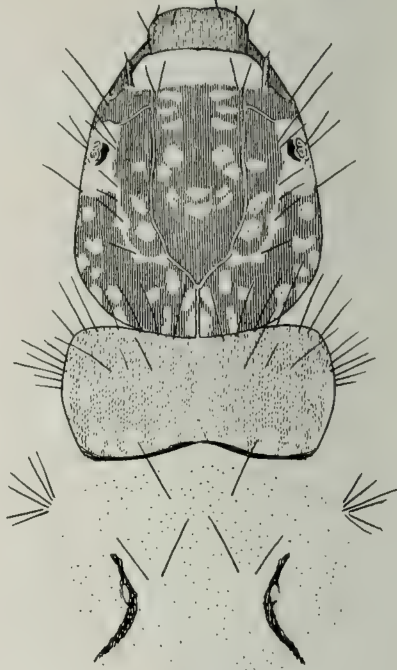

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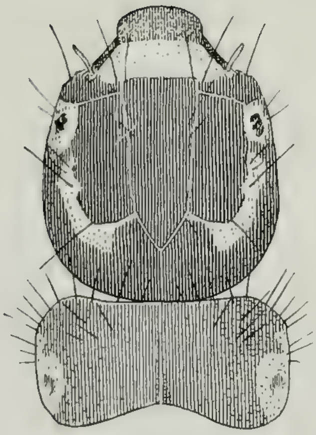

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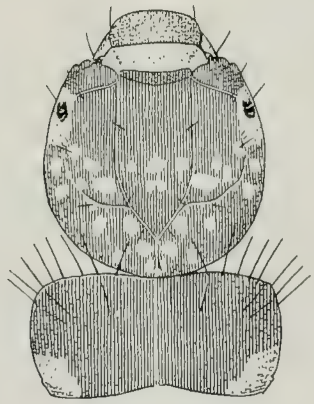

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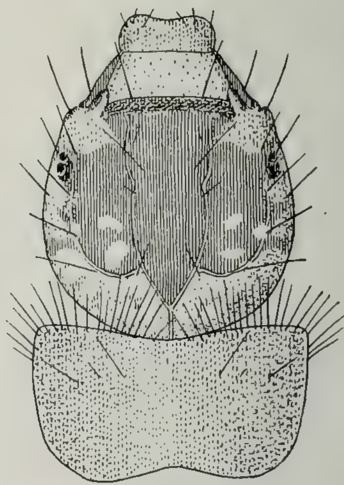

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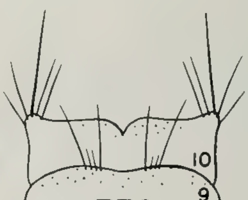
Larvae of *Athripsodes*

Fig. 763.—*A. mentieus.*
Fig. 764.—*A. alagmus.*
Fig. 765.—*A. tarsi-punctatus.*
Fig. 766.—*A. ancylus.*
Fig. 767.—*A. transversus.*
Fig. 768.—*A. cancellatus.*

769



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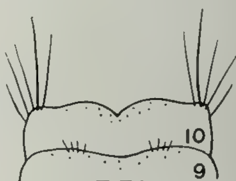

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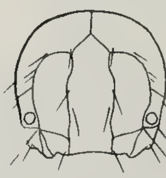

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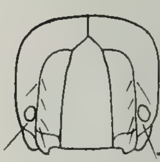

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Fig. 769.—*Athripsodes species c,* larva, mesonotal bar.

Fig. 770.—*Athripsodes cancellatus* larva, ninth tergite.

Fig. 771.—*Athripsodes dilutus* larva, ninth tergite.

Fig. 772.—*Athripsodes species b* larva, head.

Fig. 773.—*Athripsodes dilutus* larva, head.

8. Parafrontal area nearly as wide as frons, fig. 768; dorso-lateral sclerotized area over anal leg long and slender, rodlike.................... 9
   Parafrontal area only slightly wider than half width of frons, fig. 765; dorso-lateral sclerotized area over anal leg short and platelike....... 10
9. Anterior margin of pronotum with setae on central portion irregular in length and close together, fig. 768.. ....**cancellatus**, p. 233

Anterior margin of pronotum with well-separated hairs of nearly equal length, fig. 767.....**transversus,** p. 233

10. Color pattern and spots more contrasting, fig. 765..............................**tarsi-punctatus,** p. 229
    Color pattern and spots less contrasting, fig. 764...........**alagmus,** p. 229

Adults

1. Genitalia with movable claspers, figs. 774–791 (males).................. 2
   Genitalia without claspers, figs. 792-807 (females).................... 19
2. Claspers with a basal projection nearly as long as height of clasper, fig. 774 3
   Claspers with either a short basal projection or none, figs. 780, 791..... 4
3. Basal projection of claspers evenly rounded, fig. 774.......**ancylus,** p. 227
   Basal projection of claspers angled, fig. 775.................**flavus,** p. 228
4. Tenth tergite U-shaped, the base forming the bottom of the U, the ventral arm of the U divided into lateral halves, each tipped with a cluster of spines, fig. 776..........**saccus,** p. 234
   Tenth tergite not U-shaped, sometimes long and necklike, fig. 778... 5
5. Claspers with a serrate, mesal lobe; tenth tergite divided by a narrow fissure into dorsal and ventral parts, the ventral lobe with a strong, long, lateral blade, fig. 777..**erraticus,** p. 235
   Claspers without a serrate mesal lobe; tenth tergite not divided into dorsal and ventral parts................ 6
6. Basal segment of clasper with a long spur almost as stout and long as mesal process, fig. 778..................................**erullus,** p. 235
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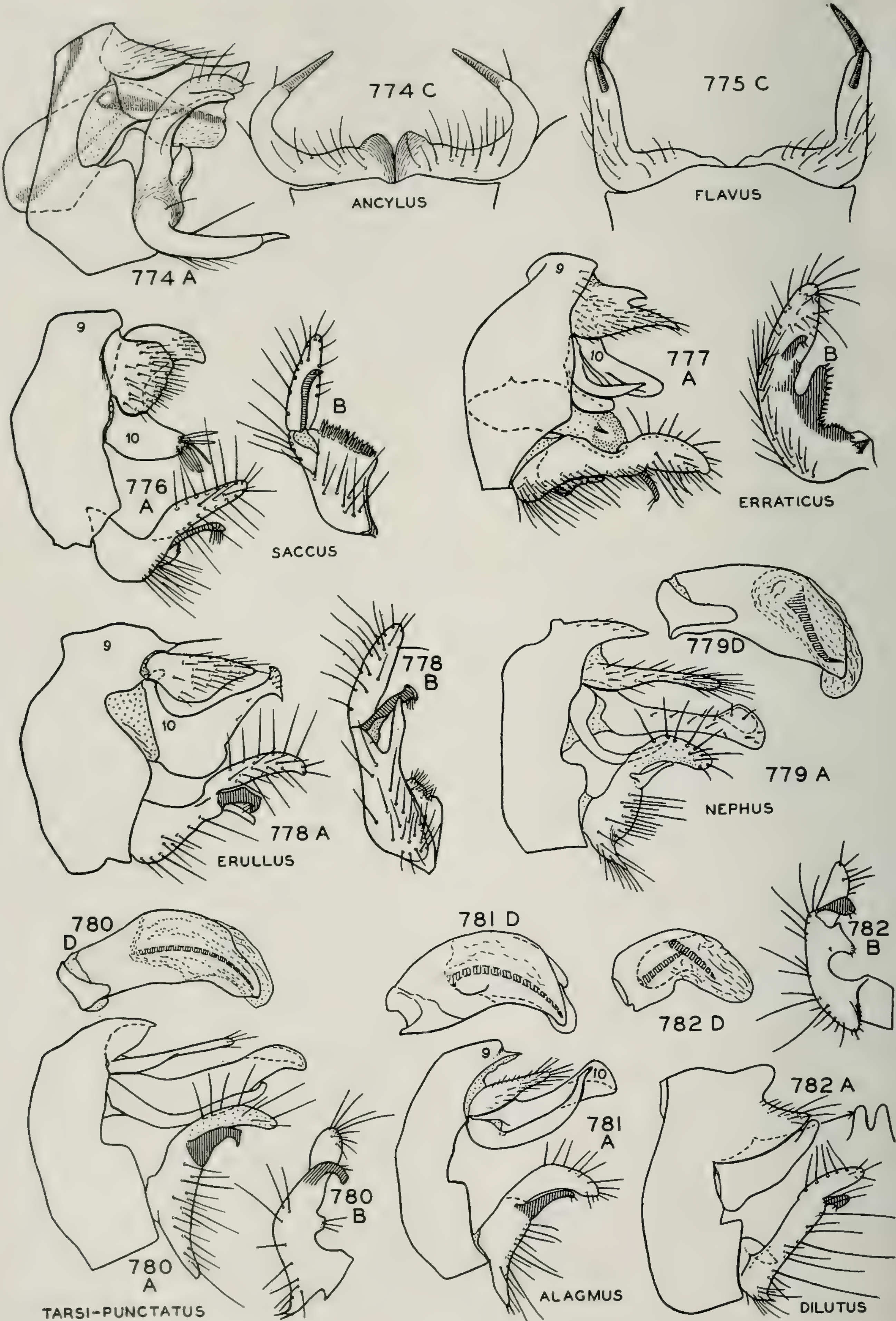
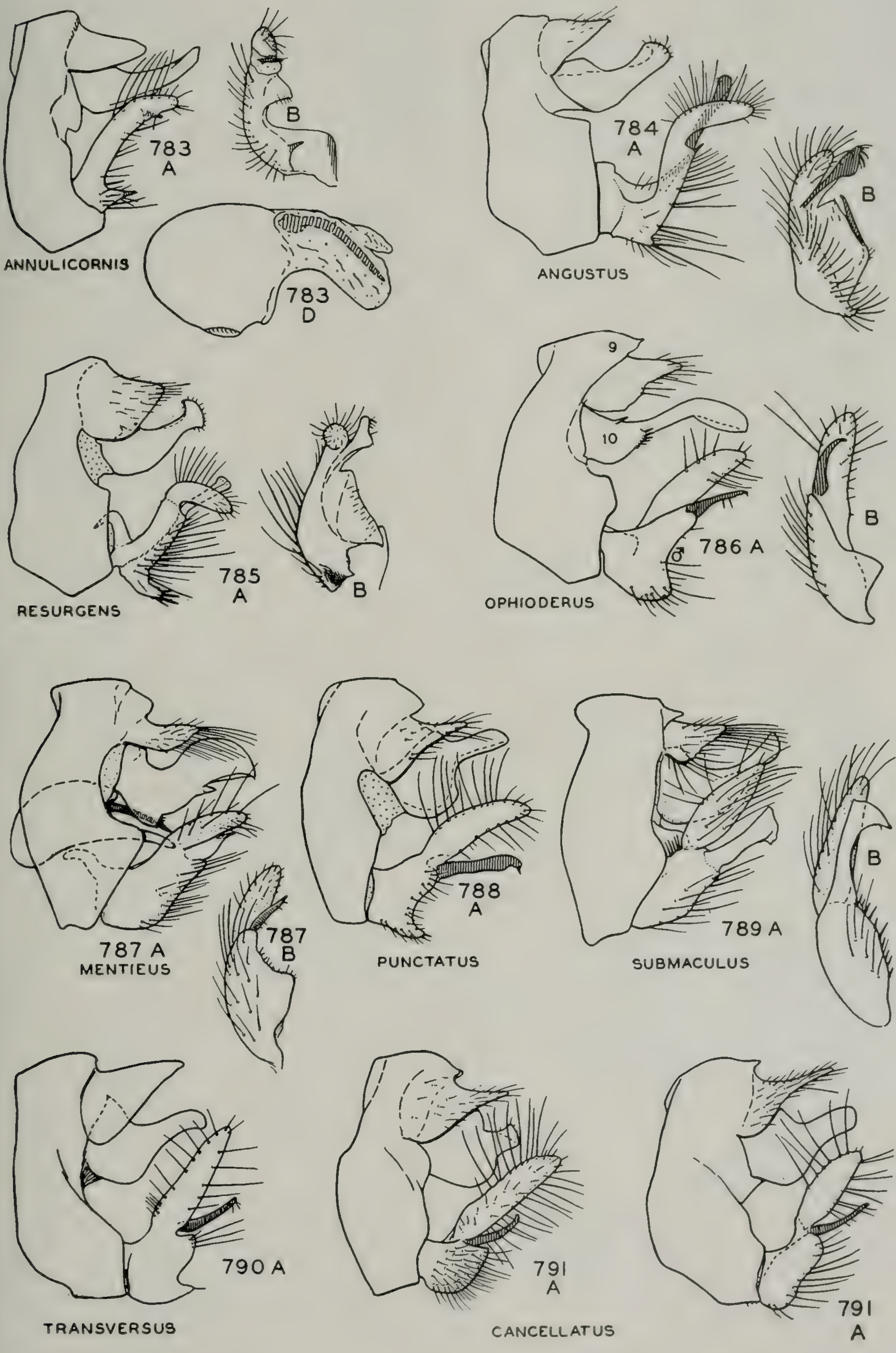
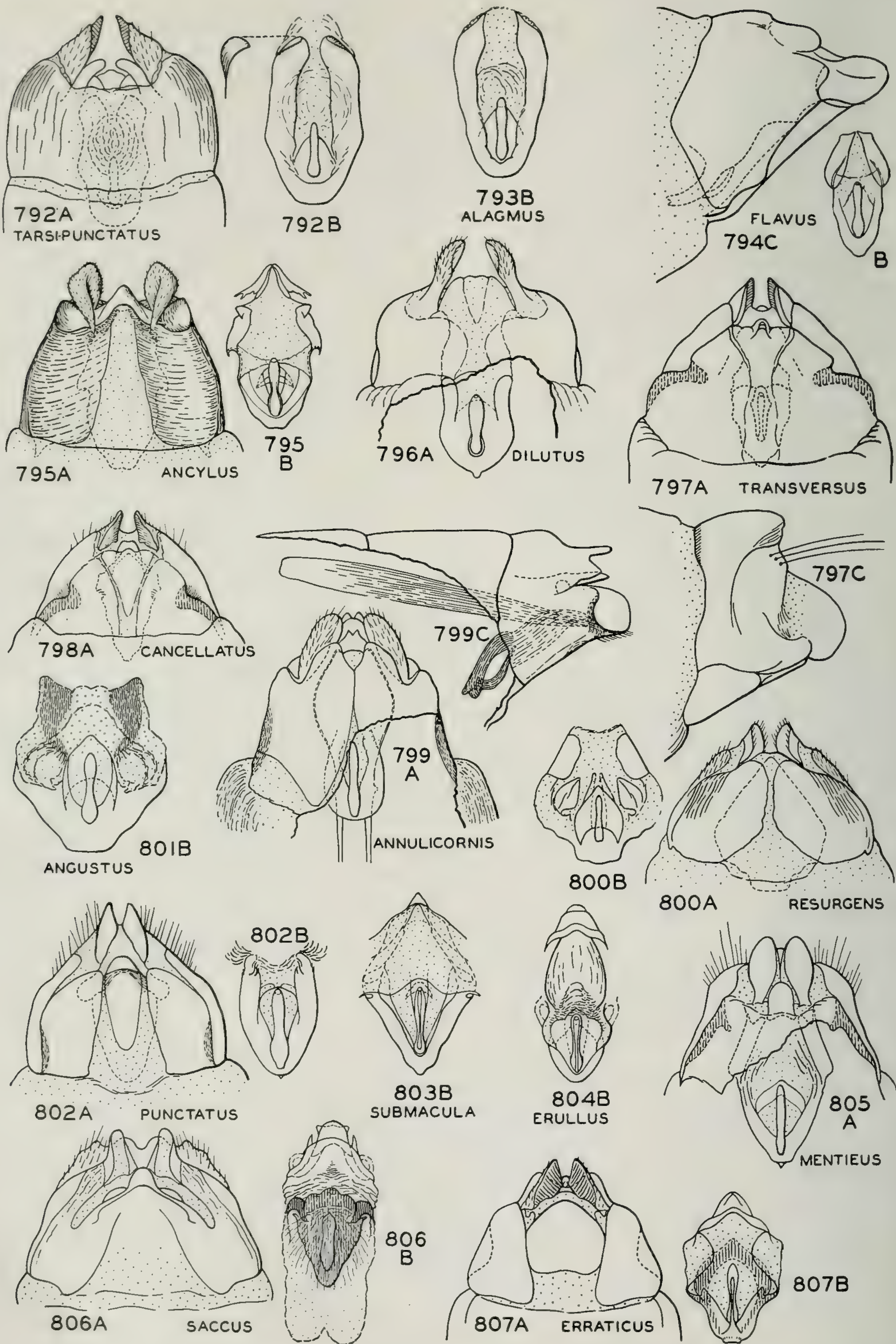
7. Tenth tergite long, somewhat hooded, and with a pair of long, sclerotized arms arising at its base and reaching almost midway to apex, fig. 779 8
   Tenth tergite either no longer than cerci, fig. 791, or without such a pair of arms, fig. 785............. 9
8. Lateral arms of tenth tergite only half length of tergite; spine of aedeagus upturned at tip, fig. 779................................**nephus,** p. 230
   Lateral arms of tenth tergite more than half length of tergite; spine of aedeagus curved ventrad, figs. 780, 781............................. 9
9. Tenth tergite very long, with a sharp, hooded apex, fig. 780; aedeagus slender.......**tarsi-punctatus,** p. 229
   Tenth tergite shorter, as in fig. 781, with a blunt and slightly enlarged apex; aedeagus robust................................**alagmus,** p. 229
10. Claspers with body long and slender, with mesal process small, scarcely longer than width of apical lobe, and the body of the clasper with a mesal lobe just under mesal process, figs. 782, 783......................... 11
    Claspers either with short body, fig. 790, longer mesal process, fig. 785, or without a mesal lobe below mesal process......................... 12
11. Base of clasper not produced into a spur, fig. 782, aedeagus small, with the base narrow and with two internal spines...........**dilutus,** p. 231
    Base of clasper produced into a spur, fig. 783, aedeagus large, with a single internal spine and with the base greatly enlarged.............................**annulicornis,** p. 232
12. Claspers with apical segment bent at right angles to basal segment, fig. 784........................... 13
    Claspers with apical segment at most slightly angled from basal segment, fig. 786......................... 14
13. Mesal lobe of clasper with a fusiform, pointed spine, fig. 784................................**angustus,** p. 231
    Mesal lobe of clasper without a spine, fig. 785.............**resurgens,** p. 230
14. Tenth tergite with a long neck and a long, somewhat hood-shaped head, fig. 786............**ophioderus,** p. 232
    Tenth tergite without a definite, long neck and head, fig. 787........... 15
15. Tenth tergite sickle shaped, the ventral margin evenly concave, fig. 787 ....**mentieus,** p. 232
    Tenth tergite not at all sickle shaped, fig. 788......................... 16
16. Sclerotized mesal process of clasper stout, fig. 788; front wings dark brown, almost black, with a scattering of white scales................ 17
    Sclerotized mesal process of clasper slender, fig. 790; front wing medium to light shades of brown without scales......................... 18
17. Tenth tergite with narrowed apical portion nearly as long as base, cylindrical and rounded at apex, fig. 788 ....**punctatus,** p. 234
    Tenth tergite with narrowed apical portion short, tapering and truncate, fig. 789...........**submacula,** p. 235



Figs 774–782.—*Athripsodes,* male genitalia. *A,* lateral aspect; *B* and *C,* claspers, respectively caudal and ventral aspects; *D,* aedeagus.



Figs. 783–791.—*Athripsodes*, male genitalia. *A*, lateral aspect; *B* and *C*, claspers, respectively caudal and ventral aspects; *D*, aedeagus.



Figs. 792–807.—*Athripsodes*, female genitalia. *A*, ventral aspect; *B*, bursa copulatrix; *C*, lateral aspect.

18. Base of claspers with ventral margin produced into a lobe, fig. 790...... ....**transversus**, p. 233
    Base of claspers with ventral margin rounded, fig. 791...**cancellatus**, p. 233
19. Ninth sternite with a pair of finger-like, apico-mesal lobes, fig. 792.... 20
    Ninth sternite without digitate lobes, at most with short points, fig. 794 21
20. Bursa copulatrix with lateral bands curved ventrad and convoluted near attachment; only a small, triangular sclerite between bursa and dorsal apodeme of tenth tergite, fig. 792 ....**tarsi-punctatus**, p. 229
    Bursa copulatrix with lateral bands flat to attachment; a large sclerite almost filling space between bursa and dorsal apodeme of tenth tergite, fig. 793..............**alagmus**, p. 229
21. Ninth sternite with plates deeply concave, apico-mesal corners pointed, lateral margin upturned and angulate near base, fig. 794............ 22
    Ninth sternite not concave, not with lateral margin upturned or angulate, figs. 796–807................ 23
22. Sclerotized halves of ninth sternite sharply tapered to base, lateral margin sharply angulate; bursa copulatrix with sides appressed to body, fig. 794...........**flavus**, p. 228
    Sclerotized halves of ninth sternite almost truncate at base, lateral margin only rounded at projection; bursa copulatrix with sides flaring laterad, fig. 795........**ancylus**, p. 227
23. Tenth segment with lateral plates as long as ninth sternite, fig. 796..... ....**dilutus**, p. 231
    Tenth segment with lateral plates much shorter than ninth sternite, fig. 797........................ 24
24. Ninth sternite with lateral margins angling more mesad than caudad from base, the angled portion marked by an internal shelf, fig. 797 25
    Ninth sternite with lateral margins not angling so sharply, either the internal shelf absent or not angling mesad more than in fig. 805...... 26
25. Apical portion of ninth sternite wide, fig. 797...........**transversus**, p. 233
    Apical portion of ninth sternite narrower, fig. 798.....**cancellatus**, p. 233
26. Bursa copulatrix situated on sclerotized ribbons which extend far past the bursa to the seventh segment, fig. 799..........**annulicornis**, p. 232
    Attachment ribbons of bursa copulatrix not extending anterior of bursa 27
27. Bursa copulatrix with wide lateral expansions, fig. 800................ 28
    Bursa copulatrix with lateral expansions absent or small, fig. 806...... 29
28. Attachment of bursa copulatrix chiefly membranous with a single pair of flat sclerites just above bursa, fig. 800................**resurgens**, p. 230
    Attachment of bursa copulatrix consisting chiefly of a sclerotized ribbon, fig. 801.............**angustus**, p. 231
29. Ninth sternite with large lateral plates and a narrow, mesal tongue, all heavily sclerotized, as in fig. 802... ....**punctatus**, p. 234
    Ninth sternite with mesal area indistinct or much wider, fig. 807...... 30
30. Bursa copulatrix triangular, fig. 803 ....**submacula**, p. 235
    Bursa copulatrix U-shaped, figs. 804–807............................ 31
31. Bursa copulatrix attached at the end of a long, vasiform, sclerotized structure, fig. 804...........**erullus**, p. 235
    Bursa copulatrix attached to short membranous folds or to paired sclerotized ribbons................... 32
32. Bursa copulatrix oval, without latero-ventral points, fig. 805........... ....**mentieus**, p. 232
    Bursa copulatrix U-shaped or somewhat vasiform, with sharp latero-ventral points, figs. 806, 807...... 33
33. Points near top of bursa copulatrix; ninth sternite composed chiefly of a single, large sclerotized plate arcuate across apex, fig. 806.....**saccus**, p. 234
    Points near middle of bursa; ninth sternite composed of a pair of large, lateral sclerotized plates and a smaller, nearly square mesal plate, fig. 807..............**erraticus**, p. 235

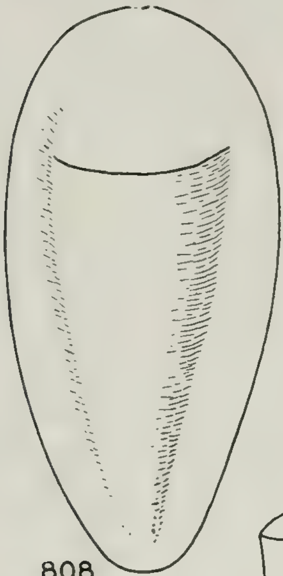
Athripsodes ancylus (Vorhies)

Leptocerus ancylus Vorhies (1909, p. 691); ♂, ♀.

Larva.—Fig. 766. Length 8 mm. Head very dark brown with pale area around eyes and subfrons, forming a pale U with a few dark dots in upper portion; pronotum dark brown with a lateral white spot; legs light brown. The frontal areas more than half width of frons. Pronotum with only long scattered hairs on anterior margin. Mesonotum with a lateral tuft of about 10 hairs, central area with only three or four scattered pairs of hairs, sclerotized bars thin and not at all sharply angled.

CASE.—Fig. 808. Length 9 mm., 4.5–5.0 mm. wide, built solidly of sand grains, the dorso-lateral margins produced into a wide flange so that from above the case appears shaped like a water-penny.

ADULTS.—Length 11 mm. Color medium to dark shades of brown without conspicuous markings on scales. Male genitalia, fig. 774: cerci short and tenth tergite long; claspers with a long prolongation of the base, as seen from ventral view forming a stout, curved, pencil-like pair of appendages, the remainder of the clasper upright, long and slender with a short mesal process and apical segment only slightly longer than the process. Female genitalia, fig. 795, with the ninth sternite divided into a pair of heavily sclerotized, markedly concave plates which are produced into a sharp apico-mesal point; bursa copulatrix as in fig. 795*B*.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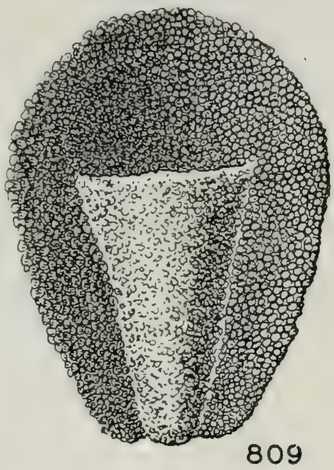
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Fig. 808.—*Athripsodes ancylus*, case.
Fig. 809.—*Athripsodes ?flavus*, case.
Fig. 810.—*Athripsodes mentieus*, case.

We have only scattered records of this species from Illinois, from some of our best aquatic habitats in the northern, central and southern parts of the state. All the material we have, both in Illinois and in other states, has a case conforming quite exactly to the above description. Lloyd (1921, p. 96) records a case markedly different in shape, but we have seen nothing that agrees with his description. Our larvae were collected in wide extremes of environment, including weed beds in the northeastern glacial lakes, and under stones in the rapid streams of the Ozark Hills. Adult emergence apparently is confined to May, June and July; this indicates a single generation per year.

The species is distributed widely through the northern and eastern states and also occurs in the Kiamichi Mountains in Oklahoma. Available records include Georgia, Illinois, New York, North Carolina, Ohio, Oklahoma and Wisconsin.

Illinois Records. — CHICAGO: July 8, 1939, G. T. Riegel, 1 ♂. EDDYVILLE, Lusk Creek: May 24, 1940, Mohr & Burks, 1 pupa. FOX LAKE: May 15, 1936, from weeds, Ross & Mohr, 2 larvae. GOLCONDA: May 30, 1928, at light, T. H. Frison, 1 ♂. JOHNSBURG, Fox River: May 10, 1938, Ross & Burks, 2 cases. MOMENCE: June 4, 1932, Frison & Mohr, 1 ♂. WILMINGTON: July 1, 1935, DeLong & Ross, 1 ♂.

Athripsodes flavus (Banks)

Leptocerus flavus Banks (1904*d*, p. 212); ♂, ♀.

LARVA.—We have no definite rearing of this species but have taken several collections of a larva which is closely related to *ancylus*, differing in the wider lateral extensions of the case and the uniformly paler color of the larval sclerites. Since this species displays the proper taxonomic characters for such a placement and in addition is slightly smaller than *ancylus*, I am regarding this larva tentatively as *flavus*. The case is 8 mm. long and 5.5–6.0 mm. wide, fig. 809.

ADULTS.—Length 9 mm. Color various shades of light brown without conspicuous markings or white scales. Male genitalia, fig. 775, distinguished by the long basal projection of the clasper, which in this species is sharply angled at the base. Female genitalia, fig. 794, with the sclerotized halves of the ninth sternite sharply tapered to base, the lateral margin sharply-angulate; bursa copulatrix with sides appressed to body so that, from ventral view, they do not flare.

This species has been taken in many scattered localities in Illinois, almost all of them along fairly large rivers such as the Ohio, Illinois and Kankakee. Our adult emergence records run from June 23 to July 14, indicating a single generation per year. The larvae which we are considering as of this species have been taken mainly in large rivers.

The species is known from adult collections from a limited number of eastern and northcentral states, including Illinois, Kentucky, Pennsylvania and Wisconsin; in addition, larvae considered as this species have been taken from Indiana and Minnesota.

Illinois Records.—Many males and females, taken June 23 to July 21, and many larvae, taken May 4 to October 30, are from Dixon, Elizabethtown (Ohio River), Fox Lake, Hardin, Hoopeston, Kampsville, Kankakee, Momence, Rockford, Rock Island, Saline Mines (Saline River), Springfield, Sterling, Wilmington.

Athripsodes tarsi-punctatus (Vorhies)

Leptocerus tarsi-punctatus Vorhies (1909, p. 694); ♂.

LARVA.—Length 6 mm. Head brown with indefinite pale spots, fig. 765. Pronotum and legs straw color to yellowish brown. Parafrons scarcely wider than half width of frons. Pronotum with long, well-separated hairs on anterior margin. Mesonotum with a lateral tuft of 6–8 hairs, mesal portion of tergite with only a few scattered hairs, sclerotized bars thin and gently curved.

CASE.—Length 7 mm., horn shaped, made of vegetable fragments and sand grains, the sand grains predominating in most situations.

ADULTS.—Length 11 mm. Color chocolate brown, the base of the tarsi ringed with white. Male genitalia, fig. 780: cerci long, the apex slender; tenth tergite very long, the extreme apex slightly downcurved, a stout sclerotized spur arising from the base and extending three-fourths distance to apex; clasper with a very long basal projection, its apical segment curved, the mesal projection stout and curved. Female genitalia, fig. 792: ninth sternite with a pair of fingerlike apico-mesal fingers which converge toward apex; bursa copulatrix with lateral bands curved ventrad and convoluted near attachment and with only a small triangular sclerite between bursa and dorsal apodeme of tenth tergite, this sclerite sometimes almost entirely membranous.

Allotype, female.—Council Hill, Illinois, along Galena River: June 26, 1940, Mohr & Riegel.

This species occurs throughout the entire state, with a preponderance of records from the northern fourth. The larvae live in lakes and streams. They are abundant in many of the glacial lakes in northeastern Illinois; the streams they frequent are generally fairly clear, rapid and cool. There is usually only one generation a year, the large wave of adults occurring during May and June.

The species is apparently widespread through the eastern half of the continent, with records available for Arkansas, Georgia, Illinois, Indiana, Kentucky, Maine, Michigan, Minnesota, Missouri, New Brunswick, New York, Ontario, Pennsylvania, Saskatchewan, South Dakota and Wisconsin.

Illinois Records.—Many males and females, taken May 4 to August 19, and many larvae, taken May 4 to June 27, are from Amboy (Green River), Antioch, Carbondale, Channel Lake, Charleston, Chicago, Council Hill (Galena River), Dixon, East Fox Lake, Elgin (Rainbow Springs), Fox Lake, Grand Tower, Harrisburg, Havana (Quiver Creek), Johnsburg (Fox River), Kankakee, McHenry, Mineola (East Fox Lake), Momence, Ottawa, Pistakee Lake, Rock Island, Rosecrans (Des Plaines River), Savanna, Serena (Indian Creek), Shawneetown, Springfield, Spring Grove (Nippersink Creek), Sterling, Urbana, Wadsworth (Des Plaines River), West Fox Lake, Wilmington, Zion (Dead River).

Athripsodes alagmus Ross

Athripsodes alagmus Ross (1938*a*, p. 155); ♂.

LARVA.—Fig. 764. Length 7 mm. Head brown with definite pale spots which do not contrast greatly with the background. Pronotum and legs straw color to yellowish brown. Frons and other structural characters similar to those of *tarsi-punctatus*.

CASE.—Length 8 mm., horn shaped, made chiefly of vegetable fragments, very rarely with some sand grains mixed with these.

ADULTS.—Length 12 mm. Color chocolate brown, the base of the tarsi ringed with white. Male genitalia, fig. 781: cerci short; tenth tergite fairly long, slightly curved, fairly thick at apex, and with a pair of stout, sclerotized lateral arms which arise at the extreme base of the tergite and nearly reach the tip; claspers with long, pointed basal projection, curved apical segment and a stout, curved mesal projection. Female genitalia, fig. 793: ninth sternite with a pair of finger-like, apico-mesal lobes; bursa copulatrix with lateral bands flat to point of attachment; a large sclerite almost fills the space between the bursa and the dorsal apodeme of the tenth tergite.

Allotype, female.—Spring Grove, Illinois, reared from hatchery ponds: June 14, 1938, B. D. Burks.

This species has been taken at only a few localities in the northern part of the state. It is apparently single brooded, our emergence records being from June 14 to July 20. We have taken the larvae only in fish hatchery ponds at Spring Grove where they were very abundant. It is interesting to note that only a few miles away the somewhat similar larvae of closely related *tarsi-punctatus* were abundant in Fox Lake, but we experienced no difficulty in separating the two on comparative coloration and case construction, nor did the two appear to mix in either habitat.

Records for this species are scattered but restricted to the northeastern states, as follows: Illinois, Michigan, Minnesota, New York and Wisconsin.

Illinois Records.—Many males and females, taken June 14 to August 15, and many larvae, taken June 9 to 14, are from Antioch, Fox Lake, Fulton, Homer, McHenry, Momence, Richmond, Spring Grove, Waukegan, Wadsworth (Des Plaines River).

Athripsodes nephus new species

LARVA.—Unknown.

MALE.—Length 10 mm. Color various shades of brown, the wings an almost uniform shade and without white scales, the tarsi banded with light and dark. General structure typical for genus. Male genitalia, fig. 779: ninth segment fairly narrow and cylindrical, the dorsal portion projecting over the base of the tenth. Tenth tergite long and narrow, the central portion narrowed, the apex expanded into a definite head; at the base of the tenth tergite arise a pair of sclerotized rods which are sharply curved at the middle and reach to the middle of the tenth tergite. Claspers stocky; basal segment short with a ventral pointed projection; apical segment stout and curved at middle, membranous and bearing long scattered setae; mesal process fairly slender and about half the length of the apical segment. Aedeagus ovate, the lateral sclerites deep, the internal sclerotized pair of rods short, wide at base, and sharply angled dorsad at apex.

Holotype, male. — Rosecrans, Illinois, along Des Plaines River: June 9, 1938, at light, Ross & Burks.

Paratypes.—ILLINOIS.—Same data as for holotype, 1 ♂.

OKLAHOMA.—Cloudy Creek near CLOUDY: May 4, 1940, Mrs. Roy Weddle, 1 ♂.

The species differs from all the previously described members of the *tarsi-punctatus* group in the short, sclerotized rod which arises from the base of the tenth tergite, the angled internal rod of the aedeagus, and also in the shape of the tenth tergite, notably the constricted central portion and expanded apex.

This is a very rare species in Illinois known only from the male and with nothing known regarding its biology. Probably locally distributed over a wide range.

Athripsodes resurgens (Walker)

Leptocerus resurgens Walker (1852, p. 70); ♂.

Leptocerus variegatus Hagen (1861, p. 278); ♂.

Leptocerus aspinosus Betten (1934, p. 255); ♂.

LARVA.—Unknown.

ADULTS.—Length 16 mm. Color grayish brown, the wings and body with a scattering of fairly large areas of white hair giving it a variegated and somewhat hairy appearance. Male genitalia, fig. 785: cerci short and rounded; tenth tergite elongate and upturned; claspers with a short, dark basal projection, very long basal segment, short and curved apical segment, and a mesal process which is straight and stout and usually extends slightly above the level of the apical segment. Female genitalia, fig. 800: ninth sternite only slightly sclerotized; bursa copulatrix with wide lateral extensions, the attachments fairly long, membranous except for a pair of plates which do not touch the bursa.

Allotype, female.—Brevort, Michigan: Aug. 8, 1936, C. Sabrosky.

Illinois records are confined entirely to the shore of Lake Michigan. The type of Hagen's *variegatus* was collected at Chicago, the types of *aspinosus* are from Lake Forest, and we have taken additional specimens at Waukegan. The larva, which is unknown, probably lives in Lake Michigan.

The range of the species extends throughout the Northeast, with a single isolated record from the Kiamichi Mountains in Oklahoma. Records include Illinois, Michigan, Minnesota, New York, Ohio, Oklahoma, Ontario, Quebec, Saskatchewan and Wisconsin.

Illinois Records.—CHICAGO: June 11–Aug. 27, W. J. Gerhard, 7♂, 3♀, FM. WAUKEGAN: July 7, 1937, at light, Frison & Ross, 3♀.

Athripsodes angustus (Banks)

Leptocerus angustus Banks (1914, p. 263); ♂.

LARVA.—Unknown.

ADULTS.—Length 13 mm. Color brown with scarcely any markings. Male genitalia, fig. 784, very similar to *resurgens*, differing in the longer apical segment of the clasper, more uniform tenth tergite, and the long, fusiform spine on the inner lobe of the clasper. Female genitalia, fig. 801, similar in general structure to *resurgens* but with supports of the bursa sclerotized for almost their entire length.

Allotype, female.—Lake Erie, Put-in-Bay, Ohio: Aug. 16, 1937, C. O. Mohr.

We have only a few scattered records of this species from the northern half of Illinois. Little is known about its habitat preference, and the larva is unknown.

The range of the species occupies a large portion of the Northeast, with a southwestward extension into the Kiamichi Mountains of Oklahoma. Records are available from Illinois, Maine, Michigan, Minnesota, New York, Ohio, Oklahoma, Ontario, Pennsylvania, Quebec and Wisconsin.

Illinois Records. — DANVILLE, Middle Fork River: Aug. 27, 1936, Ross & Burks, 3♂. Three miles east of MOMENCE: June 22, 1938, Ross & Burks, 1♂. OREGON: July 18, 1927, at light, T. H. Frison & R. D. Glasgow, 2♂. RICHMOND: June 20, 1938, Burks & Boesel, 1♂.

Athripsodes dilutus (Hagen)

Leptocerus dilutus Hagen (1861, p. 277); ♂.

LARVA.—Length 6 mm. Head, pronotum and legs cream color to yellowish, the head with scattered, indistinct, brownish spots on upper portion. Parafrontal areas only about half width of frons. Mesonotum with only a few pairs of scattered hairs, the sclerotized bars narrow and not sharply angled. Ninth segment with only one or two very short and slender dorsal hairs.

CASE.—Length 7 mm., horn shaped, nearly round in cross section, constructed of sand grains cemented together to form a fairly smooth exterior.

ADULTS.—Length 6–7 mm. Color dark brown, the wings with a few patches of light hair. Male genitalia, fig. 782: cerci short, almost completely fused at base with genital capsule; tenth tergite fairly long, divided at apex into a pair of short, rounded lobes; claspers with basal segment very long, produced into a short ventral projection, apical segment short and somewhat elliptic; mesal process short, narrow at base and widened into a spatulate apex; aedeagus with two long, black internal spines situated one beyond the other. Female genitalia, fig. 796, with ninth sternite short and only slightly sclerotized, and tenth segment with lateral plates long and slender.

This species, originally described by Hagen from Chicago specimens, is apparently confined in Illinois to the vicinity of Lake Michigan and glacial lakes in the northeastern corner of the state. Our records are too incomplete to be sure of the number of generations, but large flights have been taken from May to mid August. It is possible that there is only a single generation and that the late emergence records are from cold water situations. Vorhies (1909, p. 688) reared this species in the lakes around Madison, Wisconsin, and described the larvae and adults. We have taken pupae commonly on stones in Channel Lake near Antioch, Illinois.

The range of the species apparently includes most of the Northeast, extending westward to Minnesota and south to Georgia. We have records from Georgia, Illinois, Indiana, Minnesota, New York, Ohio, Ontario, Quebec and Wisconsin.

Illinois Records.—ANTIOCH: May 18, 1938, Ross & Burks, 3♂, 1♀ (reared in cage at Spring Grove). CHANNEL LAKE: May 27, 1936, H. H. Ross, 3♂, 4♀. CHICAGO: July 13, 1931, roof of Stevens Hotel, T. H. Frison, 8♂, 9♀; July 8, 1939, G. T. Riegel, 5♂, 7♀. FOX LAKE: May 15, 1936, Ross & Mohr, from stones, 7 pupae; May 28, 1936, H. H. Ross, 2♀. GRAYSLAKE: May 26, 1936, H. H. Ross, 1♂. North of WADSWORTH, Des Plaines River: July 7, 1937, Frison & Ross, 1♀. WAUKEGAN: Aug. 25, 1932, Ross & Mohr, 1♂; July 16, 1935, Ross & DeLong, ♂♂, ♀♀; May 25, 1936, H. H. Ross, 1♀; July 7, 1937, at light, Frison & Ross, ♂♂, ♀♀; Aug. 15, 1938, Ross & Burks, 6♀. ZION: Dead River, July 7, 1937, Frison & Ross, 4♂, ♀♀; June 4, 1938, Ross & Burks, 1♀; Aug. 15, 1936, Ross & Burks, 1♀.

Athripsodes annulicornis (Stephens)

Leptocerus annulicornis Stephens (1836, p. 199); ♂, ♀.

Leptocerus lugens Hagen (1861, p. 276); ♂, ♀.

Leptocerus recurvatus Banks (1908*b*, p. 265); ♂.

Leptocerus futilis Banks (1914, p. 264); ♂.

Athripsodes perplexus nordus Milne (1934, p. 15); ♂.

Not yet collected in Illinois, but a possible addition with future collecting. The range of the species covers the Holarctic region with North American records from Alaska, Colorado, New York, Ontario, Oregon, Quebec and Wisconsin.

Athripsodes mentieus (Walker)

Leptocerus mentieus Walker (1852, p. 71); ♂.

Leptocerus vanus Betten (1934, p. 262); ♂, ♀.

Leptocerus mentiens auct., misspelling.

LARVA.—Fig. 763. Length 6.5–7.0 mm. Head, pronotum and legs brownish yellow, the head with an irregular brown pattern. Parafrontal areas as long as frons, the three meeting at base of epicranial stem. Mesonotum relatively hairy with at least 20 pairs of hairs in addition to lateral tufts, and with sclerotized bars fairly wide. Ninth segment with two pairs of long black setae.

CASE.—Fig. 810. Length 10 mm., horn shaped and markedly curved; constructed of flattened sand grains cemented together to form an even and fenestrated exterior.

ADULTS.—Length 10 mm. Color dark brown, the tarsi ringed with white. Male genitalia, fig. 787: cerci short and ovate; tenth tergite stout, the apical portion long and expanded into a broad hood; claspers with basal segment large, produced into a mesal triangular lobe, the apical segment short and curved, the mesal process wide at base, fairly long and tapering to a sharp point. Female genitalia, fig. 805: ninth sternite only indistinctly sclerotized; bursa copulatrix oval and attached by a pair of sclerotized ribbons.

Our collections of adults have resulted in only a few scattered Illinois records of this species distributed from the extreme north to the extreme south end of the state. Bottom fauna collections made by R. E. Richardson show that in 1924-27 the larva of this species was an abundant midstream feature for almost the entire length of the Rock River. These Rock River collections have established the association of the larva and adults. Collections of adults and pupae indicate that emergence occurs from late June through August.

The few records available from Illinois, New York, Ontario and Wisconsin indicate the species to be distributed through the Northeast.

Illinois Records.—Many males, four females and many pupae, taken June 15 to August 7, and many larvae and cases, taken May 11 to August 29, are from Byron (Rock River), Como (Rock River), Dixon (Rock River), Erie (Rock River), Grand Detour, Grand Tower, Hamilton, Harrisburg, Keithsburg, Love's Park (Rock River), Lyndon (Rock River), Nelson (Rock River), Oregon (Rock River), Prophetstown (Rock River), Rockton, Sterling (Rock River).

Athripsodes ophioderus Ross

Athripsodes ophioderus Ross (1938*a*, p. 157); ♂.

LARVA.—Unknown.

ADULTS.—Length 10 mm. Color reddish brown, the wings with a few indistinct whitish spots. Male genitalia, fig. 786: cerci short but pointed at apex; tenth tergite elongate, with a small, round, basal portion bearing a short cone of stout setae near apex, the tergite beyond this prolonged into a slender neck bearing a small hoodlike portion at tip; claspers with basal segment large, with an angular ventro-mesal elongation, the apical segment fairly long, the mesal process slender and curved. Female unknown.

This species was originally described from two specimens collected at Elizabethtown, Illinois, and since then only one other male has been found, from Hoopeston in the east-central part of the state. No generalizations can be made about either its distribution or habitat preference.

Illinois Records.—ELIZABETHTOWN: June 22, 1927, at light, Frison & Glasgow, 2♂. HOOPESTON: July 14, 1940, at light, J. S. Ayars, 1♂.

Athripsodes transversus (Hagen)

Leptocerus transversus Hagen (1861, p. 279); ♂, ♀.

Leptocerus maculatus Banks (1899, p. 214); ♀.

LARVA.—Fig. 767. Length 6 mm. Head yellowish brown with indistinct lighter spots. Mesonotum and legs straw colored. Parafrontal areas nearly as wide as frons. Pronotum with evenly spaced hairs along anterior margin. Mesonotum with only two or three pairs of hairs, the lateral tufts composed of three to four hairs, the sclerotized bars narrow but fairly sharply angled. Ninth tergite with two pairs of long black setae. Anal legs with a fairly long, sclerotized dorsal bar.

CASE.—Length 8 mm., horn shaped and constructed of sand grains, these generally irregular in size and shape, giving a more or less rough external appearance to the case itself.

ADULTS.—Length 10 mm. Color varying from bright reddish brown to lighter or darker shades of brown. Male genitalia, fig. 790: cerci fairly long, pointed at apex; tenth tergite with somewhat bulbous base and finger-like apex; claspers with basal segment short, provided with a short, stout ventral projection, apical segment long and straight, mesal process slender and much shorter than apical segment. Female genitalia, fig. 797: ninth sternite sloping abruptly mesad from base, the mesal portion forming a tonguelike rounded lobe, the sloping portion marked by a distinct invagination; bursa copulatrix somewhat elliptic.

This species has been taken throughout the state, chiefly along the larger rivers and streams. The larvae were reared from Indian Creek and Nippersink Creek. The span of adult emergence is wide, from May to early September. The larvae are generally found under stones.

The range of the species is wide, extending from the eastern states southwestward to Texas and northwestward to Minnesota, with records from the following: Arkansas, District of Columbia, Georgia, Illinois, Indiana, Iowa, Kentucky, Minnesota, Missouri, New Brunswick, Ohio, Oklahoma, Pennsylvania, Tennessee, Texas and Wisconsin.

Illinois Records.—Many males, females and pupae, taken May 17 to September 11, and many larvae and seven cases, taken May 17 to August 12, are from Alton, Bartonville (Kickapoo Creek), Cairo, Charleston, Council Hill (Galena River), Dixon, Elgin (Botanical Gardens), Erie (Rock Creek), Hamilton, Hardin, Havana, Kampsville, Kankakee (Kankakee River), Lyndon, Mahomet (Sangamon River), Milan (Rock River), Momence (Kankakee River), Morris, Mount Carmel, Ottawa, Pontiac, Quincy, Rock Island, Savanna, Serena (Indian Creek), Spring Grove (Nippersink Creek), Venedy Station (Kaskaskia River), Wadsworth (Des Plaines River), Yorkville (Fox River).

Athripsodes cancellatus (Betten)

Leptocerus cancellatus Betten (1934, p. 256); ♂, ♀.

LARVA.—Length 6 mm. Head, pronotum and legs creamy white, the head with an indefinite light brownish pattern. Parafrontal areas nearly as wide as frons. Pronotum with a thick line of setae along anterior margin, the setae including long and short ones. Mesonotum with only three or four pairs of setae in addition to lateral tuft which consists of only two or three hairs.

CASE.—Length 8 mm., horn shaped, the main structure composed of fairly regular sand grains arranged in a somewhat fenestrate pattern, a few larger grains arranged along the side, giving very slightly the appearance of a lateral extension.

Adults.—Length 10–12 mm. Color dark brown with very few markings. Male genitalia similar to those of *transversus*, differing chiefly in the basal segment of the claspers, which lack the ventral projection, fig. 791. Considerable variation occurs in both tenth tergite and claspers, as shown in the two drawings. Female genitalia, fig. 798, also very similar to those of *transversus*, usually with the mesal lobe of the ninth sternite narrower and the sloping portion of the tergite longer.

This species has been collected commonly in northern Illinois, and we have also one or two scattered records from the central and southern parts of the state. It frequents medium to large streams and has an adult emergence ranging from June through August. We have reared the larvae from Nippersink Creek.

The species is widely distributed through the eastern states and westward through the Ozarks to Oklahoma. We have records from Arkansas, Georgia, Illinois, Indiana, Kentucky, Minnesota, Missouri, New York, Ohio, Oklahoma, Pennsylvania, Quebec, Tennessee and Wisconsin.

Illinois Records.—Many males and females, taken May 17 to August 2, and many larvae, taken May 17 to June 9, are from Dixon, Elgin (Botanical Gardens), Fox Lake, Freeport, Homer, Kankakee (Kankakee River), Keithsburg, Mahomet (Sangamon River), Milan (Rock River), Momence (Kankakee River), Ottawa, Richmond (Nippersink Creek), Rockford, Rock Island, Savanna, Serena (Indian Creek), Shawneetown, Spring Grove (Nippersink Creek), Wilmington, Yorkville (Fox River).

Athripsodes punctatus (Banks)

Mystacides punctatus Banks (1894, p. 180); ♀.

Larva.—Unknown.

Adults.—Length 10 mm. Color black, the wings with a scattering of flat white scales. Male genitalia, fig. 788: cerci pointed; tenth tergite robust, with a digitate apical prolongation; claspers with basal segment short, apical segment long and lanceolate, the mesal process long and stout. Female genitalia, fig. 802: ninth sternite divided into a pair of wide lateral plates and a mesal tonguelike strip, these three areas heavily sclerotized, and together making an arcuate apical margin; bursa copulatrix small and vasiform, the connectives chiefly membranous.

The male illustrated for this species by Betten (1934, p. 259) belongs to *uvalo*, which is distinguished by the pointed tenth tergite. The male which I am considering true *punctatus* has been taken in company with the female which agrees in structure of genitalia with a series of females belonging to the type lot, from Douglas County, Kansas.

Allotype, male. — Harrisburg, Illinois: June 15, 1934, at light, DeLong & Ross.

In Illinois we have taken this species at only two points, both of these in the southern part of the state. The nature of the terrain at these two points is such that these specimens could have flown to the lights from either the Ohio River or smaller sluggish and muddy streams such as the Saline, in the immediate vicinity.

The only definite records of this species which we have are from Arkansas, Illinois, Kansas and Maine.

Illinois Records.—Eldorado: Sept. 8, 1933, Ross & Mohr, 1♀. Harrisburg: June 15, 1934, DeLong & Ross, at light, 3♂, 1♀.

Athripsodes saccus Ross

Athripsodes saccus Ross (1938*b*, p. 89); ♂.

Larva.—Unknown.

Adults.—Length 13 mm. Color almost entirely black, tarsi whitish, and front wings with one or two white marks and with a scattering of broad white scales over the entire wing. Male genitalia, fig. 776: cerci short and oval; tenth tergite large, U-shaped, the ventral arm of the U divided into large, lateral prolongations tipped with a cluster of long, peglike setae; claspers with basal segment broad, its apico-mesal margin bearing a dense cone of peglike setae, the apical segment long and lanceolate, the mesal process long and slender. Female genitalia, fig. 806: ninth segment with cerci well delineated; ninth tergite composed chiefly of a single large, sclerotized plate arcuate across the apex; bursa copulatrix U-shaped, with a pair of sharp points near the top, these points curving ventrad; bursa attached to short but heavy membranous folds, and with a rather thick ventral membranous "curtain" hanging down on the ventral side of the bursa.

Allotype, female.—Lake Erie, Put-in-Bay, Ohio: 1937.

Our only definite records for this species are two females collected at Chicago, Illinois, one on July 8, 1937, along the lake front, Frison & Ross, the other on June 24, 1925, A. C. Weed, FM. There is a third female bearing the data "Northern Illinois," but without other information.

The species was originally described from Lake Erie, where it is very abundant; otherwise it is known only from Quebec and Illinois.

Athripsodes erraticus Milne

Athripsodes erraticus Milne (1936, p. 58); ♂, ♀.

Larva.—Unknown.

Adults.—Length 12 mm. Color black or nearly so, the anterior wings with a scattering of white scales. Male genitalia, fig. 777: tenth tergite divided into dorsal and ventral portions, the ventral portion with a lateral long curved blade; claspers with a large mesal lobe which is serrate with evenly spaced teeth on the mesal margin. Female genitalia, fig. 807: ninth sternite only slightly sclerotized; bursa copulatrix U-shaped with a pair of lateral points at middle and above these forming a slightly narrower, vasiform part.

Our only Illinois record of this species is a female bearing the data "Northern Illinois." The species is present in Lake Erie and has been taken in Quebec.

Athripsodes erullus Ross

Athripsodes erullus Ross (1938*b*, p. 90); ♂.

This species has not yet been taken in Illinois, but since it is common in company with both *saccus* and *erraticus* in Lake Erie, we might expect it in the northern part of the state. The male genitalia, fig. 778, are readily distinguished on the basis of characters in the key. The females resemble the males in black color and the white scales on the wings. They are readily distinguished from those of other species by the curious structure of the bursa copulatrix and the division of the ninth sternite into three fairly large areas, fig. 804.

Allotype, female.—Lake Erie, Put-in-Bay, Ohio: 1937.

Athripsodes submacula (Walker)

Leptocerus submacula Walker (1852, p. 70): ♂.

This species, like *errulus*, has not yet been taken in Illinois, although in Lake Erie it occurs in company with *erraticus* and *saccus*. As outlined by Betten & Mosely (1940, p. 70), only the male of the type series can be definitely assigned. Study of much material from Lake Erie shows that the female has the black head and white-scaled wings typical of the group, and small eyes, although slightly larger than eyes of related females; the ninth sternite is divided into extensive lateral lobes which are only moderately sclerotized, and the bursa copulatrix is heavily sclerotized and triangular, fig. 803.

Allotype, female.—Lake Erie, Put-in-Bay, Ohio: 1937.

Athripsodes species a, b and c

In addition to the larvae associated definitely with adults, there are three species of larvae segregated in our collection which have not been reared. Most likely these belong to species here treated in the adult stage only, which include *angustus*, *ophioderus*, *resurgens* and the entire complex of species with white-scaled wings such as *punctatus* and *erraticus*. These unreared larvae have been included in the key as an aid to the better recognition of the reared species and a stimulus for additional rearing work.

Species a.—Length 6 mm. Almost entirely straw colored, the sclerites scarcely darker than the body. Parafrontal areas indistinguishable. Mesonotum with only a few hairs in addition to lateral tufts of two or three hairs. This species makes a short horn case using fragments of fresh-water sponges in its construction so that it appears irregular, soft and fuzzy. We have taken this species in Nippersink Creek at Spring Grove, Illinois, in the Namekagon River at Spooner, Wisconsin, and in Meramec Springs at St. James, Missouri. This last collection had cases made of irregular pieces of stones and very little sponge material.

Species b.—Length 5 mm. Head, pronotum and legs very pale yellowish brown, not much darker than the straw-colored body; upper portion of head with scattered brown spots; parafrontal areas nearly as wide as frons. Mesonotum with only a few hairs in addition to lateral tuft of two or three hairs. Ninth segment with only one or two pairs of very weak, short setae. Case with lateral margins somewhat produced, although not as much so as in *ancylus*; constructed of sand grains and fairly smooth. We have a single collection from Apple River in Apple River Canyon State Park, Illinois, June 27, 1940, Mohr & Riegel.

Species c.—Length 8.5 mm. Head, pronotum and legs chocolate brown, the head with many light dots and dashes. Parafrontal areas only about half width of frons. Mesonotum with only a few scattered hairs in addition to lateral tufts composed of one or two hairs; sclerotized bars wide, sharply angled and almost L-shaped. Ninth segment with two pairs of long black hairs. Anal legs with long, dorsal sclerotized bars. Case made of flat stones, stout and almost cylindrical. These larvae have been collected in Lake Erie at Put-in-Bay, Ohio, and may be either *resurgens* or one of the *punctatus* group. They are conspicuous in that the abdomen is large and cylindrical, scarcely tapering toward apex. They were collected in deep water.

Oecetis McLachlan

Oecetis McLachlan (1877, p. 329). Genotype, here designated: *Leptocerus ochraceus* Curtis.

Setodina Banks (1907*a*, p. 130). Genotype, by original designation: *Setodina parva* Banks.

Oecetina Banks (1899, p. 215). Genotype, by original designation: *Oecetis incerta* of American authors, nec Walker = *inconspicua* (Walker).

Oecetodes Ulmer (1909, p. 144). Genotype, by subsequent designation of Milne (1934, p. 19): *Setodes avara* Banks.

Friga Milne (1934, p. 16). Genotype, by original designation: *Setodes immobilis* Hagen.

Quaria Milne (1934, p. 17). Genotype, monobasic: *Oecetis scala* Milne.

Yrula Milne (1934, p. 17). Genotype, by original designation: *Oecetina fumosa* Banks.

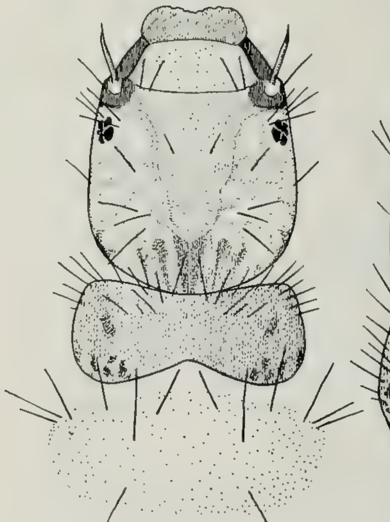
This genus is of unusual interest because of the predaceous habit of the larvae and the elongate, grasping type of mouthparts which have been developed in company with this habit. The adults may readily be distinguished by venation, the pupae by the mandibles and anal appendages.

In this genus we have possibly the most widely distributed caddis flies in North America and species which become abundant in very diverse situations. Only 15 species have been described from North America; of these we have taken 7 in Illinois. The females and larvae have both exhibited good key differences, but due to difficulties in rearing only five larvae have been associated with the adults.

KEY TO SPECIES

Larvae

1. Head brown with light spots and bars, fig. 811; case of log cabin type, fig. 833 .... **cinerascens**, p. 241
   Head straw color, sometimes with brown spots or bars, fig. 812; case of stone construction 2
2. Dorsal hump of first abdominal seg-



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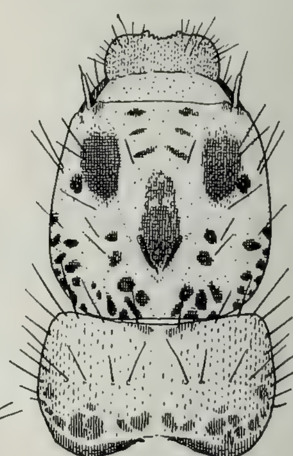

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Fig. 811.—*Oecetis cinerascens*, larva.
Fig. 812.—*Oecetis species a* larva.

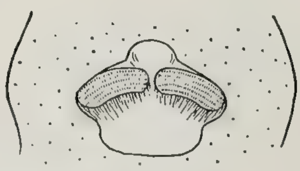

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Fig. 813.—*Oecetis avara* larva, dorsal hump.

Fig. 814.—*Oecetis eddlestoni* larva, left mandible, ventral aspect.

Fig. 815.—*Oecetis species b* larva, left mandible, ventral aspect.

ment with 4–6 rows of micro-hooks, fig. 813 . . . . **avara,** p. 240
Dorsal hump of first abdominal segment without micro-hooks 3

3. First abdominal sternite with a row of hairs extending across the segment 4
First abdominal sternite with only one or two pairs of setae 6

4. Meso- and metanotum each with a lateral tuft of 10–20 hairs; first abdominal sternite with a row of about 50 hairs; ninth tergite with about 25 hairs; head spots very dark . . . . **ochracea,** p. 244
Meso- and metanotum without distinct lateral tufts; first abdominal sternite with a row of only 25 hairs; ninth tergite with only 8–10 hairs; head spots various 5

5. Head with three dark areas on and near frons, fig. 812 . . . . . **species a,** p. 244
Head without such dark areas, fig. 834 . . . . **inconspicua,** p. 242

6. Left mandible with ventral aspect slightly convex but without creases, fig. 814 . . . . **eddlestoni,** p. 240
Ventral aspect of left mandible with a deep crease running from apical tooth, fig. 815 . . . . **species b,** p. 244

Adults

1. Apex of abdomen with movable claspers, figs. 816–824 (males) 2
Apex of abdomen without claspers, figs. 825–832 (females) 10

2. Tenth tergite consisting of a pair of long, slender, cylindrical, sclerotized rods, each bearing two stout, peglike setae, fig. 816 3
Tenth tergite either very short, composed of a single process, fig. 824, or with rods bladelike and without pegs, fig. 819 4

3. Claspers produced into a long, apical finger, fig. 816 . . . . **scala,** p. 241
Claspers in general truncate at apex, fig. 817 . . . . **eddlestoni,** p. 240

4. Claspers somewhat kidney shaped, much higher than long, fig. 818 . . . . **avara,** p. 240
Claspers elongate, longer than high . . . 5

5. Tenth tergite formed of a pair of bladelike structures wide at base and tapering to a downcurved, narrow apex; claspers with basal portion wide and apex with a very short projection, fig. 819 . . . . **osteni,** p. 241
Tenth tergite formed of either a single mesal projection, fig. 821, or very short, fig. 820 6

6. Claspers with mesal margin incised to form a short mesal tooth, fig. 820 . . . . **ochracea,** p. 244
Claspers with mesal margin straight or sinuate, not incised, figs. 821–824 7

7. Abdomen with sixth and seventh or seventh and eighth tergites finely and distinctly reticulate; apical finger of claspers long and converging at apex, fig. 822 8
Abdomen with none of tergites recticulate; apical finger of claspers diverging, fig. 824 9

8. Tenth tergite twice as long as cerci, fig. 821; seventh and eighth tergites reticulate . . . . **persimilis,** p. 243
Tenth tergite about as long as cerci, fig. 822; sixth and seventh tergites reticulate . . . . **cinerascens,** p. 241

9. Upper margin of claspers evenly sinuate, aedeagus elongate and with the apical beak projecting straight, fig. 823 . . . . **immobilis,** p. 241
Upper margin of claspers deeply emarginate to form a prominent baso-dorsal lobe, aedeagus almost circular, the beak directed ventrad, fig. 824 . . . . **inconspicua,** p. 242

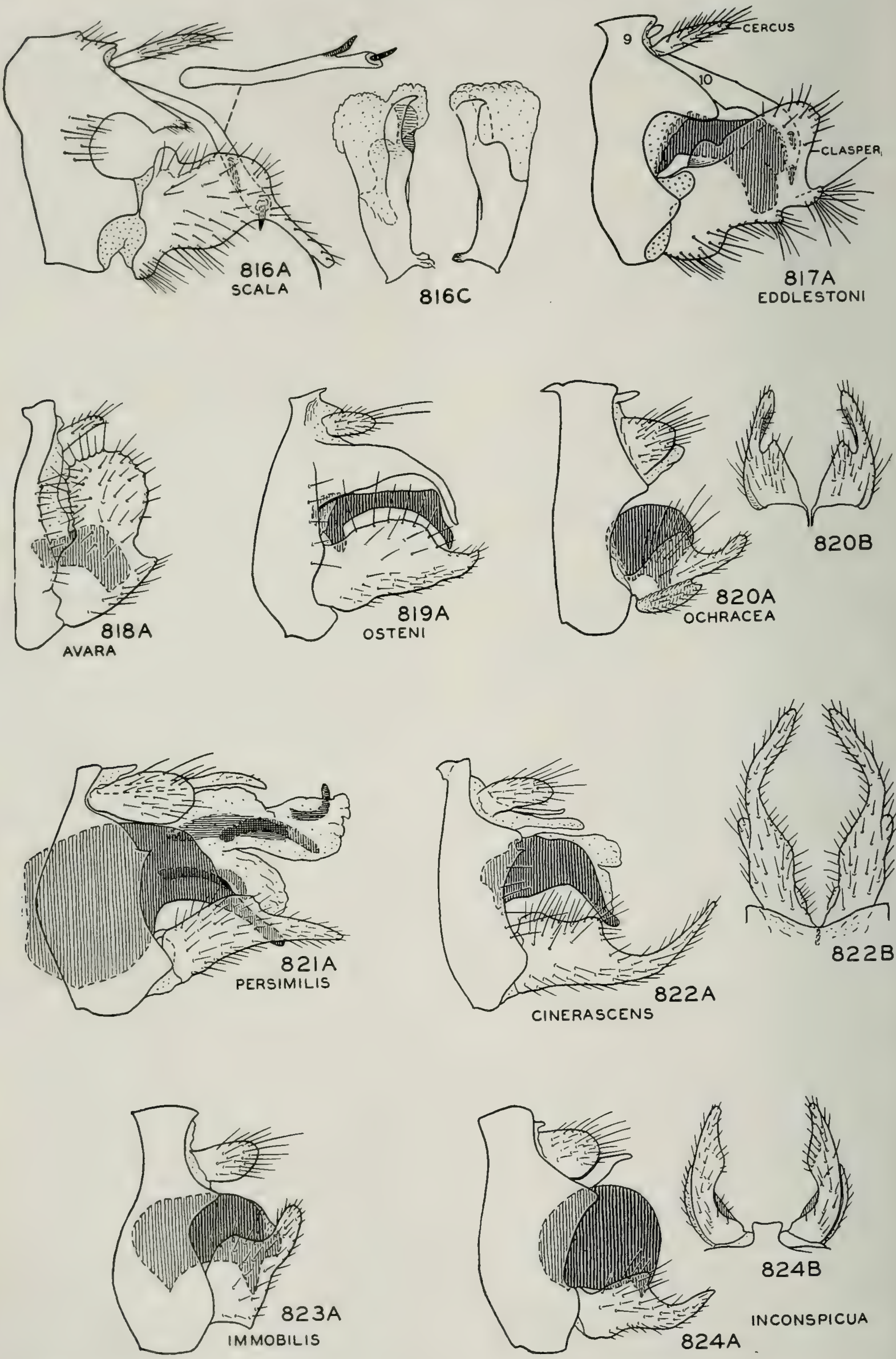
10. Bursa copulatrix attached to a large, many-lobed, heavily sclerotized internal structure with a pair of long, anteriorly directed, sclerotized rods, fig. 825 . . . . **persimilis,** p. 243
Bursa copulatrix not attached to a sclerotized, lobed internal structure, fig. 826 11

11. Eighth sternite with a purse-shaped, sclerotized area, fig. 826 . . . **osteni,** p. 241
Eighth sternite without such an area, at most with sclerotized lines, fig. 827 12

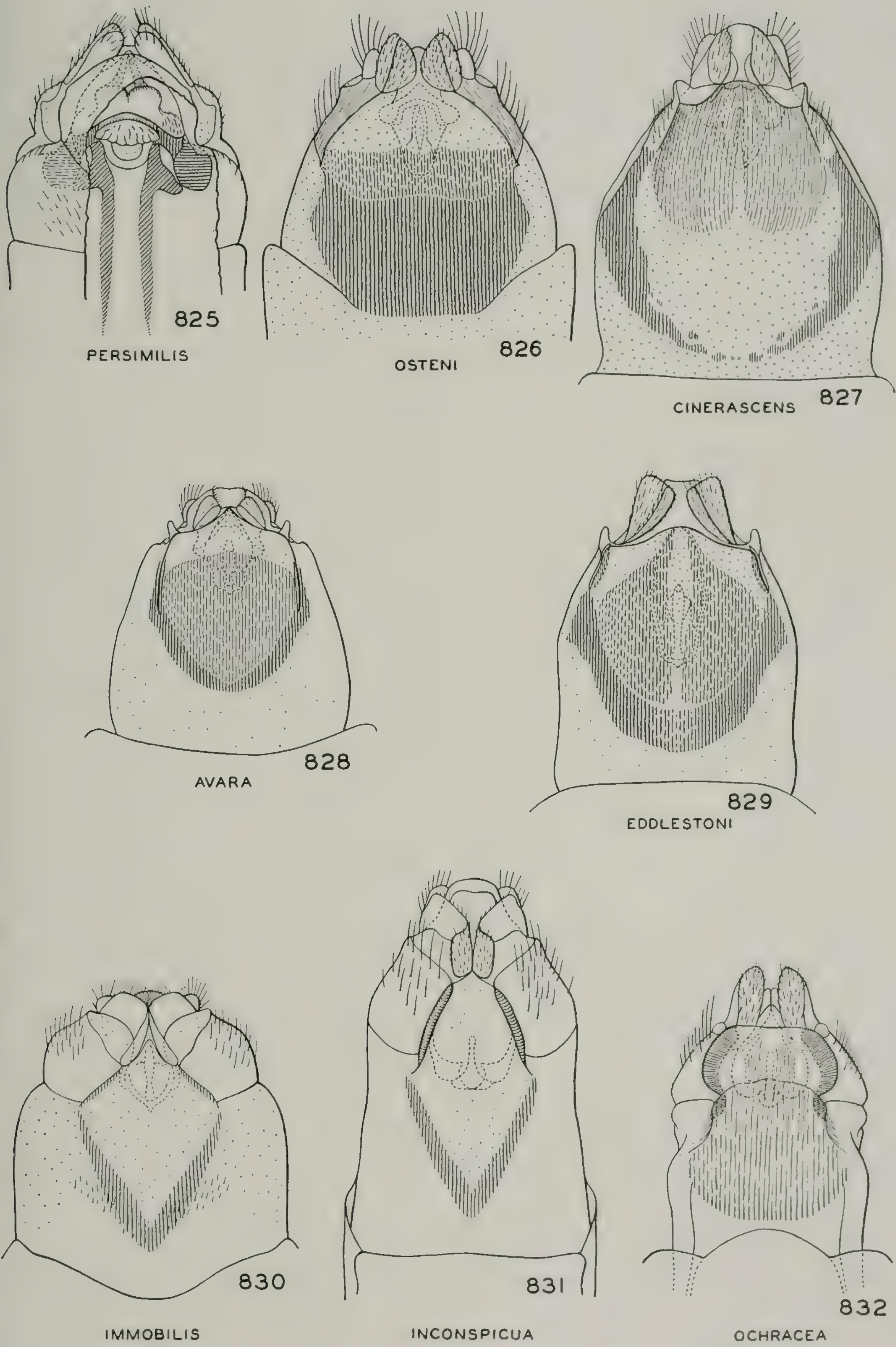
12. Ninth sternite produced into a pair of short "ears" on each side of lobes of tenth segment, fig. 827; subgenital plate outlined by a more or less circular black line 13
Ninth sternite not produced into "ears"; subgenital plate outlined as a diamond-shaped or vasiform area, figs. 830–832 15

13. Subgenital plate angled outward across middle, the base membranous, the apical declivity with a pair of sclerotized plates together forming a shallow, concave basin, fig. 827 . . . . **cinerascens,** p. 241
Subgenital plate with sclerotized plates weaker and occupying basal instead of apical portion, fig. 828 14

14. Bursa copulatrix as in fig. 828, with apex nearly truncate and basal por-



Figs. 816–824.—*Oecetis*, male genitalia. *A*, lateral aspect; *B*, ventral aspect; *C*, aedeagus.



Figs. 825–832.—*Oecetis*, female genitalia. All figures showing ventral aspect; in fig. 825 the sternites partially cut away to show bursa copulatrix.

tion with sharp lateral extensions.. ....**avara,** p. 240

Bursa copulatrix as in fig. 829, with apex rounded and without sharp, lateral extensions....**eddlestoni,** p. 240

15. Subgenital plate diamond-shaped, the posterior sides of the diamond raised and fencelike, fig. 830...... ....**immobilis,** p. 241

Subgenital plate more vasiform, the posterior sides of the vase folded laterad and shelflike, fig. 831..... 16

16. Postero-lateral, shelflike margin of subgenital plate nearly straight, the anterior portion angulate and almost membranous, fig. 831....... ....**inconspicua,** p. 242

Postero-lateral, shelflike margin of subgenital plate arcuate, the anterior portion of the sternite more ovate and distinctly sclerotized, fig. 832.................**ochracea,** p. 244

Oecetis avara (Banks)

Setodes avara Banks (1895, p. 316); ♂.

LARVA.—Length 6.5 mm. Head, pronotum and legs straw color, top of head with short brown bars.

CASE.—Length 7 mm., horn shaped, constructed of large sand grains cemented together to form a fairly smooth exterior.

ADULTS.—Length 10–11 mm. Color straw yellow to light brown, the forewings with numerous dark brown spots in the membrane. Male genitalia, fig. 818: tenth tergite short, slender and curved, consisting of only a single mesal piece; cerci short and ovate; claspers somewhat kidney shaped; aedeagus short and tubular, the apex slightly expanded ventrad. Female genitalia, fig. 828, with ninth sternite wide, delineated by arcuate dark lines, bursa copulatrix with apex nearly truncate and basal portion with sharp lateral extensions.

Allotype, female.—Momence, Illinois: Aug. 21, 1936, Ross & Burks.

This species has been taken commonly in the northern and central portions of the state where it frequents fairly rapid streams of various sizes. Larvae have been collected and associated with the adults in the Galena River at Council Hill, Illinois. The adults emerge throughout the summer months from May until early September.

The range of the species covers most of the United States, southern Canada and Mexico. The spotting on the wings varies to a considerable extent, and it is possible that the species *disjuncta* known from California may be simply a color variant of this species. We have records of *avara* from Alabama, British Columbia, Georgia, Idaho, Illinois, Indiana, Kentucky, Maine, Maryland, Michigan, Minnesota, Missouri, Montana, New Mexico, New York, Nova Scotia, Ohio, Oklahoma, Ontario, Oregon, Pennsylvania, Tennessee, Texas, West Virginia, Wisconsin and Wyoming.

Illinois Records.—Many males and females and four pupae, taken June 5 to September 7, and many larvae, taken May 5 to June 27, are from Apple River Canyon State Park, Charleston, Council Hill (Galena River), Danville (Middle Fork River), Homer, Kankakee (Kankakee River), Momence (Kankakee River), Oakwood (Middle Fork River), Oregon, Rock Island, St. Charles, Serena (Indian Creek), Wilmington, Yorkville (Fox River).

Oecetis eddlestoni Ross

Oecetis eddlestoni Ross (1938*a*, p. 160); ♂.

LARVA.—Length 5 mm. Head, pronotum and legs straw color, the head with brown bars and dots over most of its surface.

CASE.—Length 6 mm., constructed of sand grains, with a fairly smooth exterior.

ADULTS.—Length 10 mm. Color various shades of light brown, without conspicuous markings. Male genitalia, fig. 817: tenth tergite consisting of a pair of stout, cylindrical rods curved ventrad at apex, each bearing two stout spines and reaching almost to the apex of the claspers; cerci slender and lanceolate; claspers short and somewhat rhomboidal, the lower margin sinuate; aedeagus with a slender basal stalk and a footlike apex. Female genitalia, fig. 829, with the ninth sternite round, delineated by curved lines, bursa copulatrix rounded at apex and without lateral expansions at base.

Allotype, female.—Serena, Illinois: June 16, 1939, along Indian Creek, B. D. Burks.

We have collected this species in Illinois only along Indian Creek at Serena, from which locality the larvae were reared. It was originally described from Pennsylvania; we have additional records of this species only from Illinois, Ohio and Oklahoma, so that little can be said regarding its general habits and distribution.

Illinois Records.—SERENA, Indian

Creek: May 12, 1938, Ross & Burks, 7 larvae; May 17, 1938, Ross & Burks, 2♂, 2♀, 1 larva (all reared in cage at Spring Grove, Illinois); May 27, 1938, Ross & Burks, 1 larva; June 16, 1939, B. D. Burks, 1♀.

Oecetis scala Milne

Oecetis scala Milne (1934, p. 17); ♂.

Not yet taken in Illinois, but apparently with a widespread though scattered range, so that the species may be looked for in the state with future collecting. To date it has always been collected in small numbers, with records available from Maryland, New Jersey, North Carolina and Pennsylvania.

Oecetis osteni Milne

Oecetis osteni Milne (1934, p. 17); ♂, ♀.

LARVA.—Unknown.

ADULTS.—Length 9 mm. Color various shades of brown without conspicuous markings. Male genitalia, fig. 819: tenth tergite composed of a pair of fairly long, sclerotized arms, wide at base, tapering to a curved apical beak; aedeagus narrow and arcuate, in repose fitting into the V of the beak of the tenth tergite; claspers with the basal portion somewhat rectangular, tapering to a short, apical point. Female genitalia, fig. 826, readily identified by the dark area on the eighth sternite and the simple bursa copulatrix.

In Illinois this species is restricted to the extreme northern portion of the state and has been taken most commonly around the glacial lakes in the northeastern corner. The adults have been taken from late June to the latter part of August. In other states the records are most frequently associated with lakes, but the species undoubtedly occurs also in rivers.

The range of the species includes a band through the Northeast from Minnesota eastward to New Brunswick. Records are available from Illinois, Massachusetts, Michigan, Minnesota, New Brunswick, New Hampshire, New Jersey, New York, Ontario, Quebec, Virginia and Wisconsin.

Illinois Records.—ANTIOCH: July 7, 1932, at light, Frison & Metcalf, 4♂, 1♀. FOX LAKE: June 30, 1935, DeLong & Ross, ♂♂, ♀♀; June 10, 1936, Ross & Burks, 1♀. FULTON: July 20, 1927, Frison & Glasgow, 1♀. GRASS LAKE: July 14, 1926, Frison & Hayes, 1♀. GRAYSLAKE: Aug. 20, 1939, Mohr & Riegel, 1♂. RICHMOND: June 25, 1938, Burks & Boesel, 1♀. SPRING GROVE: Aug. 12, 1937, at light, Ross & Burks, 1♂.

Oecetis immobilis (Hagen)

Setodes immobilis Hagen (1861, p. 283); ♂.

LARVA.—Unknown.

ADULTS.—Length 9 mm. Color various shades of brown without conspicuous markings. Male genitalia, fig. 823: tenth tergite composed of a single semimembranous, fairly short process; cerci ovate; claspers fairly short, the dorsal margin sinuate, the apical process fairly short and the basal portion appressed for a considerable distance on meson; aedeagus stout at base, the apex forming a definite beak. Female genitalia, fig. 830, with ninth sternite diamond shaped, the posterior sides of the diamond raised and fencelike, bursa copulatrix almost circular.

In Illinois we have taken this species only in the extreme northern portion and, as with *osteni*, it has been taken abundantly only around the glacial lakes of the northeast corner of the state. All our records for Illinois are in late May, June and early July; records for other states, however, indicate an emergence which continues into August and September.

The range of the species includes most of the Northeast; records are from Illinois, Indiana, Michigan, New Brunswick, New York, Nova Scotia, Ohio, Ontario, Saskatchewan and Wisconsin.

Illinois Records.—FOX LAKE: July 1, 1931, Frison, Betten & Ross, ♂♂, ♀♀; June 30, 1935, DeLong & Ross, ♂♂, ♀♀; May 28, 1936, H. H. Ross, ♂♂, 1♂ pupa; June 10, 1936, Ross & Burks, 9♂. JOHNSBURG, Fox River: May 28, 1936, H. H. Ross, 2♂, 2♀. PISTAKEE LAKE: June 12, 1936, H. H. Ross, 1♂. ROCK CITY: May 24, 1938, Ross & Burks, 1♂. SPRING GROVE: June 9, 1938, Mohr & Burks, 1♂.

Oecetis cinerascens (Hagen)

Setodes cinerascens Hagen (1861, p. 282); ♂.
Oecetina fumosa Banks (1899, p. 216); ♀.

LARVA.—Fig. 811. Length 7 mm. Head brown with spots of a lighter shade scattered over the entire surface. Pronotum and legs straw color, the pronotum finely speckled with light brown. Labrum with

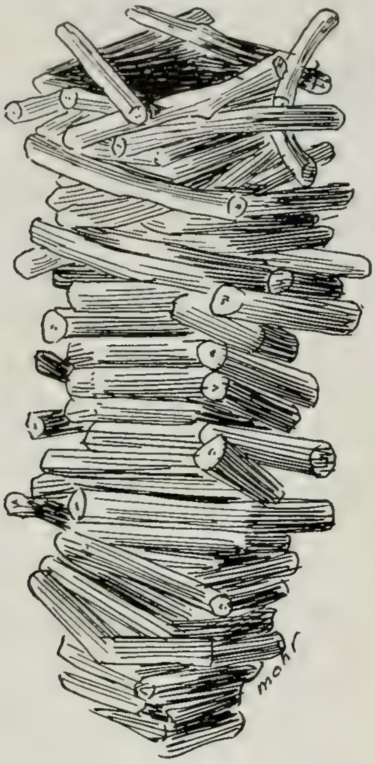


Fig. 833.—*Oecetis cinerascens*, case.

hairs forming an irregular band across apical third, first abdominal segment with dorsal holding process large and without setae.

CASE.—Fig. 833. Length 8–10 mm., constructed of bits of stems and other debris into a somewhat irregular log-cabin case.

ADULTS.—Length 11–13 mm. Color medium shades of brown; in life somewhat hoary due to the pale hair; the wing membrane with several dark spots situated at the vein forks. Male genitalia, fig. 822: tenth tergite consisting of a single stylelike projection; cerci fairly long and parallel sided, apex rounded; claspers with a wide basal portion which tapers suddenly to a long apical curved filament; aedeagus fairly long, the apex produced into a projecting beak. Female genitalia, fig. 827, with ninth sternite large and almost circular, delineated by very distinct arcuate lines, the apical portion of the sternite composed of a pair of concave sclerites; bursa copulatrix simple.

The common log-cabin case of this species is one of the most abundant features of many lakes and streams scattered throughout the state. The species is frequently taken in great numbers and occurs on the wing from May to late September, with a constant cycle of generations.

This species is widely distributed through the Northeast, and occurs south to Georgia, southwest through the Ozarks to Texas, and northwest to Saskatchewan. We have records from Arkansas, Georgia, Illinois, Maine, Massachusetts, Michigan, Minnesota, Missouri, New Brunswick, New York, Nova Scotia, Ohio, Oklahoma, Ontario, Pennsylvania, Quebec, Saskatchewan, South Dakota, Tennessee, Texas, Virginia and Wisconsin.

Illinois Records.—Many males and females and 1 pupa, taken May 7 to September 25, and many larvae and nine cases, taken April 15 to October 17, are from Algonquin, Antioch, Beardstown (Muscooten Bay), East Fox Lake, Elgin (Botanical Gardens), Fox Lake, Grass Lake, Havana (Quiver Lake, Thompson's Lake, Illinois River), Henry, Herod, Homer, Johnsburg (Fox River), Liverpool, McHenry, Meredosia, Milan, Momence, Mount Zion (Fork Lake), New Memphis (Kaskaskia River), Olive Branch (Horse Shoe Lake), Peoria, Pistakee Lake, Putnam (Lake Senachwine), Quincy (Willow Slough), Richmond, Rosecrans (Des Plaines River), Round Prairie, Savanna (Mississippi River), Springfield (Sangamon River), Spring Grove, Stewart Lake, Urbana (Crystal Lake), Wilmington, Wood River, Zion (Dead River).

Oecetis inconspicua (Walker)

Leptocerus inconspicuus Walker (1852, p. 71); ♂.
Setodes sagitta Hagen (1861, p. 284); ♂.
Setodes micans Hagen (1861, p. 283); ♂, ♀.
Setodes flaveolata Hagen (1861, p. 282); ♀.
Oecetina parvula Banks (1899, p. 215); ♀.
Oecetina flavida Banks (1899, p. 216); ♂, ♀.
Oecetina floridana Banks (1899, p. 216); ♂.
Oecetina apicalis Banks (1907*a*, p. 129); ♂.
Oecetina inornata Banks (1907*a*, p. 128); ♀.

LARVA.—Fig. 834. Length 8 mm. Sclerotized parts straw color to pale yellowish brown, the head varying from an almost immaculate condition to a distinct dark brown pattern as in fig. 834. First segment of abdomen with dorsal hump large and without setae.

CASE.—Length 9 mm. Constructed of stones and sand grains, frequently irregular and not very rigid in construction; a few larger stones are frequently attached at the sides.

ADULTS.—Length 10–12 mm. Color brown with a reddish cast, without distinct markings; specimens in liquid showing a conspicuous dark bar across the cord. Position of crossveins forming the cord extremely variable, ranging from a condition in which the three crossveins form an almost straight line to one in which they are far removed and steplike. Male genitalia, fig. 824: tenth tergite forming a single, straight, fairly long rod; cerci short and ovate; claspers with dorsal margin incised to form a conspicuous ventral lobe, their ventral margin somewhat angulate at base; aedeagus almost circular, with short beak. Female genitalia, fig. 831, with ninth sternite membranous and not bounded by dark lines, the apical shelf straight and bursa copulatrix simple.

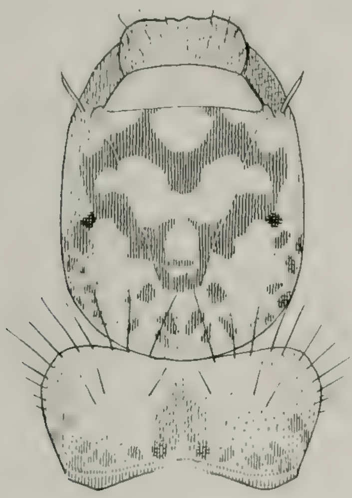


Fig. 834.—*Oecetis inconspicua* larva.

This species is one of the most common caddis flies in Illinois and has been taken throughout the state. It is one of the few caddis flies abundant in artificial ponds. The larvae live in both lakes and streams. They are seldom encountered in field collections but are frequently present, together with those of *cinerascens*, in fish stomachs. The adults emerge throughout the warmer months, from May until early October, and frequently occur in immense numbers.

The species is very widely distributed throughout the North American continent and appears to be fairly rare only in the Northwest. We have records from Alabama, Arkansas, British Columbia, California, Cuba, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Maine, Massachusetts, Mexico, Michigan, Minnesota, Missouri, Nebraska, New Brunswick, New Hampshire, New York, Nova Scotia, Ohio, Oklahoma, Ontario, Oregon, Pennsylvania, Quebec, Saskatchewan, South Carolina, South Dakota, Texas, Utah, Virginia and Wisconsin. (See fig. 13.)

Illinois Records.—Many males, females and pupae, taken May 6 to October 10, and many larvae, taken May 20 to August 7, are from Algonquin, Alton, Amboy (Green River), Antioch, Apple River Canyon State Park, Bartonville (Kickapoo Creek), Brussels, Cairo, Carbondale, Champaign, Channel Lake, Charleston, Chicago (roof of Stevens Hotel), Clinton, Council Hill, Danville, Des Plaines, Downs, East Dubuque, East Fox Lake, Eldorado, Elgin, Elizabethtown, Fieldon, Fox Lake, Frankfort (Hickory Creek), Freeport, Galena (Sinsinawa River), Galesburg, Golconda, Grafton, Grand Tower, Grass Lake, Grayslake, Hamilton, Hardin (Illinois River), Harrisburg, Havana (Chautauqua Lake), Henry, Herod, Homer, Jackson Island (Mississippi River opposite Hannibal, Missouri), Jerseyville, Kampsville, Kappa (Mackinaw River), La Rue (McCann Spring), Le Roy, Libertyville, Liverpool, Mahomet, Meredosia, McHenry, Milan (Rock River), Momence (Kankakee River), Montezuma, Mount Zion (Fork Lake), Muncie, New Memphis (Kaskaskia River), Oakwood (Salt Fork River, Middle Fork Vermilion River), Olive Branch (Horse Shoe Lake), Ottawa, Palos Park (Mud Lake), Peoria, Pontiac, Putnam (Lake Senachwine), Quincy (stream near Cave Spring, Burton Creek), Richmond, Ripley (Lamoine River), Rockford, Rochelle, Rosiclare, Rome, Round Lake, Savanna, Serena (Indian Creek), Springfield (Sangamon River), Spring Grove (Nippersink Creek), Starved Rock State Park, Sterling, Urbana, Utica, Venedy Station (Kaskaskia River), Wadsworth (Des Plaines River), Waukegan, White Pines Forest State Park, Wilmington, Yorkville, Ziegler, Zion (Dead River).

Oecetis persimilis (Banks)

Oecetina persimilis Banks (1907*a*, p. 129); ♂, ♀.

LARVA.—Unknown.

ADULTS.—Length 7–8 mm. Color light brown, venter and legs straw color; wings uniformly smoky, with long brown hair and dark shading along the cord. Abdomen of male with seventh and eighth tergites heavily sclerotized, and covered with minute and lacelike fenestrations. Male genitalia, fig. 821: tenth tergite consisting of a long stylelike projection twice as long as cerci; cerci ovate, wide and rounded at tip; claspers with a wide, long basal portion suddenly narrowed to an apical elongation; the apices of the two claspers curve mesad very much as in figure 822*B*, except that they curve more sharply and usually touch or overlap at the extreme tip; aedeagus large, with a greatly expanded bulbous base which narrows to a ventral beaklike spatula above which extrude several membranous folds which enclose three short hooks, a curved sclerotized rod twice as long as these hooks and another curved sclerotized rod stouter and longer than the preceding. Female genitalia, fig. 825, with ninth sternite mostly membranous but with the bursa copulatrix developed into several pairs of ovate sclerotized folds and with a basal pair of long sclerotized rods which project into the abdomen.

We have only a single record of this species from Illinois, a male collected at Principia College, Elsah, June 28, 1943, at light, C. L. Remington. The range of the species embraces many of the eastern states, including Georgia, Illinois, Kentucky, Maryland, Ohio, Tennessee, Virginia and Wisconsin. In spite of its wide distribution, collections of this species are infrequent, probably indicating a scattered type of distribution pattern.

Oecetis ochracea (Curtis)

Leptocerus ochraceus Curtis (1825, pl. 57).
Oecetis ochracea carri Milne (1934, p. 16); ♂, ♀. New synonymy.

Not yet taken in the state, but of very wide distribution to the north. This is a Holarctic species with records in North America from Alaska, Alberta, Manitoba, Minnesota, Saskatchewan, South Dakota and Wyoming.

Oecetis species a and *b*

We have segregated two distinctive larvae which have not yet been reared.

Species a.—Fig. 812. Length 6 mm. Head and body sclerites cream colored, the head and pronotum with small dark spots or bars, the head with three additional dark areas on and near the frons. Case tubular, slightly horn shaped, constructed of sand grains and usually even in finish. The great similarity between the structural characters of this larva to *inconspicua* suggests strongly that this is the larva of *immobilis*; *immobilis* is most closely related on adult structures to *inconspicua* and occurs in some numbers around Fox and Channel lakes, in which this larva *a* has been found.

Illinois Records. — Channel Lake: May 31, 2 larvae. Fox Lake: May 15, 1936, from stones, Ross & Mohr, 8 larvae. Mineola, East Fox Lake: June 9, 1938, Mohr & Burks, 4 larvae.

Species b.—Length 5.5 mm. Head, pronotum and legs cream colored with dark spots on head and pronotum; mesonotum with a pair of irregular dark areas on each side of the meson. Case horn shaped, constructed of sand grains and with a very smooth exterior. We have taken only one specimen of this larva, in Channel Lake near Antioch, Illinois, May 18, 1938, Ross & Burks. Aside from *immobilis*, the only species of adult taken in this region which has not been reared is *osteni*, and it is possible that this *species b* is the larva of *osteni*.

Triaenodes McLachlan

Triaenodes McLachlan (1865, p. 110). Genotype, by present designation: *Leptocerus bicolor* Curtis.

Triaenodella Mosely (1932, p. 308). Genotype, by original designation: *Triaenodella chelifera* Mosely.

Ylodes Milne (1934, p. 11). Genotype, by original designation: *Triaenodes grisea* Banks.

Diagnostic characters for the genus include the long body and case of the larva, its divided hind tibiae and lack of swimming brush on hind legs; the curious mandibles of the pupa, with their large base and slender blades; and, in the adult, the venation of the front wing, fig. 733, absence of epicranial stem on the head, and katepisternum truncate at apex. Most of the larvae make cases of short, slender twigs built into a spiral pattern, fig. 862.

The genus has been divided into *Ylodes* and *Triaenodella*; it seems best at the present time to consider these as subgenera.

The genus contains many North American species; a few are widespread, but many are known from only a limited number of localities. Eight species have been taken in Illinois, of which one is represented by an unidentified female. The specific characters of the female sex have been worked out sufficiently to show that this unidentified eighth species is different from the other seven taken in the state.

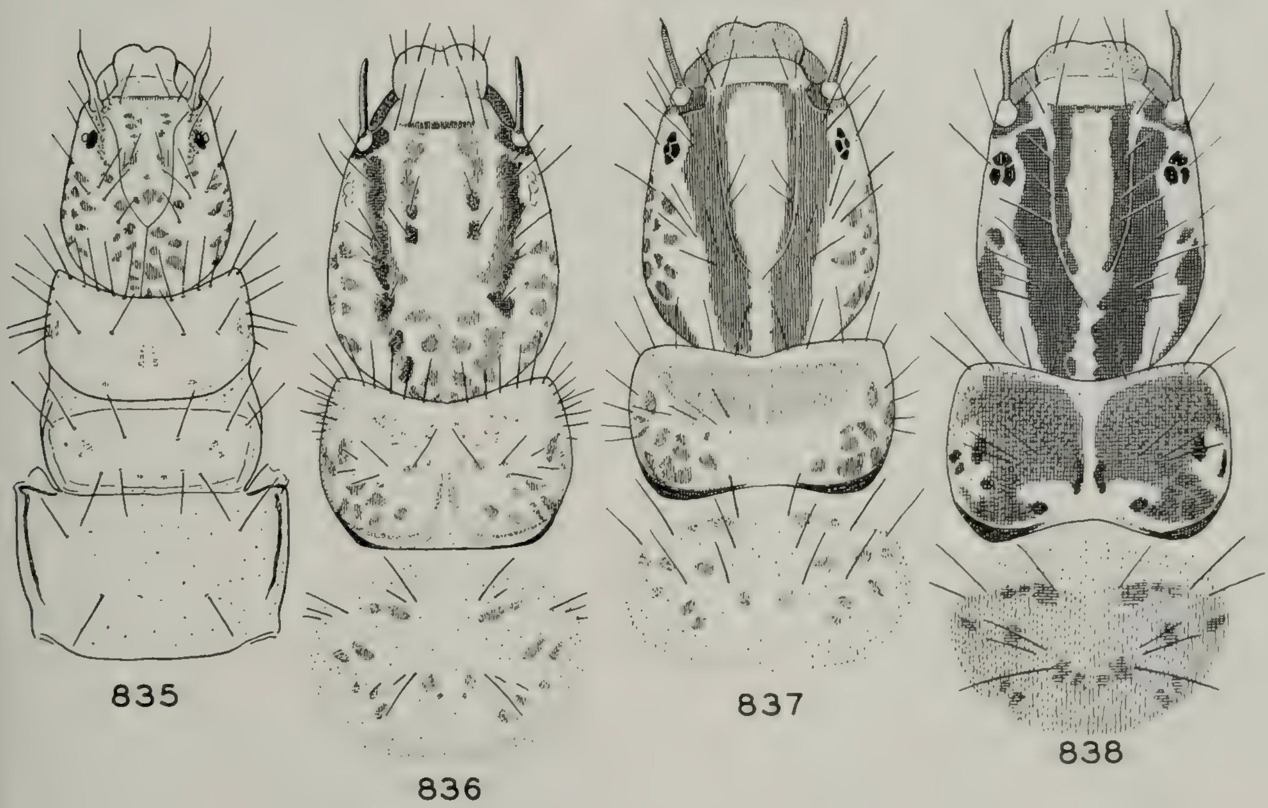
KEY TO SPECIES

Larvae

1. Head with pale antennae and with a pattern of spots, only a few anterior ones somewhat coalesced to form weak lines, fig. 835.......**tarda,** p. 250
   Head with definite lines reaching posterior portion of head, fig. 836, or antennae black.................. 2
2. Head lines broken into spots at posterior portion, fig. 836; pronotum without extensive dark areas..... ....**injusta,** p. 252
   Head lines solid to posterior margin of head, fig. 837; pronotum usually with dark patches in addition to dark spots on posterior portion......... 3
3. Lateral spots of head distinct and separate, fig. 837...........**aba,** p. 249
   Lateral spots of head connected by a fuscous area to form lines, fig. 838.. 4
4. Lateral portion of head mostly pale; pronotum with only small dark areas..............**marginata,** p. 251
   Lateral portion of head mostly dark with pale lines between the dark areas; pronotum almost entirely dark, fig. 838.........**species b,** p. 253

Adults

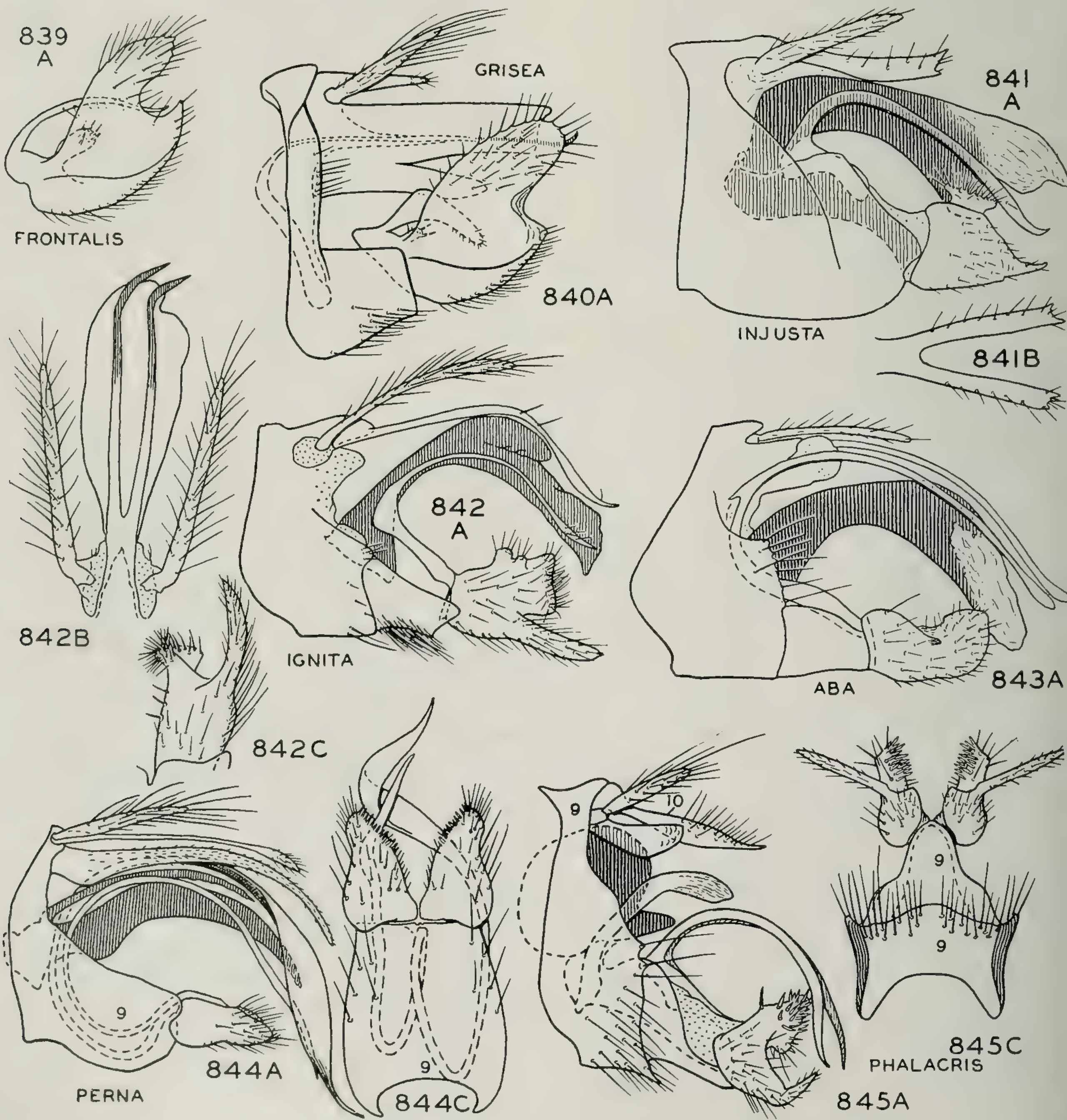
1. Genitalia with claspers and aedeagus, figs. 839–850 (males)............. 2
   Genitalia without these structures, figs. 851–861 (females)............ 13
2. Claspers consisting chiefly of a thin, vertical plate, incised on apical margin, fig. 839..................... 3
   Claspers consisting of a solid base the mass of which is distributed horizontally, and often bearing various lateral or mesal lobes, figs. 841–850 4
3. Inner spur of clasper long, curved and whiplike, fig. 839......**frontalis,** p. 249
   Inner spur of clasper short, somewhat angular and stocky, fig. 840...... ....**grisea,** p. 249
4. Tenth tergite forming a long fork, with a basal stalk, figs. 841, 842........ 5
   Tenth tergite single or vestigial, fig. 843............................ 6



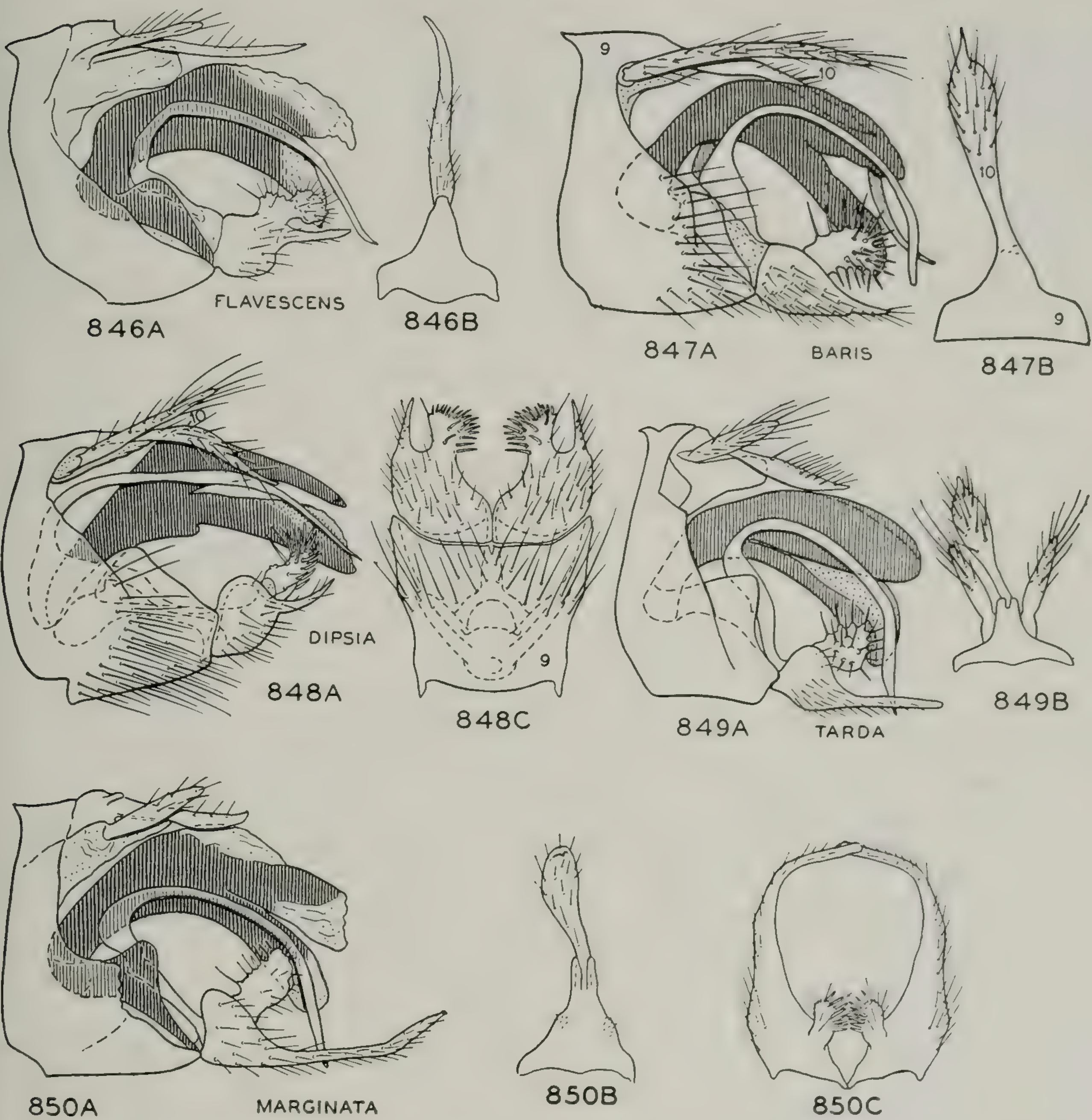
Larvae of *Triaenodes*

Fig. 835.—*T. tarda.*
Fig. 836.—*T. injusta.*
Fig. 837.—*T. aba.*
Fig. 838.—*T. species b.*

5. Arms of tenth tergite wide, short and divergent, fig. 841......**injusta**, p. 252
   Arms of tenth tergite narrow, long, parallel and curved to left at tip, fig. 842.................**ignita**, p. 252
6. Dorsal apex of tenth tergite vestigial, fig. 843....................**aba**, p. 249
   Dorsal apex of tenth tergite long, fig. 844............................ 7
7. Clasper with no postero-lateral or mesal projection, fig. 844..**perna**, p. 250
   Clasper with postero-lateral and mesal projections, fig. 845.............. 8
8. Aedeagus scarcely exserted, with an ovate body and short beak, fig. 845 ....**phalacris**, p. 250
   Aedeagus exserted to beyond base of claspers, forming a long, curved structure, fig. 846................ 9
9. Tenth tergite gradually tapering from near base to apex, fig. 846........ ....**flavescens**, p. 251
   Tenth tergite clavate, fig. 847...... 10
10. Lateral lobe of clasper only slightly longer than mesal lobe, fig. 847.... 11
    Lateral lobe of clasper at least nearly twice as long as mesal lobe, figs. 849, 850............................ 12
11. Cerci as long as tenth tergite, fig. 847. ....**baris**, p. 252
    Cerci about half as long as tenth tergite, fig. 848...........**dipsia**, p. 252

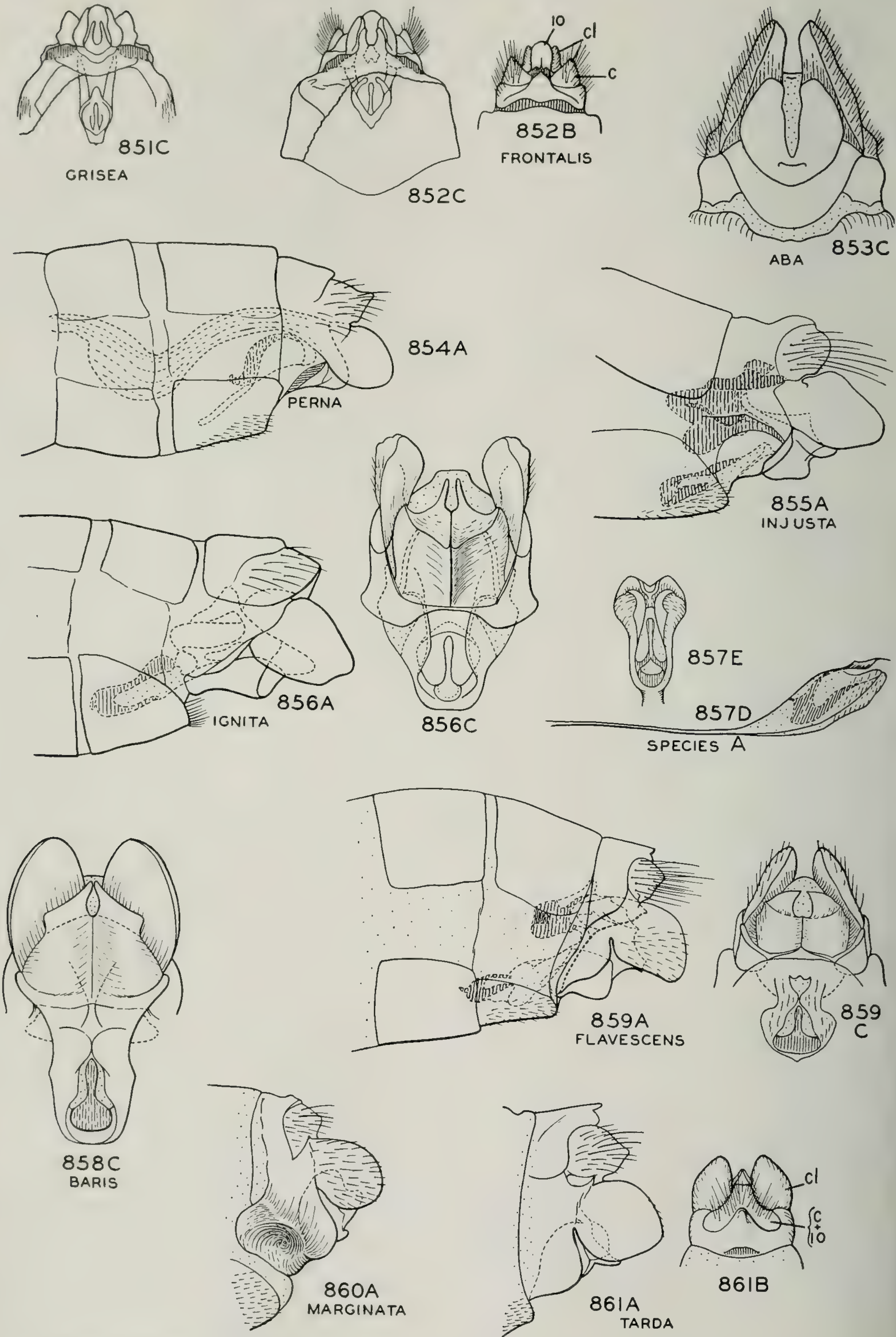


Figs. 839–845.—*Triaenodes*, male genitalia. *A*, lateral aspect; *B*, tenth tergite; *C*, claspers, ventral aspect.



Figs. 846–850.—*Triaenodes*, male genitalia. *A*, lateral aspect; *B*, tenth tergite; *C*, claspers.

12. Apex of claspers straight, tenth tergite sharply pointed, fig. 849........................... **tarda**, p. 250
    Apex of claspers bent mesad at a considerable angle, tenth tergite spatulate, fig. 850........ **marginata**, p. 251
13. Cerci present as earlike lobes; ventral margin of lateral plates of tenth segment angled to form a flat shelf, fig. 852.......................... 14
    Cerci absent, fig. 861; ventral margin of lateral plates of tenth tergite not angled.......................... 15
14. Bursa copulatrix situated at the end of a long, flat stalk, fig. 851............................ **grisea**, p. 249
    Bursa copulatrix sessile, attachments short, fig. 852......... **frontalis**, p. 249
15. Plates of ninth sternite with ventral aspect forming a V with swollen arms, lateral aspect pointed at both ends, fig. 853.............. **aba**, p. 249
    Plates of ninth sternite not shaped like the above, figs. 854–861.......... 16
16. Apodeme of tenth segment long and sinuate, reaching far past bursa copulatrix almost to sixth segment, fig. 854................. **perna**, p. 250
    Apodeme of tenth segment not reaching beyond apex of bursa copulatrix, fig. 855......................... 17
17. Apodeme above bursa copulatrix long, ending in a swollen, emarginate, sclerotized plate, fig. 855... **injusta**, p. 252
    Apodeme not extending above bursa copulatrix, fig. 856............... 18



Figs. 851–861.—*Triaenodes*, female genitalia. *A*, *B* and *C*, respectively lateral, dorsal and ventral aspects; *D* and *E*, bursa copulatrix, respectively lateral and ventral aspects; *c*, cerci; *cl*, clasper.

18. Apex of ninth sternite produced into a pair of long, slender, pointed fingers, fig. 856.................**ignita**, p. 252
    Apex of ninth sternite not produced into long fingers, fig. 858......... 19
19. Bursa copulatrix with ventral folds forming long, shelflike, sclerotized bands, fig. 857, and base of apical hook heavily sclerotized around edge.................**species a**, p. 253
    Bursa copulatrix with ventral folds either straplike and not shelflike or membranous, fig. 858, and base of apical hook uniformly sclerotized 20
20. Apical lobes of ninth sternite projecting more sharply posterad, fig. 858; a sclerotized bar, platelike at each end, is situated above base of bursa supports.................**baris**, p. 252
    Apical lobes of ninth sternite not projecting so sharply, fig. 859; only an arcuate lobe above base of bursa supports....................... 21
21. One internal fold beyond base of clasper sclerotized, fig. 859.......
    ....**flavescens**, p. 251
    All internal folds beyond base of clasper membranous, fig. 860...... 22
22. Ventro-lateral margins of ninth segment sclerotized, flared and convoluted, fig. 860.....**marginata**, p. 251
    Ventro-lateral margins of ninth segment not flared and almost entirely membranous, fig. 861.....**tarda**, p. 250

Triaenodes frontalis Banks

Triaenodes frontalis Banks (1907*a*, p. 127); ♀.

Not yet taken in Illinois, but is known from Colorado and Saskatchewan, where it frequents ponds.

Triaenodes grisea Banks

Triaenodes grisea Banks (1899, p. 214); ♀.

Not yet taken in Illinois. It is known from Colorado, Manitoba and Saskatchewan; it frequents ponds. This and *frontalis* might be looked for in some of the marsh situations of northeastern Illinois.

Triaenodes aba Milne

Triaenodes sp. Milne (1934, p. 12); ♂.
Triaenodes aba Milne (1935, p. 20); ♂.

LARVA.—Fig. 837. Length 10 mm. Head, pronotum and legs cream color, the head with a pair of dark stripes on the ventral aspect, with another pair on the dorsum and irregular small spots on the head and pronotum; the spots on the frons forming an interrupted pair of lines just inside the large stripes.

ADULTS.—Length 8–9 mm. Color reddish brown with a narrow dorsal stripe of pinkish brown when the wings are folded in repose. Male genitalia, fig. 843: tenth tergite with only a vestigial mesal process; cerci long and slender, not quite as long as aedeagus; claspers with large platelike mesal lobe, short lateral spur; aedeagus U-shaped. Female genitalia, fig. 853: ninth sternite forming a V with wide arms and a narrow cleft, from side view appearing shallow and pointed at both ends; abdomen thin, short and flat.

Allotype, female.—Zion, Illinois, along Dead River at Dunes Park: June 28, 1940, Mohr & Riegel.

This species is abundant in two marsh areas in northeastern Illinois, one the Des Plaines River at Rosecrans, the other the Dead River at Zion. It was reared from both localities. The larvae were found in weed beds, and their cases were very difficult to see in the mass of broken twigs which had accumulated in these areas. Betten (1934, p. 287) recorded the species from Lake Forest, Illinois. Our adult records are for June, July and August, indicating a single generation per year.

The range of this species is poorly defined but apparently includes most of the Northeast. Records are available from Illinois, Massachusetts, Michigan, New Hampshire, Ontario and Wisconsin.

Illinois Records.—CHICAGO: June 16, W. J. Gerhard, 2♂, FM. FOX LAKE: June 23, 1892, Hart & Shiga, 1♀; June 26, 1936, Frison & DeLong, 1♂. NORTHERN ILLINOIS: 1♂. ROSECRANS: June 14, 1938, Ross & Burks, 2♂; Des Plaines River, May 23, 1938, Ross & Burks, many larvae, ♂♂, ♀♀ (all reared); May 29, 1938, Mohr & Burks, 1 larva (reared); June 8, 1938, Ross & Burks, many larvae, 1♂; June 9, 1938, at light, Ross & Burks, ♂♂; June 13, 1938, Ross & Burks, 4♂; June 14, 1938, Ross & Burks, many larvae; June 15, 1938, Ross & Burks, 6♂; June 21, 1938, Ross & Burks, 1♀. SPRING GROVE: Aug. 12, 1937, at light, Ross & Burks, 1♂. URBANA: Aug. 25, 1892, McElfresh, 1♀. WADSWORTH, Des Plaines River: July 7, 1937, Frison & Ross, ♂♂. ZION, Dead River: July 7, 1937, Frison & Ross, ♂♂; May 23, 1938, Ross & Burks, 2 larvae and cases; June 3, 1938, Mohr & Burks, ♂♂; June 4, 1938, Ross & Burks, ♂♂, 5♀; Aug. 15, 1938, Ross & Burks, 1♀; Aug. 19, 1939, Mohr & Riegel, 1♀; May 20, 1940, Mohr & Burks, 2 larvae; June 28, 1940, Mohr & Riegel, 1 larva, 1 pupa, 1♀; June 5, 1941, Mohr & Burks, 4♂, 3♀.

Triaenodes perna Ross

Triaenodes perna Ross (1938*a*, p. 159); ♂, ♀.

LARVA.—Unknown.

ADULTS.—Length 9 mm. Color tawny, front wing with a definite pattern of cream color and brown; in repose the insect has a dorsal light stripe, a large light area along middle of front margin of wings, a dark brown area across wing at stigma, and a golden brown area beyond this along the apical margin. Male genitalia, fig. 844: tenth tergite long and hairlike with a slight thickening at apex; beneath this there is a long, membranous, curved process extending beyond the tenth tergite, claspers flat, the ventral aspect somewhat triangular, and the apico-mesal side with a row of black spines; basal whiplike processes of claspers very long, the right one convoluted and bladelike, the left one filamentous. Female genitalia, fig. 854: apex of ninth sternite forming a somewhat anvil-shaped projecting body with flat apical plates; these plates, from ventral aspect, appearing to form a sort of "hat" at the end of the anvil; most conspicuous is the very long internal apodeme of the tenth segment; this apodeme extends almost to the sixth segment, reaching far past the bursa, and has a definite enlarged central portion where it makes a sharp bend; bursa copulatrix short and inconspicuous, its apex terminating in indefinite membranous folds.

Our Illinois specimens of this species are confined to the type series of a male and two females collected at Eichorn, June 13, 1934, along Hicks Branch, DeLong & Ross. The only records which have come to our attention since that time are a male from Franklin County, Ohio, and a female from Broken Bow, Oklahoma.

Triaenodes phalacris Ross

Triaenodes phalacris Ross (1938*b*, p. 88); ♂.

Not yet taken in Illinois. It is known from Athens, Ohio, and may ultimately be taken in southern Illinois.

Triaenodes tarda Milne

Triaenodes marginata tarda Milne (1934, p. 12); ♂.

Triaenodes vorhiesi Betten (1934, p. 286); ♂, ♀. New synonymy.

Triaenodes mephita Milne (1936, p. 59); ♂, ♀. New synonymy.

LARVA.—Fig. 835. Length 10 mm. Sclerites straw color, the head with a definite pattern of small spots; the spots along the frons may be sharply coalesced to form an interrupted line. Case as in fig. 862.

ADULTS.—Length 12–13 mm. Color tawny with the same conspicuous cream and brown pattern as in fig. 863; in most specimens the dorsal stripe is divided into an elongate anterior area and a posterior diamond-shaped area. Male genitalia, fig. 849: tenth tergite long and fusiform; cerci fairly short and lanceolate; claspers with base bulbous, lateral angle produced into a long, sharp point, mesal portion produced into a knobbed lobe set with short, stout setae; aedeagus U-shaped and cleft at apex. Female genitalia, fig. 861, with apodemes entirely membranous, ninth sternite somewhat anvil shaped, its apical flanges not greatly produced on the meson.

This species is widely distributed in Illinois, occurring in both lakes and streams. We have taken it in abundance, however,

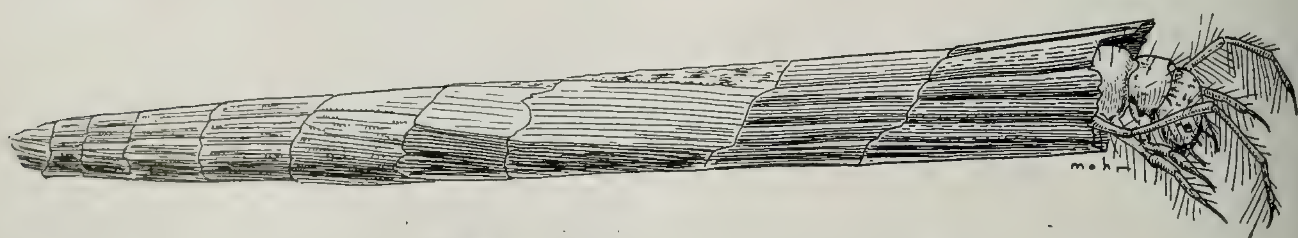


Fig. 862.—*Triaenodes tarda*, case.

only in the glacial lakes in the northeast part of the state. In these the larvae were taken in large numbers from weed beds and were reared from these collections. Our adult collections extend from May to late September, indicating that more than one generation may be produced in a year.

Female genitalia, fig. 860, similar in general structure to *tarda* but differing in the sclerotized, flared and convoluted ventro-lateral expansions of the ninth segment.

This species is a rarity in our Illinois collections; our records to date consist of only two males, from Chicago and Momence, both in the northeastern portion of the state.

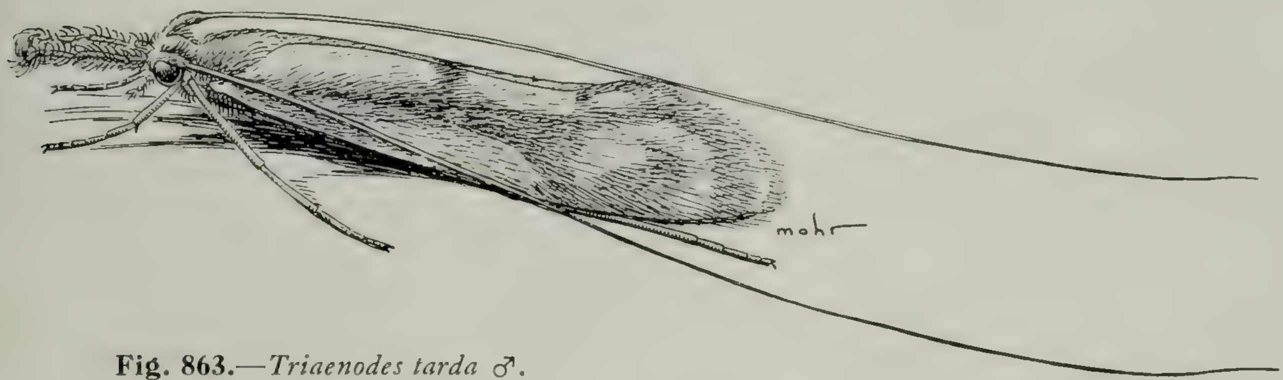


Fig. 863.—*Triaenodes tarda* ♂.

This species is widely distributed through the northeastern states and extends southwestward through the Ozarks into Oklahoma, with records from Arkansas, District of Columbia, Illinois, Minnesota, New Brunswick, New York, Ohio, Oklahoma, Ontario, Pennsylvania and Wisconsin. In addition, Milne lists the species from Arizona and British Columbia (paratypes of *tarda*).

Illinois Records.—Many males and females, taken May 31 to September 25, and many larvae, taken May 15 to August 13, are from Algonquin, Antioch, Champaign, Chicago, Elgin (Botanical Gardens), Fox Lake, Havana (Quiver Lake), New Memphis (Kaskaskia River), Richmond, Sand Lake, Spring Grove (Nippersink Creek), Urbana, Zion (Dunes Park).

Triaenodes marginata Sibley

Triaenodes marginata Sibley (1926*a*, p. 80); ♂, ♀.

LARVA (after Sibley, 1926*b*, p. 105).—Head and pronotum yellow; head with two pairs of dark lines and scattered spots; pronotum with only small dark markings on a pale background.

ADULTS.—Length 12–13 mm. Color tawny with a black and cream pattern as shown in fig. 863. Male genitalia, fig. 850, similar in general structure to *tarda*, differing chiefly in the spatulate tenth tergite and long lateral projections of the claspers, these processes curved sharply mesad at apex.

The species has a wide range, including Arkansas, Illinois, Michigan, New Jersey, New York, Nova Scotia and South Dakota.

Illinois Records.—CHICAGO: Roof of Stevens Hotel, July 13, 1931, T. H. Frison, 1 ♂. MOMENCE: June 4, 1932, Frison & Mohr, 1 ♂.

Triaenodes flavescens Banks

Triaenodes flavescens Banks (1900*a*, p. 257); ♂.

LARVA.—Unknown.

ADULTS.—Length 12 mm. Color tawny with the cream and brown wing pattern shown in fig. 863. Male genitalia, fig. 846, similar in general structure to *tarda*, differing in the long, bladelike tenth tergite and the claspers with the shorter, pointed lateral projection and the larger mesal lobe. Female genitalia, fig. 859, similar in general structure to *tarda*, differing chiefly in having one internal fold beyond the base of the claspers sclerotized.

Allotype, female.—Wilmington, Illinois: Aug. 20, 1934, DeLong & Ross.

In Illinois we have taken only one collection of this species; it bears the same data as given for the allotype and contains two males and four females. Little is known regarding the habits of the species.

Its range includes the northeastern states, with records from Illinois, New Jersey, New York, Ohio and Pennsylvania.

Triaenodes baris Ross

Triaenodes baris Ross (1938*b*, p. 88); ♂.

LARVA.—Unknown.

ADULTS.—Length 11–12 mm. Color tawny with the cream and brown pattern shown in fig. 863. Male genitalia, fig. 847: tenth tergite fairly long, simple and fusiform; cerci very long; claspers with lateral projection short, mesal lobe very large, the basal, recurved rod fairly short, not reaching base of aedeagus; aedeagus somewhat U-shaped, apex deeply cleft. Female genitalia, fig. 858: similar in general appearance to *tarda* but with the apical lobes of ninth sternite projecting more sharply posterad and with a sclerotized bar situated above base of bursa supports, the bar enlarged and platelike at each end.

This species was originally described from Zion, Illinois, and has since been taken only at that locality. We obtained a pupa in the Dead River at Zion, living in a case typical for the genus and indistinguishable from cases of *tarda* and *aba* taken in company with it.

Our collection of this species is so small that there is some doubt as to the association of male and female. Our assignment of the above female must be considered tentative; hence no allotype is designated.

Illinois Records.—ZION: June 10, 1933, Mohr & Townsend, 1 ♂, 1 ♀; along Dead River, June 6, 1940, Mohr & Burks, 1 ♂.

Triaenodes ignita (Walker)

Leptocerus ignitus Walker (1852, p. 72); ♂. *Triaenodes dentata* Banks (1914, p. 261); ♂. New synonymy.

LARVA.—Unknown.

ADULTS.—Length 11–12 mm. Color tawny with the cream and brown pattern of the wing shown in fig. 863. Male genitalia, fig. 842: tenth tergite divided near base into a pair of very long, slender filaments which curve sharply to the left near apex; cerci very long and slender; claspers with the lateral projection slightly curved and sharp, the mesal projection large and quadrate from lateral view, with small swellings on its dorsal margin, the basal filament ribbon-like at base, filamentous on the apical portion; aedeagus U-shaped, slender in the middle, and with a long, ventral portion. Female genitalia, fig. 856, with no sclerotized apodemes, ninth sternite produced at apex into a pair of long, slender fingers.

Our only Illinois record of this species is a single male taken at Vandalia, June 22, 1940, along the Kaskaskia River, Mohr & Riegel. The species has a scattered distribution over most of the eastern states, occurring west to Illinois and Oklahoma. Records are available for Alabama, Georgia, Illinois, New York, Nova Scotia, Oklahoma and Tennessee.

Triaenodes dipsia Ross

Triaenodes dipsia Ross (1938*b*, p. 89); ♂.

This species has not been taken in Illinois but is known from Athens, Ohio, and may possibly be taken in southern Illinois.

Triaenodes injusta (Hagen)

Setodes injusta Hagen (1861, p. 283); ♂.

LARVA.—Fig. 836. Length 10 mm. Head, pronotum and legs straw color, the head with two pairs of dorsal lines, the long pair from base of antennae to vertex, and a shorter, interrupted pair along inner margin of frons; pronotum with some irregular spots on posterior portion.

ADULTS.—Length 12 mm. Color tawny with the cream and brown pattern shown in fig. 863. Male genitalia, fig. 841: tenth tergite divided near base into a pair of wide, fairly short, heavily sclerotized divergent arms; cerci long and slender; claspers with lateral projection very short, dorsal projection large. Female genitalia, fig. 855, similar to *tarda* in general outline but distinct from all other species of the genus by the fairly long apodeme of the tenth segment, this apodeme produced at apex into a series of knoblike folds.

Allotype, female. — Antioch, Illinois: June 27, 1938, Ross & Burks.

We have taken this species very abundantly in the glacial lakes of northeastern Illinois; we have taken only scattered records from other parts of the state. In the lakes the larvae are found in weed beds. We have reared them from Channel Lake, near Antioch. Most of the adult emergence occurs during June and July. A few specimens have been collected in May and August. Data are insufficient to tell how many generations are produced per year.

Illinois Records.—Many males and females, taken May 18 to August 20, and many larvae, taken May 16 to June 12, are from Antioch, Channel Lake, Fox Lake, Grass Lake, Grayslake, Pistakee Lake, Richmond, Round Lake, Urbana, Wilmington, Zion.

Triaenodes species a

Female.—Length 9 mm. Color tawny with the brown and cream pattern typical of the *tarda* group. Female genitalia, fig. 857: apex of ninth sternite not greatly produced, typical in general form of the *tarda* group; tenth tergite without conspicuous apodemes; bursa copulatrix with its ventral bands folded, long and shelflike and heavily sclerotized; the hook set in the apex of the bursa is very heavily sclerotized, especially the margins of the base, giving it a hollow appearance from ventral view.

We have taken only one female of this species, from Herod, Illinois, May 29, 1935, Ross & Mohr. We have taken no male which could be positively associated with it, but it is definitely none of the other species of which we have record from the state. There is a possibility that it may be the female of *phalacris* or *dipsia*, both taken from southern Ohio, or it may be an entirely different species.

Triaenodes species b

Larva. — Fig. 838. Length 10 mm. Ground pattern of sclerites straw color; head with spots coalesced to form a pair of long, broad lines down the central portion and a pair of short, broad lines on the lateral margin, the ventral aspect almost all dark so that only narrow pale areas appear between the ventral and lateral dark markings; pronotum mostly brown with a pale mesal line, a pale postero-mesal area and a pair of pale lateral spots. Case typical for genus.

This is an unreared larva of which we have taken only one specimen, from Herod, Illinois, May 15, 1941, Mohr & Burks. It probably belongs to one of the species recorded from southern Illinois on the basis of adults, including *perna* and *species a*.

Mystacides Berthold

Mystacides Berthold (1827, p. 437). Genotype, by present designation: *Phryganea longicornis* Linnaeus, one of species first included in the genus by Burmeister (1839, p. 918).

Species of this genus construct a long, slender, parallel-sided case adorned with irregular pieces of leaf, wood or shell fragments; the case is not very rigid. The larvae have a distinct, rectangular gula, mandibles which are blunt at apex and armed with several teeth, and single abdominal gills varying in number, usually inconspicuous.

Three species are known from North America, of which we have two in Illinois, both restricted to the northeastern corner of the state.

KEY TO SPECIES

Larvae

Head with a Y-shaped black mark following epicranial stem and arms, fig. 864 .... **longicornis**, p. 255
Head with spots or parallel black lines, not forming a Y, fig. 865 .... **sepulchralis**, p. 254

Adults

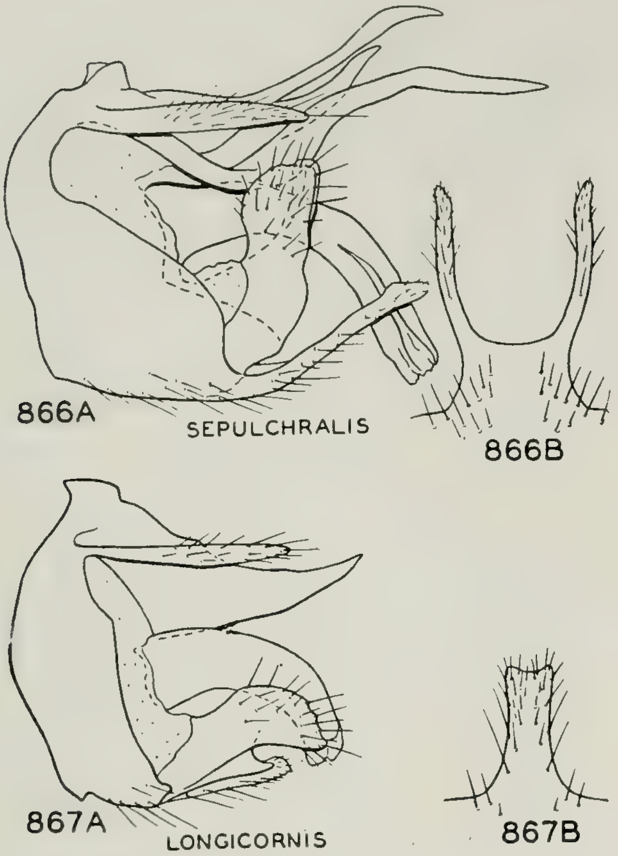
1. Genitalia with a large ventral furca, figs. 866, 867 (males) 2
   Genitalia without a ventral furca, fig. 868 (females) 3
2. Apical process of ninth sternite forked, the arms long and slender, fig. 866 .... **sepulchralis**, p. 254

Fig. 864.—*Mystacides longicornis* larva.
Fig. 865.—*Mystacides sepulchralis* larva.

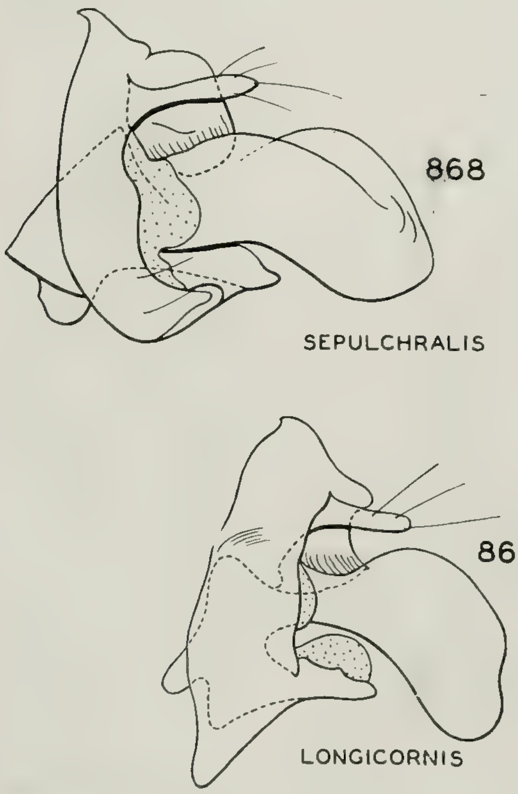
Apical process of ninth sternite single and wide, fig. 867...**longicornis,** p. 255

3. Color shining blue-black. Lateral lobes of ninth sternite not narrowed at extreme base, fig. 868.................................**sepulchralis,** p. 254

Color dull gray-black or brownish-black. Lateral lobes of ninth sternite markedly narrow at extreme base, fig. 869............**longicornis,** p. 255



Figs. 866–867.—*Mystacides*, male genitalia. *A*, lateral aspect; *B*, tongue of ninth sternite.



Figs. 868–869.—*Mystacides*, female genitalia.

Mystacides sepulchralis (Walker)

Leptocerus sepulchralis Walker (1852, p. 70); ♂, ♀.

Larva. — Fig. 865. Length 10 mm. Ground color of head straw color with a pair of dark brown longitudinal lines (sometimes broken into spots) fading at the posterior margin, and with numerous small brown dots over most of the head area; pronotum ranging from entirely dark brown with a narrow mesal light area to brownish yellow with lateral irregular brown spots; legs straw color wtih narrow dark bands.

Adults.—Fig. 870. Length 9 mm. Color blue-black, the wings and thorax with an iridescent metallic sheen. Male genitalia, fig. 866, with apical process of ninth sternite divided at base into a pair of slender long processes; claspers short and stocky; tenth tergite subdivided into a group of intricate sinuate blades. Female genitalia as in fig. 868.

In our collecting we have found this species in Illinois only in the glacial lakes of the northeastern part. Betten (1934, p. 281) recorded the species both from this locality and from Charleston, Illinois. In other states, we have found, the species occurs in both lakes and streams; so it may do this in Illinois also.

We have found the larvae under and around stones in Channel Lake, near Antioch, and reared them from this locality. Adult emergence occurs from May into September; our records from Illinois are few, but abundant records from other states indicate this long seasonal range.

This species occurs through the Northeast, south to Georgia, and southwest through the Ozarks. Records are available from Arkansas, Georgia, Indiana, Illinois, Maine, Michigan, Minnesota, New Brunswick, New Hampshire, New York, Nova Scotia, Ohio, Ontario, Pennsylvania, Quebec, Saskatchewan and Wisconsin.

Illinois Records.—Antioch: July 8, 1932, H. H. Ross, 3♂, 1♀. Channel Lake: May 27, 1936, H. H. Ross, 9♂, 9♀; May 18, 1938, Ross & Burks, 1♂, 1

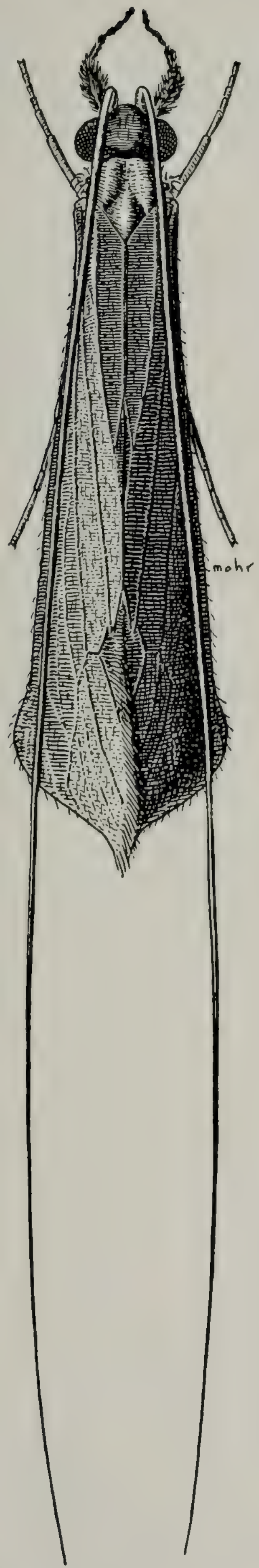


Fig. 870.—*Mystacides sepulchralis* ♂, metallic blue-black in color. This species is common in eastern states.

larva. Chicago: July 30, 1904, 1♂, FM; Aug. 4, 4♂, 1♀, FM. Fox Lake: May 28, 1936, H. H. Ross, 1♂, 2♀. Lake Villa: July 21, 1916, 1♀.

Mystacides longicornis (Linnaeus)

Phryganea longicornis Linnaeus (1758, p. 548).
Phryganea quadrifasciata Fabricius (1775, p. 308).
Oecetina interjecta Banks (1914, p. 262); ♀.
Mystacides canadensis Banks (1924, p. 448); ♂.

Larva.—Fig. 864. Length 10 mm. Head yellowish with a few spots and a large black Y following the epicranial stem and arms; pronotum varying from yellowish with a paired mesal black mark to almost entirely black with a light area in the middle of each lateral half; legs pale with narrow dark bands.

Adults.—Length 9 mm. Color rusty brown, the front wings frequently clothed with golden hair arranged to form alternate golden and brown bands; in rubbed specimens this banding never shows. Male genitalia, fig. 867, with apical process of ninth sternite long, narrow and only slightly incised at apex. Female genitalia as in fig. 869.

In Illinois we have taken this species only in company with the preceding species in glacial lakes of the northeastern part of the state (see p. 11). Betten's record (1934, p. 279) from Diamond Lake, Illinois, May 30, is in the same region. Larvae were collected and reared from Channel Lake. We found larvae of both species side by side making identical cases. Available records indicate an adult emergence throughout the warmer months of the year.

The range of the species is apparently much wider from east to west through the northern states than that of *sepulchralis*, but it does not extend as far south. We have records from Colorado, Illinois, Michigan, New York, Ontario, Pennsylvania, Quebec, Saskatchewan and Wisconsin; it is recorded from many localities in Eurasia.

Illinois Records.—Antioch: July 7, 1932, at light in town, Frison & Metcalf, 2♂; May 18, 1938, Ross & Burks, 1 larva, 1♂ (reared). Channel Lake: May 27, 1936, H. H. Ross, 2 ♂ pupae; June 11, 1936, Burks & Ross, 3♂. Fourth Lake: Aug. 9, 1887, C. A. Hart, 1♂. Fox Lake:

July 1, 1931, Frison, Betten & Ross, 1♀; June 30, 1935, DeLong & Ross, 1♀; May 15, 1936, Ross & Mohr, 1 larva; May 28, 1936, H. H. Ross, 1♂, 2♀.

Setodes Rambur

Setodes Rambur (1842, p. 515). Genotype, by subsequent designation of Milne (1934, p. 18): *Setodes punctella* Rambur.

This genus contains six or seven species, all of them rare, of which we have taken only one in Illinois. An additional species, *incerta*, will likely be found in the state with subsequent collecting.

No Nearctic larvae of this genus have been reared, but Miss Thelma Howell collected a leptocerid larva in Swain County, North Carolina, which may belong to this genus. It is characterized by a rectangular gula, mandibles with a broad dentate apex, filamentous abdominal gills which are single or double, and the curious anal plate shown in fig. 719.

Setodes oligia (Ross)

Leptocerus oligius Ross (1938*a*, p. 160); ♂, ♀.

Larva.—Unknown.

Adults.—Length 8 mm. Color almost

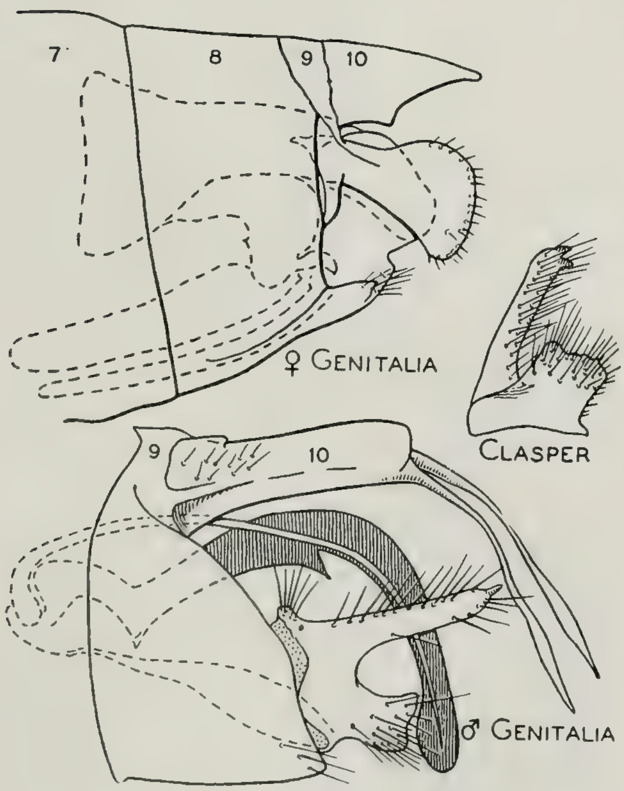


Fig. 871.—*Setodes oligia*, genitalia.

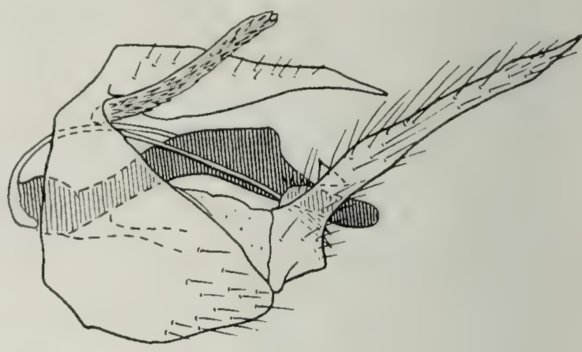


Fig. 872.—*Setodes incerta*, male genitalia.

cream, some sutures and veins light brown but without definite pattern. Male genitalia, fig. 871: tenth tergite forming a long, rectangular projection divided at apex into a pair of long slender filaments; claspers divided into a finger-like dorsal lobe and truncate ventral lobe; aedeagus cylindrical and curved; at its base originate a pair of long, slender sclerotized filaments. Female genitalia, fig. 871: tenth tergite hood shaped, ninth with a pair of handlike lobes and with extensive internal structures.

The genitalia of the male are radically different from those of *incerta*, fig. 872, the only other species of the genus which has been taken near Illinois.

Our Illinois collection of this species consists of a single record of one male and three females taken along the Kankakee River at Wilmington, August 20, 1934, DeLong & Ross. The species was described from this series of specimens. In addition, we have records from Michigan and Ontario.

GOERIDAE

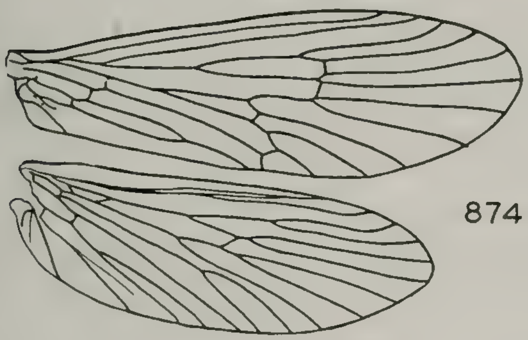
This family is represented in North America by the genera *Goera*, *Pseudogoera* and *Goerita*, all occurring in the eastern states. None of these have been reared in North America, and our knowledge of the immature stages is based chiefly on the descriptions of the immature stages of *Goera* by European writers. The case resembles that of *Neophylax autumnus* (p. 203). The adults have the maxillary palpi three segmented in the male, five in the female.

KEY TO GENERA

Adults

1. Front wings with venation reduced, R_{4+5} partially fused with M; 2A and 3A absent, fig. 873 .... **Pseudogoera,** p. 258

873



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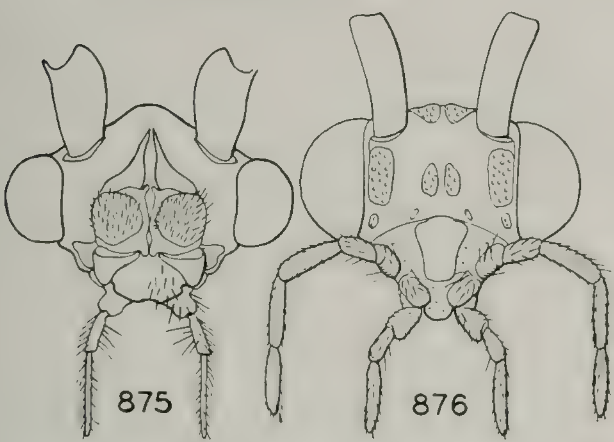


875 876

Fig. 873.—*Pseudogoera singularis*, front wing. (After Carpenter.)
Fig. 874.—*Goerita semata*, wings.
Fig. 875.—*Goerita semata* ♂, head.
Fig. 876.—*Goera calcarata* ♀, head.

Front wings without marked reduction in venation, R_s not fused with M; 2A and 3A present, fig. 874.... 2

2. Eyes small, the head forming a high crown between them, fig. 875..... ....**Goerita**, p. 258

Eyes much larger, with a smaller crown, fig. 876..........**Goera**, p. 257

Goera Curtis

Goera Curtis (1834, p. 215). Genotype, monobasic: *Phryganea pilosa* Fabricius.

Not known from Illinois. The males of this genus have complicated genitalia, as illustrated by *stylata*, known from Michigan, fig. 877.

A few pupae, presumably belonging to this genus, have been received from scattered localities in eastern states. All these pupae were collected from clear, cold, rapid streams. The stone cases were solid and tightly built.

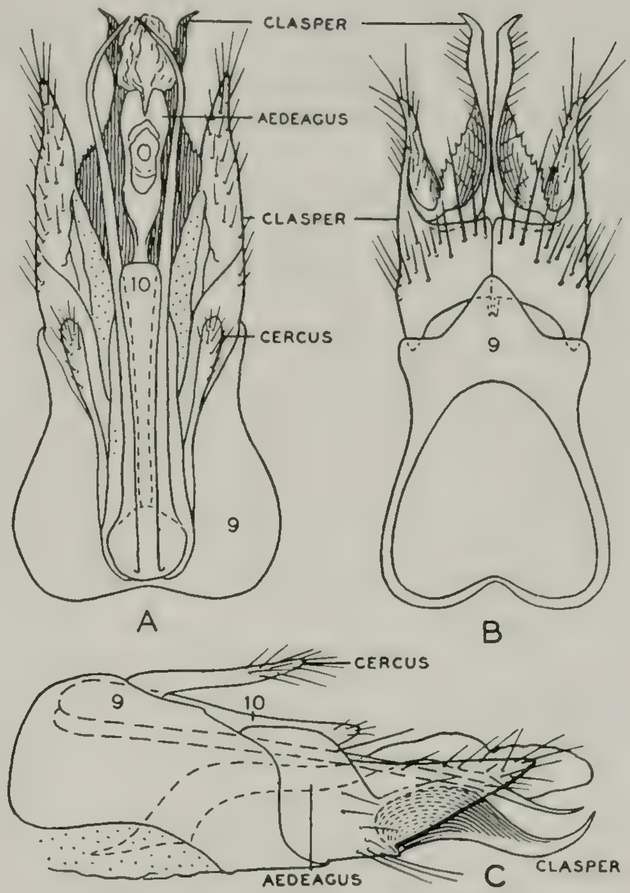


Fig. 877.—*Goera stylata*, male genitalia. *A*, dorsal aspect; *B*, ventral aspect; *C*, lateral aspect.

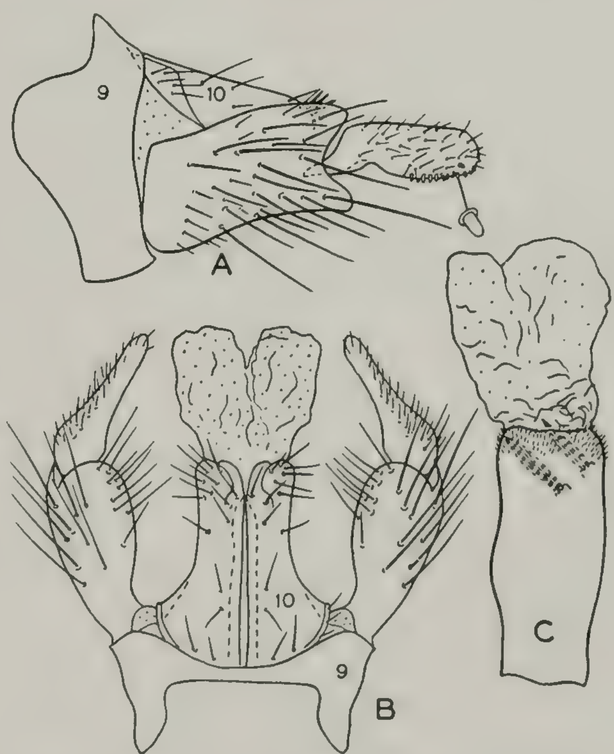


Fig. 878.—*Goerita semata*, male genitalia. *A*, lateral aspect; *B*, dorsal aspect; *C*, aedeagus. Note ventral row of peglike teeth on apical segment of clasper in *A*; one of these teeth is illustrated separately below the clasper.

Goerita Ross

Goerita Ross (1938*a*, p. 171). Genotype, by original designation: *Goerita semata* Ross.

Not known from Illinois. The only known eastern species, *semata*, has not been recorded east of the Allegheny ranges. The male genitalia are distinctive, fig. 878.

Pseudogoera Carpenter

Pseudogoera Carpenter (1933, p. 37). Genotype, by original description: *Pseudogoera singularis* Carpenter.

This genus is known only from the type series of the genotype, described from North

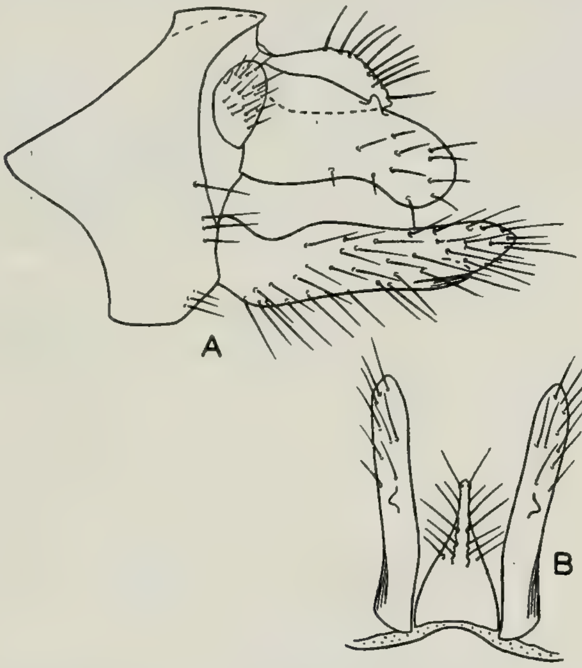


Fig. 879.—*Pseudogoera singularis*, male genitalia. *A*, lateral aspect; *B*, dorsal aspect.

Carolina. The distinctive male genitalia are illustrated in fig. 879.

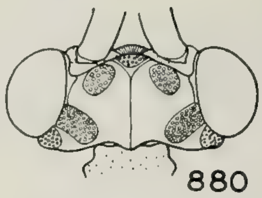
LEPIDOSTOMATIDAE

In this family the maxillary palpi of the females are five segmented, and those of the males vary from three to a curiously modified structure which may appear only one segmented. As here defined it includes only two Nearctic genera, *Lepidostoma* and *Theliopsyche*. The larvae are known for many species of *Lepidostoma*; these bear a striking superficial resemblance to many genera of Limnephilidae but may be readily separated by the antennae, which are close to the eye, and by lacking a dorsal spacing hump on the first abdominal segment. The larvae and pupae of *Theliopsyche* are unknown.

KEY TO GENERA

Adults

1. Head with posterior warts fairly wide, triangular or curved, fig. 880...... ....**Lepidostoma,** p. 258



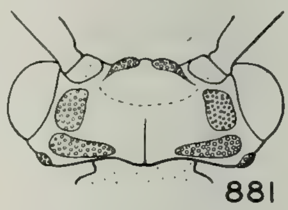


Fig. 880.—*Lepidostoma liba*, head.
Fig. 881.—*Theliopsyche* sp., head.

Head with posterior warts long, narrow and straight, fig. 881......... ....**Theliopsyche,** p. 260

Lepidostoma Rambur

Mormonia Curtis (1834, p. 215); preoccupied. Genotype, monobasic: *Phryganea hirta* Fabricius.

Lepidostoma Rambur (1842, p. 43). Genotype, by present designation: *Lepidostoma squamulosum* Rambur = *hirtum* (Fabricius).

Nosopus McLachlan (1871, p. 114). Genotype, monobasic: *Nosopus podager* McLachlan.

Olemira Banks (1897, p. 29). Genotype, monobasic: *Olemira americana* Banks.

Pristosilo Banks (1899, p. 212). Genotype, monobasic: *Pristosilo canadensis* Banks = *togatum* (Hagen). New synonymy.

Atomyia Banks (1905*b*, p. 11). Genotype, by original designation: *Atomyia modesta* Banks. New synonymy.

Notiopsyche Banks (1905*b*, p. 11). Genotype, by original designation: *Notiopsyche latipennis* Banks. New synonymy.

Mormomyia Banks (1907*a*, p. 127). Genotype, by original designation: *Mormonia vernalis* Banks. New synonymy.

Alepomyia Banks (1908*a*, p. 64). Genotype, by original designation: *Alepomyia bryanti* Banks. New synonymy.

Phanopsyche Banks (1911, p. 357). Genotype, by original description: *Phanopsyche grisea* Banks. New synonymy.

Alepomyiodes Sibley (1926*b*, p. 106). Genotype, by original designation: *Lepidostoma wisconsinensis* Vorhies = *bryanti* (Banks). New synonymy.

Arcadopsyche Banks (1930*a*, p. 129). Genotype, monobasic: *Arcadopsyche prominens* Banks. New synonymy.

Oligopsyche Carpenter (1933, p. 36). Genotype, by original designation: *Notiopsyche carolina* Banks. New synonymy.

Neuropsyche Carpenter (1933, p. 38). Genotype, by original designation: *Neuropsyche tibialis* Carpenter. New synonymy.

Jenortha Milne (1936, p. 119). Genotype, monobasic: *Jenortha cascadensis* Milne. New synonymy.

This genus is characterized in the adults by the arrangement of warts as outlined in the key. The females exhibit few characters upon which to base their classification, and to date I have been able to find no differences upon which to key most of them to species. Comparative lengths of the antennal segments, slight differences of venation, and some fairly striking differences in the female genitalia can be used to segregate the species into groups containing two or more. It is usually necessary, therefore, to rely upon association with males for specific identification of females.

An astonishing number of bizarre characters have been developed by the males. Some have leaflike legs, others extremely wide wings or folded-back portions which form large pockets filled with black scales; still others have the maxillary palpi variously developed into spoon-shaped structures with long extensile membranous organs. Organizing and correlating the differences found in both male and female genitalia give us ample evidence that this entire complex is a compact phylogenetic group. The secondary sexual characters so strikingly developed in the males appear to have no relation to the phylogeny of the true species groups in the genus. It seems necessary, therefore, to consider this entire complex one genus.

There are about 25 well-recognized species in the Nearctic region. Only one has been found in Illinois, but at least a dozen others have been taken in the eastern and northeastern states. Their distribution, however, is so local, especially west of the Alleghenies, that it is impossible to predict which ones might possibly be taken in Illinois with additional collecting.

An interesting feature of the genus is the local nature of many colonies. Only rarely are many species found occurring together in the same locality. Most species prefer streams or springs to lakes.

Lepidostoma liba Ross

Lepidostoma liba Ross (1941*b*, p. 120); ♂, ♀.

Larva.—Fig. 882. Length 7.5 mm. Head, pronotum and metanotum dark chocolate brown; legs yellowish brown; the head has a pattern of small, lighter brown markings. Frontal area of head nearly flat, frons of only medium width; upper portion of head without long setae. Pronotum with an apical row of long setae and a few scattered ones in the middle. Mesonotum with an irregular group of setae around periphery. Metanotum with two pairs of small central dark spots, each bearing a long seta, and a longer lateral sclerite bearing several setae. Middle and hind legs slender and of medium length, front legs stout and short.

Case.—Length 8 mm. Two distinct types are built, a square log-cabin type of wood fragments and a round type of stones. Both have a rough exterior, and frequently a case will be part one and part the other.

Adults.—Length 8.5–9.0 mm. Color various shades of brown, the dorsum darker, antennae, legs and venter much lighter, often tawny; the wings have patches of light hair which give the species an indistinctly checkered appearance. Male genitalia, fig. 883: ninth tergite with two large brushes of long setae, tenth tergite with a pair of lateral sclerotized irregular and short arms, and a pair of mesal, membranous triangular lobes; claspers with a long curved dorsobasal hook; from ventral view they appear slightly constricted just before apex, the apex itself irregular and oblique. Female

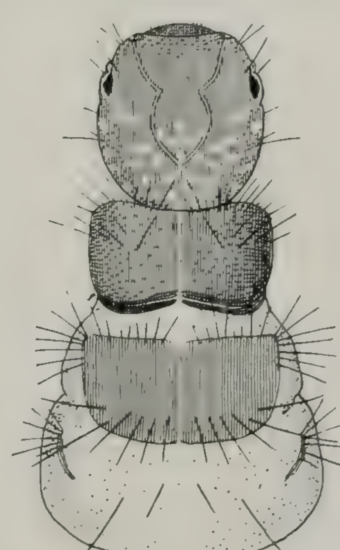


Fig. 882.—*Lepidostoma liba*, larva.

genitalia as in fig. 884, with no prominent processes; bursa copulatrix as in fig. 884*B*.

This species has been taken in considerable numbers in three spring-fed brooks in the state, one at Elgin (see p. 7), another

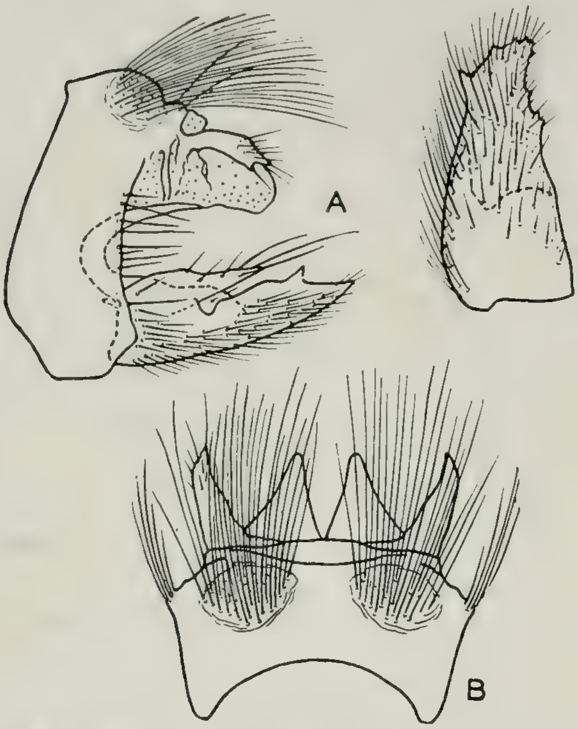


Fig. 883.—*Lepidostoma liba*, male genitalia. *A*, lateral aspect; *B*, dorsal aspect; *C*, clasper.

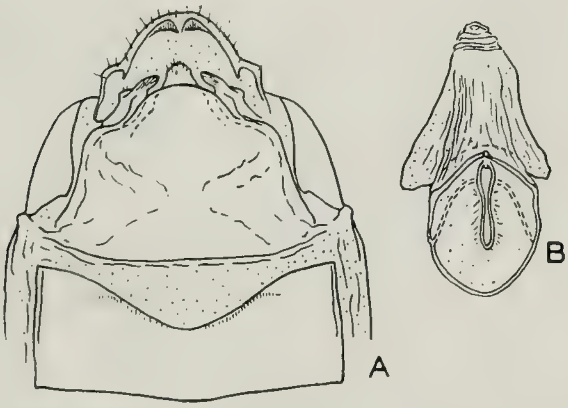


Fig. 884.—*Lepidostoma liba*, female genitalia. *A*, ventral aspect; *B*, bursa copulatrix.

at Cave Spring, Quincy, and the other at a spring near McCann School at La Rue. These are very widely scattered. In all three places we have taken the larvae in fairly good numbers, and at Quincy we collected mature pupae, linking the larval and adult forms. Our adults were taken in May, June and September, indicating a possible two-brooded cycle. Our observations at Quincy, however, where a large flight of adults was taken on September 15, indicates that the spring brood may have been skipped, so that locally this species may have a highly irregular emergence period, as was found true in certain localities for *Neophylax* (see p. 202).

This species has not been collected outside of Illinois, so that nothing can be stated regarding its general range.

Illinois Records.—Elgin, stream in Botanical Gardens: June 6, 1939, Burks & Riegel, 1♂, 2♀; June 13, 1939, Frison & Ross, 1♀. La Rue, McCann Spring: May 12, 1939, Burks & Riegel, 1♀. Quincy, Cave Spring: Sept. 15, 1939, Ross & Riegel, 3♂, ♀♀.

Theliopsyche Banks

Theliopsyche Banks (1911, p. 356). Genotype, monobasic: *Theliopsyche parva* Banks.

Subg. *Aopsyche* Ross (1938*a*, p. 174). Genotype, by original designation: *Theliopsyche corona* Ross.

No species of this genus has as yet been found in Illinois. It is represented by four species, all restricted to the eastern states.

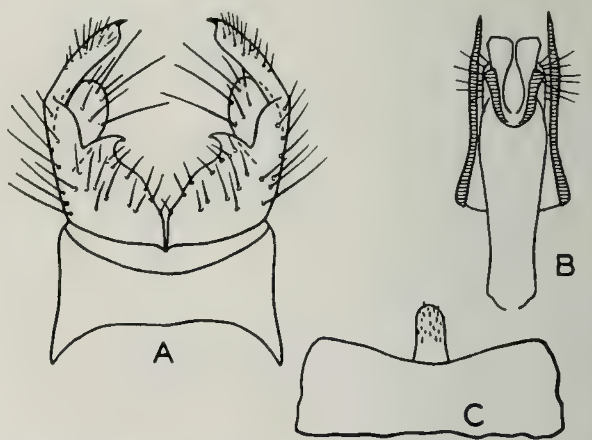


Fig. 885.—*Theliopsyche parva*, male genitalia. *A*, ventral aspect; *B*, aedeagus; *C*, eighth sternite.

The males are readily distinguished by the wide, flaplike process on the eighth sternite, fig. 885*C*. No larvae of this genus have been reared.

BRACHYCENTRIDAE

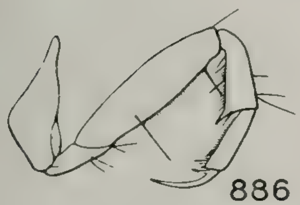
The maxillary palpi are three segmented in the male, five segmented in the female. The tibial spur count varies a great deal. The larvae are readily distinguished by having a sharp crease across the pronotum, a divided mesonotum and only two pairs of sclerites on the mesonotum; in addition, the antennae are small, closer to the mandibles than to the eyes, and situated under a carina.

The family contains two genera, represented over most of the continent.

KEY TO GENERA

Larvae

1. Middle and hind tibiae with an inner, apical, seta-bearing spur, fig. 886; hind coxae with a ventral, semicircular lobe bearing a row of long setae; mesonotum with sclerites long and narrow, plates of metanotum heavily sclerotized, fig. 896. . . . . **Brachycentrus,** p. 263



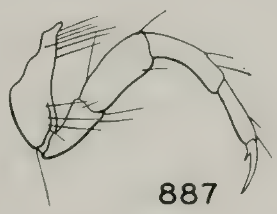


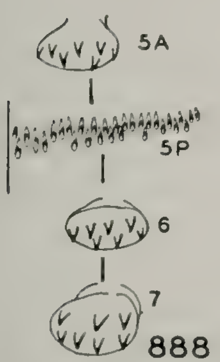
Fig. 886.—*Brachycentrus numerosus* larva, hind leg.

Fig. 887.—*Micrasema rusticum* larva, hind leg.

Middle and hind tibiae without an apical spur, fig. 887; hind coxae without a ventral lobe; mesonotum with sclerites short and very wide, plates of metanotum only lightly sclerotized but recognized chiefly by their cluster of setae, fig. 892. . . . . **Micrasema,** p. 261

Pupae

1. Hook plates of fifth and sixth segments with fewer, larger hooks, fig. 888. . . . . **Brachycentrus,** p. 263



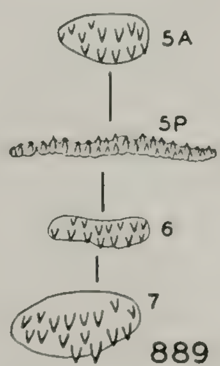


Fig. 888.—*Brachycentrus numerosus* pupa, hook plates.

Fig. 889.—*Micrasema rusticum* pupa, hook plates.

Hook plates of fifth and sixth segments with more and smaller hooks, fig. 889. . . . . **Micrasema,** p. 261

Adults

1. Front wings with R_1 suddenly arched and markedly sinuate at base of stigmal region, fig. 890. . . . . **Brachycentrus,** p. 263

Fig. 890.—*Brachycentrus numerosus*, front wing.

Fig. 891.—*Micrasema rusticum*, front wing.

Front wings with R_1 only faintly sinuate at base of stigmal region, fig. 891 . . . . **Micrasema,** p. 261

Micrasema McLachlan

Micrasema McLachlan (1876, p. 259). Genotype, here designated: *Oligoplectrum morosum* McLachlan.

This genus is very distinct from *Brachycentrus* on the basis of the larvae, but in the adults and pupae it is more difficult to make a separation. All the species of which we have larvae make round cases. Six species are known from North America; of these four are known from the eastern states, but only one has been found in Illinois.

Micrasema rusticum (Hagen)

Dasystoma rusticum Hagen (1868, p. 272); ♂, ♀.

Micrasema falcatum Banks (1914, p. 265); ♂.

LARVA.—Fig. 892. Length 6 mm. Head yellow with brown spots, the lower part of the frons entirely brown; thoracic sclerites and legs yellowish. Frons with anterior portion wide.

CASE.—Length 6 mm., constructed of

sand grains, circular in cross section and tapering fairly evenly. At pupation part of the narrow end is cut off, and the case then appears nearly cylindrical.

Adults.—Length 6–7 mm. Color uniform dark brown, appearing almost black in life. Male genitalia, fig. 893: cerci somewhat triangular, well separated to base;

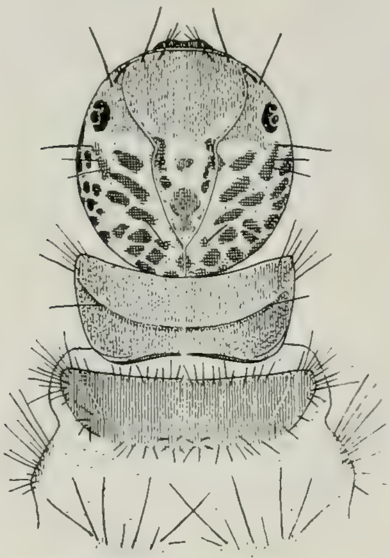


Fig. 892.—*Micrasema rusticum* larva.

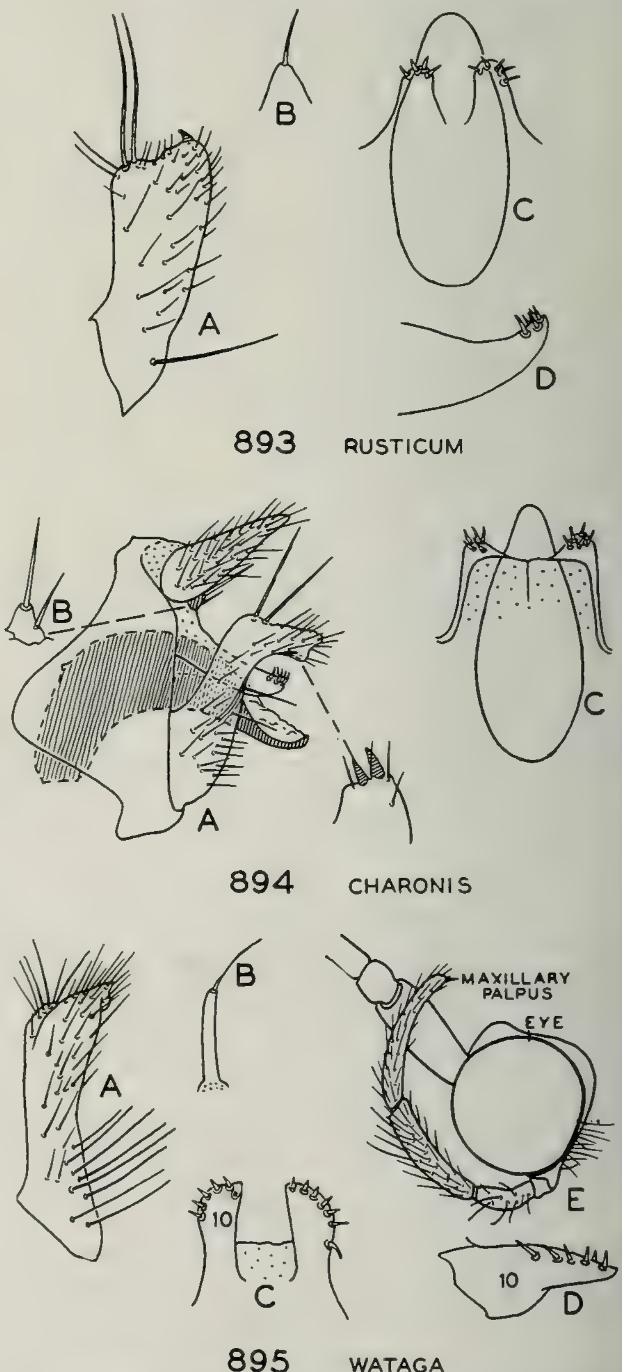
tenth tergite forming a pair of lateral sclerotized processes enlarged at apex and bearing a group of short setae; at base of these processes is a pair of low tubercles bearing a seta; claspers long and straight, the posterior margin of the apex forming a slight tooth. Female genitalia simple, similar in general structure to those for *Brachycentrus.*

This species is very similar to *charonis* and *wataga*, both of which occur in the eastern states; the diagnostic differences in the genitalia are illustrated in figs. 894, 895; *charonis* is characterized by the bent apex of the clasper, *wataga* by the long style and heavily sclerotized lateral plates of the tenth tergite, *rusticum* by the short style, weaker tenth tergite and almost straight clasper.

In Illinois we have taken this species only in and along the Kankakee River at Momence and Kankakee. At Momence the cases were found under stones in the river, and mature pupae were obtained, thus linking the larval and adult stages. In this locality we have taken this species only in spring, indicating a single-brooded condition here. The species seems to follow the two *Brachycentrus* species in seasonal succession and has been taken in abundant swarms during the middle of May.

The species is widely distributed through the eastern states, extending southwestward into Oklahoma. It appears to be fairly scattered in distribution, since we do not have a large number of locality records, but is frequently taken in swarms. Records are available for Georgia, Illinois, Indiana, Michigan, New York, Oklahoma, Saskatchewan, Virginia and Wisconsin.

Illinois Records.—Kankakee: May 31, 1938, Mohr & Burks, 1 ♂; Kankakee River, May 21, 1940, Mohr & Burks, 8 ♂, 6 ♀. Momence: Kankakee River, May 26, 1936, H. H. Ross, 1 ♀; May 17, 1937, Ross &



Figs. 893–895.—*Micrasema*, male genitalia. *A*, clasper; *B*, spine of tenth tergite; *C* and *D* tenth tergite, respectively dorsal and lateral aspects. *E*, male head.

Burks, ♂♂, ♀♀, 7 pupae, many larvae; Kankakee River, May 24, 1937, H. H. Ross, ♂♂, ♀♀; May 5, 1938, Ross & Burks, ♂♂, ♀♀, many pupae; Aug. 19, 1939, Ross & Burks, 1 larva; May 1, 1941, T. H. Frison, 5♂, 1♀.

Brachycentrus Curtis

Brachycentrus Curtis (1834, p. 216). Genotype, monobasic: *Brachycentrus subnubilus* Curtis.

Sphinctogaster Provancher (1877, p. 262). Genotype, monobasic: *Sphinctogaster lutescens* Provancher.

Oligoplectrum McLachlan (1868, p. 297). Genotype, by subsequent limitation of McLachlan (1876, p. 258): *Phryganea maculata* Fourcroy.

Subg. *Amiocentrus* Ross (1938*a*, p. 177). Genotype, by original designation: *Brachycentrus aspilus* Ross.

The larvae of this genus frequently construct the well-known chimney case, fig. 904, although the case may be cylindrical. Most of the diagnostic characters for the genus are given in the key.

Nine species are known from North America, two of which have been taken in the state, and another has been taken nearby in Wisconsin. To date characters have not been found for the separation of all females. Many of the larvae present characters useful in their diagnosis.

Of especial interest in this genus are two Say species, *lateralis* and *numerosus*. Both of these were described from along the Ohio River at Shippingsport, Kentucky (near Louisville), and recorded as occurring in vast numbers early in May, the wave of one species appearing after the wave of the other. We believe that in the Kankakee River at Momence, Illinois, we have found a duplication of this condition; in fact, so closely do our observations correspond on what are apparently these same two species (belonging to the genus *Brachycentrus*) that I am selecting neotypes from this Momence material.

KEY TO SPECIES

Larvae

1. Head entirely black.................................. **americanus**, p. 266
   Head with light marks, figs. 896, 897 2
2. Head with pattern predominantly light or bright yellow and having narrow dark lines, fig. 897.............................. **lateralis**, p. 265

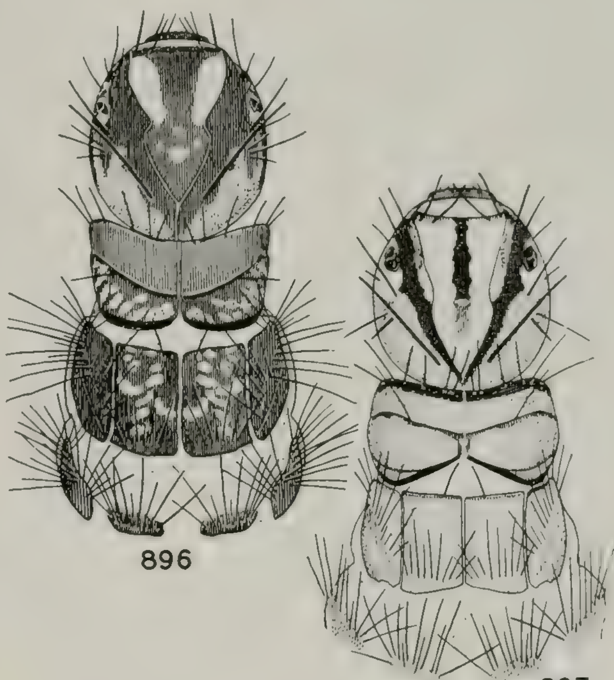
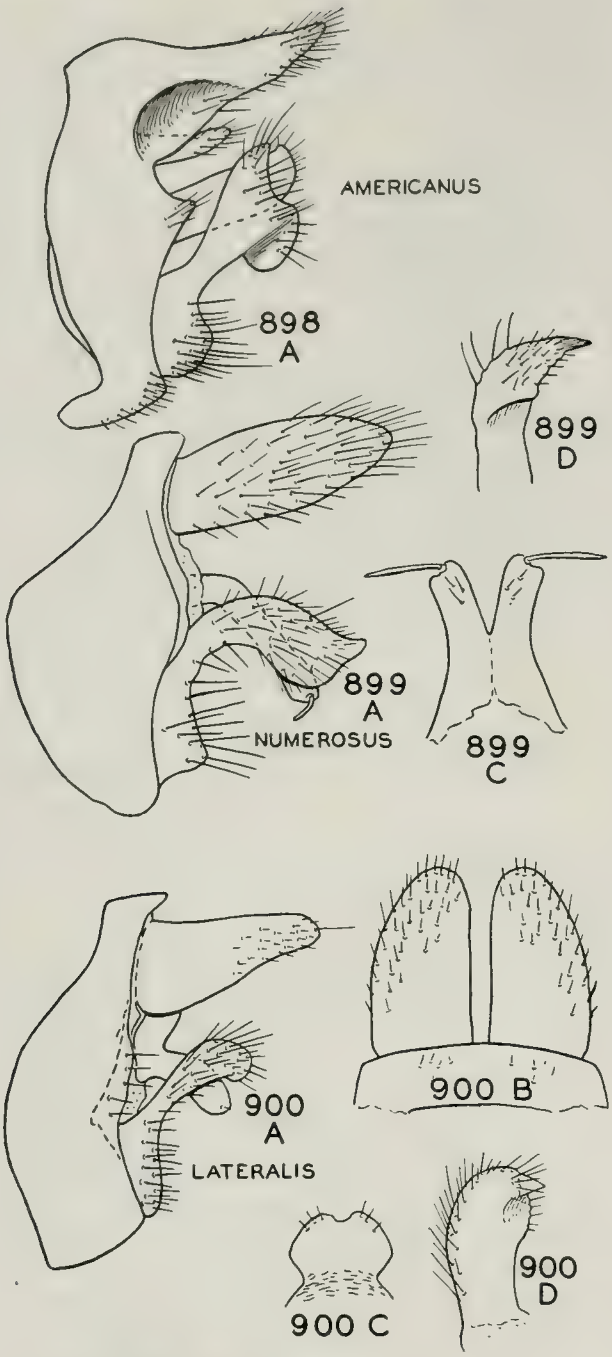


Fig. 896.—*Brachycentrus numerosus* larva.
Fig. 897.—*Brachycentrus lateralis* larva.

   Head with lower portion dark brown and having a pair of cream marks, fig. 896............ **numerosus**, p. 264

Adults

1. Genitalia with claspers, figs. 898–900 (males)........................ 2
   Genitalia without claspers, fig. 901 (females)........................ 4
2. Cerci fused on meson for at least basal half; apex of clasper with a lower, rounded platelike lobe, fig. 898.................... **americanus**, p. 266
   Cerci not fused on meson; apex of clasper without a platelike lobe, figs. 899, 900.................... 3
3. Tenth tergite divided at apex, each lobe with a long macrochaeta at tip, fig. 899............ **numerosus**, p. 264
   Tenth tergite without a pair of macrochaetae, in outline shaped as in fig. 900.............. **lateralis**, p. 265
4. Lateral aspect of apical tergite robust and long, a crease setting off the apical third as a distinct area round at tip, fig. 903......... **lateralis**, p. 265
   Lateral aspect of apical tergite short and truncate or with apical portion as long as base, figs. 901, 902...... 5
5. Lateral aspect of apical tergite short, apical portion truncate and deeper



Figs. 898–900.—*Brachycentrus*, male genitalia. *A*, lateral aspect; *B*, dorsal aspect; *C*, tenth tergite, dorsal aspect; *D*, apex of clasper, ventro-caudal aspect.

than long; eighth sternite with apical lobes wide and large, fig. 902 . . . . **numerosus**, p. 264

Lateral aspect of apical tergite long, apical portion oblique and much longer than deep; eighth sternite with apical lobes narrower and smaller, fig. 901 . . . . **americanus**, p. 266

Brachycentrus numerosus (Say)

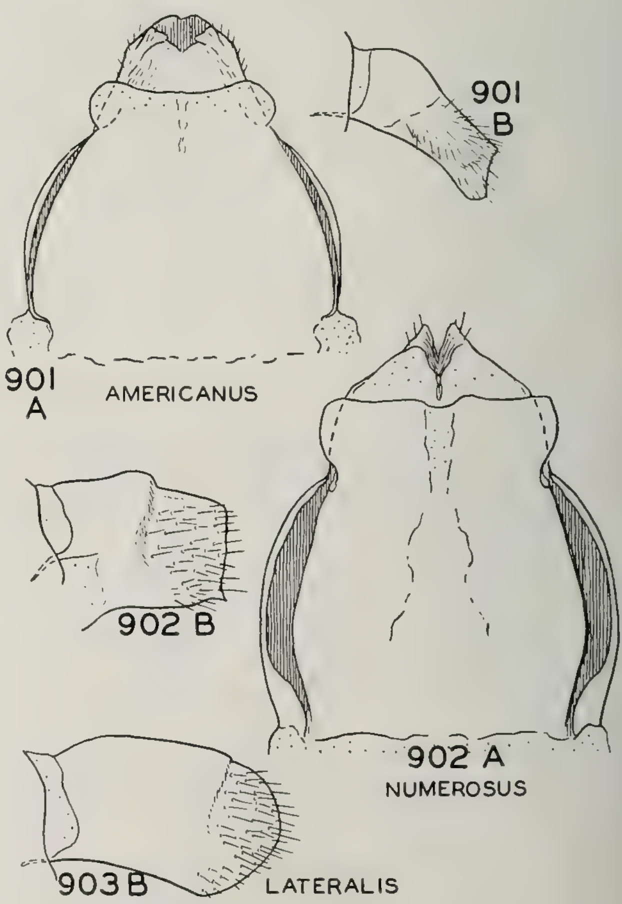
Phryganea numerosa Say (1823, p. 160).

Larva.—Fig. 896. Length 12 mm. Head with ventral portion dark brown, dorsal portion lighter brown, frons with a pair of cream-colored marks along lateral margin; thoracic sclerites dark brown. Legs with coxae brown, remainder of segments shading to a chestnut brown, the upper and lower edges of the femora black. Lateral fringe present on segments 3–7.

Case.—Fig. 904. Length 12 mm., almost square in cross section and smooth in outline, constructed of wood fragments.

Adults.—Length 9–11 mm. Head, body, antennae and most of legs dark brown to black, tarsi whitish and abdomen with a wide lateral line; wings tawny, frequently almost white, with a series of pale spots giving a somewhat checkered appearance. Male genitalia, fig. 899: cerci ovate and widely separated to base; claspers curved, the base narrow, the curve narrow and necklike, the apical portion swollen, narrowed to a sharp tip; tenth tergite divided down meson into a pair of long apical processes, each bearing one or two long macrochaetae directed laterad. Female genitalia, fig. 902, consisting of simple plates and a small bursa copulatrix.

Neotype, male. — Momence, Illinois: May 4, 1937, Ross & Mohr.



Figs. 901–903.—*Brachycentrus*, female genitalia. *A*, ventral aspect; *B*, lateral aspect of ninth and tenth tergites.

Neoallotype, female.—Same data as for neotype.

In Illinois we have taken this species at several widely scattered points. The larvae are restricted to the rapid riffles of some of our better streams such as the Kankakee River and Quiver Creek. There is only one generation a year, adult emergence taking place in late April and early May. The season timing of the species seems to be remarkably acute.

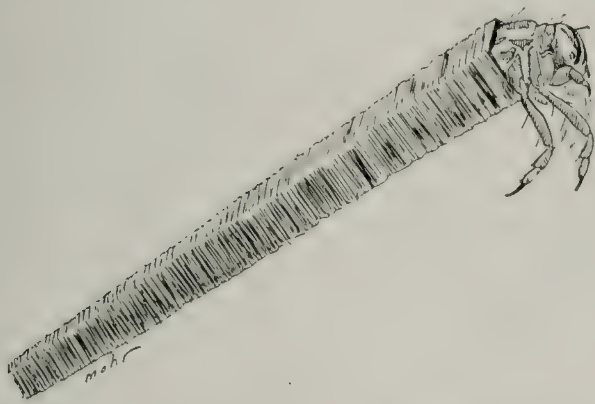


Fig. 904.—*Brachycentrus numerosus*, case.

At Momence we have taken the adults in great swarms, although not in the clouds recorded by Say. Larval and adult associations have been made from pupae collected from both Quiver Creek near Havana, Illinois, and the Kankakee River at Momence.

This is the species recorded by Betten (1934) as *Brachycentrus nigrosoma.* The type of Banks' species is a female, and it seems advisable at the present to consider it of doubtful identity.

The range of the species is poorly known, but it is widespread through many of the northern and central states. We have records from Illinois, Indiana, Maryland, Massachusetts, New York, North Carolina, Quebec and Wisconsin.

Illinois Records. — DUNCANS MILLS, Spoon River: Sept. 2, 1910, 1 larva. GARDEN PRAIRIE: Aug. 13, 1926, 1 larva. HAVANA, Quiver Creek: Aug. 7, 1895, C. A. Hart, 9 larvae; June 11, 1896, E. B. Forbes, 1 larva; July 3, 1896, C. A. Hart, many larvae; April 24, 1898, C. A. Hart, 1♂, 2♀; Aug. 25, 1910, 1 larva; May 28, 1936, Mohr & Burks, 1 larva; May 29, 1936, Mohr & Burks, many larvae; June 5, 1936, Mohr & Burks, 1♂ (reared), 3 larvae, 2 pupae; June 20, 1936, Mohr & Burks, 6 larvae. HAVANA: White Oak Run, Oct. 5, 1910, rapid current, 2 larvae; June 20, 1936, Mohr & Burks, 6 larvae. MAHOMET, Sangamon River: June 6, 1940, Ross & Riegel, 4 larvae. MOMENCE: May 26, 1936, H. H. Ross, 2 larvae; Aug. 15, 1937, Ross & Burks, 6 larvae; Oct. 27, 1938, Ross & Burks, many larvae; Nov. 3, 1938, Mohr & Burks, many larvae; Dec. 21, 1938, Mohr & Burks, 6 larvae; May 7, 1940, B. D. Burks, ♂♂, ♀♀; May 8, 1940, Mohr & Burks, 7 pupae, 5♀; preceding Momence records are from Kankakee River; July 14, 1936, B. D. Burks, many larvae; Aug. 21, 1936, Ross & Burks, 3 larvae; May 4, 1937, Ross & Mohr, ♂♂, ♀♀, 3 mating pairs.

Brachycentrus lateralis (Say)

Phryganea lateralis Say (1823, p. 161).

LARVA.—Fig. 897. Length 12 mm. Head, thoracic sclerites and legs yellowish, head with three black lines on dorsum, femora with upper and lower edges black. Structures similar to those of *numerosus.*

CASE.—Length 12 mm. Of typical log-cabin construction as for *numerosus.*

ADULTS.—Length 9–11 mm. Color chiefly black with tawny wings as with *numerosus.* Male genitalia, fig. 900: cerci not fused on meson but close enough to appear hoodlike; claspers with narrow base, fairly long neck, the apex widened, the posterior face concave and with a short, sharp tooth; tenth tergite short, emarginate at apex and humped dorsally; aedeagus tubular. Female genitalia simple, similar to those of *numerosus* in general proportions.

Neotype, male. — Momence, Illinois: May 4, 1937, Ross & Mohr.

Neoallotype, female.—Momence, Illinois: May 17, 1937, Ross & Burks.

In recent years this species has been found in Illinois at Momence only, where it is abundant in the Kankakee River. It has a very definite place in the seasonal succession about 2 weeks after the peak of *numerosus.*

We have not reared the larva of *lateralis,* but there seems to be no doubt that the larva described above belongs to this species. It occurs abundantly in the Kankakee River along with larvae of *numerosus,* differing only in a tendency to prefer deeper and less rapid points in this stream. We have made many collections at Momence, where these two species occur, and have taken only the two species of *Brachycentrus* adults. At the time of spring emergence, the river is always in flood, so that we have been able to obtain pupae of only *numerosus*, which frequents shallower water than does *lateralis*.

Little is known regarding the range of the species. Records are available for Illinois, Kentucky and Michigan.

Illinois Records.—Chicago: 1♂, fm. Momence: May 4, 1937, Ross & Mohr, 2♂; May 17, 1937, Ross & Burks, 3♂, ♀♀; June 12, 1938, Ross & Burks, 1 larva; Kankakee River, May 7, 1940, B. D. Burks, 5♂, 2♀; May 1, 1941, T. H. Frison, 2♂.

Brachycentrus americanus (Banks)

Oligoplectrum americanum Banks (1899, p. 210); ♂.
Brachycentrus similis Banks (1907*a*, p. 124); ♂, ♀.

Not as yet taken in Illinois. The species is extremely widespread through the northern part of the continent from coast to coast, with records from Alberta, California, Colorado, Michigan, Utah, Vermont, Wisconsin and Wyoming. Collections from Wisconsin are of peculiar interest because of the case-building habits of the larvae. Here we have found cases which were perfectly round in cross section rather than square, these round cases mingled with square ones, and frequently with cases which were round at the bottom and square at the top. Apparently the larva is quite as well able to make a circular case from its own secretion as to build the square case considered typical for the genus.

SERICOSTOMATIDAE

In North America this family contains only the genus *Sericostoma*. The Nearctic species have generally been placed in *Notidobia* by previous American authors. There are no Illinois representatives of this family, the species being restricted to the mountainous regions of the East and West. No Nearctic species have been reared.

As with the genus *Lepidostoma*, the genus *Sericostoma* has been divided into several genera, such as *Notidobia* and *Schizopelex*, almost entirely on the basis of the secondary sexual characters of the male. The uniformity of general characteristics in the females indicates that these differences are not of generic value; therefore I am considering the two names just mentioned as synonyms of *Sericostoma*.

HELICOPSYCHIDAE

The familiar snail case represents the only genus in this family, *Helicopsyche*. Various authors have commented upon the distinct features of this group, and Betten in particular (1934, p. 414) has given a very clear summary of the oddity of its characters. On the basis of the curious structures of both larvae and adults, it seems best to consider this as a distinct family.

Helicopsyche Hagen

Helicopsyche Hagen (1866, p. 252). Genotype, monobasic: *Notidobia borealis* Hagen.

Distinctive of the larva are the following characters: anal legs with a comb; head with frons wide, running close to eyes, with a ridge running from dorsal margin of eye to above mandible, antennae short, situated under this ridge and midway between eye and mandible; legs of medium length; pronotum long, mesonotum forming a large erect shield and divided into parts by pale areas as in fig. 905. Pupae have the anal appendages as in fig. 49. The adults are readily distinguished by the short mesoscutellum, with its narrow transverse wart, and the hamuli on the hind wings.

Four species are known from the United States, only one of which has been taken in Illinois. A key which will separate it from its allies is given on p. 288.

Helicopsyche borealis Hagen

Notidobia borealis Hagen (1861, p. 271); ♂.
Helicopsyche californica Banks (1899, p. 210); ♂. New synonymy.
Helicopsyche annulicornis Banks (1904*d*, p. 212); ♂.

Larva.—Fig. 905. Length 8 mm. Head and thoracic sclerites brown, legs straw colored. Head, thoracic sclerites and legs with abundant long hair.

Case.—Fig. 906. Built in the form of a spiral coil, its diameter about 5 mm., shaped like a snail shell, made of sand grains and small stones.

Adults.—Length 5–7 mm. Head, body and appendages straw colored, the body and wings suffused with varying shades of brown. Male genitalia, fig. 961, p. 288, with hand-shaped claspers, narrow and beaklike tenth tergite and cylindrical, curved aedeagus. An added diagnostic character is the slightly clavate, sclerotized spur of the sixth sternite. Female abdomen with very distinctive pattern of sclerites, those of the basal segments reticulate, as in fig. 907; bursa copulatrix small and stalked. The male abdomen has similar reticulation.

Fig. 905.—*Helicopsyche borealis*, larva.

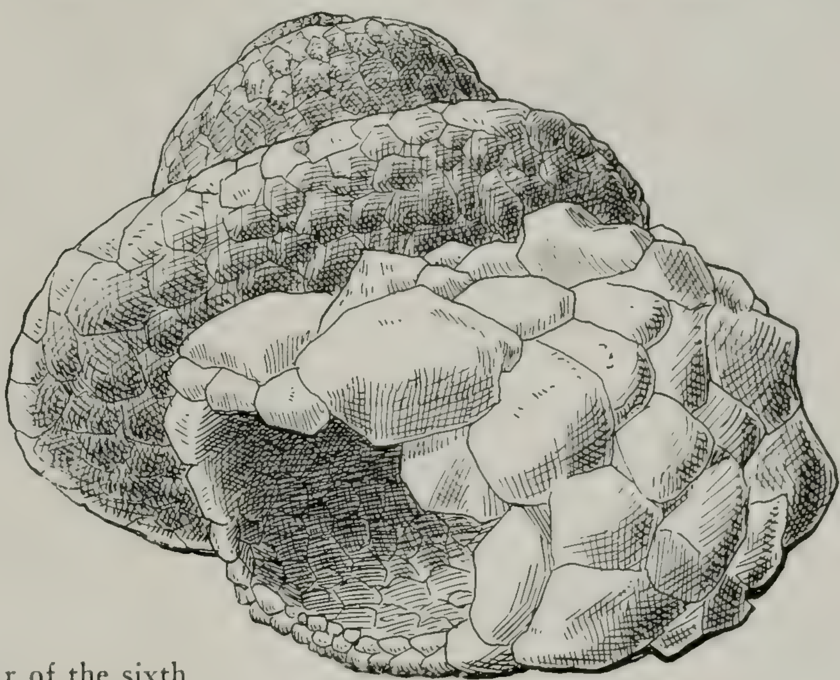


Fig. 906.—*Helicopsyche borealis*, case.

This species is widely distributed in Illinois but is confined to relatively clear and swift streams, such as the Kankakee and Salt Fork Rivers and Split Rock Brook, and is found also in the glacial lakes of the northeastern corner of the state. The larvae are found chiefly under stones. There is apparently a continuous succession of generations, our adult emergence ranging from May 28 to September 7.

This insect is one of the best known caddis flies and has received much attention. Vorhies (1909) has reared and described all stages very completely.

Betten (1934) also has illustrated characters of this species in considerable detail.

The curious snail-like case has attracted the attention of many entomologists and collectors of natural history objects. It is remarkably constant in structure, varying little in shape over the species range.

The continental range of the species is very wide, stretching from Mexico northeastward to Nova Scotia and westward to Montana and Oregon; the range embraces most of the forested areas of the continent, forming a complete circle around the Great Plains. Records are available for Arkansas, California, Colorado, Florida, Georgia, Illinois, Indiana, Kentucky, Michigan, Minnesota, Missouri, Montana, New Brunswick, New Hampshire, New York, Nova Scotia, Ohio, Oklahoma, Ontario, Oregon, Pennsylvania, Saskatchewan, South Dakota, Texas, Virginia, West Virginia, Wisconsin and Wyoming.

Illinois Records.—Many males, females and pupae, taken May 14 to September 7, and many larvae, taken February 1 to October 30, are from Antioch, Apple River Canyon State Park, Baker (Indian Creek), Cedar Lake, Channel Lake, Chemung (Piscasaw Creek), Fox Lake, Herod (east fork of Grand Pierre Creek), Homer, Kankakee (Kankakee River), Leland, Martha Iron Furnace (Hog Thief Creek), McHenry, Momence (Kankakee River), Muncie (Stony Creek), Oakwood (Salt Fork River), Richmond, Rock Island, Serena (Indian Creek), Spring Grove, Sterling, Urbana (Salt Fork River), Utica (Split Rock Brook), Wilmington (Kankakee River).

Fig. 907.—*Helicopsyche borealis*, female abdomen, ventral aspect.

EXTRALIMITAL TRICHOPTERA

During the course of the foregoing study of the Illinois caddis flies it has been necessary to examine a large amount of material from other states. Detailed studies of some of the species involved have been necessary in order to establish the species limits of some components of the Illinois fauna. Descriptions of some of the more pertinent new forms are presented here, partly to supplement identification of Illinois species and partly to supplement the check list.

Rhyacophila banksi new species

This species is unique among North American forms in the narrow, angled and bifid dorso-mesal projection of the ninth tergite. Superficially it appears closely related to *invaria* but differs from this species not only in the projection of the ninth tergite but in many characters of the claspers and tenth tergite.

Male.—Length 10 mm. Color brown, the wings without definite pattern except irregular spots of golden hair which occur over most of the surface. General structure typical for genus. Genitalia as in fig. 908. Ninth segment annular, narrowed ventrad, and with a prominent dorso-mesal projection which angles sharply dorsad, is narrow at base, and expanded and distinctly emarginate at apex. Tenth tergite with a prominent pair of dorsal lobes which are produced into a posterior point; below these is a central style with a rounded apex and narrow sinuate internal rodlike base. Claspers with basal segment short and stocky, as wide as long; apical segment almost as long as basal one, apical margin very deeply incised to form a large, rounded, dorsal lobe and a long, rounded, ventral lobe, the latter with a brush of short black setae on the mesal face. Aedeagus very similar to that of *invaria,* having a short, stocky membranous base with a mesal sclerotized body having a wide, "eared" dorsal portion and a ventral portion produced into an upturned sharp point, flanked by an extensile membranous lobe which bears a sclerotized, pointed blade.

Female.—In size, color and general structure similar to male. Eighth segment, fig. 908, with ventral margin produced into a tongue, divided at tip into a pair of narrow fingers; lateral margin sinuate and dorsal margin deeply incised.

Holotype, male.—Warren, New Hampshire: June 21, 1941, Frison & Ross.

Allotype, female.—Same data as for holotype.

Paratypes.—New Hampshire. — Pemigewasset River, near Woodstock: June 22, 1941, Frison & Ross, 1♂, 1♀. Mount Washington: June 22, in Tuckerman's Ravine, P. Darlington, 2♂, MCZ.

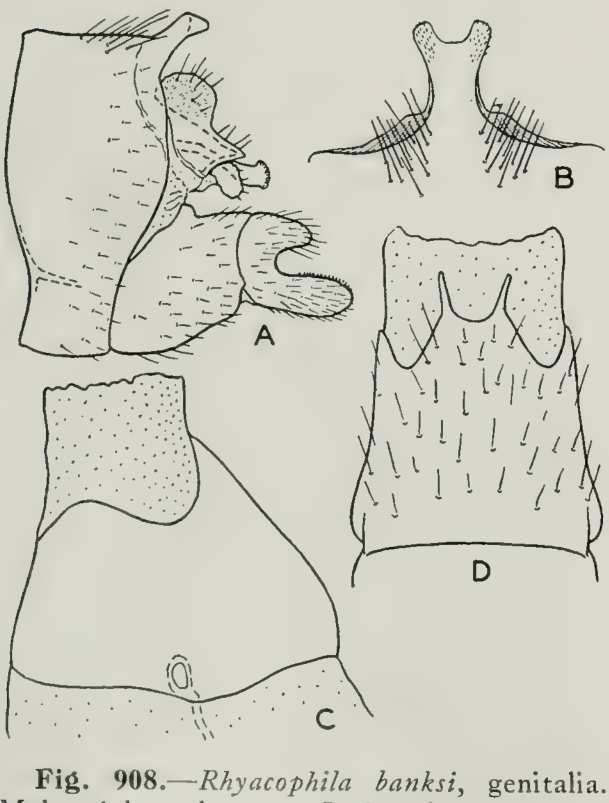


Fig. 908.—*Rhyacophila banksi,* genitalia. Male: *A,* lateral aspect; *B,* dorsal aspect. Female: *C,* lateral aspect; *D,* ventral aspect.

Rhyacophila harmstoni new species

The general structure of the genitalia indicates a close affinity between this species and *vofixa*; *harmstoni,* however, may be distinguished by the convex rather than concave tenth tergite and the short aedeagus with its two curved clusters of spines, fig. 909.

Male.—Length 11 mm. Color various shades of brown, the wings irrorate over almost their entire surface. General structure typical for genus. Male genitalia as in fig. 909. Ninth segment annular, slightly narrowed ventrad. Tenth tergite short, the apex divided into a pair of snoutlike reticulate lobes, the central and upper portion convex, the dorsal angle produced into a slight hump. Claspers with basal segment stocky, longer than wide, its apical margin almost truncate and having a scattering of medium length setae; apical segment short and boot shaped, the dorsal heel small and pointed, the ventral toe large and somewhat triangular, with a brush of short setae on

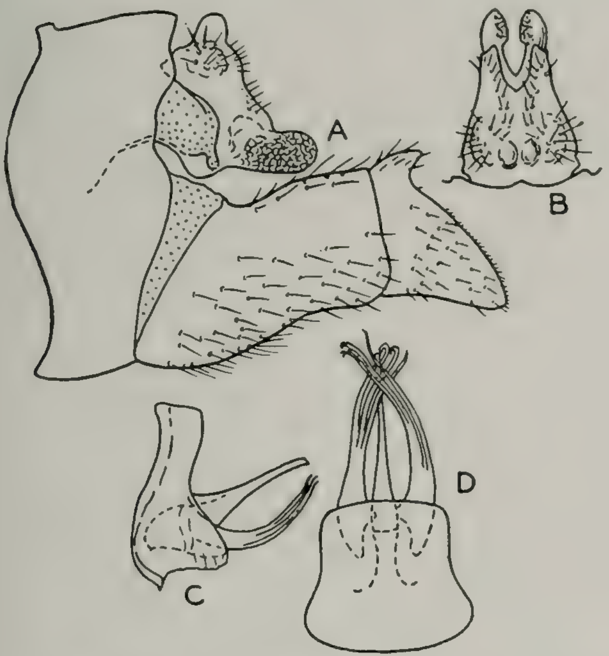


Fig. 909.—*Rhyacophila harmstoni*, male genitalia. *A*, lateral aspect; *B*, tenth tergite; *C* and *D* aedeagus, respectively lateral and ventral aspects.

the inner margin at apex. Aedeagus with dorsal portion very narrow, ventral portion expanded and wider; armature consisting of a mesal style which is widest at base and tapers rather rapidly to a slender straight apex, flanked on each side by a curved cluster of three or four spines fused on basal portion and sinuate at apex.

Holotype, male. — Strawberry Valley, Utah: July 15, 1938, Knowlton & Harmston.

Agapetus iridis new species

This species is most closely related to *pinatus*, differing from it in the truncate lateral aspect of the claspers and the conformation of the tenth tergite.

MALE.—Length 5 mm. Color dark brown, the legs beyond coxae whitish yellow with black spurs. General structure typical for genus. Genitalia as in fig. 910. Ninth segment cylindrical, its posterior margin truncate laterad and incised almost to the base on the dorsum. Cerci long and slender with a dorsal brush of long setae. Tenth tergite very long, the basal part robust, tapering

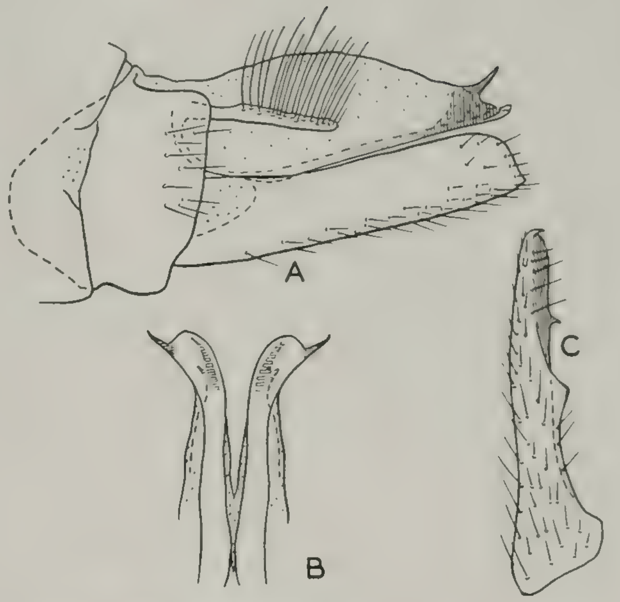


Fig. 910.—*Agapetus iridis*, male genitalia. *A*, lateral aspect; *B*, tenth tergite; *C*, clasper.

to apex; almost completely membranous except for a pair of stout sharp dorsal spines at apex and a pair of ventral sclerotized ribbons which are expanded and flat at apex and bearing on the lateral corner a fairly long, sharp spine. Claspers long, lateral aspect forming an elongate rectangle, the apico-ventral corner slightly pointed; mesal face with an apical and dorsal sclerotized tooth and with the ventro-mesal margin produced near middle into a wide, triangular lobe sclerotized at apex and evenly curved to meet the slightly wider base. Aedeagus semimembranous and tubular, typical for the genus.

FEMALE.—In size, color and general structure similar to male. Eighth segment bilaterally compressed, its apical margin slightly incised on meson and with the dorsal margin slightly shorter than the ventral one.

Holotype, male.—Small creek near Tahawus, New York, Adirondack State Park: June 20, 1941, Frison & Ross.

Allotype, female.—Same data as for holotype.

Paratypes.—NEW YORK.—Same data as for holotype, 1 ♂. Cedar River near INDIAN LAKE, June 20, 1941, Frison & Ross, 1 ♂.

Chimarra elia new species

This species is most closely related to *utahensis*, differing from it in the large, keel-like apical process of the ninth sternite, in addition to other differences in the genitalia.

From other species with the ventral keel, such as *aterrima*, this new species may be distinguished readily by the situation of the ventral keel immediately under the face of the clasper and also by the heavily sclerotized, serrate, lateral process of the tenth tergite.

MALE.—Length 6 mm. Color very dark brown, the legs whitish yellow except for the tarsi and spurs, which are brown; wings

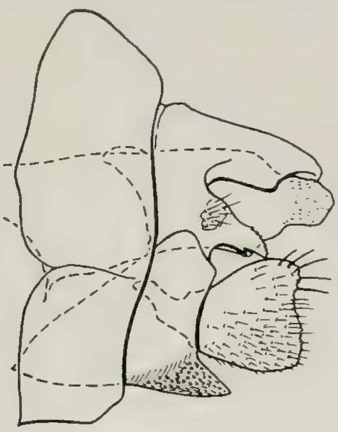


Fig. 911.—*Chimarra elia*, male genitalia.

without perceptible pattern; in life the insect looks almost black. General structure typical for genus. Male genitalia as in fig. 911. Ninth and tenth tergites fused, the anterior margin of the ninth with a short, stout, somewhat hook-shaped apodeme, the tenth tergite forming an irregular, almost membranous hood over the apex of aedeagus; ventrad of this hood are situated the small, round cerci and, beyond these, the lateral margin of the segment is produced into a sharp, minutely serrate point. Ninth sternite triangular, the apico-mesal line bearing a long, projecting, sharp keel which is slightly serrulate, is situated directly below the base of the claspers and occupies most of the exposed ventral margin of the sternite. Claspers somewhat triangular, the dorsal corner rounded and bearing several fairly long setae, the remainder of the clasper with shorter setae, the dorsal surface of the apico-mesal corner with a slender but strong black spine. Aedeagus typical in general proportions for the *aterrima* group, having the somewhat expanded internal base, beyond which it is cylindrical, the exserted apex membranous and narrow, not sclerotized.

Holotype, male.—Spring-fed stream west of Brackettville, Texas: April 17, 1939, H. H. & J. A. Ross.

Chimarra florida new species

This species is a close relative of *obscura*, differing from it, however, in the short mesal process of the ninth sternite, the longer claspers, which are wider at base and more slender at apex, and the longer and stouter lateral processes of the tenth tergite. From species of the *aterrima* group which also have the short mesal process of the ninth sternite, this new species may be distinguished by the hooked aedeagus.

MALE.—Length 7 mm. Color black, the wings without pattern, the femora sometimes brownish. General structure typical for genus. Male genitalia as in fig. 912. Tenth tergite with central part membranous, lateral area developed into strongly sclerotized curved processes rounded at apex; at the base of these is a ridgelike area representing the cerci. Ninth sternite produced dorsad to base of tenth tergite, narrow and sinuate, with a short, meso-ventral keel situated near base of segment. Claspers with ventral portion flared and somewhat saucer-like, its lateral margin appearing definitely crenulate due to the presence of fairly evenly spaced small humps, each bearing a large seta; dorsal portion of clasper elongate and evenly curved. Aedeagus with basal portion long and irregular, developed at apex into a single stout sclerotized hook.

FEMALE.—Size, color and general structure as for male. Genitalia very similar to those of *obscura*; reliable characters to separate the two have not been found.

Holotype, male.—Five miles southeast of Roberta, Georgia: May 4, 1939, P. W. Fattig.

Allotype, female.—Same data as for holotype.

Paratypes.—FLORIDA. — FREEPORT, Walton County: April 3, 1938, L. Berner, 1♂.

GEORGIA.—Same data as for holotype, 4♂, 1♀.

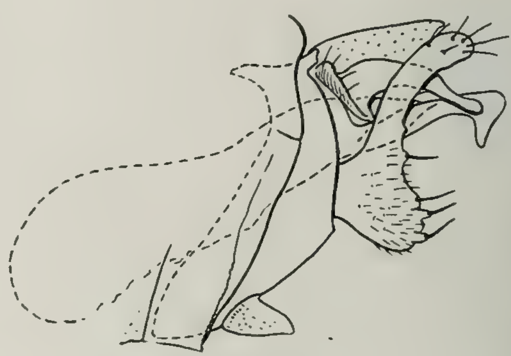


Fig. 912.—*Chimarra florida*, male genitalia.

Hydropsyche solex new species

This is most closely related to *californica*, differing from it in the extremely constricted aedeagus. In this regard it approaches *delrio*, but *delrio* is readily distinguished by the short, apical segment of the clasper and the mesal cavity of the aedeagus, which is almost entirely closed.

Male.—Length 11 mm. Head and body black; antennae very slender and yellowish, with dorsal black V-marks on the first eight segments of the flagellum; eyes red, legs yellowish brown, the femora darker; front wings tawny brown, irrorate, with abundant fenestrate cream-colored marks. General structure typical for genus. Male genitalia in general typical for the *scalaris* group. Ninth segment only slightly humped dorsad. Tenth tergite somewhat hood shaped, with a fairly wide mesal incision and with each lateral lobe produced into a very small point. Claspers slightly sinuate; apical segment nearly one-half as long as basal segment, the apex obliquely truncate. Aedeagus, fig. 913, with the base round, the stem constricted to a narrow central portion and greatly expanded at apex; apical portion definitely narrowed from stem, heavily sclerotized and almost black; mesal cavity almost entirely open; mesal plates small; lateral plates wide, from lateral view hiding the meso-dorsal portion.

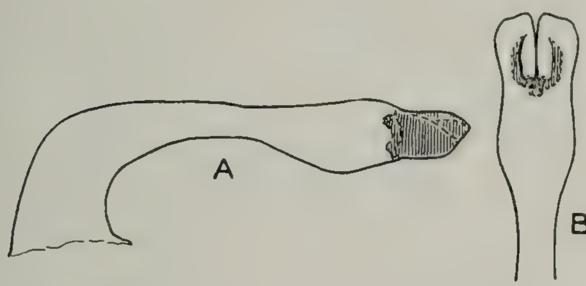


Fig. 913.—*Hydropsyche solex*, aedeagus. *A*, lateral aspect; *B*, ventral aspect.

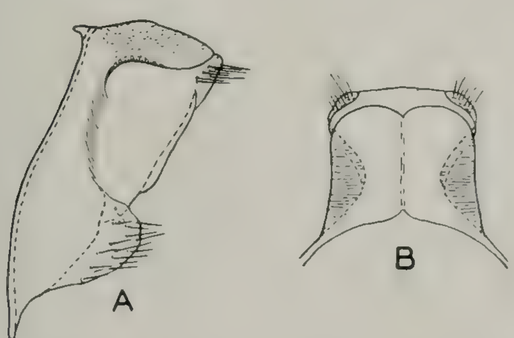


Fig. 914.—*Hydropsyche solex*, female genitalia. *A*, lateral aspect; *B*, dorsal aspect.

Female.—Length 13 mm. In color and general structure similar to male. Ninth tergite, fig. 914, with clasper groove large, invaginated only slightly under dorsal cap, from dorsal view appearing to extend deeply beneath cap; lateral lobe large, with abundant setae; postero-lateral flange well developed.

Holotype, male. — Balmorhea, Texas, along stone irrigation flume: April 19, 1939, H. H. & J. A. Ross.

Allotype, female.—Same data as for holotype.

Paratypes.—Same data as for holotype, 1 ♂, 3 ♀.

Leucotrichia Mosely

(*See also p. 120*)

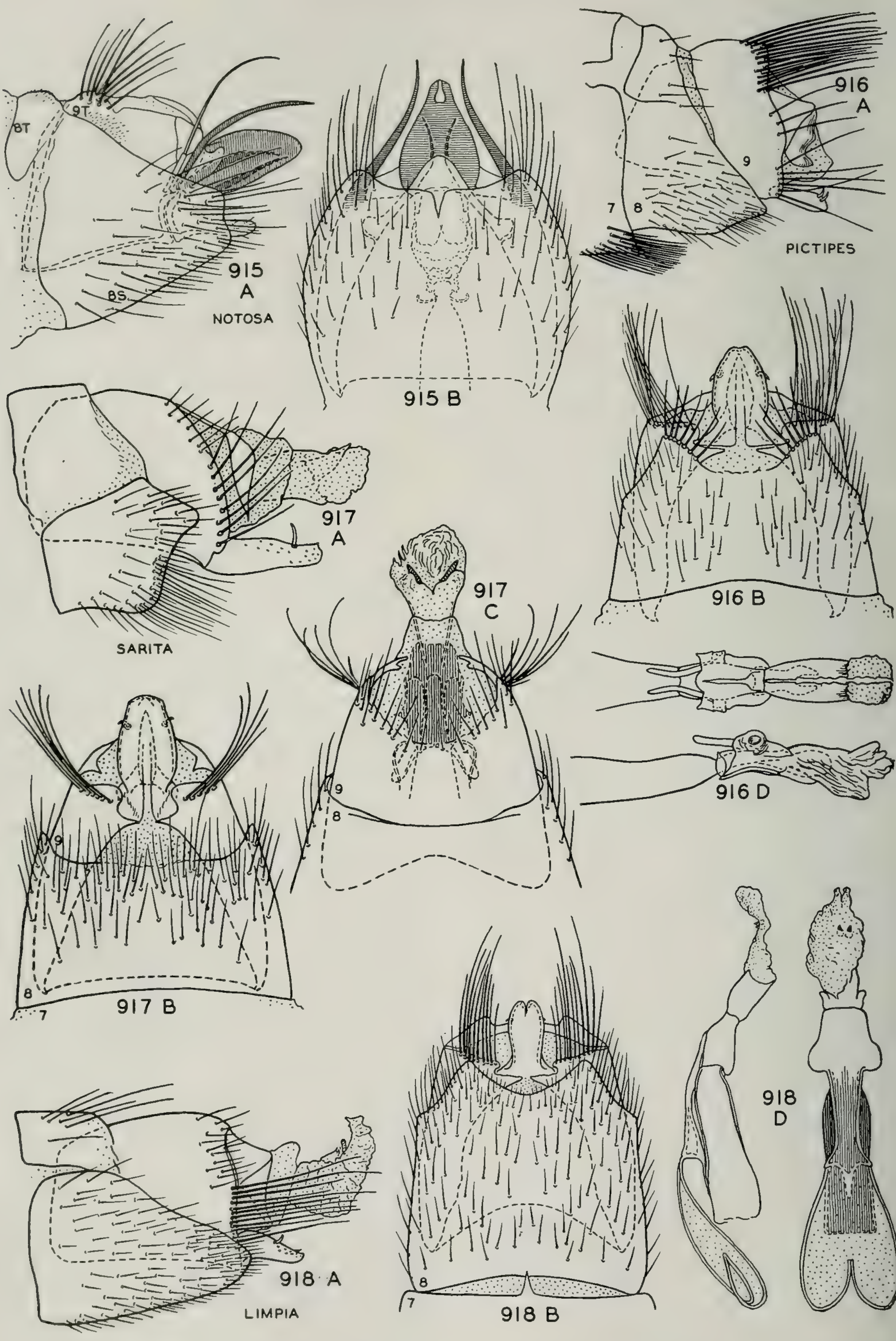
KEY TO MALES OF NEARCTIC SPECIES

1. Ninth segment with a pair of long, sclerotized spurs and long styles, fig. 915 . . . . **notosa** n. sp.
   Ninth segment without long, projecting spurs and styles, fig. 916 2
2. Eighth sternite with lateral margin forming long, triangular lobes, fig. 917 . . . . **sarita** n. sp.
   Eighth sternite without lateral lobes but with a pair of pointed lobes situated ventrad, figs. 916, 918 3
3. Seventh sternite with an apico-mesal, short process; aedeagus with a long, dorsal loop extending over its base, fig. 918 . . . . **limpia** n. sp.
   Seventh sternite with no short process but instead with an apico-mesal brush of dark setae; aedeagus with a pair of short, dorsal processes not produced into a loop, fig. 916 . . . . **pictipes** (Banks)

Leucotrichia notosa new species

The long, lateral styles of the ninth segment distinguish this species from all others in the genus, as pointed out in the preceding key.

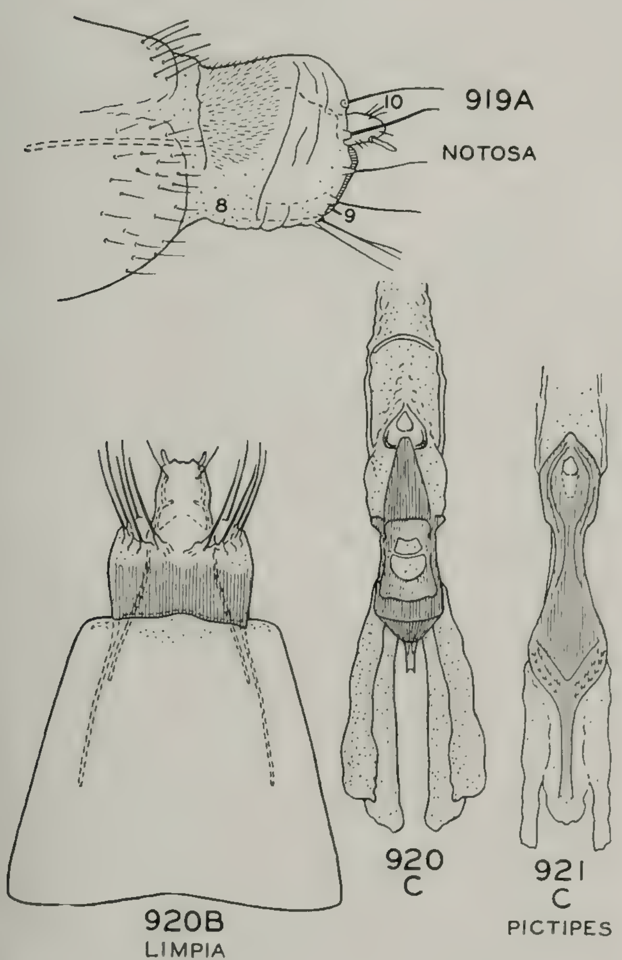
Male.—Length 4 mm. Color mottled light and dark shades of gray, the legs conspicuously banded, essentially similar in this characteristic to *pictipes*. General structure typical for the genus. Seventh segment without a mesal projection. Eighth segment with the tergite reduced to a narrow triangular



Figs. 915–918.—*Leucotrichia*, male genitalia. *A*, *B* and *C*, respectively lateral, ventral and dorsal aspects; *D*, aedeagus.

dorsal portion, the sternite large and somewhat scoop shaped, and with a broad dorsolateral corner and a narrow sharp, V-shaped mesal incision.

Genital capsule as in fig. 915, retracted so that the ventral portion is almost entirely contained within the scoop-shaped eighth sternite. Ninth segment with a large dorsal tuft of long setae, not produced into an internal lobe, the ventral portion almost entirely cut away. Tenth tergite formed of simple strap-shaped sclerites and possibly including also the upturned sclerites at the apex of the ninth segment. Near the junction of this sclerite and the ninth segment are two long structures, a long, sinuate, heavily sclerotized spine and a long, stout seta on a long, filiform base, this seta as long as the spine. Claspers fused on meson to form a short, wide lobe. Aedeagus with a small, cylindrical base, a convoluted semimembranous neck and with the apical portion semimembranous at base, expanded into a heavily sclerotized pear-shaped apical bulb containing two internal sclerotized rods.



Figs. 919–921.—*Leucotrichia*, female genitalia. *A*, lateral aspect; *B*, ventral aspect; *C*, bursa copulatrix.

Female.—In size, color and general structure similar to male. Eighth segment, fig. 919, narrow and cylindrical with a dorsal collar-like portion covered with short setae, the ninth and tenth segments membranous and simple.

Holotype, male.—Missouri River, Toston, Montana: June 22, 1940, H. H. & J. A. Ross.

Allotype, female.—Same data as for holotype.

Paratype.—Same data as for holotype, 1 ♀.

Leucotrichia limpia new species

This species is most closely related to *pictipes*, differing from it in the gray-green banding of the wings, the unmodified basal antennal segments in the male and the unique dorsal loop of the aedeagus.

Male.—Length 4.5 mm. Head and body dark brown, antennae slightly paler and legs below coxae paler yet. Pubescence of head, thorax and legs chiefly gray-green; wings dark brown, the front wings with two large patches of gray-green hair, the basal one occupying most of the basal two-fifths of the wing, the apical one separated from the first by the narrow black area and covering half of the remaining length of the wing. Structure typical for genus. Ocelli present and close to mesal margin of eye. Antennae filiform. Legs with tibial spur count of 1-3-4. Hind wings with an accessory row of hamuli across the radial cell.

Male genitalia as in fig. 918. Seventh sternite with a small mesal point. Eighth segment with tergite small, bearing a scattering of long setae. Eighth sternite narrow above and widening to a broad ventral sclerite incised on the middle, so that it forms a pair of latero-apical subtriangular lobes; the entire sclerite is clothed with a scattering of fairly long setae. Ninth segment long and round dorsally and laterally but almost completely open on the venter, its apico-lateral margins bearing a row of very long, stout setae. Tenth tergite composed of a pair of sclerotized plates close to the ninth and not projecting far posterad. Claspers fused on meson, together forming a spatulate projection and each bearing a stout spine on the lateral margin. Aedeagus very complex, consisting of a basal tube articulating with the neck, which is expanded into two lateral humps; from this neck there extends anterad a sclerotized plate which terminates in a loop encircled by a thin sclerotized thread apparently supporting a connecting membrane; apical portion of aedeagus short, with a pair of thumblike, baso-lateral projections and with the posterior margin merging into a group of membranous folds embedded in which are a pair of stout sclerotized teeth.

Female.—Similar in size, color and general structure to male. Genitalia as in fig. 920. Eighth segment short and cylindrical, sclerotized, the apex membranous and bearing a crown of long setae, each set in a conical membranous base. Ninth and tenth segments more or less tubular, not distinctly set off from each other, the tenth bearing a pair of apical styles. Bursa copulatrix complex, consisting of a series of membranous folds and narrow sclerotized rods at the attached end which culminate in a highly ornamented, lantern-like structure to which are attached two pairs of membranous ribbons.

Holotype, male.—Fort Davis, Texas: April 19, 1939, along Limpia Creek, H. H. & J. A. Ross.

Allotype, female.—Same data as for holotype.

Paratypes.—Same data as for holotype, 2♂, 1♀.

Leucotrichia sarita new species

This species may be distinguished from the preceding by the longer claspers and different shape of the eighth sternite.

Male.—Length 4 mm. In color similar to preceding species but without any conspicuous gray-green patch of hair on front wings. General structure typical for preceding species. Seventh segment without a mesal projection. Eighth segment with tergite fairly wide but much narrower than sternite; sternite with postero-dorsal corner produced into a large triangular lobe, ventral margin transverse and indistinct on the meson. Genitalia as in fig. 917. Ninth segment long and round dorsally and laterally, but with the ventral margin almost completely open; postero-lateral margin bears a row of long, stout setae. Tenth tergite consisting of a pair of widely separated sclerotized lobes between which are membranous folds. Claspers fused, projecting beyond the tenth tergite, each one bearing a long spine on its dorso-lateral margin. Aedeagus consisting of a short base, a heavily sclerotized neck which is thrown up into a series of ridges and points, with a pair of threads attached to base; apical portion widening from base to apex, the tip bearing a pair of sclerotized teeth embedded in an expanse of membranous folds.

Holotype, male. — Balmorhea, Texas: April 19, 1939, along stone irrigation flume, H. H. & J. A. Ross.

Ochrotrichia weddleae new species

This species is most closely related to the genotype, *insularis*, described from Jamaica. It differs from this species and all others in the genus in the peculiar, short claspers with their almost circular apical incision, fig. 922. The simple type of tenth tergite indicates a primitive condition similar to that found in *xena* and *unio*. It is entirely possible that this species is the most primitive yet discovered in the genus.

Male.—Length 2.5 mm. Color very dark, almost black, the wings with a few indistinct light areas and with a slight indication of a whitish line across middle. General structure typical for genus.

Genitalia as in fig. 922. Ninth segment short and stout, the lateral portion set off from the ventral by a curved distinct fold, dorsal portion with a wide, U-shaped incision almost to base. Tenth tergite set in

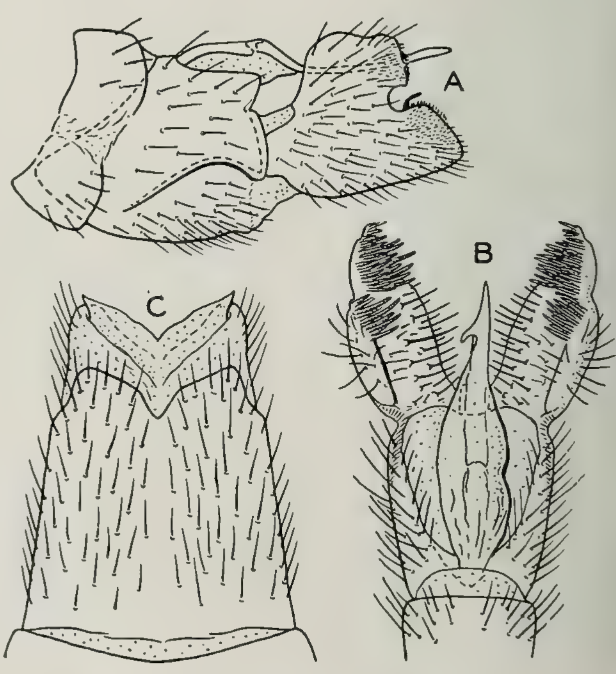


Fig. 922.—*Ochrotrichia weddleae*, genitalia. Male: *A*, lateral aspect; *B*, dorsal aspect. Female: *C*, ventral aspect.

this incision, somewhat fusiform and almost entirely membranous, with a slight constriction near base, the apex tapering to a sharp barbed point. Claspers short and wide, divided by an almost circular apical incision into two lobes; the dorsal lobe has a truncate apex, swollen dorsal margin, and a thick cluster of long, dark spines on its mesal face at apex; the ventral lobe has an oblique apex and a larger cluster of long, dark spines on its mesal face at apex. Aedeagus simple and filiform, typical for the genus.

Female.—In size, color and general structure similar to male. Eighth sternite, fig. 922, set off distinctly from structures of the ninth, the apex wide and divided by a small U-shaped mesal incision into a pair of fairly large lobes which are clothed with long, scattered setae similar to those on the rest of the segment. Bursa copulatrix very long and shaped like a tuning fork, typical for the genus.

Holotype, male. — Cloudy Creek near Cloudy, Oklahoma: May 4, 1940, Mrs. Roy Weddle.

Allotype, female.—Same data as for holotype.

Paratypes.—Same data as for holotype, 1♂, 1♀.

Ochrotrichia capitana new species

This is one of the more primitive members of the genus, most closely related to *xena*. It may be separated from this, however, by the definitely marked sclerotized bands of the tenth tergite and the much different arrangement of the black spines on the inner face of the claspers.

Male.—Length 2.5 mm. General color and structure typical for genus. Genitalia as in fig. 923. Ninth segment annular, with a triangular apical incision on the dorsum for the reception of the tenth tergite. Tenth tergite long and narrow, the dorsal portion mostly semisclerotized with some definite, heavily sclerotized bands running along the dorsum; these converge at the apex and terminate in an upturned, spinelike process. Claspers more or less boot shaped and similar in shape; the outer face is covered with scattered setae and the mesal face with a dense brush of dark spines near the middle and a linear area of long, stout spines from above that point to the apex; seen from ventral view, the claspers appear to taper evenly from base to the bladelike apex, the mesal face concave. Aedeagus typical for genus.

Female.—Similar in size and general structure to male. Genitalia simple, fig. 923, the eighth tergite forming a single rounded sclerite clothed with a scattering of long setae. Bursa copulatrix with the arms of the fork slightly shorter than in other species.

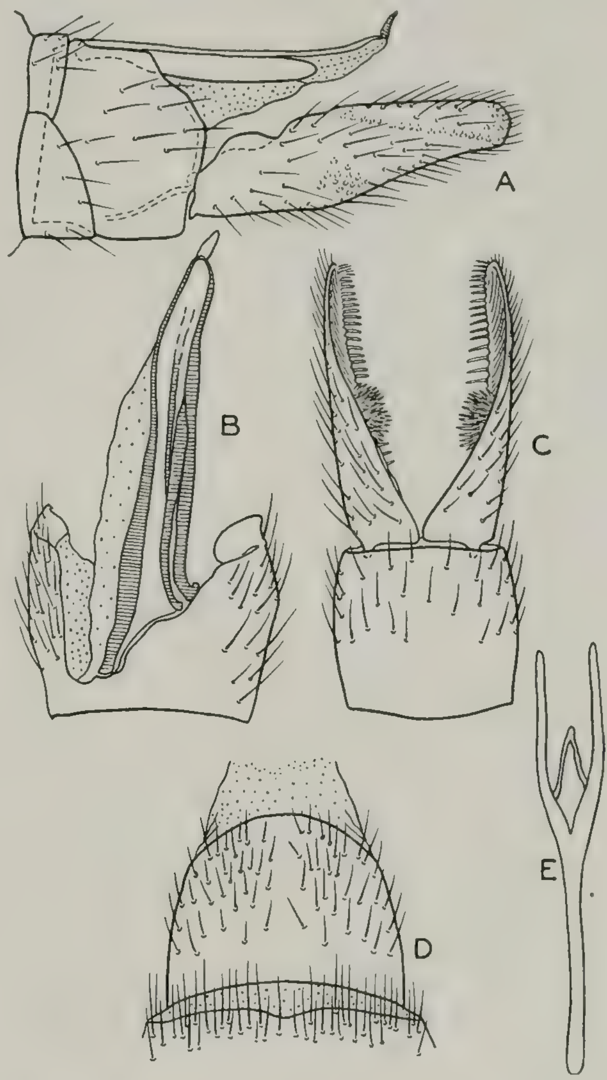


Fig. 923—*Ochrotrichia capitana*, genitalia. Male: *A*, lateral aspect; *B*, tenth tergite; *C*, ventral aspect. Female: *D*, ventral aspect; *E*, bursa copulatrix.

Holotype, male. — McKittrick Creek, McKittrick Canyon (near Frijole) Texas: April 26, 1939, J. A. & H. H. Ross.

Allotype, female.—Same data as for holotype.

Ochrotrichia felipe new species

The closest ally of this species is *tenanga* Mosely, fig. 925, from southern Mexico. The two may be distinguished by the differ-

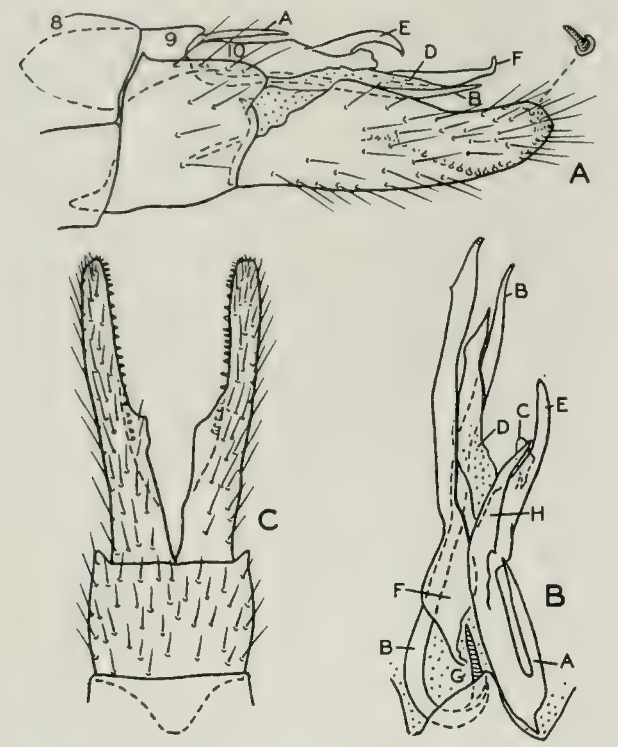


Fig. 924.—*Ochrotrichia felipe*, male genitalia. *A*, lateral aspect; *B*, tenth tergite; *C*, ventral aspect.

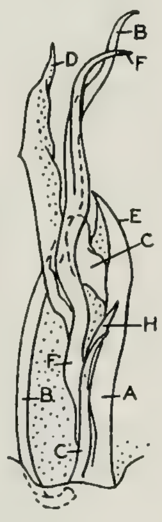


Fig. 925.—*Ochrotrichia tenanga*, male tenth tergite. The small capital letters in this figure and that above have been used to facilitate comparison with similar parts in figs. 468–470.

ent arrangement of the sclerotized processes making up the dorsal complex of the tenth tergite.

MALE.—Similar in size, color and general structure to the male of *capitana*. Genitalia as in fig. 924. Ninth segment annular, with the dorsal portion incised on the meson to accommodate the tenth tergite. Tenth tergite composed of a large number of sclerotized blades and processes making up the dorsal complex. These are arranged in three main groups, a right group, a left group and a dorsal, long, sinuate blade which arises between them. Claspers almost symmetrical, the lateral aspect boot shaped, the mesal face with a sinuate row of short, stout, rounded spines. From ventral view, these appear in silhouette on the narrower apical portion and continue under the mesal angle where the clasper narrows abruptly. Aedeagus simple, tubular and filamentous, as in other species of the genus.

Holotype, male.—San Felipe Springs, Del Rio, Texas: April 19, 1939, H. H. & J. A. Ross.

Paratypes.—Same data as for holotype, 2♂.

Hydroptila waskesia new species

This species is closely related to both *delineata* and *vala*, differing from both of them in the very long lateral projections of the ninth sternite and in having the spur on the membranous appendages arising below the tenth tergite.

MALE.—Length 3.7 mm. Color various shades of dark gray and cream, the two mixing to form a salt-and-pepper pattern typical for the group. General structure typical for genus.

Genitalia as in fig. 926. Ninth segment produced into a long, triangular pair of internal projections, the posterior margin of the sides produced into a long, bladelike, tapering and sharply pointed projection which curves slightly mesad and turns slightly dorsad at apex. Tenth tergite long, composed of a pair of lateral sclerotized areas

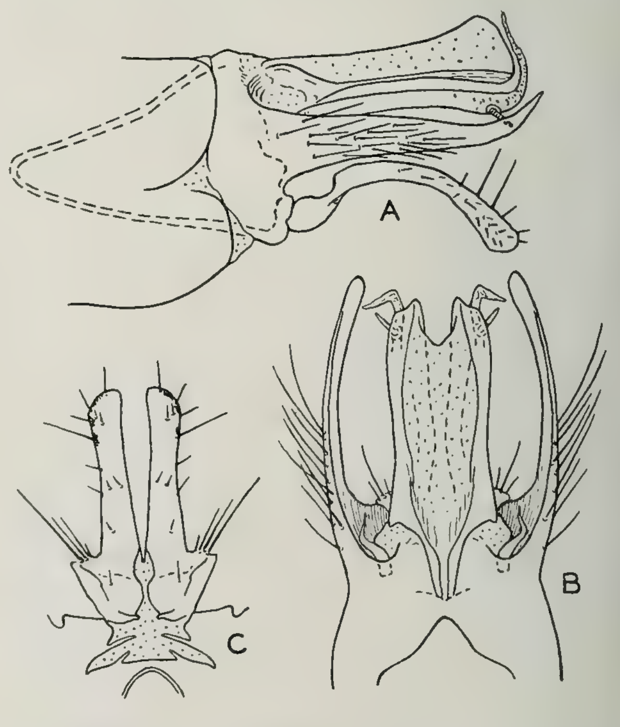


Fig. 926.—*Hydroptila waskesia*, male genitalia. *A*, lateral aspect; *B*, dorsal aspect; *C*, claspers.

separated by a high membranous fold. From below the base of the tenth tergite arise a pair of long, membranous filaments which continue beneath the full length of the tergite and then curve sharply dorsad around its tip; just before the turn these processes have a large, sharp lateral spur. Claspers with a small, triangular base and a long, slightly spatulate blade irregularly set with setae, the two blades close together at base and diverging slightly toward apex; lateral aspect curved and slightly arcuate. Aedeagus almost exactly as for *vala* (see fig. 515), having a long narrow neck, long stout spiral, the apical portion long, cylindrical and sharply angled at tip.

FEMALE.—In size, color and general stucture similar to male. Genitalia apparently identical with those of *vala*; eighth sternite with a central Y-shaped plate, the apex with an arcuate lobe bearing six long setae (see fig. 530).

Holotype, male.—Lake Waskesieu, Prince Albert National Park, Saskatchewan: Aug. 15, 1940, L. T., No. 8, Don Milne.

Allotype, female.—Same data as for holotype.

Paratypes.—Same data as for holotype, 1♂, 1♀.

Neotrichia sonora new species

This species is most closely related to *okopa*, but may be separated from it by the slender and upturned apex of the claspers, in addition to the different conformation of the tenth tergite.

MALE.—Length 2.25 mm. Color of body and appendages a uniform light shade of brown. General structure typical of the subgenus *Exitrichia.*

Genitalia as in fig. 927. Ninth segment annular, the invaginated basal portion short and subtriangular, the dorsum covered with a scattering of very short setae; the apical margin of the dorsum appears to be produced into a somewhat irregular, membranous hood covering the tenth tergite. Tenth tergite pointed at apex, seen from above, produced into a rounded mesal lobe from the base of which arise a pair of long setae. From the sides of this structure arise a pair of heavily sclerotized, long points curved slightly ventrad, and below these a pair of heavily sclerotized, triangular bodies. From the lateral margin of the ninth arise a pair of cercus-like appendages which are slightly enlarged toward apex, clothed with a scattering of long setae and concave on the mesal face. Claspers very heavily sclerotized and black, seen from lateral view; thick at base, tapering to a flat and slightly upturned apical portion; somewhat rectangular from ventral view but with irregular margins and with apex triangular; mesal margin bearing a pair of small toothlike projections below apex, and below these there arises a stylelike appendage from the mesal face. Aedeagus practically identical with that of *okopa* except that the spiracle extends closer to the apex.

FEMALE.—Size, color and general structure as for male. Genitalia, including ornamentation and coloration of eighth sternite and bursa copulatrix, apparently identical with those of *okopa.*

Holotype, male.—Neville Spring at foot

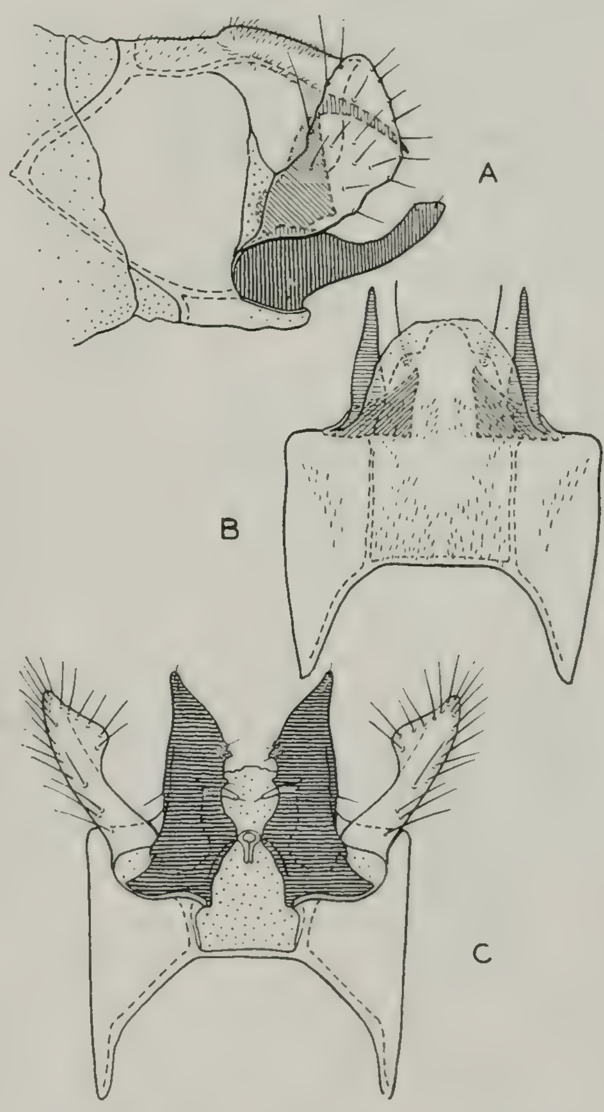


Fig. 927.—*Neotrichia sonora*, male genitalia. *A*, lateral aspect; *B*, dorsal aspect; *C*, ventral aspect.

of Chisos Mountains, Texas: April 20, 1939, J. A. & H. H. Ross.

Allotype, female.—Same data as for holotype.

Paratype.—Same data as for holotype, 1 ♂.

Neotrichia osmena new species

This species belongs with certain Mexican species of the subgenus *Exitrichia*, especially *digitata* Mosely and *eroga* Mosely. From the former, *osmena* differs in the curved and spatulate lateral processes of the ninth segment, and from the latter in the shorter, black claspers.

MALE.—Length 2.2 mm. Color dark brown. General structure, including wing venation, spur count, and other characters of head and thorax, identical with other described members of the genus.

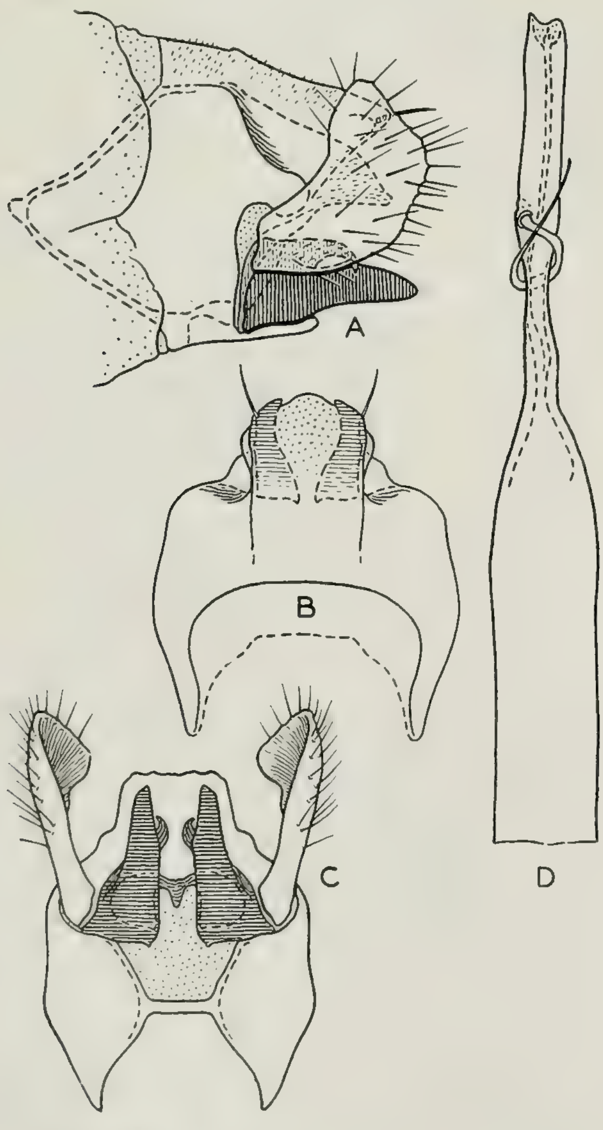


Fig. 928.—*Neotrichia osmena*, male genitalia. *A*, lateral aspect; *B*, dorsal aspect; *C*, ventral aspect; *D*, aedeagus.

Genitalia as in fig. 928. Ninth segment with invaginated portion triangular, dorsum covered with sparse short setae. Tenth tergite blunt, the medium portion of its apex produced into a rounded lobe from the base of which arise a pair of long spines. From beneath this structure arise a pair of large, heavily sclerotized, blunt structures which appear slightly forceps-like from dorsal view. From an incision on the lateral margin of the ninth segment arises a cercus-like flap which is expanded at apex, is clothed with a scattering of long setae, and is concave on the mesal face. Claspers black, with a broad base that tapers more or less regularly to the apex, and with a dorsal hook which reaches two-thirds of the distance to the apex. Aedeagus with a wide tubular base which constricts rapidly to a long narrow neck; from the apex of the neck arises a spiral process which encircles the tube slightly more than once; the apex is fairly evenly cylindrical, with the apex incised.

Holotype, male.—Blacksmith Fork Canyon, Utah: Sept. 16, 1938, at light, Knowlton.

Mayatrichia Mosely

(*See also p. 160*)

KEY TO SPECIES

Males

1. Aedeagus ending in a small, sclerotized three-pronged structure; claspers each with about 6 setae on mesal lobe, fig. 929 . . . . . **ayama** Mosely
   Aedeagus ending in a simple point, usually only lightly sclerotized; claspers each with 3 setae on mesal lobe, figs. 930, 931 2
2. Claspers with mesal lobe nearly truncate, the apical setae very long and stout, fig. 930 . . . . **ponta** n. sp.
   Claspers with mesal lobe oblique, each apical seta situated much lower than the one above, and all 3 short and slender, fig. 931 . . . . . . **acuna** n. sp.

Mayatrichia ponta new species

This species is most closely related to the Mexican *rualda* Mosely, from which it differs in having three instead of two large setae on each clasper and in shape of other sclerites of the genital capsule.

Male.—Length 2.5 mm. Color brown without any conspicuous or distinctive markings. General structure typical for genus.

Male genitalia as in fig. 930. Ninth segment short, its posterior angle slightly obtuse, its posterior margin with a large, triangular, dorsal lobe bearing a line of setae near apex, and with a mitten-like projection below the triangle; this projection with its main body oval, concave on its mesal face, with a sclerotized point near apex and with a more or less thumblike postero-ventral process. Tenth tergite semimembranous and more or less hood shaped. Claspers with a broad base, a somewhat sinuate, digitate dorso-lateral lobe and a truncate, ventro-mesal lobe which bears at its apex three long, strong setae the bases of which are almost contiguous. Above the claspers is a long, sclerotized, beaklike structure which is wide at apex and bears a pair of small setae. Aedeagus long and simple, the extreme apex tapering to a very slender, filiform style.

Holotype, male.—Turner Falls State Park, Oklahoma, along Honey Creek: June 2, 1937, H. H. Ross.

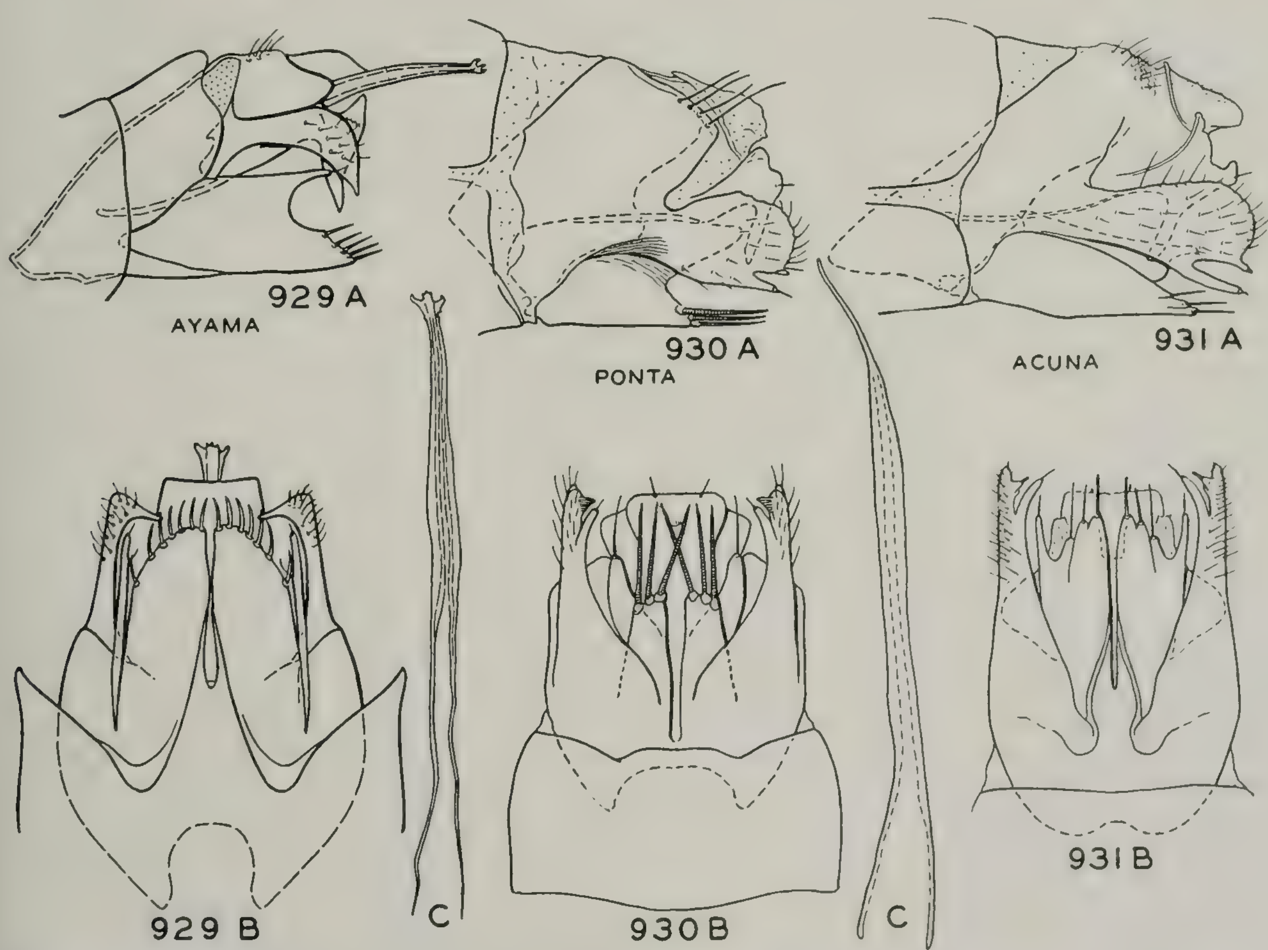
Paratypes.—Oklahoma.—Same data as for holotype, 5 ♂. Reagan, along Pennington Creek: June 1, 1937, H. H. Ross, 4 ♂. Turner Falls State Park: June 7, 1938, Carl F. Grubb, 1 ♂.

This species has always been taken in company with *ayama*, and no female has been differentiated in these collections which could be associated definitely with *ponta*.

Mayatrichia acuna new species

This species is most closely related to *ponta* but may be readily distinguished from it by the very small dorso-lateral lobe of the claspers and the undulate margin of the meso-ventral lobe with its staggered and well-separated short setae.

Male.—Length 2 mm. Color light brown, without conspicuous markings. General structure typical for genus. Male genitalia as in fig. 931. Ninth segment with the anterior projections of the lateral margin acute, the dorsal portion of this segment bearing an indefinite patch of setae, the postero-lateral margin with a long, mitten-like lobe which tapers gradually from the



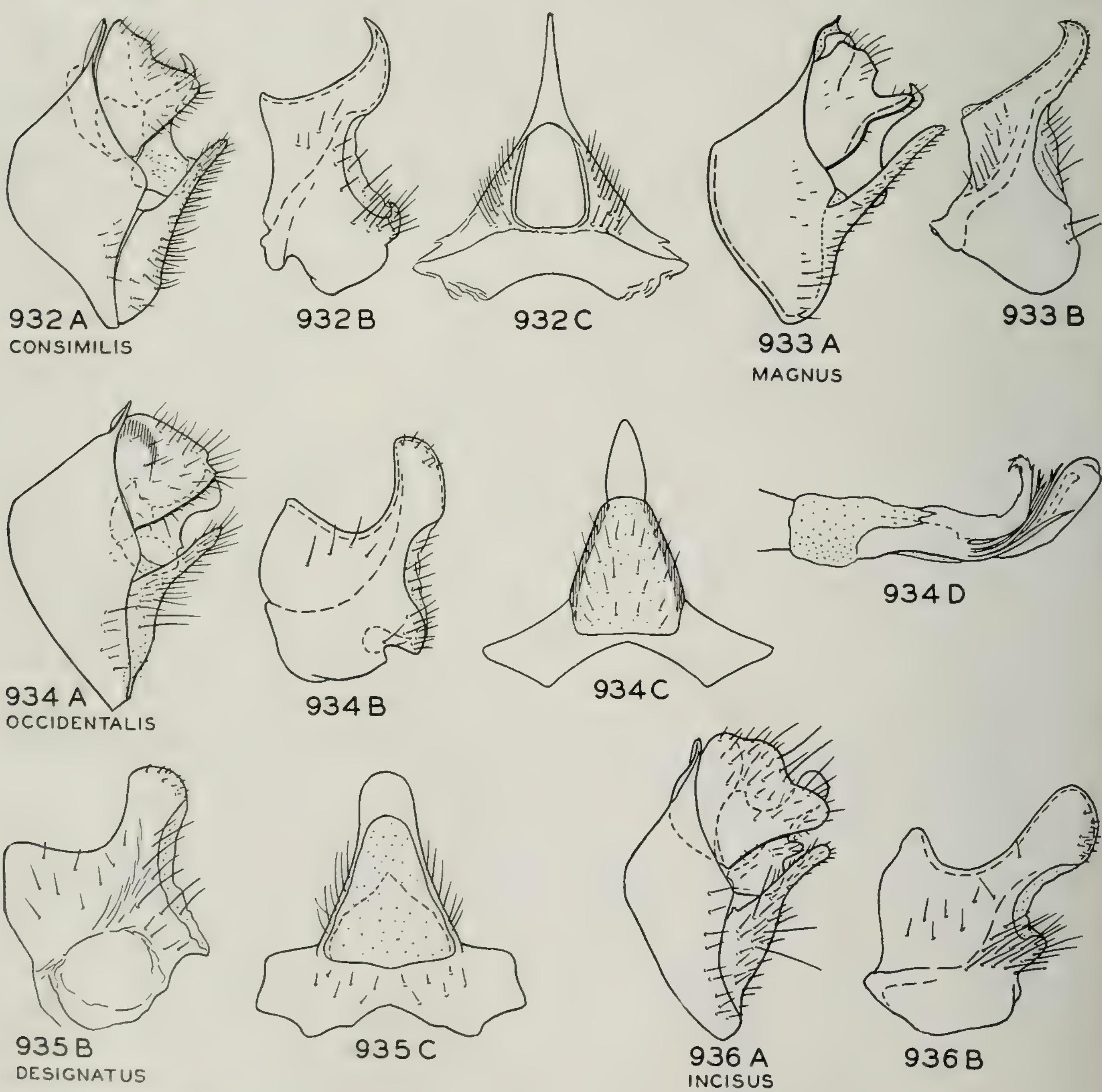
Figs. 929–931.—*Mayatrichia*, male genitalia. *A*, lateral aspect; *B*, ventral aspect; *C*, aedeagus.

base to the middle, the ventral margin with a short apical projection and a longer digitate subapical projection, the apico-dorsal portion evenly rounded. Tenth tergite semimembranous, with a basal carina. Claspers with a small and digitate dorso-lateral lobe and with the ventro-mesal lobe subdivided into three staggered tubercles, each bearing a seta of medium length, the mesal one the stoutest. Above the claspers is a beaklike ventral projection, the central part wide and bearing a pair of sharp setae. Aedeagus similar to that of *ponta*, consisting of a small conical base, a long, tubular central portion and a threadlike apex, as in fig. 930*C*.

Holotype, male.—San Felipe Springs, Del Rio, Texas: April 19, 1939, H. H. & J. A. Ross.

Hesperophylax Banks

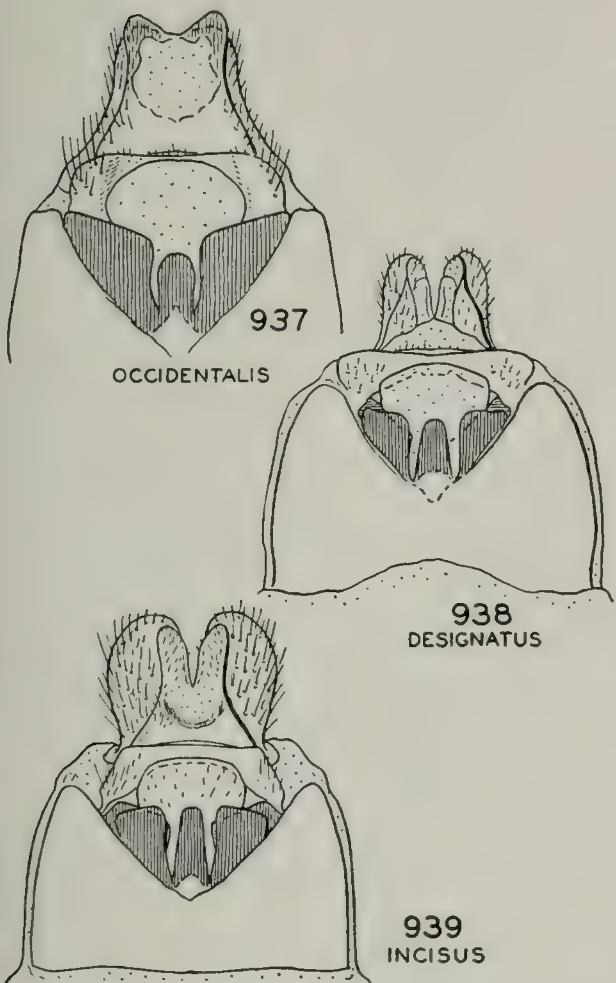
In this genus the ranking of various described species and varieties has varied considerably with different authors, at times all of them being considered forms of a single species. Detailed study of the genitalia of both males and females indicates that, in the material at my disposal, five species can be segregated definitely; the differences are comparative structures of the male genitalia and, where associated material is available, in the genitalia of the females, also. I have seen no material of *minutus* nor definitely associated females of *magnus* and *consimilis*. With the exception of these forms, the following key will separate the North American species.



Figs. 932–936.—*Hesperophylax*, male genitalia. *A*, lateral aspect; *B* and *C*, tenth tergite, respectively lateral and caudal aspects; *D*, aedeagus.

KEY TO SPECIES

1. Apex of abdomen with a complex set of clasping organs, fig. 932 (males) 2
   Apex of abdomen with a pair of dorsal plates, fig. 937 (females).......... 6
2. Apex of tenth tergite sharp and appearing pointed from both lateral and caudal view, fig. 932.......... 3



Figs. 937–939.—*Hesperophylax*, female genitalia.

   Apex of tenth tergite appearing rounded from either lateral or caudal view, or both, figs. 934, 935............ 4
3. Cerci with apico-ventral corner produced into a long, narrow finger, fig. 933; silver streak of front wings conspicuous and bright.............. ....**magnus** Banks
   Cerci with apico-ventral corner much less produced, fig. 932; silver, inconspicuous.........**consimilis** Banks
4. Ninth segment with lateral area short, anterior angle wide, fig. 936...... ....**incisus** Banks
   Ninth segment with lateral area longer, anterior angle less obtuse, fig. 934........................ 5
5. Caudal aspect of tenth tergite wide, the lateral projections long and angulate, the membranous caudal area short, fig. 934............... ....**occidentalis** Banks
   Caudal aspect of tenth tergite narrower, the lateral projections shorter and trapezoidal, the membranous caudal area longer, fig. 935........ ....**designatus**, p. 183
6. Tenth segment with lateral projections scarcely developed, fig. 937.. ....**occidentalis** Banks
   Tenth segment with lateral projections forming definite wide flanges, figs. 938, 939.................... 7
7. Tenth tergite with lateral projections occupying about a third of ventral aspect, fig. 938......**designatus**, p. 183
   Tenth tergite with lateral projections occupying nearly two-thirds of ventral aspect, fig. 939......**incisus** Banks

Limnephilus nogus new species

Most closely related to *pacificus*, this species is readily characterized by the long tenth tergite and cerci, and the curious pointed process of the claspers, fig. 940.

MALE.—Length 15 mm. Color tawny, with irregular darker brown markings on antennae, body and legs; wings tawny with a dark stigmal spot, a dark line on cord, and other irregular dark areas variable in nature. Macrochaetae of head and thorax

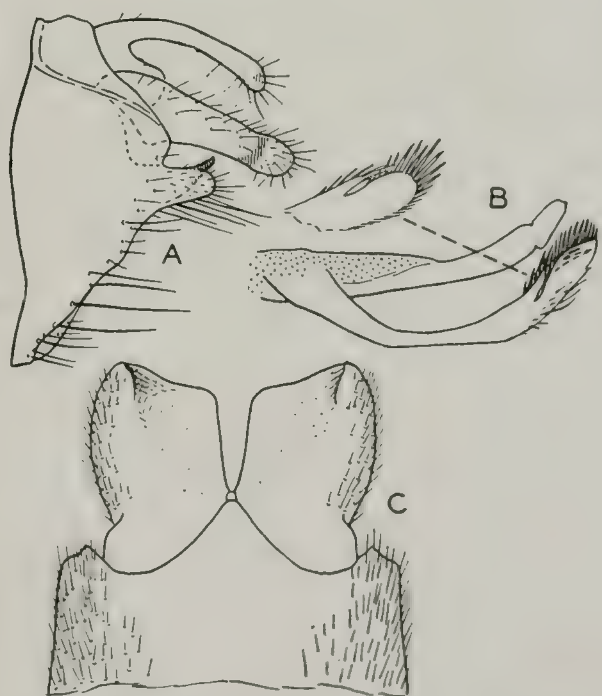


Fig. 940.—*Limnephilus nogus*, genitalia. Male: *A*, lateral aspect; *B*, aedeagus. Female: *C*, ventral aspect.

strong, tawny on head, dark brown on mesonotum. Front tibiae with basitarsus longer than succeeding segments. Eighth tergite without patch of dark spines. Genitalia as in fig. 940. Ninth segment very narrow on dorsum and venter but wide laterally. Tenth tergite forming a pair of long, curved, somewhat flattened processes with a sclerotized ridge on meson at apex. Cerci also very long, finger-like, with a heavily sclerotized bar across mesal face near apex. Clasper short and rounded, somewhat flattened, with a black, spurlike mesal projection. Aedeagus with lateral arms long, ending in a sharp mesal process and a somewhat spatulate, hairy lateral process.

FEMALE.—Similar in general color and structure to male except for five-segmented maxillary palpi. Genitalia as in fig. 940. Ninth sternite wide, with a large apicomesal triangle and with lateral margins produced into somewhat angular apical corners. Tenth segment forming a sclerotized paired structure, appearing somewhat rectangular from ventral view but with each lobe deeply excavated from dorsal view.

Holotype, male.—Near McMinnville, Oregon: Nov. 2, 1937, Kenneth Fender.

Allotype, female.—Same data as for holotype.

Paratypes.—BRITISH COLUMBIA.—VANCOUVER: Sept. 16, 1932, H. H. Ross, 1 ♀; April 15, 1932, H. H. Ross, 1 ♀.

OREGON.—BROWNSVILLE: Aug. 19, 1907, 1 ♂. Same data as for holotype, 1 ♂, 1 ♀; same but Sept. 20–Oct. 2, 1938, 1 ♂, 2 ♀.

WASHINGTON.—CHEHALIS: Oct. 14–18, 1911, M. A. Yothers, 1 ♂. PULLMAN: 1 ♂, 6 ♀; May 29, 1897, 1 ♀; May 14, 1898, 1 ♀; Aug. 6, 1898, 1 ♀; Aug. 10, 1898, 1 ♀; Aug. 25, 1898, 1 ♀; Sept. 26, 1898, 1 ♀; May 13, 1904, 1 ♂; June 6, 1908, 1 ♂.

Paratypes are deposited with the holotype and also in the collection of Washington State College.

Limnephilus frijole new species

This species is most closely related to *aretto*, differing chiefly in the curious arcuate apex of the tenth tergite.

MALE.—Length 15 mm. Color tawny brown, the body, legs and wings marked with small dark brown lines and dots which give the species a salt-and-pepper mottling. Macrochaetae of head and thorax long and stout, dark brown. Front basitarsus longer than half length of succeeding segment, front femur with a long inner patch of minute black spines. Eighth tergite with a produced area bearing a patch of dense short spines. Genitalia as in fig. 941. Ninth segment straplike across dorsum, moderately

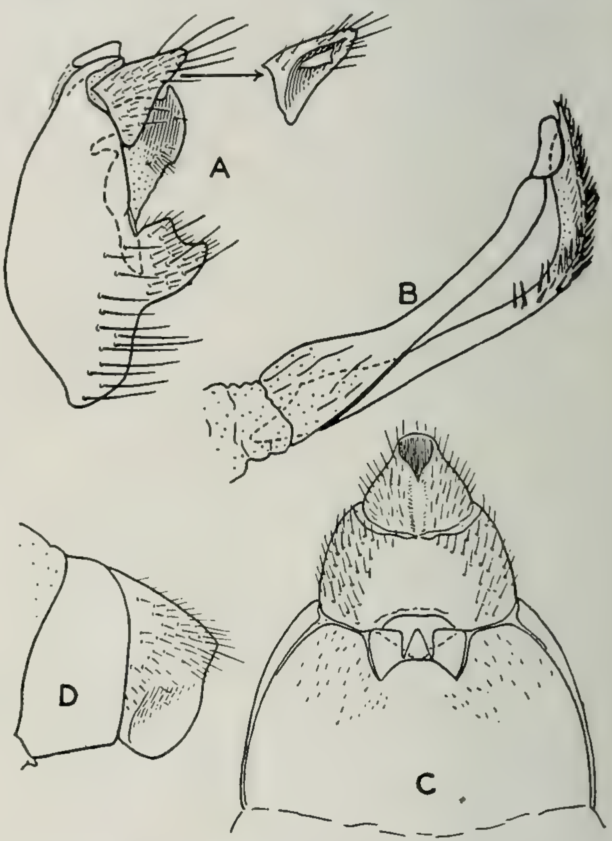


Fig. 941.—*Limnephilus frijole*, genitalia. Male: *A*, lateral aspect; *B*, aedeagus. Female: *C*, ventral aspect; *D*, lateral aspect.

wide across lateral area. Tenth tergite composed of a pair of sclerotized plates with a flanged, arcuate apex. Cerci short and triangular, with a short platelike projection on meson. Claspers simple, short, wide and with apical margin concave. Aedeagus with center style and lateral arms very long, lateral arms bent sharply near apex and bearing a brush of moderately short spines.

FEMALE.—Length 18 mm. General structure typical for male. Genitalia, fig. 941, with very simple parts. Ninth segment almost cylindrical, the sides somewhat flattened. Tenth segment tubular, the dorsal portion fairly evenly rounded, the ventral portion produced into a narrow mesal keel.

Holotype, male.—Manzaneta Spring, Frijole, Texas: April 26, 1939, J. A. & H. H. Ross.

Allotype, female.—Same data as for holotype.

Paratypes.—NEW MEXICO.—FORT WINGATE: Aug. 8, 1908, John Woodgate, 1 ♀; Aug. 24, 1 ♀; Sept. 1, 1 ♀; Sept. 21, 1 ♀.

MEXICO.—CERRO POTOSI, elevation 8,000 feet, Municipio de Galeana: July 8, 1938, H. Hoogstraal, 1 ♂, 1 ♀.

TEXAS.—Same data as for holotype: 1 ♂, 1 ♀. McKittrick Creek, MCKITTRICK CANYON: April 26, 1939, J. A. & H. H. Ross, 1 ♂, 1 ♀.

Three of the paratypes from Fort Wingate are deposited with the Academy of Natural Sciences of Philadelphia.

Chyranda new genus

ADULTS.—General structure typical for family. Head without macrochaetae behind ocelli. Maxillary palpi very long in both male, fig. 942, and female. Mesonotum with warts elongate. Tibial spur count 1-3-4. Apical segment of tarsi without black spines. Wings very similar in general aspect to those of *Limnephilus*, see fig. 636.

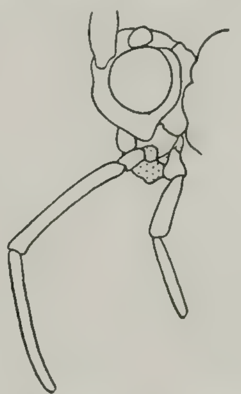


Fig. 942. — *Chyranda centralis* ♂, head.

Genotype.—*Asynarchus centralis* Banks.

The very long palpi distinguish this genus from *Limnephilus* and others to which it is related. In the North American fauna this character will separate it from all genera which do not differ from it in wing venation.

Oligophlebodes Ulmer

Additional material secured from various localities in the western mountains indicates that there are at least five species in this interesting genus. To a certain extent color characters have been found of some use in making identifications, but for the most part reliable differences are confined to the genitalia.

For the species so far differentiated, characters have been found to separate the females to species as indicated in the key.

KEY TO SPECIES

1. Eighth and ninth sternites well separated, the ninth segment annular and bearing a complicated set of parts, fig. 943 (males)............ 2
   Eighth and ninth sternites merged together, the ninth platelike, fig. 948 (females)........................ 6
2. Claspers twisted so that their apex is nearly in a vertical plane and projecting almost directly back, the apex somewhat truncate in lateral view, fig. 943.................... 3
   Claspers in a horizontal plane, fig. 946, sometimes sinuate, the end narrow in lateral view, fig. 945........... 4
3. Lateral projection of ninth segment large, at least equal in area to lateral aspect of claspers; below lateral projection the segment is incised less than half its width to receive claspers; apex of ninth sternite forming a wide angle, fig. 943.......**sierra** n. sp.
   Lateral projection of ninth segment much smaller than lateral aspect of claspers; below lateral projection the segment is incised more than half its width to receive claspers; apex of ninth sternite acute, fig. 944 ....**minutus** Banks
4. Blade of claspers long, sometimes sinuate, narrow at tip; apex of ninth sternite long and sharp, fig. 945.... ....**ruthae** n. sp.
   Blade of claspers short, stocky at tip; apex of ninth sternite shorter and with a much broader apical angle, fig. 946......................... 5
5. Blade of claspers directed almost straight back, robust, and with mesal margin armed with short teeth, fig. 946; body dark brown to black.....................**ardis** Ross
   Blade of claspers angled obliquely mesad, slender, with only the curved tooth forming the apex, fig. 947; body yellow.............**sigma** Milne
6. Lateral lobes of subgenital plate truncate except for a slight emargination at middle, fig. 948....**ruthae** n. sp.
   Lateral lobes of subgenital plate rounded, fig. 949, or oblique, fig. 951............................ 7
7. Lateral lobes of subgenital plate rounded and projecting markedly beyond mesal lobe, fig. 949........ ....**minutus** Banks
   Lateral lobes of subgenital plate not projecting beyond mesal lobe, fig. 950.............................. 8
8. Mesal lobe of subgenital plate scarcely

projecting above mesal portion of lateral lobes; ventral structure of bursa copulatrix very narrow, fig. 950 .... **sierra** n. sp.

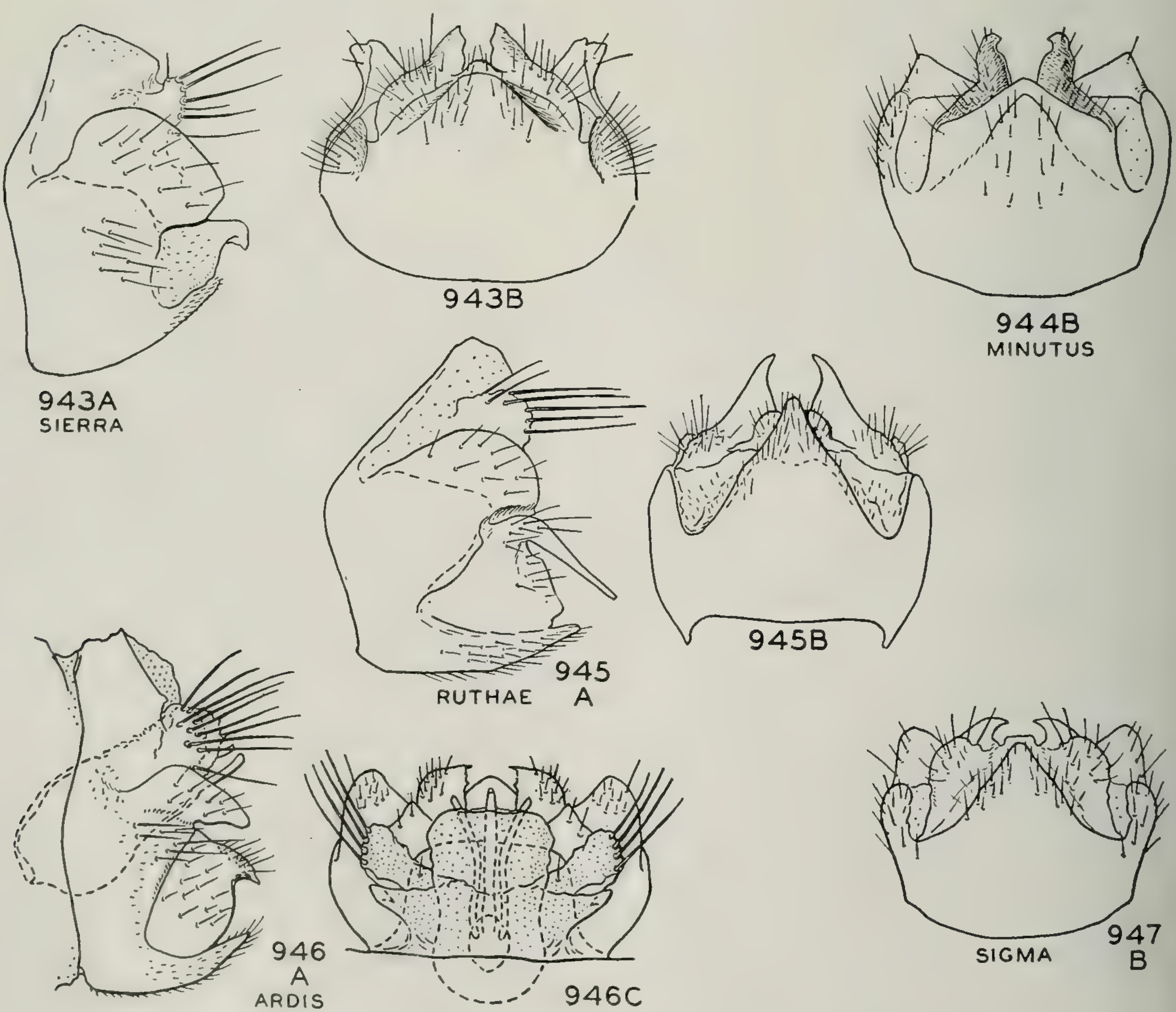
Mesal lobe of subgenital plate projecting conspicuously beyond mesal portion of lateral lobes; ventral structure of bursa wider, fig. 951 .... **ardis** Ross

Oligophlebodes sierra new species

In color this species approaches most closely *sigma* but differs from it in the twisted apex of the claspers, large lateral lobe of the ninth segment and other characters of the genitalia. The female may be distinguished from other members of the genus by the combination of the narrow ventral lobe of the bursa copulatrix and the low and evenly sloping lateral lobes of the ninth sternite.

MALE.—Length 8 mm. Color yellowish brown, the wings without conspicuous darker markings. General structure typical for genus. Genitalia as in fig. 943. Ninth segment reduced to a line dorsally, expanded into a wide ventral portion which is produced on the meson into a short angular process; the lateral margin bears a platelike projection which is wide and high and equal to the lateral aspect of the claspers in area. Each clasper with a rounded base and a short, apical blade which is twisted into an almost vertical position and appears somewhat beaked in the lateral view. Tenth tergite entirely membranous, consisting of concave and inconspicuous membranous folds. Cerci triangular, small and bearing long setae. Aedeagus membranous and tubular and containing a pair of sclerotized rods.

FEMALE.—In size, color and general structure similar to male. Subgenital plate, fig. 950, with a low, narrow mesal lobe and wide, sloping lateral lobes; bursa copulatrix



Figs. 943–947.—*Oligophlebodes*, male genitalia. *A*, *B* and *C*, respectively lateral, ventral and dorsal aspects.

with dorsal portion only slightly flared at apex, ventral portion fusiform, narrow and pointed at apex.

Holotype, male. — Yosemite National Park, California, along Dana Fork, Toulumne River, elevation 8,500 feet: Aug. 15, 1935, H. J. Rayner.

Allotype, female.—Same data as for holotype.

Paratypes.—Same data as for holotype, 6♂.

Oligophlebodes ruthae new species

The horizontal claspers place this species in the same group as *sigma* and *ardis*; it differs from both of these in the long apex of the claspers and the long and narrow mesal projection of the ninth sternite. The female may be distinguished by the scalloped lateral lobes of the ninth sternite.

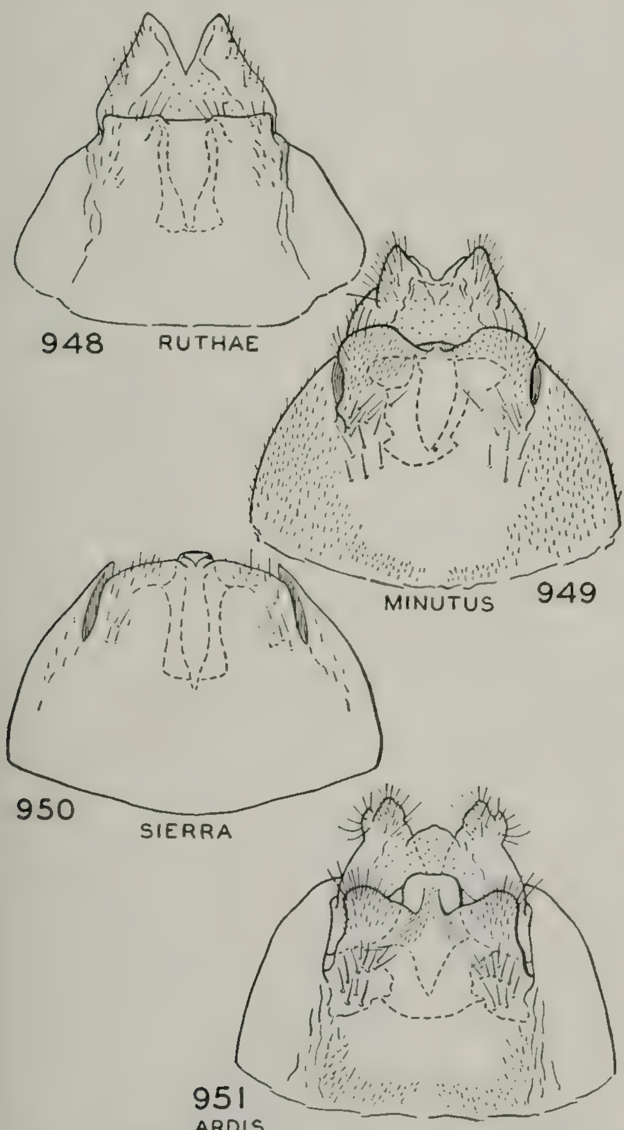
Male.—Length 8 mm. Color mostly dark brown, the legs below coxae yellowish and the wings pale brown without conspicuous markings. In life the insect appears black with brown wings. General structure typical for genus. Genitalia as in fig. 945. Ninth segment reduced to a linelike collar on the dorsum, expanded into a broad lateral portion and a long, tonguelike and angular ventral projection; the lateral margin bears a platelike process which is large and confluent at outer margin with the posterior margin of the segment below it. Apical blade of clasper long, sharp, sometimes sinuate and with a slightly expanded base. Tenth tergite consisting of indefinite membranous folds. Cerci small with abundant, long setae. Aedeagus cylindrical and tubular, with a pair of internal sclerotized rods in addition to the central style.

Female.—Similar to male in size, color and general structure. Subgenital plate, fig. 948, with a low mesal process and with lateral lobes which are nearly truncate but which have a distinct emargination in the middle of the posterior margin. Bursa copulatrix with dorsal lobe expanded at extreme tip, ventral lobe fairly wide, scarcely narrowed at base but tapering to a long, sharp point at apex. Tenth tergite with lateral lobes sclerotized dorsally.

Holotype, male.—Roe's Creek, Glacier National Park, Montana: July 12, 1940, H. H. & J. A. Ross.

Allotype, female.—Same data as for holotype.

Paratypes.—Montana: Same data as for holotype, 23♂, 10♀; same data but Sunrift Creek, 1♂; same data but east of Summit, Logan Pass, 1♂.



Figs. 948–951.—*Oligophlebodes*, female genitalia.

Psilotreta Banks

Accumulated material in this genus indicates that there are five Nearctic species readily separated by characters of the male genitalia. After the discovery of these characters I was very fortunate in being able to restudy the Banks and Hagen types in the Museum of Comparative Zoology; in addition, the redescription by Betten & Mosely (1940) of Walker's *indecisa* has cleared up the identity of that species. It is now possible to place all the names in literature except for *dissimilis* and *borealis*. Insufficient material is available to tabulate the females and immature stages. A complete list of synonymy is given in the check list.

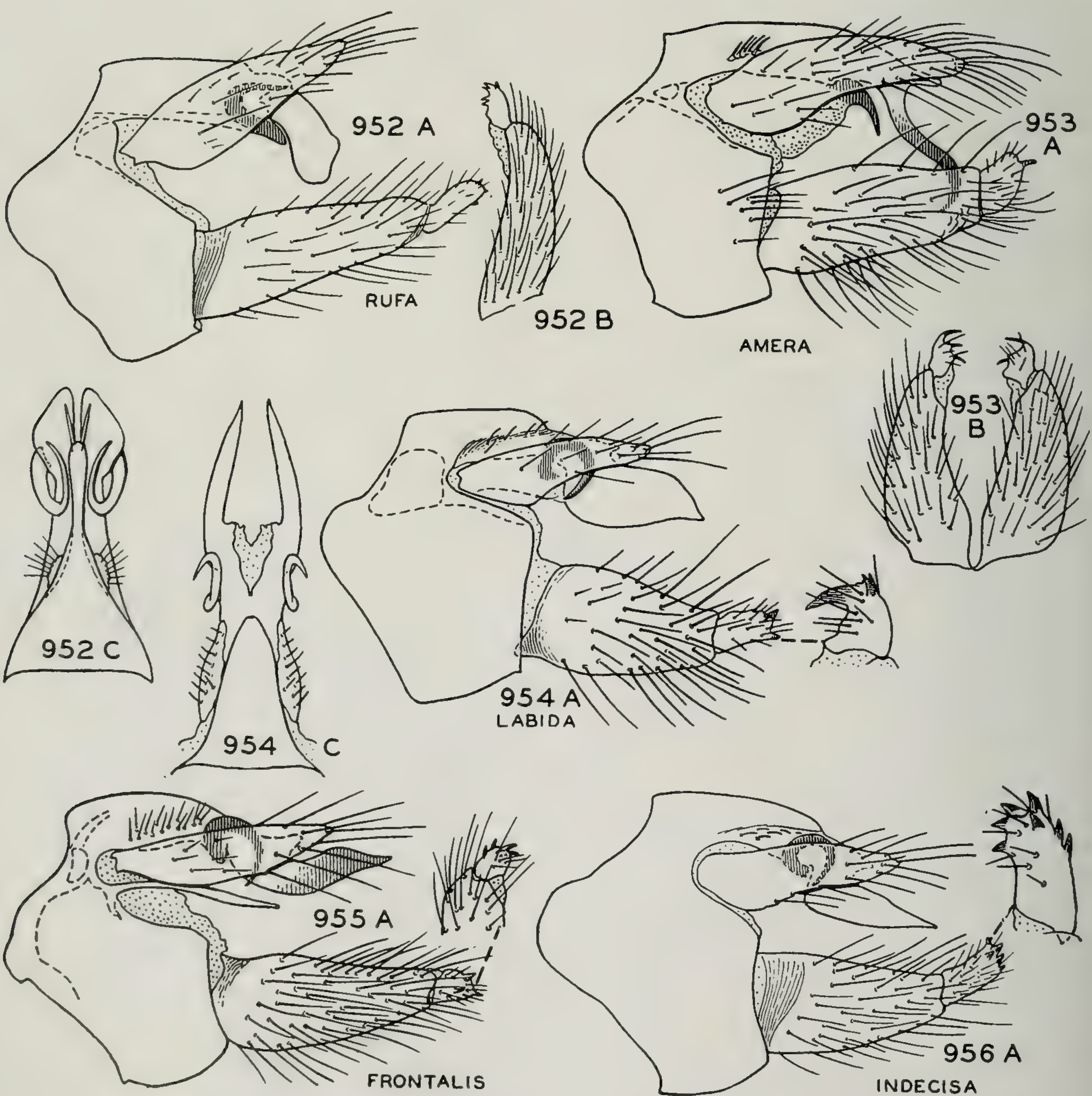
KEY TO NEARCTIC SPECIES

Males

1. Tenth tergite forming a pair of short, broad, sclerotized plates, fig. 952 . . . . **rufa** (Hagen)
   Tenth tergite forming a pair of long, bladelike plates well separated on the meson, fig. 954 2
2. Apical processes of tenth tergite long and sinuate, basal hook arcuate but not curled, fig. 953 . . . . . . **amera** (Ross)
   Apical processes of tenth tergite wide and only slightly sinuate, basal hook curled, fig. 954 3
3. Apical segment of clasper with a very long, stout mesal tooth, fig. 954 . . . . **labida** n. sp.
   Apical segment of clasper with several short teeth but without a long mesal one, fig. 955 4
4. Ninth segment with a long, slender style running beneath cerci; apical segment of clasper short, fig. 955 . . . . **frontalis** Banks
   Ninth segment without any process of this kind; apical segment of clasper long, armed with many teeth, fig. 956 . . . . **indecisa** (Walker)

Psilotreta rufa (Hagen)

This species has been placed in various genera, but the genitalia clearly indicate its affinity with other members of the genus *Psilotreta*. The species *connexa*, described



Figs. 952–956.—*Psilotreta*, male genitalia. *A*, lateral aspect; *B*, clasper, caudal aspect; *C*, tenth tergite.

by Banks in *Astoplectron* Banks, also belongs here. I have studied cleared preparations of both Banks' and Hagen's types, and they appear identical.

Psilotreta frontalis Banks

There is considerable variation in the shape of the apical blades of the tenth tergite, the holotype of *gameta* representing the narrow extreme, fig. 955, and the holotype of *frontalis* representing a wide extreme in which these blades are nearly as wide as in fig. 954. Intergrades in addition to both extremes have been taken at nearby localities in New York.

Psilotreta labida new species

The shape of cerci and tenth tergite indicates that this species is most closely related to *indecisa* but is readily separated from that and other species of the genus by characters given in the preceding key.

Male.—Length 12 mm. Color almost entirely black, the legs and mouthparts with lighter areas of grayish brown; wings grayish brown, fairly dark, with very small and irregularly scattered lighter dots. Maxillary palpi with first two segments short, the second with a long mesal brush which usually extends the full length of, and is usually appressed to, the third segment; third segment as long as the first and second combined, fourth half the length of third, and fifth slightly longer than third; the fifth also has a basal brush of long hair which extends almost the full length of the segment and gives it a bushy appearance. Male genitalia as in fig. 954. Ninth segment deep, narrowed at the point of insertion of the cerci, and forming a long, narrow dorsal tongue which is fused with the tenth. Tenth tergite with its apex divided into a pair of long, curved, pointed wide sclerites; at the base of each of these is a curled hook. Cerci long and somewhat pointed, widest near base. Claspers with basal segment robust and fairly short, apical segment also fairly short and small, with two or three short, sclerotized lateral teeth and a long, sharp mesal tooth. Aedeagus tubular and curved, typical for genus.

Female.—In size, color and general structure similar to male. Maxillary palpi of approximately the same proportion as in the male but without brushes. Genitalia simple, without processes or conspicuous characters.

Holotype, male.—Cedar River near Indian Lake, Adirondack State Park, New York: June 20, 1941, Frison & Ross.

Allotype, female.—Same data as for holotype.

Paratypes.—Maryland.—Garrett County: June 6, 1931, J. H. Roberts, 1 ♂, UM.

New Hampshire.—Whitcherville Brook near Benton: June 21, 1941, Frison & Ross, 2 ♂.

New York.—Same data as for holotype, 2 ♂, 1 ♀. Small creek near Tahawus, Adirondack State Park: June 20, 1941, Frison & Ross, 1 ♂. McLean, Seaver County: June 13, 1935, M. E. Davis, 1 ♂.

Pennsylvania.—Penn's Creek, Union County: May 16, 1938, C. M. Wetzel, 1 ♂. Monroe County, near Swiftwater: 1928, F. R. Nevin (Lot 258), 2 ♂, 1 ♀.

Tennessee.—Elkmont, fork of Little Pigeon River: May 27, 1934, T. H. Frison, 1 ♂.

Virginia.—Curles Neck Bridge: April 19, 1938, M. E. Davis & D. T. Ries, 1 ♂.

Leptocella tavara new species

The claspers, fig. 957, which have a large, truncate apical head and a moderate-sized basal flap, readily distinguish this species

Fig. 957.—*Leptocella tavara*, claspers.

from all other Nearctic members of the genus. The well-developed basal flap will separate the species from *exquisita* and *candida*, these two having no flap; all other species of the genus have the flap much larger, as in fig. 752.

Male.—Length 13.5 mm. Head and body light brown to straw colored, the legs below coxae almost white; head, body and legs clothed with white hair. Wing membrane transparent, the color pattern formed entirely by hair; the entire front wing white with small, yellowish linear spots situated fairly closely along every vein and with the apical fringe brownish; the contrast between the white and yellowish-brown spots small, so that the wing appears only indistinctly speckled. General structure typical for genus. Eyes small.

Male genitalia in general typical for the genus, with ninth segment with long, somewhat hoodshaped dorso-mesal portion and a long pair of finger-like processes below this. Tenth tergite long and projected, apex upturned and narrow. From near base of tenth tergite arise a pair of curved, "swan's neck" organs which are expanded at apex into a reticulate plate. Claspers, fig. 957, with the base expanded into a moderate-sized flap, above this constricted into a fairly wide neck, divided at apex into a spoonlike subapical mesal lobe and an apical, lateral area which projects some distance above subapical lobe and is fringed with very long setae; between the bases of the clasper arise a pair of medium length curved filaments, each with two or three long setae at apex. Aedeagus mostly membranous and with a spoonlike ventral plate.

Female.—In size, color and general structure similar to male. Abdomen bright green. Genitalia typical for genus.

Holotype, male.—Chiefland, Florida: July 17, 1938, W. Stehr.

Allotype, female.—Same data as for holotype.

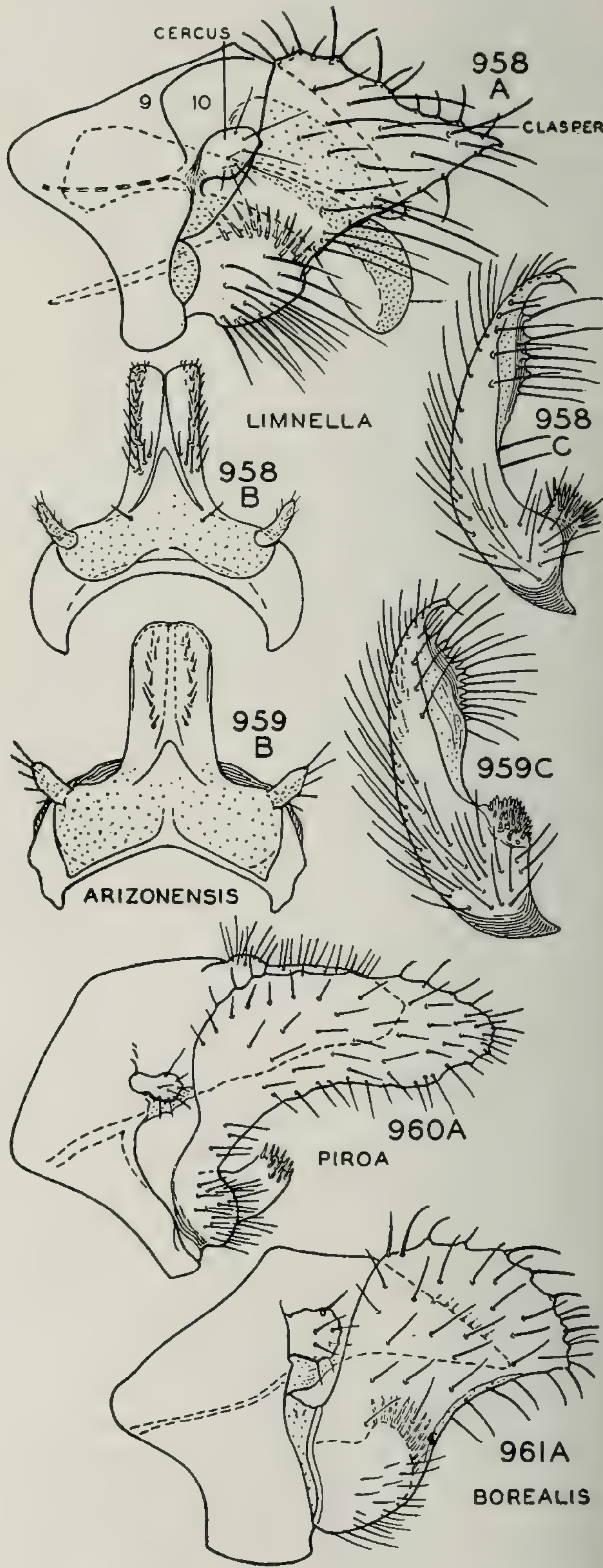
Paratypes.—Florida.—Same data as for holotype, 6♂, 3♀. Winter Park: March 25, E. M. Davis, 1♂; March 26, E. M. Davis, 3♂; April 9, E. M. Davis, 1♂. Tavares, Lake County: March 23, 1936, F. N. Young, 3♂.

Helicopsyche Hagen

Many collections of this genus, especially from the southwestern states, have considerably simplified the picture of the Nearctic species. It is clear that *borealis* is very widespread over most of the North American continent; Banks' species *arizonensis* proves to be the female of *mexicana*; and a third species common to both Mexico and the United States appears to be undescribed. I have examined the types of all available Antillean species, and these seem to be quite distinct from the continental species.

KEY TO NEARCTIC MALES

1. Claspers with apical corner produced into a sharp, triangular point, fig. 958 2
   Claspers with apical corner rounded, figs. 960, 961 3
2. Sclerotized mesal projection of sixth



Figs. 958–961.—*Helicopsyche*, male genitalia. *A*, lateral aspect; *B*, tenth tergite; *C*, claspers, caudal aspect.

sternite black, as long as or longer than the sternite; claspers with a small, somewhat stalked cluster of spicules upon mesal face at base, fig. 958 .... **limnella** Ross

Sclerotized mesal projection of sixth sternite yellowish, only about half as long as the sternite; claspers with a large, cushion-like pad of spicules upon mesal face at base, fig. 959 ... . **mexicana** Banks

3. Claspers angled and shaped like a boomerang, fig. 960 .... **piroa** n. sp.

Claspers only slightly curved, broad and spatulate, fig. 961 .... **borealis** Hagen

Helicopsyche mexicana Banks

The type of *mexicana* agrees perfectly with males taken from near the type locality of *arizonensis*. The females of this species have the first antennal segment longer than in related forms, which further identifies the type of *arizonensis*. This difference, however, is quite relative, and its use should be based on actual comparison of specimens.

In addition to various localities in Mexico, this species is now known from springs at Frijole, Texas, and from Oak Creek Canyon, Arizona, as well as Nogales, Arizona, the type locality of *arizonensis*. These United States localities are all situated in arid mountain country typical of large areas in Mexico.

Helicopsyche piroa new species

This species appears most closely related to *borealis* but may be readily separated from it by the slender, L-shaped claspers.

Male.—Length 6.5 mm. Head, body and appendages straw color to yellowish brown, the wings with a few irregular, colorless spots, and a short, colorless bar along the cord; rows of spines along middle legs, black. General structure, including shape of palps, wing venation, spur count, typical for genus. Sixth sternite with a long, sclerotized black spur which is about as long as the segment, slightly flattened and spatulate. Male genitalia as in fig. 960. Ninth segment with ventral half reduced to a narrow band, the dorsal portion merging with the tenth tergite. Tenth tergite about twice as long as wide, fairly deep and with a dorso-lateral ridge running its entire length and bearing a regular row of medium length setae. Claspers L-shaped, with a short, narrow vertical base and a long, wide horizontal apex which is rounded at tip; at the base of the mesal face is a short projection bearing a row of spicules along its apical margin. Aedeagus cylindrical and slightly curved, the apex subdivided into upper and lower pairs of membranous folds.

Female.—Similar in size, color and general structure to male. Third and fourth sternites with a central reticulate area. Remainder of abdomen typical for genus.

Holotype, male.—San Antonio, Texas, along San Antonio River: Aug. 10, 1939, Harold Alexander.

Allotype, female.—Hacienda Vista Hermosa, Villa Santiago, Nuevo Leon, Mexico, Hoogstraal & Knight.

Paratypes.—Same data as for allotype, 6♂, 2♀.

In addition to the above records are larvae of this species taken by Mr. Hoogstraal in a spring at Sabinas Hidalgo, Nuevo Leon, Mexico. This species makes a case which is exactly like that of other species in the genus. The larva is very similar in appearance to that of *borealis*.

CHECK LIST OF NEARCTIC TRICHOPTERA

This list is presented chiefly as an aid in placing to genera and families, as defined in this report, those species which are not treated specifically in the preceding pages. Following is an explanation of the form used in the list. Each species line has these items in this order: the species name, the describer, the place of original description (indicated by date and page reference); in some cases, the species has, in addition, the genus in which it was originally described (if different from that under which it appears here). The item "**P. 00**" indicates that the species is treated in this report on that page. If not so treated, a brief summary of range is indicated by key letters: if the species is known from only one or two states, these are listed, standard abbreviations being used; if from more, the general section of the continent is indicated in which the species is known, abbreviations of the cardinal directions and their combinations being given; e.g., E for East, W for West, NE for Northeast. Trans. indicates transcontinental; N. Am. signifies North America, but the exact location not determined. Other abbreviations are unid. for unidentified, emend. for emendation, *N. syn.* for new synonymy, unassoc. for unassociated.

Synonyms are listed in italics under genus or species.

References are included in the bibliography.

RHYACOPHILIDAE

Rhyacophila Pictet 1834
atrata Banks 1911:351. E
valuma Milne 1936:100. B. C.
vobara Milne 1936:94. B. C.
pellisa Ross 1938*d*:118. W
doddsi Ling 1938:61. *N. syn.*
minora Banks 1924:444. E
manistee Ross 1938*a*:104. Mich.
blarina Ross 1941*b*:36. Oreg.
melita Ross 1938*a*:104. NE
acropedes Banks 1914:201. W, N
grandis Banks 1911:350. W
vohrna Milne 1936:94. *N. syn.*
vao Milne 1936:93. W
vu Milne 1936:93. *N. syn.*
brunnea Banks 1911:352. W
ledra Ross 1939*a*:65. **P. 37**
carolina Banks 1911:353. E
gordoni Sibley 1926*a*:79
fenestra Ross 1938*a*:102. **P. 36**
teddyi Ross 1939*b*:628. N. C., Tenn.
kiamichi Ross. **P. 37**
carpenteri Milne 1936:98. E
nigrita Banks 1907*a*:132. E
mycta Ross 1941*b*:38. N. C.
montana Carpenter 1933:42. N. C., Tenn.
lobifera Betten 1934:131. **P. 35**
perda Ross 1938*a*:105. Wash.
nevadensis Banks 1924:443. Nev.
rotunda Banks 1924:443. W
norcuta Ross 1938*d*:117. W
novarotunda Ling 1938:61. *N. syn.*
vaccua Milne 1936:94. W
complicata Ling 1938:60. *N. syn.*
bruesi Milne & Milne 1940:154. *N. syn.*
vagrita Milne 1936:91. Alta., B. C.
unimaculata Denning 1941*a*:198. B. C.
verrula Milne 1936:90. W
oregonensis Ling 1938:62. *N. syn.*
viquaea Milne 1936:92. Oreg.
visor Milne 1936:101. B. C.
vofixa Milne 1936:95. Alta.
harmstoni Ross. **P. 268**
iranda Ross 1938*a*:103. Wash.
alberta Banks 1918:21. NW
angelita Banks 1911:352. W
bipartita Banks 1914:201
basalis Banks 1911:352. W
oreta Ross 1941*b*:39. Utah, Oreg.
glaberrima Ulmer 1907*b*:85. **P. 35**
fairchildi Banks 1930*a*:130
andrea Betten 1934:127
coloradensis Banks 1905*b*:10. W
stigmatica Banks 1904*a*:108, preoccupied
anomala Banks 1924:444
bifila Banks 1914:201. W
fuscula (Walker) 1852:10; Neuronia. **P. 36**
hyalinata Banks 1905*b*:10. W
vocala Milne 1936:100. B. C.
invaria (Walker) 1852:101; Polycentropus. E
luctuosa Banks 1911:351
banksi Ross. **P. 268**
ecosa Ross 1941*b*:37. Oreg.
torva Hagen 1861:296. E
terminata Banks 1907*a*:132.
vinura Milne 1936:100. *N. syn.*
vaefes Milne 1936:96. B. C.
vedra Milne 1936:97. Oreg.
phryganea Ross 1941*b*:40. Calif., Oreg.
vemna Milne 1936:92. Wash.
vibox Milne 1936:101. **P. 36**
vepulsa Milne 1936:96. Oreg., B. C.
vetina Milne 1936:91. Wash.
vujuna Milne 1936:99. Oreg.
vuphipes Milne 1936:99. N. Y., Ont.
vuzana Milne 1936:97. Oreg.
gemona Ross 1938*d*:117. Wash.
betteni Ling 1938:59. Calif.
californica Ling 1938:60. Calif.
formosa Banks 1911:353. Unid. ♀; N. J.
mainensis Banks 1911:354. Unid. ♀; Maine
pacifica Banks 1895:316. Unid. ♀; Wash.
soror Provancher 1878:135. Unid.; Que.

Atopsyche Banks 1905*b*
tripunctata Banks 1905*b*:17. Ariz.

Palaeagapetus Ulmer 1912
nearcticus Banks 1936*a*:265. Wash.
celsus (Ross) 1938*a*:111; Paragapetus. N. H., Tenn.

Glossosoma Curtis 1834
Mystrophora Klapálek 1892
alascense Banks 1900*b*:472. W and NW
pyroxum Ross 1941*b*:42. Oreg.
parvulum Banks 1904*a*:108. W
montana Ross 1941*b*:42. Mont.
penitum Banks 1914:202. W
idaho Ross 1941*b*:41. Idaho
traviatum Banks 1936*a*:266. W
ventrale Banks 1904*a*:109. W
velona Ross 1938*a*:109. W
excita Ross 1938*a*:109. Oreg.
oregonense Ling 1938:62. Oreg.
nigrior Banks 1911:355. E
unica (Denning) 1942:46; Eomystra. *N. syn.*
lividum (Hagen) 1861:295; Tinodes. E
verdona Ross 1938*a*:110. W
intermedium (Klapálek) 1892:19; Mystrophora. **P. 39**
americanum Banks 1897:31. Unid. ♀; N. H.

Anagapetus Ross 1938*a*
debilis Ross 1938*a*:108. W

Agapetus Curtis 1834
malleatus Banks 1914:202. Calif.
marlo Milne 1936:108. Calif.
minutus Sibley 1926*a*:79. N. Y.
boulderensis Milne 1936:108. Colo.
artesus Ross 1938*a*:106. **P. 40**
vireo Ross 1941*b*:43. Ga., Tenn.
tomus Ross 1941*b*:44. Ga.
pinatus Ross 1938*a*:107. Tenn.
celatus McLachlan 1871:139. Calif.
illini Ross 1938*a*:106. **P. 40**
medicus Ross 1938*a*:107. **P. 40**
rossi Denning 1941*a*:200. NE
crasmus Ross 1939*a*:66. **P. 40**
iridis Ross. **P. 269.**
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Protoptila Banks 1904*d*
?Clymene Chambers 1873, preoccupied
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palina Ross 1941*b*:46. **P. 43**
lega Ross 1941*b*:48. **P. 43**
alexanderi Ross 1941*b*:48. Tex.
tenebrosa (Walker) 1852:134; Hydroptila. **P. 43**
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cantha Ross 1938*a*:113. NE to W
thoracica Ross 1938*a*:114. Wyo.
erotica Ross 1938*a*:113. **P. 44**
balmorhea Ross 1941*b*:45. Tex.
?aegerfasciella (Chambers) 1873:114; Clymene. Unid.; Ky.
?viridiventris (Say) 1823:160; Phryganea. Unid.; Ohio

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Trentonius Betten & Mosely 1940
distinctus (Walker) 1852:104; Philopotamus. **P. 47**
americanus (Banks) 1895:316; Philopotamus
pallidipes (Banks) 1936*a*:267; Philopotamus. W
aequalis (Banks) 1924:450; Philopotamus. W
dorcus (Ross) 1938*a*:132; Philopotamus. W
oregonensis (Ling) 1938:63; Philopotamus
novusamericanus (Ling) 1938:63; Philopotamus. Calif.

Dolophilus McLachlan 1868
Paragapetus Banks 1914
Dolophiliella Banks 1930*b*
moestus (Banks) 1914:202; Paragapetus. **P. 47**
breviatus Banks 1914:254
major Banks 1914:254. N. C., Tenn.
gabriella (Banks) 1930*b*:230; Dolophiliella. W
occideus Ross 1938*a*:134. Oreg.
shawnee Ross 1938*a*:133. **P. 46**
arizonensis Ling 1938:63. SW
cruzensis Ling 1938:64. Calif.
strotus Ross 1938*d*:118. Okla.
anillus Ross 1941*b*:50. B. C.

Chimarra Stephens 1829
Chimarrha Burmeister *et al.*, emend.
aterrima Hagen 1861:297. **P. 50**
elia Ross. **P. 269**
feria Ross 1941*b*:51. **P. 50**
angustipennis Banks 1903*a*:242. Tex., Ark.
socia Hagen 1861:297. **P. 51**
femoralis (Banks) 1911:358; Wormaldia
obscura (Walker) 1852:121; Beraea? **P. 51**
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lucia Betten 1934:175
florida Ross. **P. 270**
argentella Ulmer 1906*a*:92. Tropical Am.
utahensis Ross 1938*a*:134. W
idahoensis Ling 1938:64
texana Banks 1920:360. Unid. ♀; Tex.

PSYCHOMYIIDAE

Phylocentropus Banks 1907*a*
Acrocentropus Betten 1934
lucidus (Hagen) 1861:294; Polycentropus. **P. 56**

placidus (Banks) 1905*b*:15; Holocentropus. **P. 55**
maximus Vorhies 1909:711
carolinus Carpenter 1933:43. N. C.
auriceps (Banks) 1905*a*:218; Plectrocnemia. N. C.
rabilis Milne 1936:84. *N. syn.*

Neureclipsis McLachlan 1864
bimaculatus (Linnaeus) 1758:548; Phryganea. **P. 57**
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validus (Walker) 1852:100; Polycentropus. **P. 58**
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signatus (Banks) 1897:30; Polycentropus

Polycentropus Curtis 1835*a*
cinereus Hagen 1861:293. **P. 67**
canadensis Banks 1897:31
flavicornis (Banks) 1907*b*:162; Holocentropus
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lutea (Betten) 1934:219; Plectrocnemia
nascotius Ross 1941*b*:73. **P. 68**
remotus Banks 1911:359. **P. 67**
albipunctus (Banks) 1930*a*:131; Plectrocnemia. NE
iculus Ross 1941*b*:74. Que.
variegatus Banks 1900*a*:259. Wash., B.C.
colei Ross 1941*b*:76. Tenn.
crassicornis Walker 1852:101. **P. 64**
adironica (Banks) 1914:256; Plectrocnemia
australis (Banks) 1907*a*:131; Plectrocnemia
aureolus (Banks) 1930*a*:130; Plectrocnemia. **P. 64**
clinei (Milne) 1936:87; Plectrocnemia. NE
charlesi Ross 1941*b*:74. Tex.
halidus Milne 1936:86. N. Mex.
arizonensis Banks 1905*b*:16. Ariz.
centralis Banks 1914:258. **P. 64**
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pixi Ross. **P. 66**
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interruptus (Banks) 1914:257; Holocentropus. **P. 69**
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longus (Banks) 1914:258; Holocentropus
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Nyctiophylax Brauer 1865
vestitus (Hagen) 1861:293; Polycentropus. **P. 70**
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Cyrnellus Banks 1913
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zernyi Mosely 1934*a*:142

Cernotina Ross 1938*a*
pallida (Banks) 1904*d*:214; Cyrnus. **P. 73**
calcea Ross 1938*a*:137. **P. 72**
oklahoma Ross 1938*a*:137. Okla.
spicata Ross 1938*a*:138. **P. 73**
ohio Ross 1939*b*:628. **P. 73**
astera Ross 1941*b*:76. Tex.
fraterna (Banks) 1905*b*:17; Cyrnus. Unid. ♀; D. C.

Lype McLachlan 1879
diversa (Banks) 1914:253; Psychomyia. **P. 74**
griselda Betten 1934:229. *N. syn.*

Tinodes Stephens 1829
consueta McLachlan 1871:138. Calif.

Psychomyia Pictet 1834
Quissa Milne 1936
flavida Hagen 1861:294. **P. 75**
pulchella Banks 1899:217
moesta Banks 1907*a*:131
nomada (Ross) 1938*a*:138; Psychomyiella. **P. 75**
lumina (Ross) 1938*a*:139; Psychomyiella. Oreg.
?parva (Walker) 1852:134; ?Hydroptila. Type lost. Ont.

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Parapsyche Betten 1934
apicalis (Banks) 1908*b*:266; Arctopsyche. **P. 83**
elsis Milne 1936:66. W
brevipennis (Ling) 1938:64; Arctopsyche. *N. syn.*
divergens Banks 1943:368. Calif.
cardis Ross 1938*d*:119. **P. 83**
almota Ross 1938*d*:119. W
oregonensis (Ling) 1938:65; Arctopsyche

Arctopsyche McLachlan 1868
ladogensis (Kolenati) 1859*b*:201; Aphelocheira. Arctic Am.
grandis (Banks) 1900*a*:258; Hydropsyche. W
phryganoides Banks 1918:21
irrorata Banks 1905*a*:217. **P. 83**
californica Ling 1938:65. Calif.
inermis Banks 1943:368. Colo.

Diplectrona Westwood 1840
modesta Banks 1908*b*:266. **P. 84**
californica Banks 1914:253. Calif.
doringa Milne 1936:68. Unid.; N. C.

Aphropsyche Ross 1941*b*
aprilis Ross 1941*b*:78. **P. 83**

Oropsyche Ross 1941*b*
howellae Ross 1941*b*:79. **P. 83**

Homoplectra Ross 1938*d*
nigripennis (Banks) 1911:358; Diplectrona. Calif.
alseae Ross 1938*d*:120. Oreg.
oaklandensis (Ling) 1938:66; Diplectrona. Calif.

Potamyia Banks 1900*a*
flava (Hagen) 1861:285; Macronema. **P. 85**
kansensis (Banks) 1905*b*:15; Hydropsyche

Smicridea McLachlan 1871
fasciatella McLachlan 1871:136. **P. 85**
dispar (Banks) 1905*b*:16; Polycentropus
divisa (Banks) 1903*a*:244; Hydropsyche

Rhyacophylax Müller 1879
Pellopsyche Banks 1903*b*
signatus (Banks) 1903*b*:243; Pellopsyche. SW, Mexico

Hydropsyche Pictet 1834
slossonae Banks 1905*b*:14. **P. 99**
ventura Ross 1941*b*:92. Ont.
oslari Banks 1905*b*:13. W
partita Banks 1914:252
protis Ross 1938*d*:120. Utah
venada Ross 1941*b*:91. SW
tana Ross 1938*a*:151. Mont.
amblis Ross 1938*d*:120. Oreg.
morosa Hagen 1861:287. **P. 98**
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walkeri Betten & Mosely 1940:23. **P. 96**
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piatrix Ross 1938*a*:148. **P. 97**
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codona Betten 1934:187
cockerelli Banks 1905*b*:14. W
centra Ross 1938*a*:150. Wash.
bifida Banks 1905*b*:15. **P. 97**
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riola Denning 1942:49. Minn.
delrio Ross 1941*b*:85. Tex., Mexico
occidentalis Banks 1900*a*:258. W
novamexicanus Banks 1904*a*:110
californica Banks 1899:217. W
solex Ross. **P. 271**
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scalaris Hagen 1861:286. **P. 106**
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cuanis Ross 1938*a*:147. **P. 100**
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carolina Banks 1938:77. N. C.
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dubia Walker 1852:112. Unid. ♀; N. Am. ?
reciproca (Walker) 1852:104; Philopotamus. Unid. ♀; N. Am. ?
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marqueti Navás 1907:398. Unid.; Mont.

Cheumatopsyche Wallengren 1891
sordida (Hagen) 1861:290; Hydropsyche. **P. 110**
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enonis Ross 1938*a*:153. Wyo.
analis (Banks) 1903*b*:243; Hydropsyche. **P. 112**
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nigritta (Banks) 1907*b*:163; Orthotrichia. **P. 121**

Dibusa Ross 1939*a*
angata Ross 1939*a*:67. **P. 121**

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Hydrorchestria Kolenati 1848
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fraterna Banks 1907*b*:164
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clavata Morton 1905:67. **P. 124**
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albicornis Hagen 1861:275. **P. 151**
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scolops Ross 1938*a*:128. **P. 152**
melia Ross 1938*a*:128. Okla.
berneri Ross 1941*b*:67. Fla.
strepha Ross 1941*b*:68. Pa.
perdita Morton 1905:67. **P. 153**
pecos Ross 1941*b*:64. N. Mex.
consimilis Morton 1905:65. **P. 153**
arctia Ross 1938*a*:129. Idaho
angusta Ross 1938*a*:130. **P. 152**
protera Ross 1938*a*:131. Okla.
argosa Ross 1938*a*:131. W
xera Ross 1938*a*:132. Idaho
xoncla Ross 1941*a*:16. N. S.
waubesiana Betten 1934:160. **P. 150**
nicoli Ross 1941*b*:69. N. S.
acadia Ross 1941*b*:63. N. S.
salmo Ross 1941*b*:66. Wis.
maculata (Banks) 1904*b*:116; Allotrichia. E
transversus Banks 1907*b*:163
icona Mosely 1937:161. Okla., Mexico
perplexa Mosely 1924: 293. Unid. ♂

Neotrichia Morton 1905
Cyllene Chambers 1873, preoccupied
Exitrichia Mosely 1937
Dolotrichia Mosely 1937
Guerrotrichia Mosely 1937
Lorotrichia Mosely 1937
collata Morton 1905:72. **P. 159**
minutisimella (Chambers) 1873:125; Cyllene. **P. 157**
falca Ross 1938*a*:119. **P. 159**
vibrans Ross 1938*a*:119. **P. 159**
caxima (Mosely) 1937:179; Guerrotrichia. Tex., Mexico
okopa Ross 1939*b*:629. **P. 158**
osmena Ross. **P. 278**
sonora Ross. **P. 277**
edalis Ross 1941*b*:62. **P. 158**
riegeli Ross 1941*b*:61. **P. 159**
kitae Ross 1941*b*:60. **P. 158**

Mayatrichia Mosely 1937
ayama Mosely 1937:182. **P. 279**
ponta Ross. **P. 278**
acuna Ross. **P. 279**

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Agrypnia Curtis 1835*b*
Agrypnetes McLachlan 1876
Dasystegia Wallengren 1880
Phryganomyia Banks 1907*a*
Prophryganea Martynov 1924
Jyrvia Milne 1934
pagetana Curtis 1835*a*:540. Holarctic
subsp. *nearctica* Milne 1934:3
straminea Hagen 1873:425. **P. 165**
curvata (Banks) 1900*a*:252; Agrypnetes
obscura (Banks) 1907*a*:122; Phryganomyia
glacialis Hagen 1864:802. N and NW
alascensis (Banks) 1900*b*:471; Asynarchus
dextra Ross 1938*a*:161. Utah
colorata Hagen 1873:424. NW and N
bradorata (Milne) 1931:230; Prophryganea
deflata (Milne) 1931:230; Prophryganea. N
improba (Hagen) 1873:417; Phryganea. W and NE
var. sackeni Banks 1943:367
macdunnoughi (Milne) 1931:230; Prophryganea. N
vestita (Walker) 1852:10; Neuronia. **P. 166**
commixta (Walker) 1852:10; Neuronia

Fabria Milne 1934
inornata (Banks) 1907*a*:117; Neuronia. **P. 166**
complicata (Banks) 1924:440; Ecclisomyia. Ont.

Oligostomis Kolenati 1848
ocelligera (Walker) 1852:8; Neuronia. **P. 167**
stygipes (Hagen) 1873:388; Neuronia

Eubasilissa Martynov 1930
Regina Martynov 1924, preoccupied
pardalis (Walker) 1852:7; Neuronia. **P. 168**
var. *redmani* (Betten & Mosely) 1940:96; Neuronia

Banksiola Martynov 1924
concatenata (Walker) 1852:8; Neuronia. Fla., Ga.
dossuaria (Say) 1828:44; Neuronia. NE
calva Banks 1943:366. Mass.
smithi (Banks) 1914:149; Neuronia. NE
canadensis (Banks) 1907*a*:118; Neuronia. Ont.
childreni (Betten & Mosely) 1940:90; Neuronia. Unid. ♀; locality unknown but may be N. Am.
selina Betten. **P. 169**
crotchi Banks 1944:80. B.C.

Ptilostomis Kolenati 1859*b*
angustipennis (Hagen) 1873:400; Neuronia. **P. 174**
postica (Walker) 1852:9; Neuronia. **P. 173**
ocellifera (Walker) 1852:8; Neuronia. **P. 172**
simulans (Betten & Mosely) 1940:107; Neuronia. *N. syn.*
semifasciata (Say) 1828:44; Phryganea. **P. 173**
fusca (Walker) 1852:9; Neuronia
dubitans (Betten & Mosely) 1940:105; Neuronia. *N. syn.*
kovalevskii Kolenati 1859*b*:198. Unid.; N. Am.

Oligotricha Rambur 1842
lapponica (Hagen) 1864:852; Neuronia. Alaska

Phryganea Linnaeus 1758
cinerea Walker 1852:4. **P. 175**
sayi Milne 1931:228. **P. 176**
interrupta Say 1828:44, preoccupied
californica Banks 1907*a*:117. Calif.

LIMNEPHILIDAE

Radema Hagen 1864
Apatidea McLachlan 1874
Apatelia Wallengren 1886
incerta (Banks) 1897:28; Enoicyla. NE
stigmatella (Zetterstedt) 1840:1066; Phryganea. N
pallida (Hagen) 1861:270; Apatania
frigida (McLachlan) 1867:57; Apatania
shoshone (Banks) 1924:442; Apatania. W
sorex Ross 1941*b*:101. Oreg.
aenicta (Ross) 1938*a*:162; Apatelia. Man.
nigra (Walker) 1852:83; Potamaria. NE
pictula (Banks) 1943:355; Apatania. Ariz.
hirtipes (Curtis) 1835*b*:64; Tinodes? Arctic Am.
mongolica (Martynov) 1914:44; Apatania. Alaska
arctica (Boheman) 1865:568; Goniotaulius. Greenland
groenlandica (Kolbe) 1912:41; Apatania. Greenland

Lepania Ross 1941*b*
cascada Ross 1941*b*:102. Oreg.

Dicosmoecus McLachlan 1875
atripes (Hagen) 1875:600; Platyphylax. W
jucundus Banks 1943:358. W
nigrescens Banks 1943:359. W
pallicornis Banks 1943:359. Calif.
gilvipes (Hagen) 1875:601; Stenophylax. B. C.
grandis Ulmer 1905*b*:62. Wash.
obscuripennis Banks 1938:76. Alaska
unicolor (Banks) 1897:27; Anabolia. Wash.
occidentalis Banks 1943:362. W
alascensis Banks 1943:363. Alaska
tristis (Banks) 1900*a*:254; Asynarchus. Colo.
quadrinotatus (Banks) 1908*a*:62; Anabolia. Newf.
coloradensis Ulmer 1905*b*:64. Colo.
atripennis (Banks) 1924:440. Anisogamus. Unid. ♀; Calif.

Allocosmoecus Banks 1943
partitus Banks 1943:365. Idaho

Allomyia Banks 1916
tripunctata (Banks) 1900*b*:472; Apatania. Alaska
renoa (Milne) 1935:31; Algonquina. Nev.

Parachiona Thompson 1891
pilosa Banks 1907*a*:121. Wash.

Platycentropus Ulmer 1905*a*
Hylepsyche Banks 1916
plectrus Ross 1938*a*:169. NE
radiatus (Say) 1824:308; Phryganea. **P. 181**
indicans (Walker) 1852:23; Limnephilus. *N. syn.*
maculipennis (Kolenati) 1859*b*:176; Halesus. *N. syn.*
hostis (Hagen) 1861:266; Hallesus. *N. syn.*
amicus (Hagen) 1861:265; Halesus. Unassoc. ♀; La.
fraternus (Banks) 1943:349; Hylepsyche. Mass.
indistinctus (Walker) 1852:37; Limnephilus. NE

Glyphotaelius Stephens 1837
Glyphidotaelius Kolenati 1848
hostilis Hagen 1864:814. **P. 183**

Astenophylax Ulmer 1907*b*
argus (Harris) 1869:333; Phryganea. **P. 183**

Hesperophylax Banks 1916
designatus (Walker) 1852:24; Limnephilus. **P. 183**
var. isolatus Banks 1943:347
magnus Banks 1918:20. Ariz.
occidentalis (Banks) 1908*b*:265; Platyphylax. W
alaskensis (Banks) 1908*b*:265; Platyphylax
consimilis (Banks) 1900*a*:253; Limnephilus. W
minutus Ling 1938:67. Calif., Oreg.
incisus Banks 1943:348. W

Ironoquia Banks 1916
parvula (Banks) 1900*a*:256; Chaetopterygopsis. **P. 184**

Leptophylax Banks 1900*a*
gracilis Banks 1900*a*:252. **P. 184**

Clistoronia Banks 1916
magnifica (Banks) 1899:209; Halesus. W
magnus Banks 1916:119; (misspelling)
formosa (Banks) 1900*a*:255; Halesus. W
maculata (Banks) 1904*a*:107; Dicosmoecus. W

Grammotaulius Kolenati 1848
interrogationis (Zetterstedt) 1840:1063; Phryganea. N
praecox Hagen 1873:451
lorettae Denning 1941*b*:233. Colo.
betteni Griffin 1912:18. W
sibiricus McLachlan 1874:40. Greenland

Limnephilus Leach 1815
Anabolina Banks 1903*a*
Apolopsyche Banks 1916
Algonquina Banks 1916
Rheophylax Sibley 1926*b*

gravidus Hagen 1861:257. W
rotundatus Banks 1918:19. Calif.
vastus Hagen 1861:257. Alaska
?intermedius Banks 1918:20 (♀)
rillus Milne 1935:46. Nev.
oreus Milne 1935:46. Oreg.
keratus Ross 1938*a*:165. NE
rho Milne 1935:45. W
bifidus (Ling) 1938:68; Clistoronia (also a homonym)
taronus Ross 1941*b*:110. Alaska
pulchellus Banks 1908*a*:63. Newf.
sperryi (Banks) 1943:346; Rhadicoleptus. Ariz.
flavicollis (Banks) 1900*b*:470; Asynarchus. Alaska
fumosus (Banks) 1900*b*:470; Asynarchus. W
caroli (Denning) 1941*a*:196; Anabolia. B.C.
kennicotti Banks 1920:344. N
coloradensis (Banks) 1899:208; Goniotaulius. W
miser McLachlan 1875:89. Greenland
crassus Banks 1920:343. Mass.
ornatus Banks 1897:27. **P. 189**
elegans Mosely 1929:504
morrisoni Banks 1920:343. Nev.
extractus Walker 1852:34. Ont.
hyalinus Hagen 1861:258. **P. 191**
sericeus (Say) 1824:309; Phryganea. **P. 192**
despectus Walker 1852:31. Holarctic
multifarius Walker 1852:32
perforatus Walker 1852:33
eminens Betten 1934:323
deceptus (Banks) 1899:208; Anabolia. Wash.
fagus Ross 1941*a*:18. Oreg.
abbreviatus Banks 1908*b*:263. Colo.
arizona Ross 1941*b*:108. Ariz., Wyo.
forcipatus Banks 1924:439. Alta.
modestus (Hagen) 1861:265; Anabolia. NE
nigriculus (Banks) 1908*b*:262; Anabolia. W
emarginatus (Banks) 1919:4; Anabolia. Alaska
montanus (Banks) 1907*a*:119; Anabolia. NE
curtus (Banks) 1920:345; Anabolia. NE
simplex (Banks) 1900*b*:469; Anabolia. Alaska
planifrons (Kolenati) 1848:56; Desmotaulius. Labr., Greenland
aldinus Ross 1941*a*:19. Alta.
nepus Ross 1938*c*:38. W
pacificus (Banks) 1900*a*:254; Stenophylax, preoccupied
mutatus (Hagen) 1861:267; Hallesus. NE
bimaculatus Walker 1852:30. **P. 189**
sordidus (Hagen) 1861:264; Anabolia. **P. 189**
longicercus (Denning) 1941*a*:195; Anabolia
ozburni (Milne) 1935:39; Arctoecia. NE
consocius Walker 1852:33. **P. 190**
medialis (Banks) 1905*b*:8; Colpotaulius
?oslari (Ling) 1938:67; Anabolia (also a homonym)
pacificus Banks 1899:207. W
harrimani Banks 1900*b*:468. W
aequalis Banks 1914:150
moestus Banks 1908*a*:62. **P. 191**
hingstoni Mosely 1929:504
cockerelli Banks 1900*c*:124. W
nogus Ross. **P. 281**
brevipennis (Banks) 1899:209; Stenophylax. W
minusculus (Banks) 1907*a*:120; Stenophylax. W
thorus Ross 1938*a*:167. Utah
externus Hagen 1861:257. Holarctic
congener McLachlan 1875:56
?oslari Banks 1907*a*:121 (♀)
flavostellus Banks 1918:20
luteolus Banks 1899:207
tersus Betten 1934:334. *N. syn.*
argenteus Banks 1914:152. NE
occidentalis Banks 1908*b*:264. W
ectus Ross 1941*b*:105. Oreg.
internalis (Banks) 1914:154; Anisogamus. NE
nebulosus Kirby 1837:253. N
femoralis Kirby 1837:253
stipatus Walker 1852:29
parvulus (Banks) 1905*b*:9; Stenophylax? NE
pallidus (Banks) 1924:442; Apolopsyche
roberti Banks 1930*b*:226. *N. syn.*
rohweri Banks 1908*b*:262. W
indivisus Walker 1852:34. **P. 191**
subguttatus Walker 1852:34
rhombicus (Linnaeus) 1758:548; Phryganea. **P. 190**
combinatus Walker 1852:28
sublunatus Provancher 1877:243. NE
?americanus Banks 1900*a*:253 (♀)
macgillivrayi Banks 1908*b*:263
elongatus Banks 1920:344. N
hageni Banks 1930*b*:226. N
partitus Walker 1852:32. N
adustus Banks 1920:343. *N. syn.*
sansoni Banks 1918:19. Alta.
sackeni Banks 1930*b*:227. N
kincaidi Banks 1900*b*:468. Trans.
clausus Banks 1924:440. *N. syn.*
quaeris (Milne) 1935:41; Colpotaulius. Trans.
perpusillus Walker 1852:35. N and NE
rhaeus Milne 1935:42; Colpotaulius
merinthus Ross 1938*a*:166
labus Ross 1941*b*:105. W
lunonus Ross 1941*b*:107. Calif., Oreg.
acrocurvus Denning 1942:48. Minn.
acnestus Ross 1938*a*:164. Calif.
diversus (Banks) 1903*a*:244; Anabolina. SW
productus Banks 1914:150. Utah
lithus (Milne) 1935:40; Anabolina. SW

secludens Banks 1914:152. Trans.
tarsalis (Banks) 1920:342; Colpotaulius. W
ademus Ross 1941*a*:18. N.B.
canadensis Banks 1908*b*:264. NE
frijole Ross. **P. 282**
aretto Ross 1938*d*:121. Wash.
tehamia (Ling) 1938:67; Colpotaulius. *N. syn.*
spinatus Banks 1914:149. W
assimilis (Banks) 1908*b*:262; Anabolia. W
janus Ross 1938*c*:37. W
minusculus (Banks) 1924:439; Colpotaulius, preoccupied
taloga Ross 1938*a*:166. Okla., Utah
submonilifer Walker 1852:33. **P. 192**
pudicus Hagen 1861: 262
bifidus Banks 1908*b*:263. Unassoc. ♀; W
concolor Banks 1899:207. Abdomen of type lost; Wash.
perjurus Hagen 1861:258. Abdomen of type lost; Alaska
plaga Walker 1852:35. Abdomen of type lost; Ont.
sitchensis Kolenati 1859*a*:17. Unid.; Alaska
trimaculatus Zetterstedt—a Eurasion species reported from N. Am. in error—Hagen 1861:261
subpunctulatus Zetterstedt—a Eurasion species reported from N. Am. in error—Hagen 1861:259

Chyranda Ross. **P. 283**
centralis (Banks) 1900*a*:253; Asynarchus. W
pallidus (Banks) 1903*b*:242; Asynarchus
signatus (Banks) 1907*a*:120; Parachiona

Stenophylax Kolenati 1848
antennatus Banks 1900*a*:254. Wash.

Clostoeca Banks 1943
sperryae Banks 1943:352. Calif.
disjunctus (Banks) 1914:156; Anisogamus. W

Philocasca Ross 1941*b*
demita Ross 1941*b*:111. Oreg.
banksi (Denning) 1941*a*:199; Anisogamus. Idaho

Halesochila Banks 1907*a*
taylori (Banks) 1904*c*:140; Halesus. B.C.

Zaporota Banks 1920
pallens Banks 1920:342. Alaska

Pycnopsyche Banks 1905*b*
Allegophylax Banks 1916
Eustenace Banks 1916
circularis (Provancher) 1877:260; Platyphylax. NE
divergens (Walker) 1852:30; Limnephilus. NE
dan (Sibley) 1926*a*:81; Halesus
flavata (Banks) 1914:154; Stenophylax. N.C.
hespera (Banks) 1914:152; Stenophylax. W
needhami (Ling) 1938:66; Astenophylax
luculenta (Betten) 1934:345; Stenophylax. **P. 196**
scabripennis (Rambur) 1842:488; Limnephilus. Mass.
antica (Walker) 1852:9; Neuronia. **P. 196**
minima Banks 1943:345. E
conspersa Banks 1943:345. NE
perplexa Betten & Mosely 1940:149. N. Am.
sonso (Milne) 1935:32; Stenophylax. N.C.
subfasciata (Say) 1828:44; Phryganea. **P. 194**
indiana (Ross) 1938*d*:121; Stenophylax. **P. 196**
lepida (Hagen) 1861:269; Enoicyla. **P. 195**
limbata (McLachlan) 1871:108; Stenophylax. NE
gentilis (McLachlan) 1871:108; Stenophylax. NE
guttifer (Walker) 1852:16; Halesus. **P. 196**
similis Banks 1907*a*:122
aglona Ross 1941*a*:18. NE

Caborius Navás 1918
Allophylax Banks 1907*a*, preoccupied
punctatissimus (Walker) 1852:17; Halesus. **P. 197**
lyratus Ross 1938*a*:163. **P. 198**
kaskaskia Ross. **P. 198**

Chilostigma McLachlan 1876
areolatum (Walker) 1852:35; Limnephilus. Arctic Am.

Frenesia Betten & Mosely 1940
missa (Milne) 1935:35; Chilostigma. **P. 199**
difficilis (Walker) 1852:34; Limnephilus. NE
pallida (Banks) 1899:209; Chilostigma

Grensia Ross. **P. 201**
praeterita (Walker) 1852:32; Limnephilus. N

Glyphopsyche Banks 1904*c*
irrorata (Fabricius) 1781:389; Phryganea. B.C., Ont.
intercisus (Walker) 1852:30; Limnephilus
bryanti Banks 1904*c*:141
missouri Ross. **P. 200**

Psychoglypha Ross. **P. 201**
subborealis (Banks) 1924:441; Chilostigma. **P. 202**
ormiae (Ross) 1938*a*:163; Glyphopsyche. W
atlinensis (Ling) 1938:68; Chilostigma. *N. syn.*
bella (Banks) 1903*b*:241; Glyphotaelius. B.C.
prita (Milne) 1935:25; Glyphopsyche. Alta.
ulla (Milne) 1935:24; Glyphopsyche. W
avigo (Ross) 1941*b*:113; Glyphopsyche. Oreg.

Phanocelia Banks 1943
canadensis (Banks) 1924:442; Apatania. **P. 201**

Drusinus Betten 1934
uniformis Betten 1934:360. **P. 202**
virginicus (Banks) 1900*a*:256; Potamorites. NE
sparsus (Banks) 1908*a*:63; Halesus. NE
calypso (Banks) 1911:350; Stenophylax
edwardsi (Banks) 1920:345; Anisogamus. W
frontalis Banks 1943:350. B.C.

Psychoronia Banks 1916
brevipennis (Banks) 1904*a*:108; Psilopteryx? ♀; N. Mex.
costalis (Banks) 1901*a*:286; Asynarchus. W

Ecclisomyia Banks 1907*a*
conspersa Banks 1907*a*:123. Wash.
scylla Milne 1935:37. B.C.
simulata Banks 1920:346. Nev.
maculosa Banks 1907*a*:123. Colo.

Homophylax Banks 1900*a*
crotchi Banks 1920:345. B.C.
flavipennis Banks 1900*a*:255. Colo.
nevadensis Banks 1903*b*:242. Nev.
andax Ross 1941*b*:112. B.C., Oreg.

Neophylax McLachlan 1871
Acronopsyche Banks 1930*b*
autumnus Vorhies 1909:669. **P. 203**
fuscus Banks 1903*b*:242. **P. 205**
mitchelli Carpenter 1933:32. N.C.
nacatus Denning 1941*a*:198. NE
consimilis Betten 1934:376. N.Y.
ornatus Banks 1920:346. NE
rickeri Milne 1935:22. W
pulchellus Ling 1938:68
concinnus McLachlan 1871:111. Unid.; N.Y.
stolus Ross 1938*a*:169. E
ayanus Ross 1938*a*:168. **P. 205**
oligius Ross 1938*a*:168. NE
sinuatus Navás 1917:10. Unid.; Mont.
occidentis Banks 1924:441. W
pilosus (Banks) 1930*b*:228; Acronopsyche
slossonae Banks 1943:353. N.H.
delicatus Banks 1943:354. Pa.

Oligophlebodes Ulmer 1905*b*
minutus (Banks) 1897:28; Halesus. W
coloradensis Ulmer 1905*b*:66
sigma Milne 1935:22. Utah, N. Mex.
ardis Ross 1941*b*:103. Colo.
sierra Ross. **P. 284**
ruthae Ross. **P. 285**

Neothremma Banks 1930*b*
alicia Banks 1930*b*:229. W

Farula Milne 1936
rainieri Milne 1936:116. Wash.

MOLANNIDAE

Molanna Curtis 1834
Apatania Kolenati 1848
uniophila Vorhies 1909:705. **P. 206**
musetta Betten 1934:248. **P. 207**
tryphena Betten 1934:248. **P. 207**
flavicornis Banks 1914:261. **P. 208**
blenda Sibley 1926*b*:105. **P. 208**
cinerea Hagen 1861:276. Unid. ♀; Ont.

BERAEIDAE

Beraea Stephens 1836
Thya Curtis 1834
nigritta Banks 1897:31. **P. 208**
gorteba Ross. **P. 208**

ODONTOCERIDAE

Marilia Müller 1878 (see also 1879)
flexuosa Ulmer 1905*b*:70. SW
fusca (Banks) 1905*b*:19; Anisocentropus
nobsca Milne 1936:79. Tex.

Namamyia Banks 1905*b*
plutonis Banks 1905*b*:10. Calif.

Nerophilus Banks 1899
californicus (Hagen) 1861:272; Silo. W
oregonensis Banks 1899:212

Psilotreta Banks 1899. **P. 285**
Astoplectron Banks 1914
rufa (Hagen) 1861:276; Molanna. NE
connexa (Banks) 1914:265; Astoplectron
indecisa (Walker) 1852:95; Goera. NE
frontalis Banks 1899:213. E
gameta Ross 1939*a*:69; Heteroplectron. *N. syn.*
labida Ross. **P. 287**
amera (Ross) 1939*a*:68; Heteroplectron. Tenn.
borealis (Provancher) 1877:263; Heteroplectron. Unid; Que.
dissimilis (Banks) 1897:30; Heteroplectron? Unid. ♀; N.Y.

CALAMOCERATIDAE

Ganonema McLachlan 1866
americanum (Walker) 1852:85; Sericostoma. E
nigrum Lloyd 1915*b*:19

Anisocentropus McLachlan 1863*a*
pyraloides (Walker) 1852:90; Notidobia. Ga.
latifascia (Walker) 1852:90; Notidobia. An Australian species, probably recorded erroneously from N. Am.
elegans (Walker) 1852:95; Goera

Notiomyia Banks 1905*b*
mexicana (Banks) 1900*a*:257; Heteroplectron. Ariz., Mexico
ornata Banks 1909:342. Tex.

Heteroplectron McLachlan 1871
californicum McLachlan 1871:125. Calif.

LEPTOCERIDAE

Leptocerus Leach 1815
Ymymia Milne 1934
americanus (Banks) 1899:215; Setodes. **P. 212**
grandis (Banks) 1907*a*:128; Setodes

Leptocella Banks 1899
pavida (Hagen) 1861:282; Setodes. **P. 218**
candida (Hagen) 1861:280; Setodes. **P. 217**
exquisita (Walker) 1852:72; Leptocerus. **P. 217**
piffardii (McLachlan) 1863*b*:160; Setodes. NE
tavara Ross. **P. 287**
albida (Walker) 1852:71; Leptocerus. **P. 220**
nivea (Hagen) 1861:281; Setodes
diarina Ross. **P. 218**
texana Banks 1905*b*:19. Tex.
intervena Banks 1914:262. Tex.
spiloma Ross. **P. 219**
exilis Banks 1905*b*:19. SW
gracilis Banks 1901*b*:369, preoccupied
coloradensis Banks 1899:215. Colo.
minuta Banks 1900*a*:257. Wash.
stigmatica Banks 1914:262. N.Mex.
uwarowii (Kolenati) 1859*b*:249; Mystacides. Unid.; Alaska

Athripsodes Billberg 1820
tarsi-punctatus (Vorhies) 1909:694; Leptocerus. **P. 229**
nephus Ross. **P. 230**
alagmus Ross 1938*a*:155. **P. 229**
resurgens (Walker) 1852:70; Leptocerus. **P. 230**
variegatus (Hagen) 1861:278; Leptocerus
aspinosus (Betten) 1934:255; Leptocerus
angustus (Banks) 1914:263; Leptocerus. **P. 231**
alces Ross 1941*b*:95. Ont., Wis.
annulicornis (Stephens) 1836:199; Leptocerus. **P. 232**
lugens (Hagen) 1861:276; Leptocerus
recurvatus (Banks) 1908*b*:265; Leptocerus
futilis (Banks) 1914:264; Leptocerus
perplexus var. *nordus* Milne 1934:15. *N. syn.*
dilutus (Hagen) 1861:277; Leptocerus. **P. 231**
miscus Ross 1941*b*:93. Wis., Minn.
wetzeli Ross 1941*b*:94. NE
arielles Denning 1942:48. Minn.
mentieus (Walker) 1852:71; Leptocerus. **P. 232**
vanus (Betten) 1934:262; Leptocerus
slossonae Banks 1938:77. Fla., Pa.
transversus (Hagen) 1861:279; Leptocerus. **P. 233**
maculatus (Banks) 1899:214; Leptocerus
inornatus (Banks) 1914:263; Leptocerus. Tex.
cancellatus (Betten) 1934:256; Leptocerus. **P. 233**
ophioderus Ross 1938*a*:157. **P. 232**
punctatus (Banks) 1894:180; Mystacides. **P. 234**
uvalo Ross 1938*b*:89. Pa., N.Y.
submacula (Walker) 1852:70; Leptocerus. **P. 235**
erraticus Milne 1936:58. **P. 235**
saccus Ross 1938*b*:89. **P. 234**
erullus Ross 1938*b*:90. **P. 235**
cophus Ross 1938*a*:156. W
ancylus (Vorhies) 1909:691; Leptocerus. **P. 227**
flavus (Banks) 1904*d*:212; Leptocerus. **P. 228**
albostictus (Hagen) 1861:276; Leptocerus. Unid. ♀; N. Am.
floridanus (Banks) 1903*b*:242; Leptocerus. Unid. ♀; Fla.
retactus (Banks) 1914:263; Leptocerus. Unid. ♀; Ont.
stigmaticus (Navás) 1917:8; Leptocerus. Unid.; N. Mex.

Oecetis McLachlan 1877
Oecetina Banks 1899
Setodina Banks 1907*a*
Oecetodes Ulmer 1909
Friga Milne 1934
Quaria Milne 1934
Yrula Milne 1934
avara (Banks) 1895:316; Setodes. **P. 240**
disjuncta (Banks) 1920:351; Oecetina. W
eddlestoni Ross 1938*a*:160. **P. 240**
scala Milne 1934:17. **P. 241**
sphyra Ross 1941*b*:99. Ga.
ochracea (Curtis) 1825:57; Leptocerus. **P. 244**
ssp. *carri* Milne 1934:16. *N. syn.*
persimilis (Banks) 1907*a*:129; Oecetina. **P. 243**
georgia Ross 1941*b*:98. Ga.
immobilis (Hagen) 1861:283; Setodes. **P. 241**
cinerascens (Hagen) 1861:282; Setodes. **P. 241**
fumosa (Banks) 1899:216; Oecetina
osteni Milne 1934:17. **P. 241**
inconspicua (Walker) 1852:71; Leptocerus. **P. 242**
sagitta (Hagen) 1861:284; Setodes
micans (Hagen) 1861:283; Setodes
flaveolata (Hagen) 1861:282; Setodes
parvula (Banks) 1899:215; Oecetina
flavida (Banks) 1899:216; Oecetina

floridana (Banks) 1899:216; Oecetina
apicalis (Banks) 1907*a*:129; Oecetina
inornata (Banks) 1907*a*:128; Oecetina
parva (Banks) 1907*a*:130; Setodina. Fla.

Triaenodes McLachlan 1865
Triaenodella Mosely 1932
Ylodes Milne 1934
helo Milne 1934:12. SE
perna Ross 1938*a*:159. **P. 250**
aba Milne 1935:20. **P. 249**
nox Ross 1941*b*:96. Ont.
ochracea (Betten & Mosely) 1940:77; Triaenodella. Ga.
tridonta Ross 1938*a*:158. Okla.
baris Ross 1938*b*:88. **P. 252**
phalacris Ross 1938*b*:88. **P. 250**
dipsia Ross 1938*b*:89. **P. 252**
flavescens Banks 1900*a*:257. **P. 251**
tarda Milne 1934:12. **P. 250**
vorhiesi Betten 1934:286. *N. syn.*
mephita Milne 1936:59. *N. syn.*
marginata Sibley 1926*a*:80. **P. 251**
injusta (Hagen) 1861:283; Setodes. **P. 252**
ignita (Walker) 1852:72; Leptocerus. **P. 252**
dentata Banks 1914:261. *N. syn.*
taenia Ross 1938*a*:157. Tenn.
florida Ross 1941*b*:96. Fla.
frontalis Banks 1907*a*:127. **P. 249**
grisea Banks 1899:214. **P. 249**
borealis Banks 1900*a*:257. Unid. ♀; Minn.

Mystacides Berthold 1827
sepulchralis (Walker) 1852:70; Leptocerus. **P. 254**
alafimbriata Griffin 1912:19. W
longicornis (Linnaeus) 1758:548; Phryganea. **P. 255**
quadrifasciata (Fabricius) 1775:308; Phryganea
interjecta (Banks) 1914:262; Oecetina
canadensis Banks 1924:448
nigra (Linnaeus)—a Eurasian species rereported from N. Am. in error—Hagen 1861:277

Setodes Rambur 1842
incerta (Walker) 1852:71; Leptocerus. NE and E
vernalis Banks 1907*a*:127
stehri (Ross) 1941*b*:99; Leptocerus. Ga., N.C.
oxapia (Ross) 1938*b*:88; Leptocerus. Okla.
guttatus (Banks) 1900*a*:257; Oecetina. NE
autumnalis Banks 1907*a*:128
oligia (Ross) 1938*a*:160; Leptocerus. **P. 256**
floridana Banks 1905*b*:19. Unid. ♀; Fla.

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Goera Curtis 1834
calcarata Banks 1899:211. E
fuscula Banks 1905*a*:216. N.C.
stylata Ross 1938*a*:172. **P. 257**

Goerita Ross 1938*a*
semata Ross 1938*a*:172. **P. 258**
genota Ross 1941*b*:116. Oreg.

Pseudogoera Carpenter 1933
singularis Carpenter 1933:38. **P. 258**

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Lepidostoma Rambur 1842
Nosopus McLachlan 1871
Olemira Banks 1897
Pristosilo Banks 1899
Atomyia Banks 1905*a*
Notiopsyche Banks 1905*a*
Mormomyia Banks 1907*a*
Alepomyia Banks 1908*a*
Phanopsyche Banks 1911
Alepomyiodes Sibley 1926*b*
Arcadopsyche Banks 1930*a*
Neuropsyche Carpenter 1933
Oligopsyche Carpenter 1933
Jenortha Milne 1936
togatum (Hagen) 1861:273; Mormonia. E, NE
canadensis (Banks) 1899:212; Pristosilo
pallidum (Banks) 1897:29; Silo
knowltoni Ross 1938*a*:175. Utah
carolina (Banks) 1911:356; Notiopsyche. N.C.
tibialis (Carpenter) 1933:39; Neuropsyche. N.C.
latipennis (Banks) 1905*a*:216; Notiopsyche. N.C.
podager (McLachlan) 1871:116; Nosopus. Calif.
quercina Ross 1938*a*:176. Oreg.
strophis Ross 1938*a*:177. N, NW
frosti (Milne) 1936:119; Atomyia. E
unicolor (Banks) 1911:357; Mormomyia. W, N
prominens (Banks) 1930*a*:129; Arcadopsyche. E
bryanti (Banks) 1908*a*:65; Alepomyia. NE
wisconsinensis Vorhies 1909:685
griseum (Banks) 1911:357; Phanopsyche. NE
roafi (Milne) 1936:120; Atomyia. W
sackeni (Banks) 1936*a*:267; Mormomyia. NE
cascadensis (Milne) 1936:119; Jenortha. Wash.
pleca Ross 1938*a*:175. *N. syn.*
americanum (Banks) 1897:29; Olemira. NE
pictilis (Banks) 1899:211; Mormonia
costalis (Banks) 1914:265; Olemira. NE
pluviale (Milne) 1936:117; Olemira. W
rayneri Ross 1941*b*:117. Calif., Oreg.
ontario Ross 1941*b*:119. NE

cantha Ross 1941*b*:118. Calif.
modestum (Banks) 1905*a*:217; Alepomyia. E
swannanoa Ross 1939*a*:69. E
lydia Ross 1939*a*:70. E
vernalis (Banks) 1897:29; Mormonia. E
liba Ross 1941*b*:120. **P. 259**
cinereum (Banks) 1899:210; Silo. Unid. ♀; Calif.
deceptivum (Banks) 1907*a*:125; Thremma. Unid. ♀; N.Mex.
stigma Banks 1907*a*:125. Unid. ♀; Colo.

Theliopsyche Banks 1911
subg. *Aopsyche* Ross 1938*a*
parva Banks 1911:356. N.Y.
epilone Ross 1938*a*:173. N.C.
corona Ross 1938*a*:174. N.C.
grisea (Hagen) 1861:273; Silo. N.Y.

BRACHYCENTRIDAE

Micrasema McLachlan 1876
rusticum (Hagen) 1868:272; Dasystoma. **P. 261**
falcatum Banks 1914:265
charonis Banks 1914:266. **P. 262**
wataga Ross 1938*a*:178. **P. 262**
scissum McLachlan 1884:26. Alaska
bactro Ross 1938*d*:122. Oreg.
sprulesi Ross 1941*b*:115. NE

Brachycentrus Curtis 1834
Sphinctogaster Provancher 1877
Oligoplectrum McLachlan 1868
subg. *Amiocentrus* Ross 1938*a*
notabulus Milne 1936:112. Va.
dimicki Milne 1936:113. Oreg.
americanus (Banks) 1899:210; Oligoplectrum. **P. 266**
similis Banks 1907*a*:124
lateralis (Say) 1823:161; Phryganea. **P. 265**
numerosus (Say) 1823:160; Phryganea. **P. 264**
fuliginosus Walker 1852:88. Ont., Man.
occidentalis Banks 1911:355. W
incanus Hagen 1861:272. E
arizonicus (Ling) 1938:69; Oligoplectrum. Ariz.
aspilus Ross 1938*a*:178. W
californicus (Ling) 1938:69; Oligoplectrum. *N. syn.*
lutescens (Provancher) 1877:262; Sphinctogaster. Unid. ♀; Que.
nigrisoma (Banks) 1905*b*:12; Sphinctogaster. **P. 265**

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Sericostoma Berthold 1827
Notidobia Stephens 1836
Schizopelex McLachlan 1876
Agarodes Banks 1899
Psiloneura Banks 1914
pele Ross 1938*a*:170. N.C.
crassicornis (Walker) 1852:113; Hydropsyche. Ga.
distinctum (Ulmer) 1905*b*:67; Agarodes. NE
lobata (Banks) 1911:356; Schizopelex
moesta (Banks) 1914:264; Psiloneura
griseolum McLachlan 1871:112. Calif.
nigriculum McLachlan 1871:113. Calif.
arizonicum (Banks) 1943:369; Notidobia. Ariz.
assimilis Banks 1907*a*:124. Calif.
griseum (Banks) 1899:218; Agarodes. NE
americana Banks 1900*a*:256
hesperum (Banks) 1914:266; Schizopelex. Unid. ♀; Utah

HELICOPSYCHIDAE

Helicopsyche Hagen 1866
borealis (Hagen) 1861:271; Notidobia. **P. 266**
californica Banks 1899:210. *N. syn.*
annulicornis Banks 1904*d*:212
piroa Ross. **P. 289**
mexicana Banks 1901*b*:368. SW
arizonensis Banks 1907*a*:125. *N. syn.*
limnella Ross 1938*a*:179. Ark., Okla.

LITERATURE CITED

Balduf, Walter Valentine

1939. The bionomics of entomophagus insects. Pt. 2. 384 pp., 228 figs. St. Louis.

Banks, Nathan

1894. On a collection of neuropteroid insects from Kansas. Ent. News **5**:178–80.

1895. New neuropteroid insects. Am. Ent. Soc. Trans. **22**:313–6.

1897. New North American neuropteroid insects. Am. Ent. Soc. Trans. **24**:21–31.

1899. Descriptions of new North American neuropteroid insects. Am. Ent. Soc. Trans. **25**:199–218.

1900*a*. New genera and species of Nearctic neuropteroid insects. Am. Ent. Soc. Trans. **26**:239–59.

1900*b*. Papers from the Harriman Alaska expedition. Entomological results (4). Neuropteroid insects. Wash. Acad. Sci. Proc. **2**:465–73, pls. 27–8.

1900*c*. Some insects of the Hudsonian zone in New Mexico: Neuroptera. Psyche **9**:124.

1901*a*. Some insects of the Hudsonian zone in New Mexico: neuropteroid insects. Psyche **9**:286–7.

1901*b*. A list of neuropteroid insects from Mexico. Am. Ent. Soc. Trans. **27**:361–71, pl. 12.

1903*a*. Neuropteroid insects from Arizona. Wash. Ent. Soc. Proc. **5**:237–45. 1 pl.

1903*b*. Some new neuropteroid insects. N. Y. Ent. Soc. Jour. **11**:236–43.

1904*a*. Neuropteroid insects from New Mexico. Am. Ent. Soc. Trans. **30**:97–110. 1 pl.

1904*b*. Two species of Hydroptilidae. Ent. News **15**:116.

1904*c*. Two new species of caddice-flies. Wash. Ent. Soc. Proc. **6**:140–2.

1904*d*. A list of neuropteroid insects, exclusive of Odonata, from the vicinity of Washington, D. C. Wash. Ent. Soc. Proc. **6**(4):201–17.

1905*a*. Descriptions of new species of Nearctic neuropteroid insects from the Black Mountains, N. C. Am. Mus. Nat. Hist. Bul. **21**:215–8.

1905*b*. Descriptions of new Nearctic neuropteroid insects. Am. Ent. Soc. Trans. **32**:1–20. 2 pls.

1907*a*. Descriptions of new Trichoptera. Wash. Ent. Soc. Proc. **8**(3–4):117–33, pls. 8–9.

1907*b*. New Trichoptera and Psocidae. N. Y. Ent. Soc. Jour. **15**:162–6. 5 figs.

1908*a*. Some Trichoptera, and allied insects, from Newfoundland. Psyche **15**(4):61–7, pl. 2.

1908*b*. Neuropteroid insects—notes and descriptions. Am. Ent. Soc. Trans. **34**:255–67, pls. 17–9.

1909. Two new caddice flies. Ent. News **20**:342.

1911. Descriptions of new species of North American neuropteroid insects. Am. Ent. Soc. Trans. **37**(4):335–60, pls. 11–3.

1913. The Stanford Expedition to Brazil: neuropteroid insects from Brazil. Psyche **20**: 83–9. 1 pl.

1914. American Trichoptera—notes and descriptions. Can. Ent. **46**:149–56, 201–5, 252–8, 261–8, pls. 9, 10, 15, 20.

1916. A classification of our limnephilid caddice flies. Can. Ent. **48**:117–22.

1918. New neuropteroid insects. Harv. Univ. Mus. Comp. Zool. Bul. **62**:3–24. 26 figs.

1919. Neuropteroid insects of the Canadian Arctic Expedition 1913–8. Can. Arctic Exp. Report **3**(pt. B):3–5. 1 pl.

1920. New neuropteroid insects. Harv. Univ. Mus. Comp. Zool. Bul. **64**:297–362. 7 pls.

1924. Descriptions of new neuropteroid insects. Harv. Univ. Mus. Comp. Zool. Bul. **65**: 421–55. 4 pls.

1930*a*. Trichoptera from Cape Breton, Nova Scotia. Brooklyn Ent. Soc. Bul. **25**(3):127–32. 10 figs.

1930*b*. New neuropteroid insects from the United States. Psyche **37**:223–33. 15 figs.

1936*a*. Four new Trichoptera from the United States. Arbeiten über Morphologische und Taxonomische Entomologie aus Berlin-Dahlem **3**(4):265–8. 9 figs. Nov. 7.

1936*b*. Notes on some Hydropsychidae. Psyche **43**(4):126–30. 10 figs. Dec.

1938. New native neuropteroid insects. Psyche **45**(1):72–9. 9 figs.

1943. Notes and descriptions of Nearctic Trichoptera. Harv. Univ. Mus. Comp. Zool. Bul. **92**:341–69. 6 pls.

1944. New Neuroptera and Trichoptera from the United States. Psyche **50**(3–4):74–81.

Berthold, A. A.
1827. Natürliche Familien des Thierreichs mit Anmerkungen und Zusätzen. 8+602 pp. (Translation of Latreille 1825.) Weimar.

Betten, Cornelius
1902. The larva of the caddis-fly *Molanna cinerea* Hagen. N. Y. Ent. Soc. Jour. **10**:147–54. 2 figs.
1934. The caddis flies or Trichoptera of New York state. N. Y. State Mus. Bul. **292**. 576 pp., 61 text figs., 67 pls.

Betten, Cornelius, and Martin E. Mosely
1940. The Francis Walker types of Trichoptera in the British Museum. 248 pp., 122 figs. London.

Billberg, Gustav Johann
1820. Enumeratio insectorum in Museo Billberg. 138 pp. Stockholm.

Boheman, Carl Heinrich
1865. (Title unknown.) Ofversigt af Kongl. Vetenskaps-Akademiens Förhandlingar **22**:568.

Brauer, Friedrich
1865. Zweiter Bericht über die auf der Weltfahrt der Kais. Fregatte Novara gesammelten Neuropteren. Kaiserlich-Königlichen Zoologisch-Botanischen Gesellschaft in Wien Verhandlungen **15**:415–22.

Burks, B. D., H. H. Ross and T. H. Frison
1938. An economical, portable light for collecting nocturnal insects. Jour. Econ. Ent. **31**: 317–8. 1 fig.

Burmeister, H. C. C.
1839. Handbuch der Entomologie. Neuroptera, **2**(2):757–1050. Berlin.

Carpenter, F. M.
1933. Trichoptera from the mountains of North Carolina and Tennessee. Psyche **40**:32–47, figs. 1–17.

Chambers, V. T.
1873. Micro-Lepidoptera. Can. Ent. **5**:110–5, 124–8.

Curtis, John
1825. British entomology. **2**:pls. 51–98. London.
1834. Descriptions of some hitherto nondescript British species of mayflies of anglers. London and Edinburgh Philosophical Magazine and Journal of Science **4**:120–5, 212–8.
1835*a*. British entomology. **12**:pls. 530–77. London.
1835*b*. Insects, *in* James Clark Ross' Appendix to John Ross' Narrative of a second voyage in search of a northwest passage. Trichoptera, p. 64.

Dalman, Johann Wilhelm
1819. Några nya insekt-genera, beskrifna. Svenska Vetenskapsakademien Handlingar **40**: 117–27. 8 pls.

DeLong, D. M., and R. H. Davidson
1937. Methods in study and preparation of leafhopper genitalia. Jour. Econ. Ent. **30**:372–4. 1 fig.

Denning, Donald G.
1937. The biology of some Minnesota Trichoptera. Am. Ent. Soc. Trans. **63**:17–43. 45 figs.
1941*a*. Descriptions and notes of new and little known species of Trichoptera. Ent. Soc. Am. Ann. **34**:195–203. 12 figs.
1941*b*. The genus *Grammotaulius* in North America, with the description of a new species (Trichoptera, Limnephilidae). Can. Ent. **73**:232–5. 1 pl.
1942. Descriptions of new Trichoptera from the United States. Can. Ent. **54**:46–51. 6 figs.
1943. The Hydropsychidae of Minnesota (Trichoptera). Ent. Am. **23**:101–71. 41 figs.

Eaton, Alfred Edwin
1873. On the Hydroptilidae, a family of the Trichoptera. London Ent. Soc. Trans. **1873** (2):125–51, pls. 2–3.

Elkins, Winston A.
1936. The immature stages of some Minnesota Trichoptera. Ent. Soc. Am. Ann. **29**:656–81. 6 pls.

Fabricius, Johann Christian
1775. Systema Entomologiae. 30+832 pp. Flensburg and Leipzig.
1781. Species Insectorum. **1**:552 pp. Hamburg.

Frison, Theodore H.
1935. The stoneflies, or Plecoptera, of Illinois. Ill. Nat. Hist. Surv. Bul. **20**:281–471. 343 figs.

Griffin, Laura Hill
1912. New Oregon Trichoptera. Ent. News **23**:17–21, pls. 3–4.

Hagen, Herman A.
1860. Die Phryganiden Pictets nach Typen bearbeitet. Stettiner Entomologische Zeitung **21**:274–90.
1861. Synopsis of the Neuroptera of North America, with a list of the South American species. Smithsn. Inst. Misc. Collect. 347 pp. Trichoptera, pp. 249–98, 328–9.
1864. Phryganidarum synopsis synonymica. Kaiserlich-Königlichen Zoologisch-Botanischen Gesellschaft in Wien Verhandlungen **14**:799–890.
1866. Description of a genus of caddis-flies, of which the larvae construct cases, known as Helicopsyche. Ent. Monthly Mag. **2**:252–5.
1868. Monographie der Gattung *Dasystoma* Rambur. Stettiner Entomologische Zeitung **29**:267–73.
1873. Beiträge zur Kenntnis der Phryganiden. Kaiserlich-Königlichen Zoologisch-Botanischen Gesellshaft in Wien Verhandlungen **23**:377–452.
1875. Report of the Pseudo-Neuroptera collected by Lieut. W. L. Carpenter in 1873 in Colorado. U. S. Geol. Survey Terr. Report for 1873, pp. 571–606.

Harris, Thaddeus William
1869. Entomological correspondence. Edited by S. H. Scudder. 375 pp., 4 pls. Boston.

Kirby, William
1837. Fauna Boreali—Americana. Pt. 4: Insects. Trichoptera, p. 253. London.

Klapálek, Franz
1892. Trichopterologický Výzkum Čech v. r. 1891. Česká akademie císaře Františka Josefa pro védy, slovesnost a umĕní v Praze Rozpravy **5**:1–22.

Kolbe, Herman Jul.
1912. Glazialzeitliche Reliktenfauna im Hohen Norden. Deutsche Entomologische Zeitschrift **7**:33–63.

Kolenati, Friedrich A.
1848. Genera et species Trichopterorum. Pars prior, 108 pp., 3 pls. Moscow.
1859*a*. Systematisches Verzeichniss der dem Verfasser Bekannten Phryganiden und deren Synonymik. Wiener Entomologische Monatschriften, pp. 15–23, 56–9.
1859*b*. Genera et species Trichopterorum. Pars altera, pp. 143–296, 5 pls. Moscow.

Latreille, Pierre André
1829. Les crustacées, les arachnides et les insects, *in* Le règne animal (general series by Cuvier) **5**. 24+556 pp. Paris.

Leach, William Elford
1815. Article "Entomology" in Brewster's Edinburg Encyclopedia **9**(1):52–172.

Ling, Shao-win
1938. A few new caddis flies in the collection of the California Academy of Sciences. Pan-Pacific Ent. **14**(2):59–69.

Linnaeus, Carl von

1758. Systema Naturae. Tenth edition. 826 pp. Stockholm.

Lloyd, John Thomas

1915*a*. Notes on *Ithytrichia confusa* Morton. Can. Ent. **47**:117–21. 1 pl.

1915*b*. Wood-boring Trichoptera. Psyche **22**:17–21, pl. 2, figs. 1–20.

1921. The biology of North American caddis fly larvae. Lloyd Library of Botany, Pharmacy and Materia Medica Bul. **21**:1–124, figs. 1–197.

Martynov, Andreas B.

1914. Die Trichopteren Siberiens und der Angrenzenden Gebiete, III. Apataniinae (Fam. Limnophilidae). St. Pétersbourg Musée Zoologique de l'Académie Impériale des Sciences Annuaire **19**:1–87. 69+3 figs.

1924. Preliminary revision of the family Phryganeidae, its classification and evolution. Annals and Magazine of Natural History, London, series 9, **14**:209–24. 2 figs.

1930. On the trichopterous fauna of China and Tibet. Zoological Society of London Proceedings **1930**:65–112. 71 figs.

McLachlan, Robert

1863*a*. On *Anisocentropus*, a new genus of Trichoptera, with descriptions of five species, and of a new species of *Dipseudopsis*. Entomological Society of London Transactions, series 3, **1**:492–6. 1 pl.

1863*b*. Notes on North American Phryganeidae, with special reference to those contained in the collection of the British Museum. Entomologist's Annual **1863**:155–63.

1864. On the trichopterous genus *Polycentropus* and the allied genera. Entomologist's Monthly Magazine **1**:25–31.

1865. Trichoptera Britannica. A monograph of British species of caddis flies. Entomological Society of London Transactions, series 3, **5**:1–184. 14 pls.

1866. Descriptions of new or little known genera and species of exotic Trichoptera, with observations on certain species described by Mr. F. Walker. Entomological Society of London Transactions, series 3, **5**:247–75. 3 pls.

1867. Bemerkungen über europäische Phryganiden, nebst Beschreibungen einiger neuer Genera und Species. Stettiner Entomologische Zeitung **28**:50–63.

1868. Contributions to a knowledge of European Trichoptera. Entomological Society of London Transactions **1868**:289–308. 1 pl.

1871. On new forms, etc., of extra-European trichopterous insects. Journal of the Linnaean Society of London, Zoology, **11**:98–141. 3 pls.

1874–80. A monographic revision and synopsis of the Trichoptera of the European fauna. Pt. 1, 1874:1–46, pls. 1–5. Pt. 2, 1875:47–108, pls. 6–11. Pt. 3, 1875:109–44, pls. 12–15. Pt. 4, 1876:145–220, pls. 16–23. Pt. 5, 1876:221–80, pls. 24–31, w. supplement I–XII. Pt. 6, 1877:281–348, pls. 32–37. Pt. 7, 1878:349–428, pls. 38–44. Pt. 8, 1879:429–500, pls. 45–51. Pt. 9, 1880:501–23, w. supplement XIII–LXXXIV, pls. 52–59.

1884. A monographic revision and synopsis of the Trichoptera of the European fauna. First additional supplement. 76 pp., 7 pls.

Mickel, Clarence E., and Herbert E. Milliron

1939. Rearing the caddis fly, *Limnephilus indivisus* Walker, and its hymenopterous parasite, *Hemiteles biannulatus* Grav. Ent. Soc. Am. Ann. **32**(3):575–80.

Milne, Lorus J.

1931. Three new Canadian *Prophryganea*. Can. Ent. **63**:228–32. 21 figs.

1934–36. Studies in North American Trichoptera. Pt. 1, 1934:1–19. Pt. 2, 1935:20–55. Pt. 3, 1936:56–128, with 2 pls. Cambridge, Mass.

Milne, Lorus J., and Margery J. Milne

1938. The Arctopsychidae of continental America north of Mexico (Trichoptera). Brooklyn Ent. Soc. Bul. **33**(3):97–110. 3 pls.

Milne, Margery J.

1938. The "metamorphotype method" in Trichoptera. N. Y. Ent. Soc. Jour. **46**:435–7.

1939. Immature North American Trichoptera. Psyche **46**:9–19.

Milne, Margery J., and Lorus J. Milne
1939. Evolutionary trends in caddis worm case construction. Ent. Soc. Am. Ann. **32**(3): 533–42. 1 fig.
1940. A new species of *Rhyacophila*, described from metamorphotypes (Rhyacophilidae: Trichoptera). Brooklyn Ent. Soc. Bul. **35**(5):153–6. 1 pl.

Morton, Kenneth J.
1888. The larva and case of *Ithrytrichia lamellaris* Eaton, with references to other species of Hydroptilidae. Ent. Monthly Mag. **24**:171–5. 7 figs.
1905. North American Hydroptilidae. N. Y. State Mus. Bul. **86**:63–85. 1 text fig. and pls. 13–5.

Mosely, Martin E.
1924. Scent-organs in the genus *Hydroptila*. Entomological Society of London Transactions **1923**:291–4. 2 pls.
1929. Trichoptera and Ephemeroptera of Greenland. Annals and Magazine of Natural History, series 10, **4**:501–9. 6 figs.
1932. Some new African Leptoceridae (Trichoptera). Annals and Magazine of Natural History, series 10, **9**:297–313. 29 figs.
1934*a*. Some new exotic Trichoptera. Stylops **3**:139–42. 13 figs. June 15.
1934*b*. New exotic Hydroptilidae. Royal Entomological Society of London Transactions **82**(1):137–63. 58 figs. June 30.
1937. Mexican Hydroptilidae (Trichoptera). Royal Entomological Society of London Transactions **86**(10):151–90. 37 figs.
1939. The Brazilian Hydroptilidae (Trichoptera). Novitates Zoologicae **41**:217–39. 93 figs.

Müller, Fritz
1878. Sobre as casas constuidas pelas larvas de insectos Trichopteros da provincia de Santa Catharina. Museu Nacional do Rio de Janeiro Archivos **3**:99–134, 209–14, pls. 8–11.
1879. Notes on the cases of some South Brazilian Trichoptera. Entomological Society of London Transactions **1879**:131–144.

Navás, Longinos
1907. Trichópteros nuevos. R. Sociedad española de historia natural Boletín **7**:397–400. 3 figs.
1917. Insecta nova. Accademia Pontificia dei Nuovi Lincei Memorie **3**:22 pp.
1918. Neurópteros nuevos o poco conocidos (Decima serie). R. Academia de Ciencias y Artes de Barcelona Memorias **14**:339–66.
1933. Neurotteri e Tricotteri del "Deutsches entomologisches Institut" di Berlin-Dahlem. Bollettino della Societá Entomologica Italiana **65**:105–13. 8 figs.

Needham, James G.
1902. A probable new type of hypermetamorphosis. Psyche **9**:375–8. 5 figs.

Pictet, François Jules
1834. Recherches pour servir à l'histoire et à l'anatomie des Phryganides. 235 pp., 20 pls. Geneva.
1836. Description de quelques nouvelles espèces de Nevroptères du Musée de Genève. Société de Physique et d'Histoire Naturelle de Genève Mémoires **7**:396–403. 1 pl.

Provancher, M. Abbé
1877. Petite faune entomologique du Canada. Trichoptères. Le Naturaliste Canadien **9**:212–7, 241–4, 257–69.
1878. Additions et corrections aux Nevroptères de la Province de Québec. Le Naturaliste Canadien **10**:124–47, 367–9.

Rambur, J. Pierre
1842. Histoire naturelle des insectes. Nevroptères. 17+534 pp., 12 pls. Paris.

Ross, Herbert H.
1938*a*. Descriptions of Nearctic caddis flies (Trichoptera) with special reference to the Illinois species. Ill. Nat. Hist. Surv. Bul. **21**(4):101–83. 123 figs.
1938*b*. Descriptions of new leptocerid Trichoptera. Ent. Soc. Am. Ann. **31**(1):88–91. 8 figs.

1938*c*. Lectotypes of North American caddis flies in the Museum of Comparative Zoology. Psyche **45**(1):1–61. 10 pls.
1938*d*. Descriptions of new North American Trichoptera. Wash. Ent. Soc. Proc. **40**(5):117–24. 2 pls.
1939*a*. New species of Trichoptera from the Appalachian Region. Wash. Ent. Soc. Proc. **41**(3):65–72. 11 figs.
1939*b*. Three new species of Nearctic Trichoptera. Ent. Soc. Am. Ann. **32**(3):628–31. 3 figs.
1941*a*. New species of Trichoptera from Canada and northern United States. Can. Ent. **73**(1):15–9. 1 pl.
1941*b*. Descriptions and records of North American Trichoptera. Am. Ent. Soc. Trans. **67**(1084):35–126. 13 pls.

Say, Thomas
1823. Descriptions of insects belonging to the order Neuroptera Linné and Latreille, collected by the expedition under the command of Major Long. West. Quart. Report **2**:160–5. Cincinnati.
1824. From the narrative of the expedition to the source of the St. Peter's River, etc., under the command of Stephen H. Long, Major U. S. T. E., **2**:268–378. Philadelphia.
1828. American entomology, or descriptions of the insects of North America. **3**, pls. 37–54. Philadelphia.

Sibley, Charles K.
1926*a*. New species of New York caddis flies. N. Y. Ent. Soc. Jour. **34**:79–81.
1926*b*. Trichoptera, *in* A preliminary biological survey of the Lloyd-Cornell Reservation. Lloyd Library of Botany, Pharmacy and Materia Medica Bul. **27** (Ent. series 5):102–8, 185–221, pls. 8–13.

Stephens, James Francis
1829. A systematic catalogue of British insects. Pt. 1. 416 pp. London.
1836–37. Illustrations of British entomology, **6**:146–234.

Thomson, C. G.
1891. Bidrag till Phryganeernas systematik och synonymi. Opuscula Entomologica **15**:1537–1600.

Tjeder, Bo
1930. *Ithytrichia lamellaris* Eat. and *clavata* Mort. in Dalecarlia. Entomologisk Tidskrift **51**:134–8. 2 pls.

Ulmer, Georg
1902. Trichopterologische Beobachtungen aus der Umgegend von Hamburg. Stettiner Entomologische Zeitung **63**:360–67, 384–7. 2 pls.
1905*a*. Zur Kenntnis aussereuropäischer Trichopteren. Stettiner Entomologische Zeitung **66**:1–119.
1905*b*. Neue und wenig bekannte aussereuropäische Tricopteren, hauptsächlich aus dem Wiener Museum. Naturhistorischen Hofmuseums Wien Annalen **20**:59–98. 75 figs.
1906*a*. Neuer Beitrag zur Kenntnis aussereuropäischer Trichopteren. Leyden Museum Notes **28**:1–116. 114 figs.
1906*b*. Uebersicht über die bisher bekannten Larven europäischer Trichopteren. Zeitschrift für Wissenschaftlichen Insekten-Biologie **2**:111–7, 162–8, 209–14, 253–8, 288–96.
1907*a*. Trichoptera. Catalogues de Collections Zoologiques du Baron Edm. de Selys Longchamps **6**(1):1–102. 4 pls., 132 figs.
1907*b*. Trichoptera. Genera Insectorum **60**. 259 pp., 41 pls.
1909. Trichoptera. Die Süsswasserfauna Deutschlands, **5–6**. 326 pp., 467 figs.
1912. Die Trichopteren des baltischen Bernsteins. Beiträge zur Naturkunde Preussens, Königsberg **10**. iv+380 pp.

Vorhies, Charles T.
1909. Studies on the Trichoptera of Wisconsin. Wis. Acad. Sci. Trans. **16**:647–738, pls. 52–61.

Walker, Francis
1852. Catalogue of the specimens of neuropterous insects in the collections of the British Museum. Pt. 1, 192 pp. London.

Wallengren, H. D. J.
1880. Om Skandinaviens arter af familjen Phryganeidae. Entomologisk Tidskrift **1**:64–75.
1886. Skandinaviens arter af Trichopter-Familjen Apataniidae. Entomologisk Tidskrift **7**:73–80.
1891. Skandinaviens Neuroptera. Andra afdelningen. Svenska Akademien Handlingar **24**(10): 173 pp.

Westwood, John Obadiah
1840. An introduction to the modern classification of insects. Generic synopsis, **2**:49–51. London.

Zetterstedt, Johann Wilhelm
1840. Insecta Lapponica; sectio quinta. Neuroptera, 1025–74. Leipzig.

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A.—ILLINOIS NATURAL HISTORY SURVEY BULLETIN.

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Volume 21, Article 4.—Descriptions of Nearctic Caddis Flies (Trichoptera), with special reference to the Illinois species. By Herbert H. Ross. March, 1938. 84 pp., frontis. + 123 figs., foreword, index. $1.00.

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BULLETIN
of the
ILLINOIS NATURAL HISTORY SURVEY
THEODORE H. FRISON, *Chief*

Duck Populations and Kill

An Evaluation of Some Waterfowl Regulations in Illinois

FRANK C. BELLROSE, Jr.

Printed by Authority of the
STATE OF ILLINOIS
DWIGHT H. GREEN, *Governor*

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NATURAL HISTORY SURVEY DIVISION
THEODORE H. FRISON, *Chief*

Volume 23 | BULLETIN | Article 2

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Duck Populations and Kill

An Evaluation of Some Waterfowl Regulations in Illinois

FRANK C. BELLROSE, JR.

ONLY after a wildlife regulation has been in force for a number of years is it possible to evaluate its total effect. To check depletion of the duck population of North America, several new waterfowl hunting regulations and drastic modifications of existing regulations were inaugurated in the United States and Canada during the 1930's. It is evident to all now that the added restrictions, combined with increased waterfowl productivity resulting largely from greater precipitation on the breeding grounds and a program of habitat restoration, swung the duck population pendulum upward. Populations have made a noticeable comeback since the low ebb of 30,000,000 ducks estimated for 1934, and, as duck numbers have increased, some of the waterfowl regulations have been relaxed.

Demands for abolishing certain regulations and relaxing others have increased in tempo with mounting waterfowl numbers. Some sportsmen desire the return of decoys, others want to use bait and still others would like to see larger bag limits and longer seasons. What effect might the relaxing of each or all of the existing regulations have on the duck kill? With an army of almost 1,500,000 hunters pursuing waterfowl in the United States, an unwise loosening of restrictions might halt, if not actually cause a decline in, waterfowl on the comeback trail.

The U. S. Fish and Wildlife Service through its flyway biologists, its co-operative waterfowl observers, its refuge personnel and game agents, and its midwinter inventory of the population annually ascertains the status of the continent's waterfowl population (Gabrielson & Lincoln 1941). Cottam (1935) and Pirnie (1935) have studied and discussed the broad aspects of the influence of gunning practices and waterfowl regulations. But little has been done to evaluate each of the various regulations employed to limit the waterfowl kill.

This paper was conceived and written in an attempt to evaluate the effect of various hunting regulations on the kill of ducks in Illinois, and to ascertain the optimum dates for Illinois hunting seasons of various lengths.

Acknowledgments

The writer of this paper is indebted to Messrs. Homer Bradley and Milfred J. Smith of the U. S. Fish and Wildlife Service stationed at the Chautauqua National Wildlife Refuge, Havana, Illinois, for their co-operation in making censuses on that refuge. He appreciates the constructive criticisms of the manuscript by Dr. Clarence Cottam and Messrs. Cecil Williams and Robert H. Smith of the U. S. Fish and Wildlife Service. Mr. Ferd Luthy of Peoria not only provided helpful suggestions on the study but furnished kill records of the Duck Island Preserve dating back to 1885. Dr. Ralph E. Yeatter and Dr. David H. Thompson of the Illinois Natural History Survey furnished unpublished data they compiled from the Duck Island Preserve kill records. Dr. Thompson also aided the writer in the statistical analyses of duck population and kill data. Miss Eleanor G. Wolff, Assistant Technical Editor of the Survey, aided in compiling

the history of waterfowl regulations. Grateful appreciation is due to Mr. Bob Becker, writer on wildlife, for photographs used for the frontispiece and five other halftones. The frontispiece pictures sunrise on a bayou along the Illinois River, as seen from a duck blind. Appreciation is due also to Mr. Arthur S. Hawkins for his encouragement, which he has continued even while on leave for military service.

Legal Protection

Written laws establishing closed seasons on waterfowl date back at least to Henry VIII of England. In the year 1533 his government decreed partial protection for waterfowl "between the last Day of May and the last Day of August" and, beginning in 1534, full protection for their eggs "from the first Day of March . . . . unto the last Day of June then next ensuing" (Anonymous 1770). As early as 1846 in the United States, Rhode Island passed a law prohibiting spring shooting of certain waterfowl (Palmer 1912). Although this law was later repealed, by 1900 in 9 states, or the territory now covered by them, all spring shooting had been abolished, and in 38 some form of legal protection for migratory waterfowl had been passed. By 1918 the number of states prohibiting all spring shooting had increased to 31, and only 3 states afforded no legal protection whatever for waterfowl (Lawyer 1918).

Up to 1913, no important waterfowl hunting regulations had been enacted by the federal government except in relation to territories. Although many attempts had been made by conservationists to establish uniformity in the laws among different groups of states, very little had been accomplished. Finally, a federal law known as the Migratory Bird Act, placing birds that regularly migrate beyond state limits under the protection of the federal government, was passed and made effective in 1913. In 1916, a treaty was signed with Canada, which, besides covering certain migratory non-game birds, provided for limited open seasons on migratory game birds. The Migratory Bird Treaty Act, making this treaty effective in the United States, was passed in 1918. Regulations issued in conformity with this act then and since then over a period of years include a reduction in the length of season, in bag limit, daily shooting hours and number of shells in gun; prohibition of the use of bait and live decoys; the placing of some species under complete protection, and others under special protection by limiting the number taken.

Regulations for Illinois

The principal federal waterfowl regulations that apply to Illinois relate to open season, shooting hours, bag limit, the increased or complete protection of certain species, use of bait and live decoys, and number of shells in gun.

Open Season.—Changes in the length of the waterfowl hunting season in Illinois from 1900 through 1944 are shown in fig. 1. The long open season on waterfowl prevailing throughout the nation until enactment of the federal Migratory Bird Act is indicative of the desire of state legislators to get for the hunters of their respective states as many birds as possible before their passage into other states. "The fact that seasons and bag limits on migratory birds have remained so much more liberal than seasons on resident game," states Leopold (1933), "strongly substantiates the assertion . . . . that people can be induced to conserve what stays on their own land, but only the exceptional individual will voluntarily conserve what he shares with the community at large." In 1913, through federal regulations, the Illinois waterfowl hunting season was shortened from 225 days to 105 days and from that time until the drastic cut of 1931 the length of the waterfowl seasons changed little.

Information on hunting seasons and other federal waterfowl regulations as they applied to Illinois from 1929 through 1944 are given in table 1. Even for seasons of the same length, there were various opening and closing dates. A 30-day open season extended through November in 2 years, from October 21 through November 19 in another year. A season of 45 days extended from October 15 through November 28 in 1938 and from October 22 through December 5 the following year. In 1934 a season having rest days or lay days was permitted; states were given the option of having 30 shooting days run consecutively or at intervals over a period not to exceed approximately 3½ months. Only two states selected a season of 30 consecutive days. A few states chose a season of 5 days a week for 6 weeks and a few 2 days a week for 15 weeks; 30 states chose a season of 3 days a week for 10 weeks. Illinois chose 2 days a week, October 6–January 13. According to More Game Birds in America, a sportsmen's organization that has since disbanded, in the 48 states there were 21 different combinations of shooting days and 17 different opening and closing dates (Anonymous 1936).

The Migratory Bird Act of 1913 empowered the Secretary of Agriculture to prescribe and fix closed seasons on waterfowl, "having due regard to the zones of temperature, breeding habits, and times and line of migratory flight." The Migratory Bird Treaty Act of 1918 in granting similar powers included references to "zones of temperature," and "times and lines of migratory flight" with respect to the hunting of migratory birds.

The 1913 regulations divided the United States into two zones with respect to closed seasons, a northern "breeding zone" and a southern "wintering zone," but within the zones made several local exceptions to the general dates established for these zones. For the next few years, numerous variations in the dates of hunting seasons were tried. In 1918, four zones, on the basis of opening dates, were established. In 1935, the states were grouped into two zones, with the open season October 21 through November 19 for the northern zone and November 20 through December 19 for the southern zone. In 1936, three zones were established, with the hunting season October 10 through November 8 for the northern zone, November 1 through November 30 for the central zone and November 26 through December 25 for the southern zone. These zones followed closely the zones of temperature as determined from records of the U. S. Weather Bureau. In most instances zones were established along state lines and thus kept at a minimum the confusion and

Fig. 1.—Length of the waterfowl hunting seasons in Illinois, 1900–1943. The length was determined in some years by state law and in others by federal regulations.

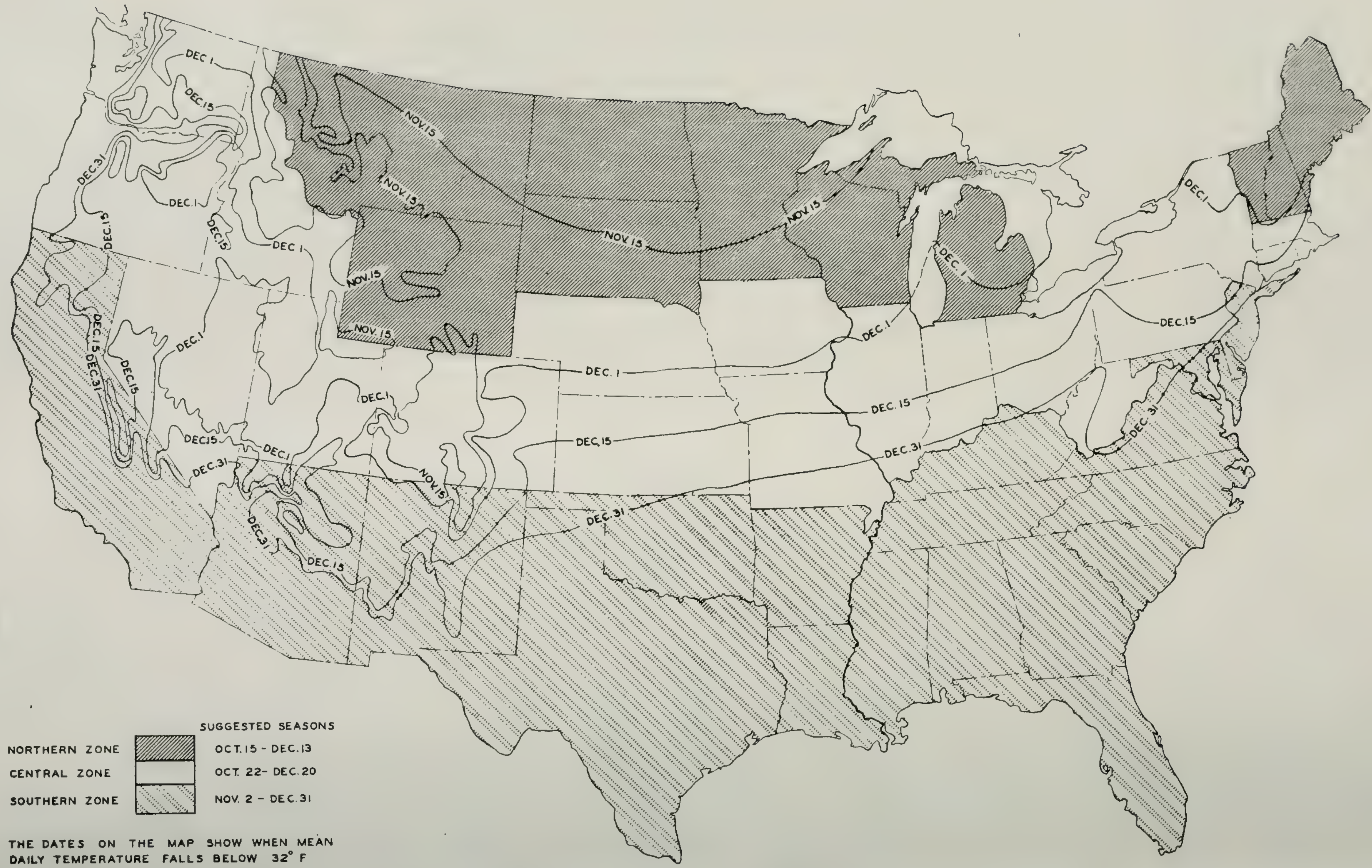

Fig. 2.—Separation of the United States into three waterfowl hunting zones, as advocated by More Game Birds in America, 1936. Zones are based U. S. Weather Bureau records over a period of about 46 years. Date lines show when the mean daily temperature drops below 32 degrees F.

the difficulty of law enforcement that are apt to arise when a single state lies in two or more zones.

More Game Birds in America, after objecting to drastic year-to-year changes in waterfowl regulations, proposed in 1936 to standardize these regulations and to divide the nation into three definitely prescribed hunting zones (Anonymous 1936). The criterion for placing states in the various prescribed zones (as well as for establishing the opening and closing dates of a 60-day season for each zone) was temperature records reported by the U. S. Weather Bureau over a period of about 46 years. This foundation proposed a season from October 15 through December 13 for the northern zone; October 22 through December 20 for the central zone; and November 2 through December 31 for the southern zone.

Fig. 2 shows the zoning of the United States as proposed by More Game Birds in America and average dates on which the mean daily temperature falls below 32 degrees F. The report of this organization (Anonymous 1936) contains the following: "It . . . . is reasonable to state that the bulk of our wild ducks and geese migrate with the annual sweep of Old Boreas from the north to the south. And it is equally reasonable to assume that open seasons, based on the average freezing or 'freeze-up' dates in various sections of the country, provide a far sounder basis for fixing open seasons than arbitrary dates set by human decision and subject to political or other pressure."

Recent federal regulations have arranged the states, with minor exceptions, into zones similar to those shown in fig. 2. In the 1943 regulations, Iowa, Ohio and Pennsylvania were in the northern zone instead of the central, as in fig. 2; and California, Kentucky, New Jersey and Oklahoma in the central instead of the southern zone. In 1942, Iowa and Pennsylvania had been in the central zone and, in 1940, Ohio also had been in the central zone. Other

Table 1.—Federal duck hunting regulations as they applied in Illinois, 1929–1944.

Year	Open Season, Dates Inclusive	Days	Bag	Possession	Time*	Live Decoys	Bait	Miscellaneous
1929	Sept. 24–Jan. 7	106	25†	Undefined†	a	Yes	Yes	
1930	Sept. 24–Jan. 7	106	15	30	a	Yes	Yes	
1931	Nov. 1–Nov. 30	29½	15	30	a	Yes	Yes	Season opened at noon
1932	Oct. 16–Dec. 15	60½	15	30	a	25 limit	Yes	Season opened at noon
1933	Oct. 16–Dec. 15	60½	12	24	a	25 limit	Yes	Season opened at noon
1934	Oct. 6–Jan. 13‡	30	12	24	b	25 limit	By permit	Duck stamp
1935	Oct. 21–Nov. 19	30	10	10	c	No	**	Duck stamp; 3-shell law
1936	Nov. 1–30	30	10	10	c	No	No	Same as for 1935
1937	Nov. 1–30	30	10	10	c	No	No	Same as for 1935
1938	Oct. 15–Nov. 28	45	10	20	c	No	No	Same as for 1935
1939	Oct. 22–Dec. 5	45	10	20	c	No	No	Same as for 1935
1940	Oct. 16–Dec. 14	60	10	20	d	No	No	Same as for 1935
1941	Oct. 16–Dec. 14	60	10	20	d	No	No	Same as for 1935
1942	Oct. 15–Dec. 23	70	10	20	e	No	No	Same as for 1935
1943	Oct. 15–Dec. 23	70	10	20	a	No	No	Same as for 1935
1944	Oct. 14–Jan. 1	80	10–15††	20–30††	a	No	No	Same as for 1935

*Shooting hours:
a. One-half hour before sunrise to sunset.
b. Sunrise to sunset, except that in 1934 on baited grounds closing time was 3 P.M., Central Standard Time.
c. 7 A.M. to 4 P.M., Central Standard Time.
d. Sunrise to 4 P.M.
e. Sunrise to sunset.

†Illinois law specified bag limit 15, possession 60.

‡Thirty days within the period October 6–January 13 (Illinois chose Saturdays and Sundays). Baiting was allowed only if a permit had been obtained from the U. S. Bureau of Biological Survey.

**Baiting prohibited but law so interpreted as to allow feeding on parts of premises not shot over.

††Bag limit 10 plus 5 mallards, widgeons or pintails; possession limit 20 plus 10 mallards, widgeons or pintails.

borderline states have been shifted from one zone to another from time to time. Hunters in certain borderline states prefer to have their states in the northern zone because of the later opening date in the central zone.

Recent shifts in the populations of various waterfowl species and the variety of experiments in setting the dates and lengths of the waterfowl hunting seasons suggest a need for additional information on the seasonal waterfowl flight and kill in various sections of the country. If lowered waterfowl populations necessitate shortening of the shooting season, it is important to adjust the open season to a time that favors any endangered species and yet furnishes hunting that is as good as possible under the circumstances. On the other hand, if increases in the waterfowl populations seem to justify a lengthening of the shooting season, it is equally important to adjust the dates to place the greatest pressure on the species that can best withstand increased shooting.

Shooting Hours.—The Migratory Bird Act regulations of 1913 provided that there be no waterfowl hunting between sunset and sunrise. The Migratory Bird Treaty Act regulations of 1918 stipulated shooting hours of one-half hour before sunrise to sunset. Since 1918, shooting hours have changed from time to time upon recommendation of the Secretary of Agriculture, 1918 through June 30, 1939, and the Secretary of the Interior, July 1, 1939, to date. Table 1 gives the changes in shooting hours from 1929 to the present. They have gone through a complete cycle: from one-half hour before sunrise to sunset, then from sunrise to sunset, from 7 A.M. to 4 P.M., from sunrise to 4 P.M., again from sunrise to sunset, and finally, in 1943 and 1944, from one-half hour before sunrise to sunset.

Bag Limit.—Legal restrictions on the take of waterfowl have been in operation since 1887 (Palmer 1912), when the federal government limited the number of ducks that could be taken per day in the Dakota Territory to 25. Illinois did not have a duck bag limit until 1903, when the number of ducks taken by a shooter in a day was limited to 50. In 1905, the Illinois limit was lowered to 35 per day; in 1907 to 20; and in 1909 to 15. From 1918 through 1929, federal regulations limited the daily bag to 25. During those years the Illinois bag limit remained at 15, 10 under the federal limit. In 1930 the federal limit became 15, and since then the Illinois bag limit has conformed to the federal limit: in 1930 and the 2 following years it was 15; in 1933 and 1934 it dropped to 12 per day; from 1935 to date it has been 10 per day, except that in 1944 five additional mallards, widgeons or pintails could be taken. As the nation's waterfowl supply dwindled, bag limits were reduced in an effort to restrict the kill.

Favoring Depleted Species.—Regulations authorized by the Migratory Bird Act of 1913 placed a 5-year closed season on swans, certain other migratory game birds and, in a number of states, wood ducks. The Migratory Bird Treaty Act of 1918 in giving effect to the Treaty of 1916 extended the closed season on swans and placed a closed season on wood ducks for at least 5 years in all states. The protection has been extended but in recent years somewhat altered. Commencing in 1932, several other species have been given increased or complete protection. Ruddy ducks and buffleheads could not be taken legally from 1932 through 1937; canvasbacks and redhead ducks were placed on the closed list in 1936 and 1937. There was, in 1932, a daily limit of not more than 10 of any one, or in the aggregate of two or more, of the following species: canvasback, redhead, greater scaup, lesser scaup, ring-neck, blue-winged teal, green-winged teal, cinnamon teal, shoveler and gadwall. (Scientific names of duck species common in Illinois are listed in table 12.) In 1933 not more than eight alone or in the aggregate of the above named species could be taken, and in 1934 not more than five alone or in the aggregate. In 1938, 1939 and 1940, it was permissible to take three alone or in the aggregate of ruddy, bufflehead, redhead and canvasback ducks. In 1941, 1942 and 1943, this limit was left on the redheads and buffleheads but removed from the others. In 1944, it was removed from redheads and buffleheads. In 1941, one wood duck could be taken in 15 states. The 1942 and 1943 regulations permitted throughout the nation one wood duck in each hunter's daily bag or in his possession. The 1944 regulations on wood ducks were the same except that in South Dakota and Massachusetts no wood ducks could be taken.

Bait and Live Decoys.—The first Illinois restriction on the employment of bait to attract waterfowl dates back to a state law effective in 1909. This was repealed in 1911, and it was not until federal regulations prohibited baiting in 1935 that this method of enticing ducks to a shooting stand was again illegal. In 1934 it was necessary to secure a permit from the federal government to employ bait; a federal regulation prohibited the use of bait in 1935, but it was interpreted to permit feeding on one section of the premises if the shooting stand was sufficiently remote to allow birds free access to the feed without being shot at. The regulation was so worded the next year as to prohibit feeding under any shooting conditions.

Prior to 1900, baiting was almost unknown in Illinois. The consensus of old-time duck hunters is that baiting of ducks began in the early 1900's in the bottoms of the Sangamon River, near the confluence of this river with the Illinois. It seems to have started there because diversion of water from Lake Michigan resulted in raised water levels in the Illinois River valley that brought about a paucity of native duck foods in the Sangamon bottoms.

From the mouth of the Sangamon, the practice of employing bait to attract ducks spread up and down the Illinois River bottomlands; by the 1920's it was widespread throughout most of the valley. In the early 1920's, it was discovered that bait placed on the uplands in Mason County would attract ducks. Soon baited areas with pens of decoys dotted the sand hills of that area.

Live decoys were limited by federal regulations to 25 in 1932, 1933 and 1934; they have been prohibited since that time.

Three-Shell Limit.—Beginning in 1935, federal regulations have prohibited the taking of migratory game birds with a shotgun capable of holding more than three shells at any one loading.

Evaluating Regulations

The seasonal chronology of the flight of the more important duck species in Illinois was determined from censuses made by the author in the Illinois River valley from Bureau to Meredosia, a distance of 140 miles, each week, 1938–1942, figs. 3–15. Fortunately, the Illinois River waterfowl habitat consists of open lakes, averaging about 1,000 acres each, which are readily accessible to observers and many of which can be viewed from bluffs or other high points. It is the belief of Robert H. Smith, Mississippi Flyway Biologist of the U. S. Fish and Wildlife Service, that these circumstances make it possible to census waterfowl in the Illinois River valley more quickly and with a greater degree of accuracy than in any other region of comparable size in the nation.

It is popularly supposed that the larger the flock or raft of resting ducks, the greater is the error in the estimate of its numbers. However, in my opinion, the reverse is more likely to be true, for the larger the flock size the smaller is the per cent of error in the measurement of its surface. The basis for making estimates used by the U. S. Fish and Wildlife Service (one duck per square yard minus one-third for gaps) applies as well to large rafts as to small flocks.

The duck kill data in this paper were taken from the records of duck clubs. The game code of Illinois requires that all waterfowl clubs report the kill, by species, for each day and for each hunter. There has been an average of about 700 waterfowl clubs in Illinois during recent years. In the Illinois River valley, clubs own about 90 per cent of the hunting land. Printed forms to record the kill are provided clubs by the State Department of Conservation. Many clubs recorded their kill for years before being required to do so. Club records are the most nearly complete ones available for a long period of time.

Banding data, as well as kill records,

offer a means of determining comparative mortality rates among waterfowl by species or by years. The ratio of the number of first-year returns (bands recovered before the beginning of the hunting season next after banding) to the number of birds banded gives a comparative, if not quite accurate, measure of mortality. The actual hunting mortality among waterfowl is higher than that indicated by band returns, for a recent study made by the writer revealed that Illinois hunters report only about two-thirds of the bands taken.

Of about 30,000 ducks banded by the Illinois Natural History Survey, only three species—mallard, black duck and pintail—are in significant numbers. The banding data we have obtained can be used to compare mortality rates for each of these three species from year to year, but, because of the few species banded, we cannot employ such data to compare mortality rates among all the species of ducks in Illinois.

To determine the optimum dates for the open duck season in Illinois, it is necessary first to evaluate the vulnerability to hunting of each important species and the shooting pressure placed upon it. Because the ducks banded in Illinois do not include all species in significant numbers, we have not used banding data but have compared the Illinois kill of each principal species with its Illinois population during the open season to determine its vulnerability to hunting in relation to the vulnerability of other species. The term *vulnerability*

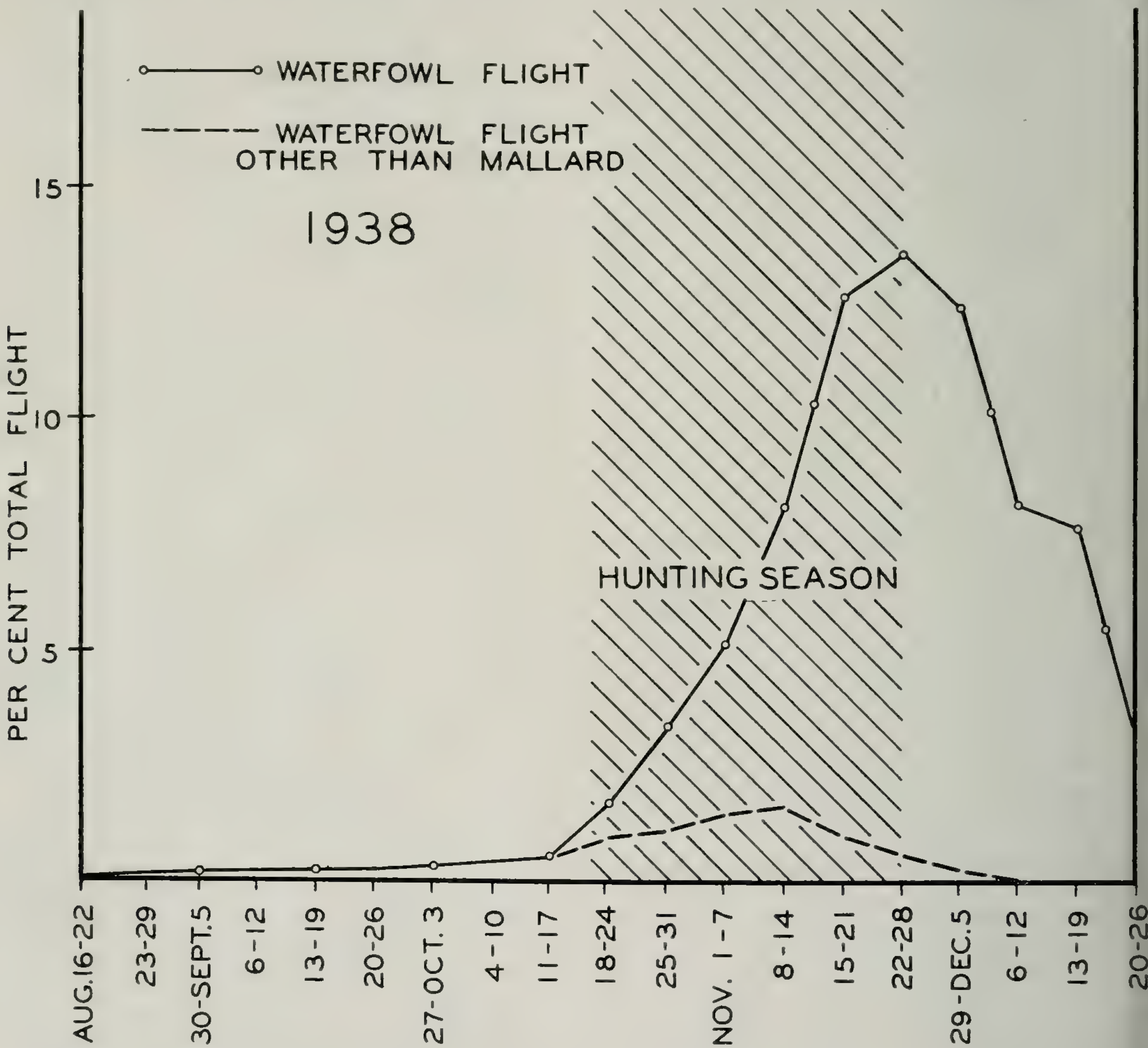

Fig. 3.—Chronology of flight of all duck species, and species other than mallard, in relation to the hunting season in the Illinois River valley, 1938.

quotient is given to the ratio that exists between the percentage a species contributes to the duck bag and the percentage that species makes of the duck

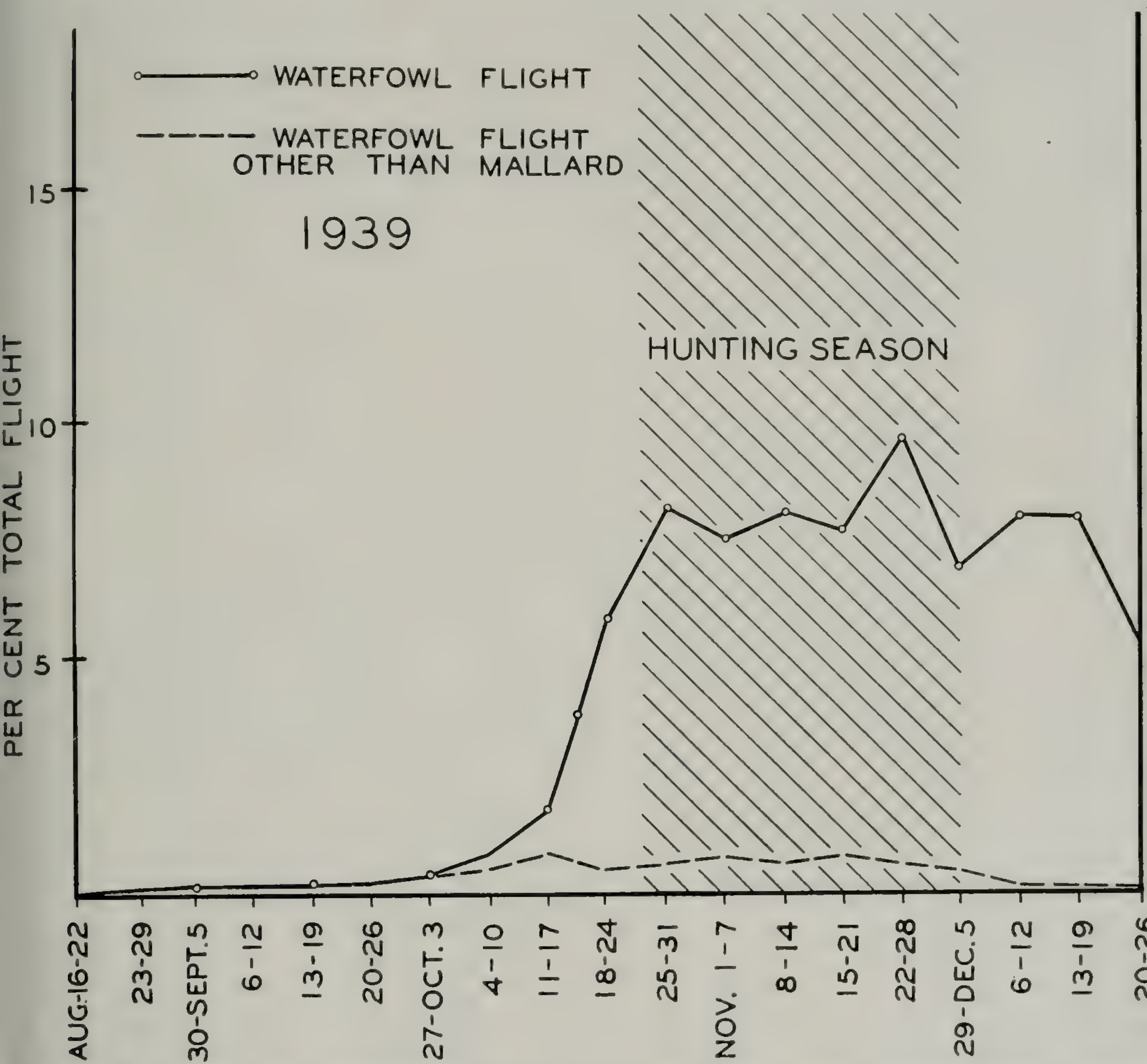

Fig. 4.—Chronology of flight of all duck species, and species other than mallard, in relation to the hunting season in the Illinois River valley, 1939.

flight during the *open season.* For example, the pintail, which for a 5-year period contributed 9.65 per cent of the total Illinois bag, comprised 1.17 per cent of the total Illinois flight during the open season. The vulnerability quotient for this period is 9.65 divided by 1.17, or 8.25, table 2. This quotient, when compared with vulnerability quotients for other ducks, may be considered as a relative measure of the killability of the pintail, or the relative ease or difficulty with which it is bagged.

The relationship of the bag for any species to the *entire fall flight* of that species also is necessary in determining optimum dates for the hunting season. This relationship is expressed by a *mortality quotient,* which is similar to the vulnerability quotient except that it takes into account a longer period of migration, tables 2–7. It is a measure of the shooting pressure placed upon a species by its vulnerability and its chronology of migration in relation to the hunting season.

The comparative influence on each principal duck species of changes in the hunting season may be obtained by finding the ratio of the mortality quotient to the vulnerability quotient. A numerical expression of this relationship, obtained by dividing the mortality quotient by the vulnerability quotient, is termed the *shooting pressure quotient,* tables 2 and 8. In this figure, vulnerability differences between the species are partially or entirely nullified, and a measure is derived for the influence of the open season. The shooting pressure quotient can be changed for any species by altering the opening or closing dates of the season.

The relative vulnerability, or killability, of species is summarized for a 5-year period, 1938–1942, in table 2. A period of this length, rather than a shorter period, was used because we believe there is little difference from year to year in the inherent wariness, or in the flight, flocking and feeding habits, changed materially from year to year in the period 1938–1942.

Vulnerability of Species

Because of variations in habits, species of ducks differ in their likelihood of being killed by hunters. Species differ in inherent wariness. Food habits influence the killability of species; preference for a certain food may entice one kind of duck into heavily gunned areas, while another kind remains in open water, out of reach of hunters. Flocking habits also influence the vulnerability

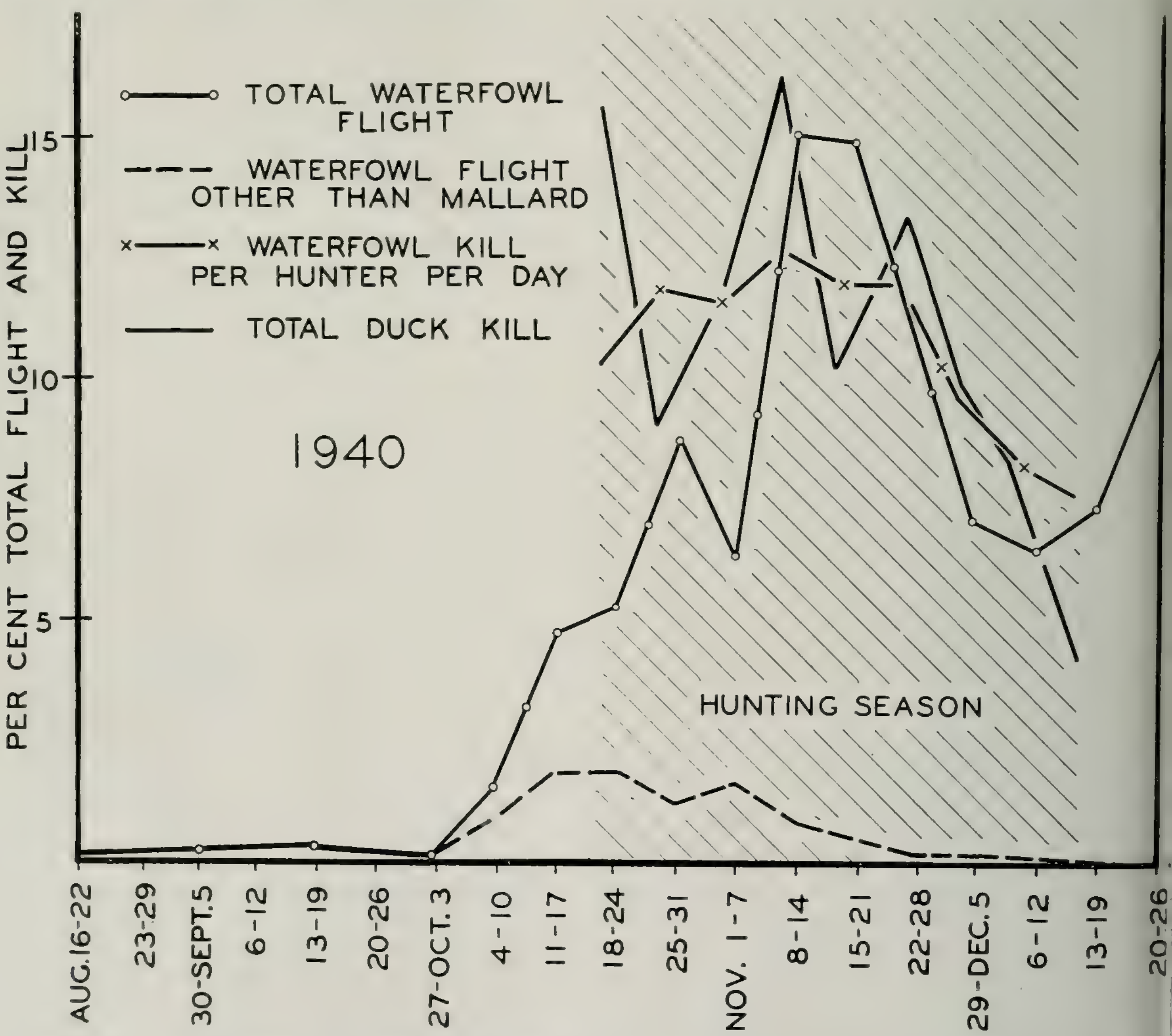

Fig. 5.—Chronology of flight of all duck species, and species other than mallard, bag per hunter per day and total daily duck kill (weekly averages expressed as per cent of yearly total) in the Illinois River valley, 1940.

of a given species. However, in evaluating the comparative mortality of duck species, we used yearly data, tables 3–7, because the hunting regulations and chronology of migration—which may greatly influence the kill of a species— of species, for, generally, singles are more readily decoyed than a flock of 10, which in turn is more readily decoyed than a flock numbering 100. As figs. 5–7 show, the greater the concentration of ducks, under ordinary conditions, the smaller is the percentage of ducks likely to be killed. A flock of 1,000 mallards or bluebills passing over a blind is unlikely to have many more individuals killed from it than a flock numbering only 10 or 100, for after the first shot the individuals left are warned and have an opportunity to swing or climb out of range. Experienced duck hunters usually refrain from shooting into large flocks, for they know such shooting "educates" ducks to avoid the area from which the shots have been fired.

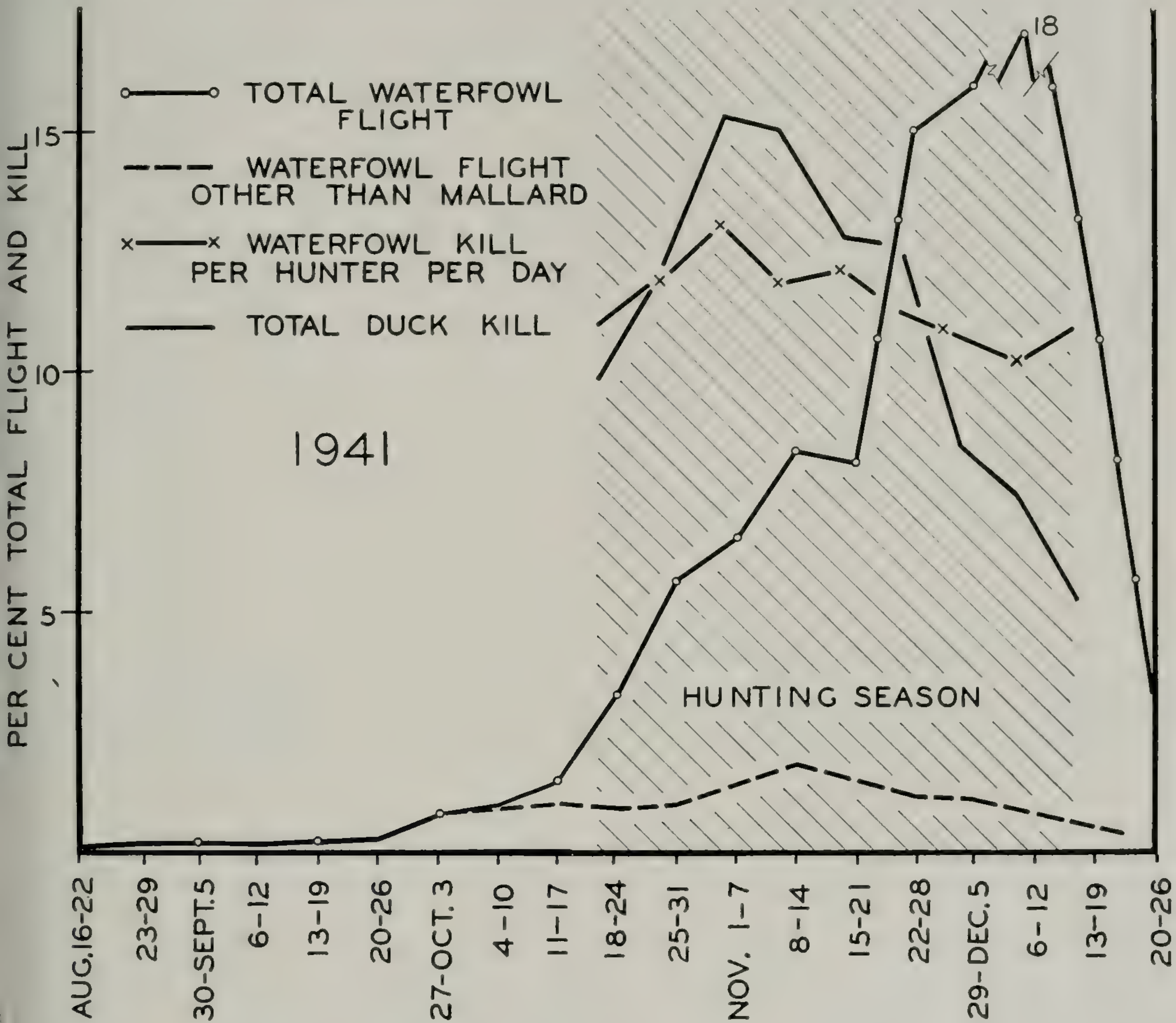

Fig. 6.—Chronology of flight of all duck species, and species other than mallard, bag per hunter per day and total daily kill (weekly averages expressed as per cent of yearly total) in the Illinois River valley, 1941.

Of all kinds of Illinois ducks, mallards and black ducks, considered together, were found through this study to be the least vulnerable to hunting, table 2. In sporting circles, many heated debates have arisen over the question of whether the mallard, the black duck or the pintail is the wariest of our ducks. While many instances can be cited favoring each species, veteran duck hunters generally give the edge to the pintail. However, in Illinois, the flocking and feeding habits of mallards and black ducks are such that a much lower percentage of the flight is killed.

Mallards and black ducks now frequent the open waters of large lakes much of the day and night during the fall migration season in Illinois. Near sunset or before sunrise, they wing high overhead to feed in cornfields. Pintails obtain most of their food from small-seeded plants growing in marshes and along the edges of lakes. In seeking this food, they generally come within gun range much more frequently than do mallards. The mallard habit of concentrating by the tens of thousands on about a dozen large lakes of the Illinois River valley results in a lower proportional kill than if the population were more evenly distributed over more areas and in smaller flocks, as in the case of the pintail.

Widgeons and gadwalls were taken in the years of this study more readily than were pintails by Illinois hunters, table 2. These "gray ducks" feed principally on coontail (*Ceratophyllum demersum*) in Illinois, and, in most instances, this plant reaches peak development in the ponds and potholes of river bulrush (*Scirpus fluviatilis*) marshes. Widgeons and gadwalls consequently chance to come within range of hunters frequently, and, while they may not respond to calling and decoys as readily as do mallards or pintails, the "gray ducks," once they decide to decoy, approach with much less caution.

Blue-winged and green-winged teals were killed in greater proportion to numbers present than was either species of "gray ducks," table 2. Teals, which feed extensively on the seeds of smartweeds (*Polygonum* spp.), nutgrasses (*Cyperus* spp.) and other small-seeded plants, spend much time along the edges of marshes and lakes. While teals are fast and erratic flyers, and are thereby responsible for more misses than most of the other species, they are very unwary. They decoy readily, often with no more than a half circle to the blocks, and frequently return after being shot at. Kortright (1942) says that their habit of flying in a dense, closely bunched flock renders them very vulnerable to the fire of the gunner, and two or more birds will often fall from a single shot. They are easily killed when hit.

Shovelers, or spoonbills, were found

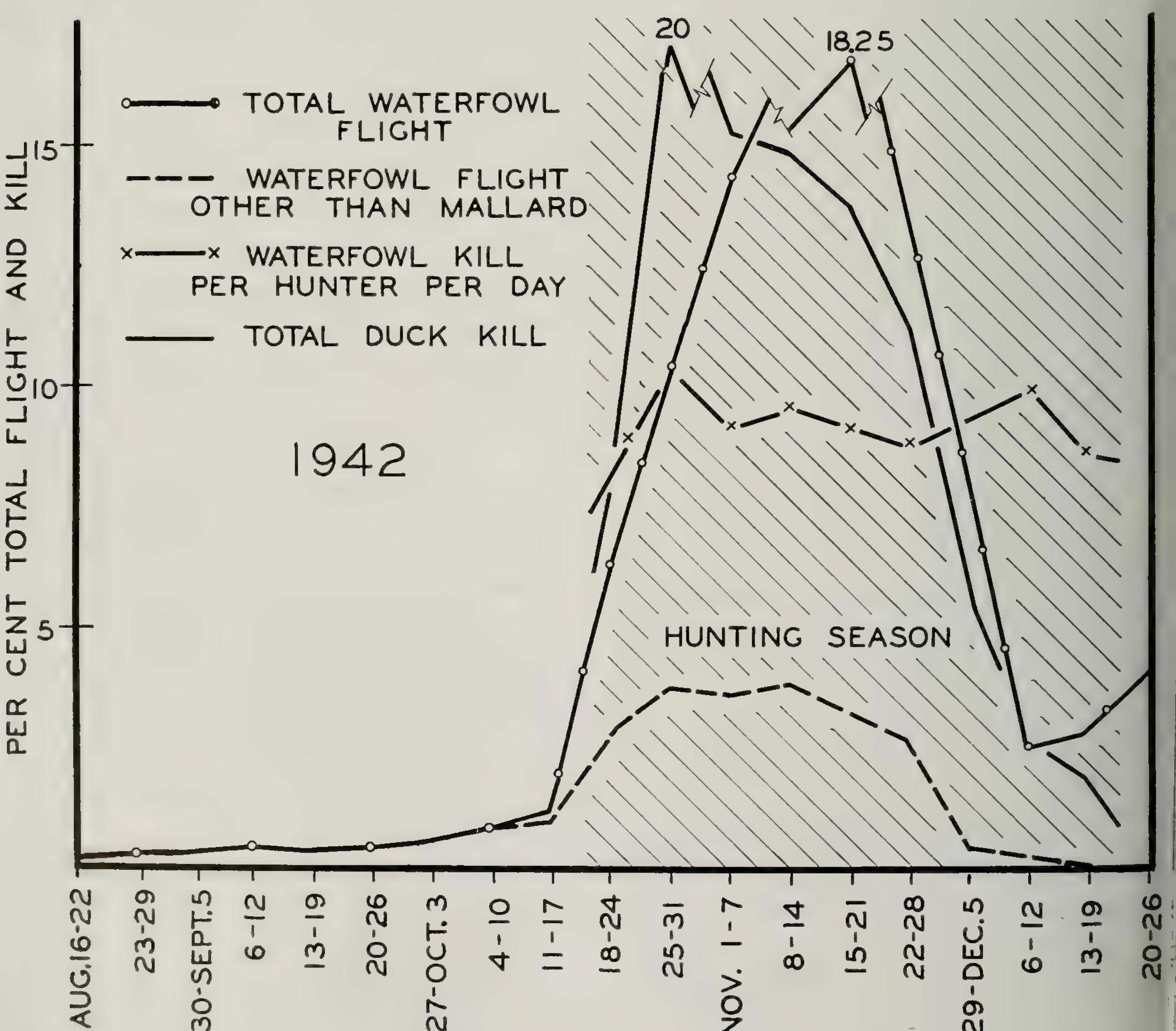

Fig. 7.—Chronology of flight of all duck species and species other than mallard, bag per hunter per day and total daily kill (weekly averages expressed as per cent of yearly total) in the Illinois River valley, 1942.

to be the most vulnerable of Illinois ducks, table 2. Their feeding habits frequently bring them within range of the hunter. Spoonbills do not furnish as difficult a target as do teals, for their flight is slower and less erratic. They are undoubtedly one of the least wary of ducks, frequently dropping into decoys without circling, and decoying to the same blind after being shot at.

Table 2.—The vulnerability, mortality and shooting pressure quotients for each of the important duck species or groups in the Illinois River valley, 1938–1942. The higher the figures, the greater is the vulnerability, mortality and shooting pressure.

Species	Per Cent of Flight During Open Season	Per Cent of Total Bag	Vulnerability Quotient	Per Cent of Flight During Entire Fall	Per Cent of Total Bag	Mortality Quotient	Shooting Pressure Quotient
Mallard and black duck*	91.39	66.46	0.73	89.70	66.46	0.74	1.01
Pintail	1.17	9.65	8.25	1.80	9.65	5.36	0.65
Widgeon and gadwall*	0.43	5.40	12.56	0.51	5.40	10.59	0.84
Green-winged and blue-winged teals	0.09	6.42	71.33	0.74	6.42	8.68	0.12
Shoveler	0.01	1.32	132.00	0.02	1.32	66.00	0.50
Lesser scaup	5.96	6.45	1.08	6.53	6.45	0.99	0.92
Canvasback	0.30	1.04	3.47	0.22	1.04	4.73	1.36
Ruddy duck	0.16	0.56	3.50	0.13	0.56	4.31	1.23
Ring-necked duck	0.49	2.70	5.51	0.35	2.70	7.71	1.40
	100.00	100.00		100.00	100.00		

*Species with similar inherent wariness, flying, flocking and feeding habits were combined to reduce possible error resulting from small proportional amount of data on certain species. The comparatively small population and kill data for certain species was due to the enormous population and kill of mallards; some species have been omitted because of insufficient data on them. The great range in percentage figures has caused some inexactness in the smaller figures, especially those for the teals and shoveler, with a resulting distortion in the quotients. However, differences in quotients for the various species are large enough to be significant, and the figures are statistically useful.

As a group, diving ducks were found to be less vulnerable to shooting than were dabbling ducks in the Illinois River valley, undoubtedly because of the fact that most diving ducks congregate in the open water of large lakes. In Illinois, where duck hunting consists almost entirely of marsh and lake shore shooting, ducks at a distance from shore furnish few shots. All diving species were bagged in proportionally smaller numbers than was the wary pintail, table 2. Diving ducks are reputed to be able to carry more lead than dabbling species, and it is evident that many crippled diving ducks escape capture because of their diving ability.

Lesser scaups, or bluebills, have a lower proportional kill, table 2, than any other diving duck in the Illinois River valley. This is partly the result of their habit of seeking the extensive open water areas of large lakes and congregating in tremendous rafts, which in size are next to those of the mallard. As discussed elsewhere, the greater the concentration of ducks the smaller is the percentage killed.

Canvasbacks, bagged in proportion to their numbers more often than lesser scaups, are credited with being more wary, table 2. However, canvasbacks are more readily decoyed along the Illinois River than lesser scaups, perhaps because they assemble in smaller flocks. Canvasbacks frequent the inshore areas of large lakes more than lesser scaups, probably because of the occurrence there of wild celery (*Vallisneria spiralis*), duck potato (*Sagittaria latifolia*) and other aquatic plants which form the bulk of their food. Many hunters make a greater effort to bag canvasbacks than lesser scaups.

Ruddy ducks, taken by Illinois River club hunters in only slightly greater proportion to population than canvasbacks, are fast flyers, but they are unsuspicious and fly at low levels across the water, making them easy targets for open water hunters, table 2. Because of their aversion to crossing marshes or timbered necks of land, they do not furnish many targets for shore and marsh hunters. Club hunters in Illinois seldom resort to open water gunning, but where this type of hunting occurs, as at the Sparland Public Shooting Ground, large proportions of the ruddies present are taken (Bellrose 1944).

Proportionally more ring-necked ducks than ruddies were bagged by club hunters in the years of this study, table 2. There can be little doubt that much of the difference in vulnerability between blackjacks, as ring-necked ducks are often called in Illinois, and the lesser scaups resulted because blackjacks inhabit small bodies of water and marshy or inshore areas of large lakes instead of open water, and are more likely to pass under the muzzles of guns than are bluebills, as lesser scaups are sometimes known. The greater fondness of ring-necks for shoal water is reflected in their food habits; Cottam (1939) reports 81.47 per cent of the ring-neck's food consists of aquatic plants, about the same per cent as is found in the canvasback's diet, whereas only 59.55 per cent of the lesser scaup's diet is made up of aquatic plant items.

Evidence obtained in 1941 and 1942 indicates that redheads are much more readily bagged in proportion to the population than are ring-necked ducks. I believe that redheads are the least wary of the *Nyroca*, the most important group of diving ducks. They decoy more readily in Illinois to blocks than other members of the genus, but whether this is due to their flying in small flocks or to lack of wariness, or to both, is uncertain. In Illinois, redheads frequent marshy lakes and the inshore of large lakes more than any other diving ducks with the possible exception of the ring-necks. Cottam (1939) reports the food of the redhead to be 89.66 per cent vegetable material; this is the largest proportion of plant items in the diet of any diving duck important in Illinois.

Because of differences in flocking and feeding habits, types of habitats in which they are hunted and methods by which they are hunted, the ducks discussed above may not have the same relative vulnerability to the shotgun throughout North America. However, the ratings determined by this study show which species are in need of the most protection in Illinois, and probably they may serve as useful indicators of the species that are most likely to suffer from overshooting in the Midwest.

Observations made in 1943 on Grass Lake, in northeastern Illinois, suggest that coots may be more readily killed than ducks (Bellrose 1944). Careful calculations indicate that, on the opening day of the hunting season, 18,225 coots and 108 ducks were killed. These figures represent about 95 per cent of the coot and 15 per cent of the duck population then present. The ducks that made up the bulk of the population on Grass Lake were blue-winged teals, considered highly vulnerable in comparison with most other duck species.

Influence of Open Season.—Because duck species differ from each other to some extent in the chronology of their migration, figs. 8–10, if the relative vulnerability of species is known the opening and closing of the hunting season may be adjusted to lift some or all of the shooting pressure from the most vulnerable species, or those most needing protection.

Leopold once wrote (1933) that a number of states purposely set the open season on deer late in the year so that severe weather will keep all but the hardiest hunters at home. He also remarked that several states, including Michigan, open the season on prairie chickens at a late fall date to take advantage of the fact that these birds are harder to kill late than early in the autumn.

How have the open seasons from 1938 through 1942 influenced the duck species that migrate through Illinois? We have attempted to answer this question by comparing the vulnerability quotient with the mortality quotient for each important species to obtain what we have termed the shooting pressure quotient. This shooting pressure quotient gives a comparative evaluation of the effect of the open season on important duck species in Illinois for the

1938–1942 period, table 2, and for each year during the period, table 8.

Comparative Shooting Pressure.—Table 8 discloses that the blue-winged teal had the lowest shooting pressure quotient of all important ducks in Illinois during the years of this study and may therefore be considered as the species most favored by the open seasons from 1938 through 1942. A glance at fig. 8 and figs. 11–15 reveals that most blue-wings passed through the valley

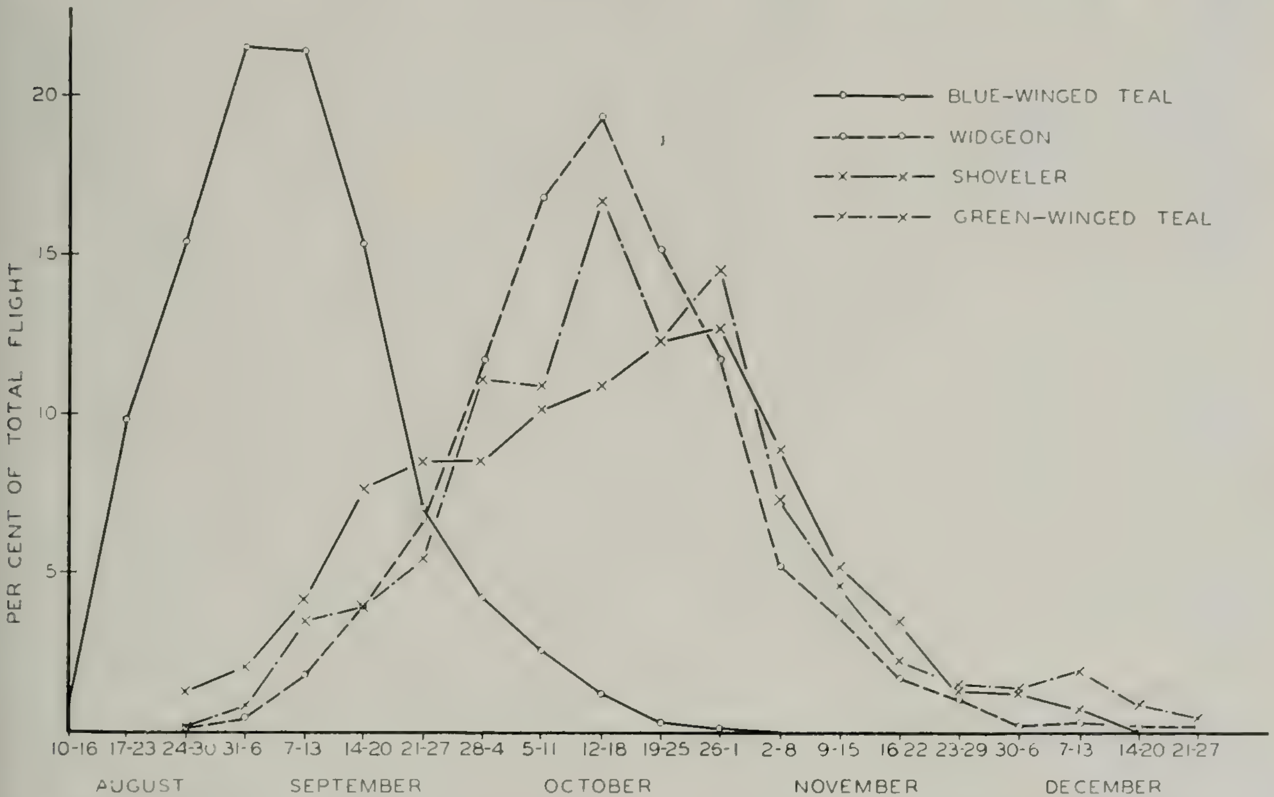

Fig. 8.—Five-year average, 1938–1942, of the seasonal migration of the blue-winged and green-winged teals, widgeon and shoveler in the Illinois River valley.

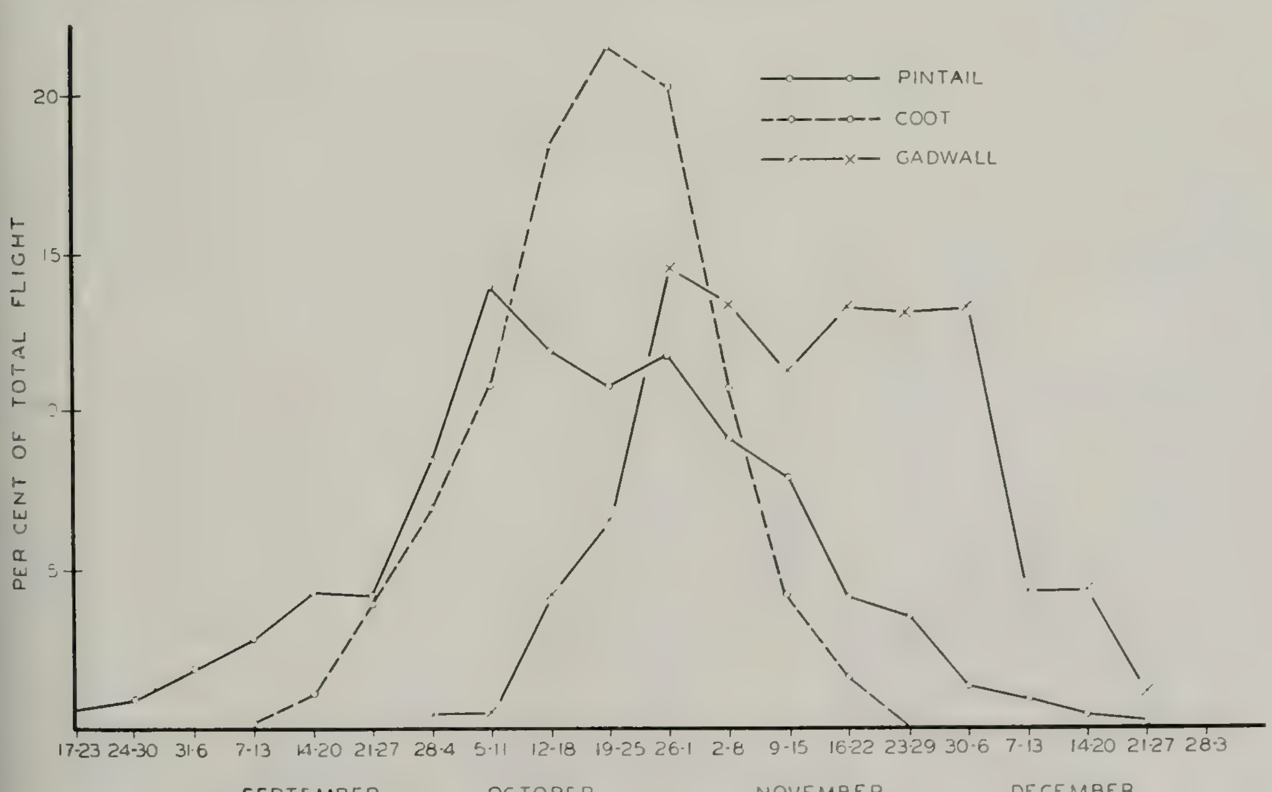

Fig. 9.—Five-year average, 1938–1942, of the seasonal migration of the pintail, coot and gadwall in the Illinois River valley.

prior to the opening of the hunting season. A greater proportion of the flight was present during the open seasons of 1938 and 1941 than during the other three seasons. Table 8 shows for 1938 and 1941 the highest shooting pressure quotients for this species.

Second among the species most favored in Illinois by the established open seasons, 1938–1942, was the shoveler. As shown by fig. 8 and figs. 11–15, much of the shoveler migration in this state occurred before the season opened. A larger proportion of the population of this species than of any other species, except the blue-winged teal, passed south before opening day. Data in table 8 disclose that extending the season to 60 days in 1940 and 70 days in 1942 did not increase the shooting pressure quotient for this species in those years.

Figs. 11–15 reveal that much of the green-winged teal flight, like that of the blue-winged teal and shoveler, had passed through Illinois by opening day, 1938–1942. Table 8 shows that the green-wing was the third most favored species. High water in 1941 caused a large part of the green-winged teal flight to leave the Illinois River valley earlier than usual. In that year, green-wings were under less shooting pressure than in other years and were next to the blue-winged teal in being little affected by the open season, table 8.

Next to the blue-winged teal, the pintail was, in the years of this study, the earliest migrant to arrive in Illinois, fig. 9. However, because greater proportions of its flight occurred during the hunting season, figs. 11–15, the pintail was subject to more shooting pressure than either of the teals or the shoveler, table 8. High water in 1941 resulted in a mass exodus of pintails from the Illinois River valley early in October, accounting at least in part for a low shooting pressure in that year, table 8 and fig. 14. While the 1942 flight was small, the majority of birds arrived during the hunting season. A late flight in 1938 helped to place pintails under greater shooting pressure in that season than in others.

The widgeon, in the years of this study, was subject to more shooting pressure in Illinois than was the pintail, table 8. The figure for 1938 indicates that the later-than-usual widgeon flight in that year contributed to a heavier-

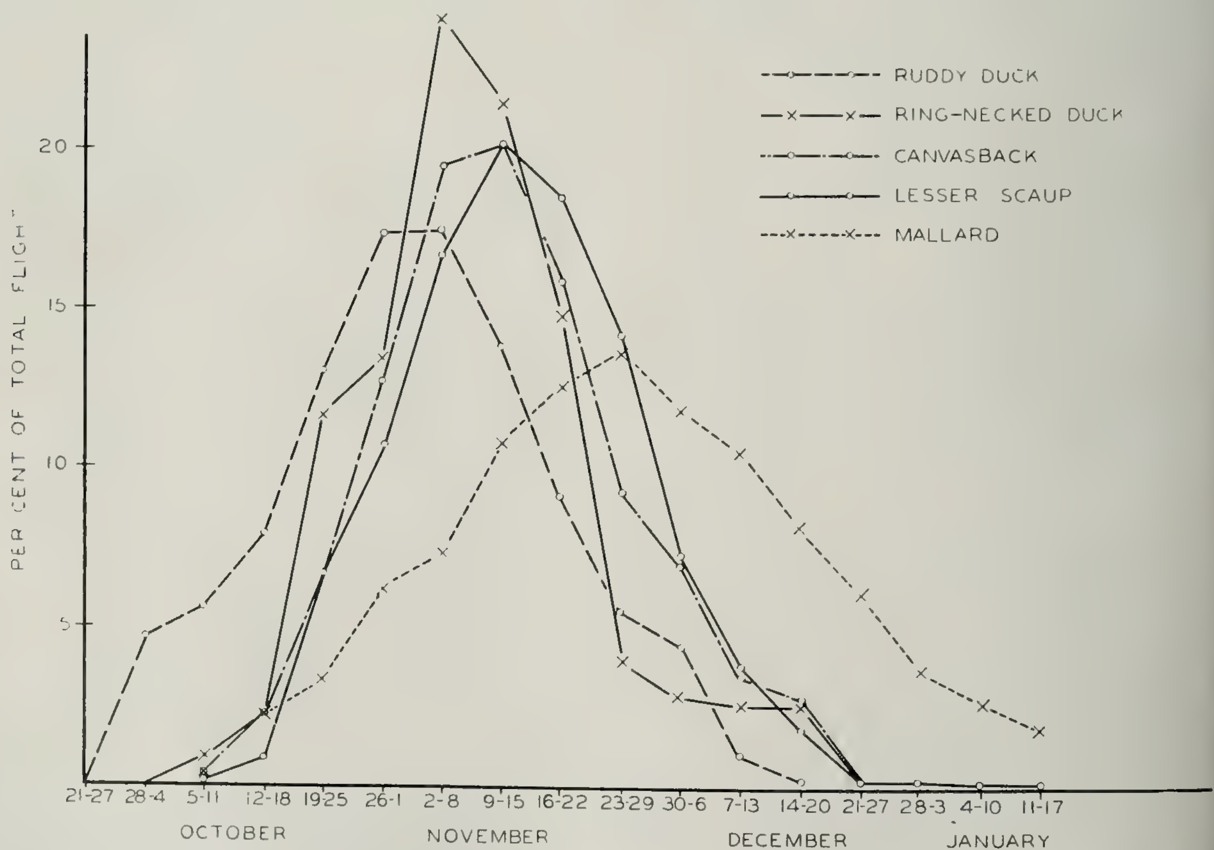

Fig. 10.—Five-year average, 1938–1942, of the seasonal migration of the ruddy duck, ring-necked duck, canvasback, lesser scaup and mallard in the Illinois River valley.

Table 3.—Per cent of entire fall flight, per cent of total bag, and mortality quotient (indicating relative mortality from hunters) for each of the important duck species or groups in the Illinois River valley, 1938.

Species*	Per Cent of Flight During Entire Fall	Per Cent of Total Bag	Mortality Quotient
Mallard and black duck	94.61	57.07	0.60
Pintail	1.44	12.76	8.86
Green-winged teal	0.10	9.54	95.40
Blue-winged teal	0.35	3.35	9.57
Widgeon	0.30	7.27	24.23
Gadwall	0.06	2.27	37.83
Shoveler	0.02	2.43	121.50
Lesser scaup	3.01	4.48	1.49
Canvasback	0.07	0.40	5.71
Ruddy duck	0.04	0.43	10.75
	100.00	100.00	

*Certain species omitted because of lack of sufficient data.

than-usual hunting pressure. Comparative figures show that hunting pressure on the widgeon was least in 1940 and 1942, table 8; in those years the widgeon population in the Illinois River valley was relatively high, tables 3–7.

The gadwall, which appears to be similar to the widgeon in most habits, including wariness, was subject to about three times as much shooting pressure. This disparity existed because more of the gadwall flights than of the widgeon flights occurred during the hunting seasons, figs. 11–15. The seasons of 1939 and 1940, which ended before the gadwall flight had passed through the Illinois River valley, were marked by shooting pressures that were comparatively low for this species, table 8. There is no apparent reason for the comparatively low pressure in 1942.

In calculating the kill of the widgeon and the gadwall, it was necessary to begin with the total kill of the two species for 1938 through 1940 as reported by duck clubs; hunters often placed widgeons in the gadwall column. An attempt was then made to correct this error through use of data obtained from our own inspecting of hunters' bags to determine the ratio between the

Table 4.—Per cent of entire fall flight, per cent of total bag, and mortality quotient (indicating relative mortality from hunters) for each of the important duck species or groups in the Illinois River valley, 1939.

Species*	Per Cent of Flight During Entire Fall	Per Cent of Total Bag	Mortality Quotient
Mallard and black duck	93.47	62.90	0.67
Pintail	2.19	11.54	5.27
Green-winged teal	0.28	7.23	25.83
Blue-winged teal	0.79	1.53	1.94
Widgeon	0.40	5.16	12.90
Gadwall	0.09	2.72	30.22
Shoveler	0.04	1.67	41.75
Lesser scaup	2.61	6.38	2.44
Canvasback	0.07	0.35	5.00
Ruddy duck	0.06	0.52	8.67
	100.00	100.00	

*Certain species omitted because of lack of sufficient data.

Table 5.—Per cent of entire fall flight, per cent of total bag, and mortality quotient (indicating relative mortality from hunters) for each of the important duck species or groups in the Illinois River valley, 1940.

Species*	Per Cent of Flight During Entire Fall	Per Cent of Total Bag	Mortality Quotient
Mallard and black duck	92.76	72.66	0.78
Pintail	3.35	11.67	3.48
Green-winged teal	0.18	4.19	23.28
Blue-winged teal	0.63	1.39	2.21
Widgeon	0.56	2.14	3.82
Gadwall	0.04	1.14	28.50
Shoveler	0.04	1.09	27.25
Lesser scaup	1.97	3.36	1.71
Ring-necked duck	0.21	1.81	8.62
Canvasback	0.17	0.37	2.18
Ruddy duck	0.09	0.18	2.00
	100.00	100.00	

*Certain species omitted because of lack of sufficient data.

two species. Numerals applying to these species in 1938–1940 are based upon the ratio obtained. In 1941 and 1942 the kill record sheets were more clearly marked to differentiate the species.

Hunting seasons following 1938 placed the mallard and black duck under more shooting pressure than in that year. An early ingress of mallards and black ducks into the valley in 1939, together with a season that was set 1 week later than in 1938, placed more pressure on these species in 1939 than in the previous year, fig. 12 and table 8. The season was extended in 1940 from 45 to 60 days. It resulted in a marked increase in shooting pressure on mallards and black ducks because most of the extension was on the end of the season, when about 95 per cent of the waterfowl population in Illinois was made up of these species. There was a slight drop in shooting pressure on these species in 1941, because high water, which prevailed throughout the season, made them difficult to kill. Still more days were added to the end of the water-

Table 6.—Per cent of entire fall flight, per cent of total bag, and mortality quotient (indicating relative mortality from hunters) for each of the important duck species or groups in the Illinois River valley, 1941.

Species*	Per Cent of Flight During Entire Fall	Per Cent of Total Bag	Mortality Quotient
Mallard and black duck	88.07	64.24	0.73
Pintail	2.48	8.67	3.49
Green-winged teal	0.12	1.64	13.67
Blue-winged teal	0.71	2.34	3.30
Widgeon	0.37	3.15	8.51
Gadwall	0.05	1.91	38.20
Shoveler	0.01	0.95	95.00
Lesser scaup	6.68	7.92	1.19
Ring-necked duck	1.00	6.68	6.68
Canvasback	0.33	1.68	5.09
Redhead	0.01	0.31	31.00
Ruddy duck	0.17	0.51	3.00
	100.00	100.00	

*Certain species omitted because of lack of sufficient data.

Table 7.—Per cent of entire fall flight, per cent of total bag, and mortality quotient (indicating relative mortality from hunters) for each of the important duck species or groups in the Illinois River valley, 1942.

Species*	Per Cent of Flight During Entire Fall	Per Cent of Total Bag	Mortality Quotient
Mallard and black duck	84.98	75.12	0.88
Pintail	1.18	6.16	5.22
Green-winged teal	0.03	1.48	49.33
Blue-winged teal	1.22	2.54	2.08
Widgeon	0.99	1.98	2.00
Gadwall	0.04	1.20	30.00
Shoveler	0.03	0.94	31.33
Lesser scaup	10.14	5.29	0.52
Ring-necked duck	0.55	2.31	4.20
Canvasback	0.47	1.78	3.79
Redhead	0.01	0.41	41.00
Ruddy duck	0.36	0.79	2.19
	100.00	100.00	

*Certain species omitted because of lack of sufficient data.

fowl season in 1942. This extension in the season placed the mallard and black duck under greater shooting pressure in 1942 than in any other year of this study, table 8. Other species were not materially affected adversely by the lengthened seasons, according to the comparative data in table 8. Whereas this table discloses an almost uninterrupted rise in the shooting pressure on mallards and black ducks during the 5 years of this study, it indicates that no such trend has occurred in other species.

As a group, diving ducks were under more shooting pressure in recent open seasons than were dabbling ducks, table 8. Figs. 10–15 disclose that most of the diving ducks arrived after October 16, and that most of them departed southward by December 16; thus, most of the migration occurred during the hunting season.

There is comparatively little difference in the shooting pressure on most species of diving ducks; as fig. 10 shows, the species migrate at almost the same time. Shooting pressure was unusually high on the ruddy duck in 1938 and 1939 when the population was relatively low.

Shooting pressure on most of the duck species varied from year to year during

Table 8.—Shooting pressure quotient for important Illinois River valley ducks, 1938–1942; derived by comparing vulnerability quotient of species (5-year average) with mortality quotient for 5 separate years.

Species*	1938	1939	1940	1941	1942
Mallard and black duck	0.82	0.92	1.07	1.00	1.20
Pintail	1.07	0.63	0.42	0.42	0.63
Green-winged teal	1.33	0.36	0.32	0.19	0.69
Blue-winged teal	0.13	0.03	0.03	0.05	0.03
Widgeon	1.93	1.03	0.30	0.68	0.16
Gadwall	3.01	2.40	2.27	2.90	2.38
Shoveler	0.92	0.32	0.21	0.72	0.24
Lesser scaup	1.38	2.26	1.57	1.10	0.48
Ring-necked duck	....	....	1.57	1.21	0.76
Canvasback	1.65	1.44	0.63	1.47	1.09
Ruddy duck	3.07	2.48	0.57	0.86	0.63

*Figures for ring-necked duck omitted, 1938 and 1939, and figures for redhead omitted, 1938–1942, because of insignificant population and kill data. Figures for widgeon and gadwall for 1938–1940, calculated as explained in text.

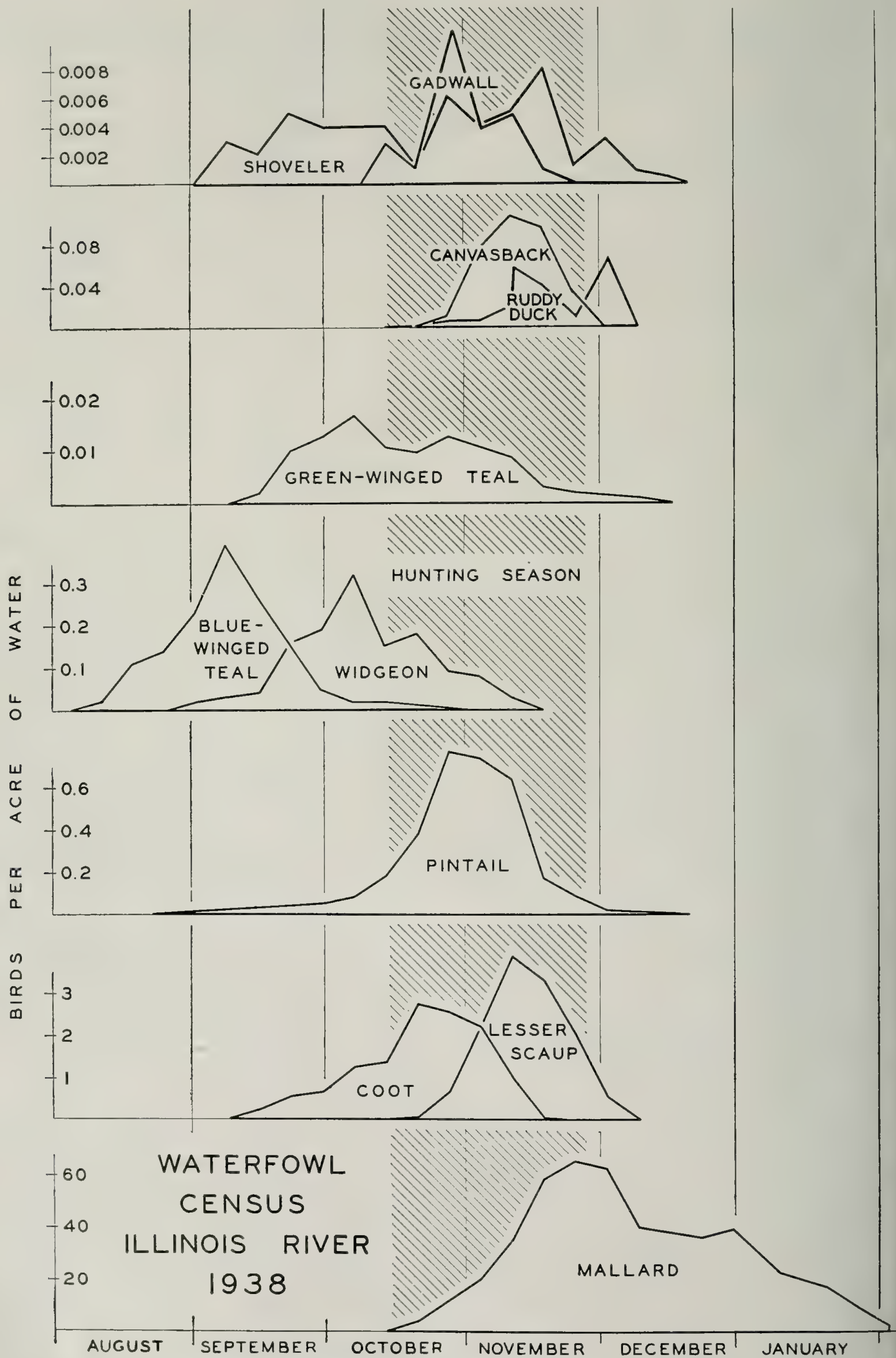

Fig. 11.—Polygons, based upon number of birds per acre of water surface in the Illinois River valley in 1938, showing the chronology of flight of 11 species of waterfowl in relation to the hunting season.

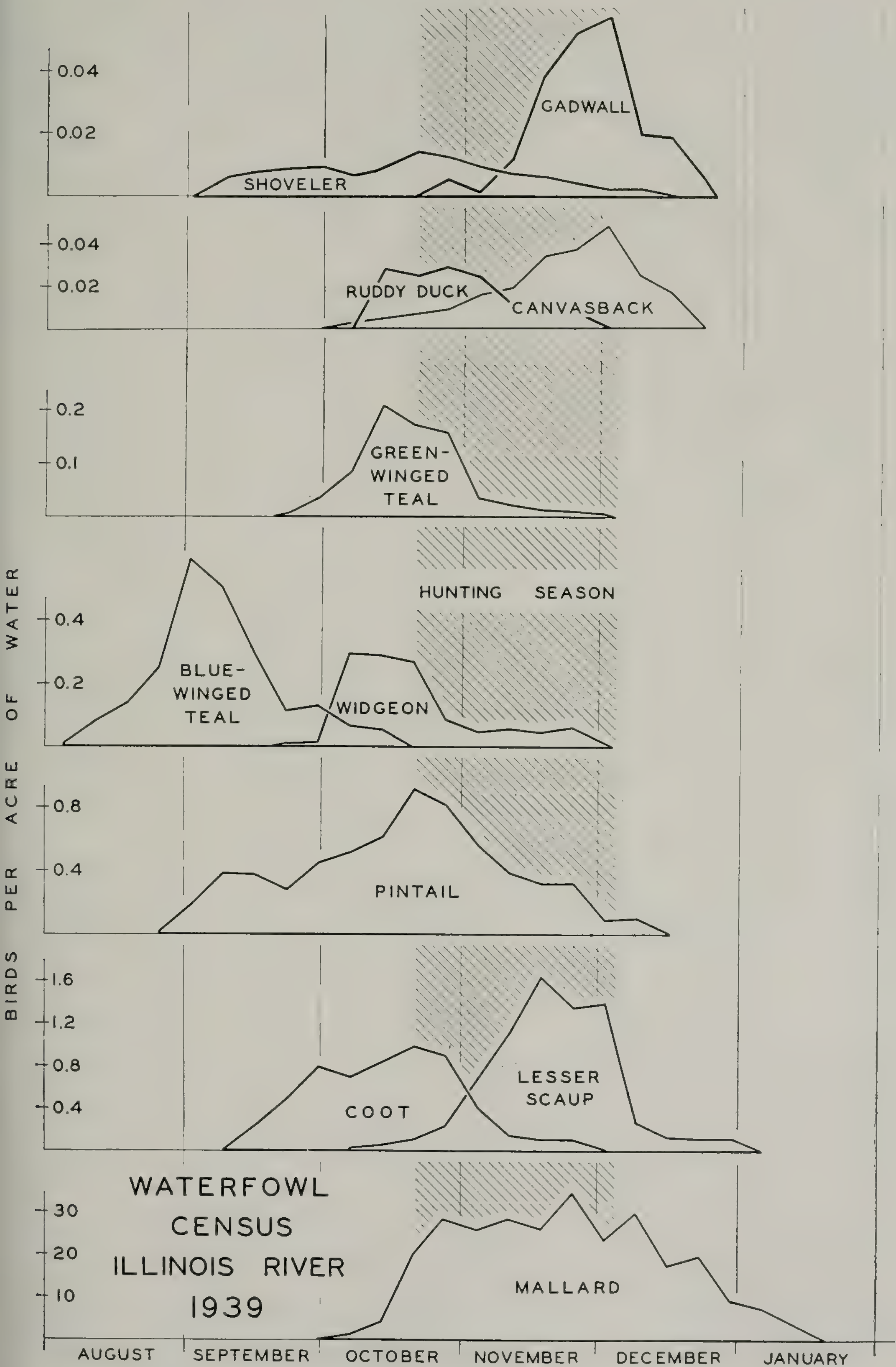

Fig. 12.—Polygons, based upon number of birds per acre of water surface in the Illinois River valley in 1939, showing the chronology of flight of 11 species of waterfowl in relation to the hunting season.

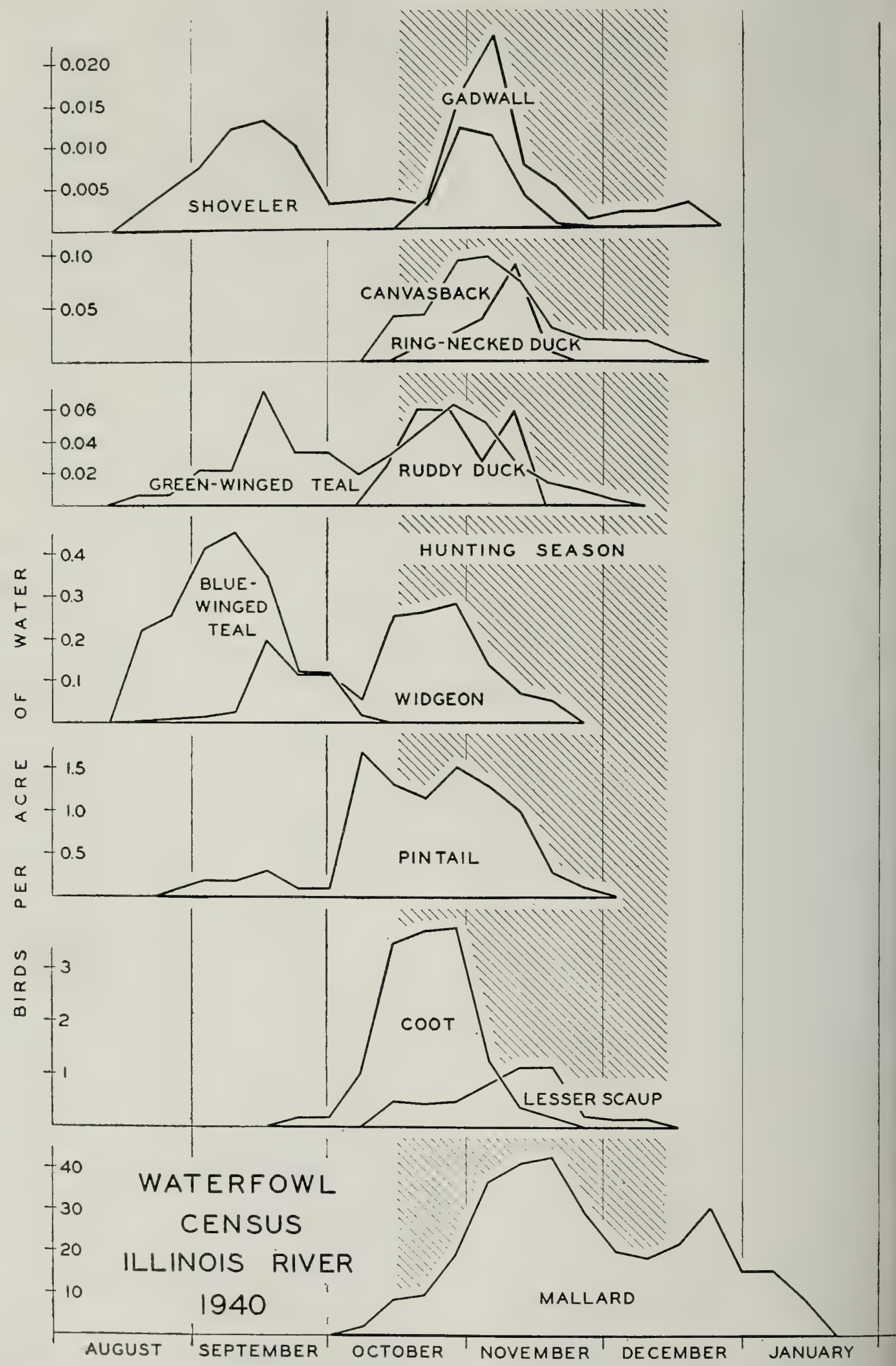

Fig. 13.—Polygons, based upon number of birds per acre of water surface in the Illinois River valley in 1940, showing the chronology of flight of 12 species of waterfowl in relation to the hunting season.

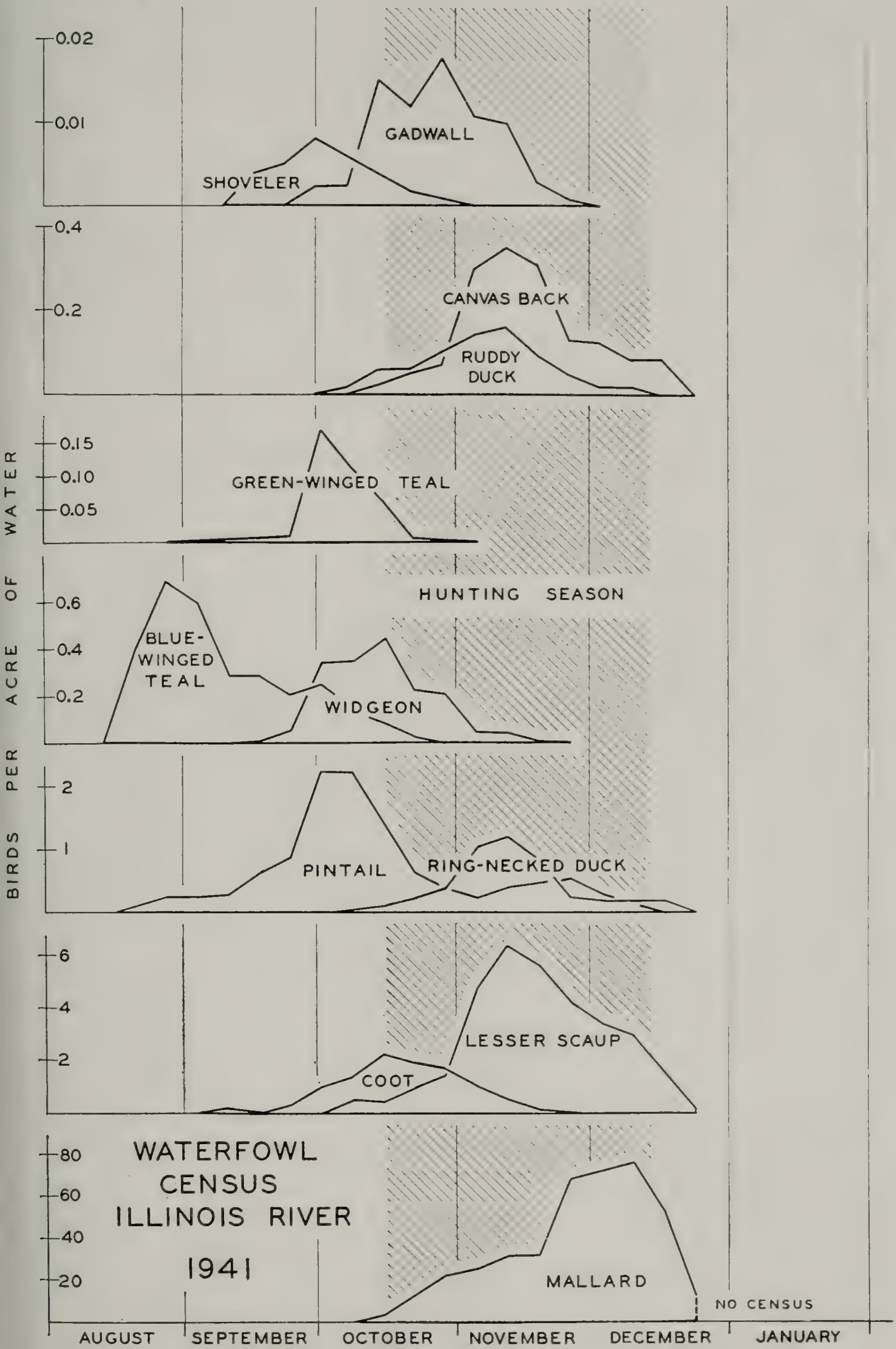

Fig. 14.—Polygons, based upon number of birds per acre of water surface in the Illinois River valley in 1941, showing the chronology of flight of 12 species of waterfowl in relation to the hunting season.

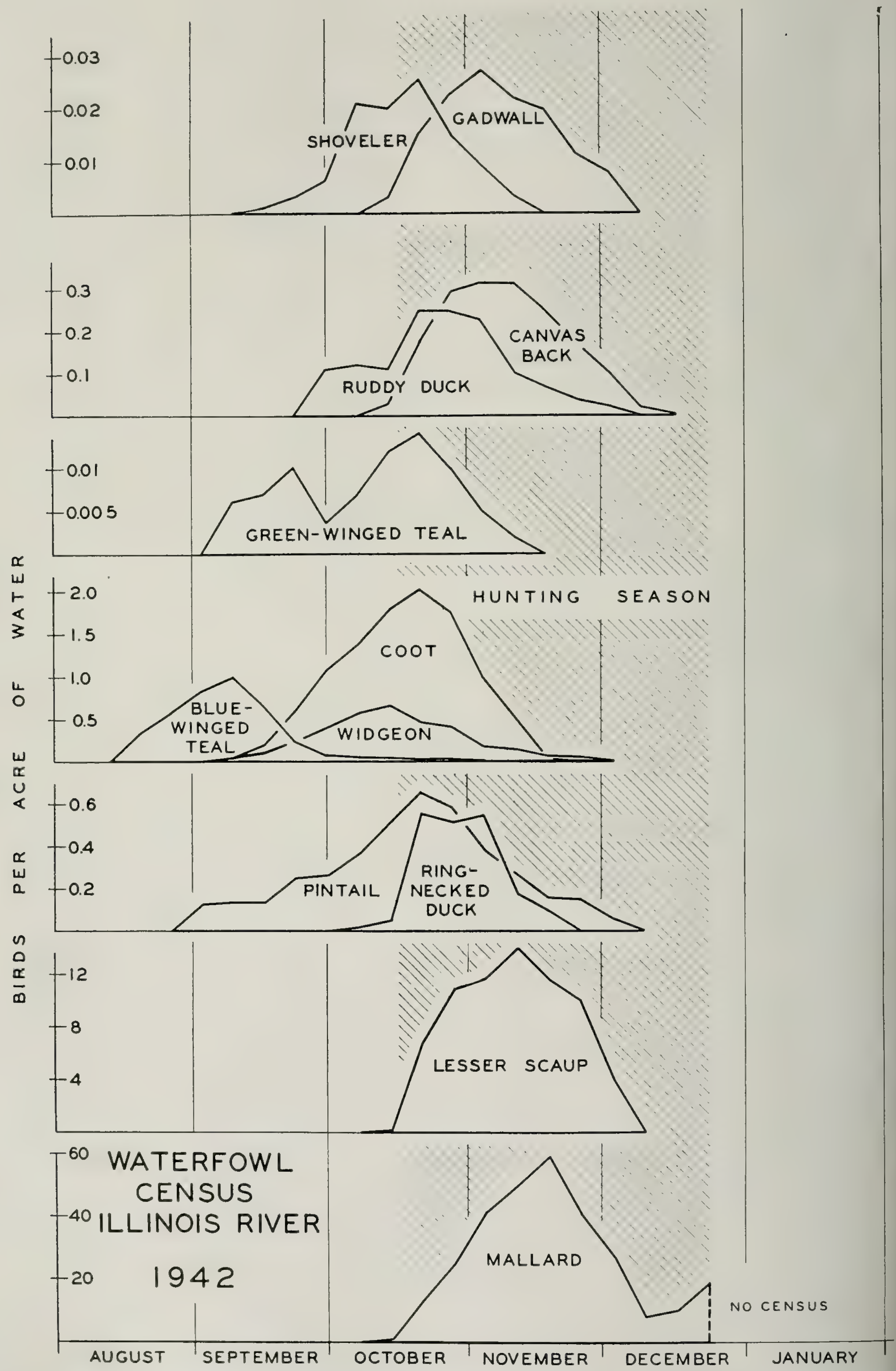

Fig. 15.—Polygons, based upon number of birds per acre of water surface in the Illinois River valley in 1942, showing the chronology of flight of 12 species of waterfowl in relation to the hunting season.

Table 9.—Average daily kill per shooter, Duck Island Preserve, 1914–1936.*

Week	Mallard	Pintail	Blue-Winged Teal	Green-Winged Teal	All Other Ducks†	Total
Sept. 13–19	0.8	1.3	6.8	...	0.3	9.2
Sept. 20–26	1.6	2.2	6.7	0.3	1.0	11.8
Sept. 27–Oct. 3	2.4	3.0	3.6	0.1	1.3	10.4
Oct. 4–10	2.9	3.8	3.2	0.2	1.6	11.7
Oct. 11–17	7.2	2.4	1.9	0.5	0.7	12.7
Oct. 18–24	8.5	2.1	0.6	0.3	1.0	12.5
Oct. 25–31	10.9	0.8	0.2	0.4	0.7	13.0
Nov. 1–7	11.4	0.5	0.1	0.4	0.5	12.9
Nov. 8–14	11.7	0.4	0.1	0.2	0.4	12.8
Nov. 15–21	11.4	0.3	...	0.3	0.4	12.4
Nov. 22–28	10.8	0.2	...	0.4	0.3	11.7
Nov. 29–Dec. 5	10.2	...	...	0.2	0.3	10.7
Dec. 6–12	6.6	0.2	...	1.4‡	0.7	8.9
Dec. 13–19	7.1	...	...	...	0.7	7.8

*Data assembled by Dr. R. E. Yeatter and Dr. D. H. Thompson of the Illinois Natural History Survey.
†Designated in the record book as canvasback, redhead, gadwall, golden-eye, blackjack, bluebill, spoonbill, widgeon, butterball and black mallard.
‡This figure is unusually high because of 157 green-winged teals killed December 8–9, 1920.

the period of this study due to differences in the chronology of flight, but the low pressure on lesser scaups in 1942 appears attributable to the fact that the enormous numbers present in that year materially lowered the percentage killed, tables 7 and 8.

In the years of this study, coots, or mud hens, were subject to little shooting in the Illinois River valley because most club hunters there showed little interest in pursuing them. Mississippi River shooters killed coots in somewhat greater numbers per hunter-day. In the Chain-o'-Lakes region of northeastern Illinois, coots were considered a sporting bird, worthy of real hunting effort. On Grass Lake, opening day, 1942, hunters killed at least 24,000 coots (Bellrose 1944). Evidently, most waterfowl hunters in that region were interested mainly in coots, for, as the coot bag declined, fewer persons hunted, despite an increase in the daily individual duck bag.

About 40 per cent of the coot flight, fig. 9, had arrived in the Illinois River valley by the middle of October, the opening date for most recent waterfowl seasons. If the opening date were earlier, undoubtedly many more coots would be killed by Illinois hunters.

Influence of Population Density.—The popular assumption that the waterfowl kill is directly proportional to the population is not substantiated by data gathered during this study. Both per-hunter and total daily kills were highest during the early part of recent seasons, figs. 5–7, before flights had reached their peaks.

Records of the Duck Island Preserve, near Banner, Illinois, from 1914 through 1936, table 9, show that the average daily kill per member at this hunting club varied but little from September 20 through December 5.* The daily kill before and after those dates was somewhat lower. Table 9 shows that blue-winged teals and pintails made up the bulk of the early season bag, with mallards not forming an appreciable part of the daily kill until the week of October 11–17. As shown by figs. 3–7, ducks do not arrive in large numbers in the Illinois River valley until the middle of October. The fact that the waterfowl population was many times greater from October 15 through December 5 than up to that time does not appear to have added much to the daily kill of the hunter.

The comparatively high kill per hunter-day early in the season might indicate (1) that more hunters hunt during the latter part of the season than the

*Records on which table 9 and fig. 17 are based were made available through courtesy of Ferd Luthy, Secretary-Treasurer, Duck Island Preserve; figures summarized by Dr. R. E. Yeatter and Dr. D. H. Thompson of the Illinois Natural History Survey.

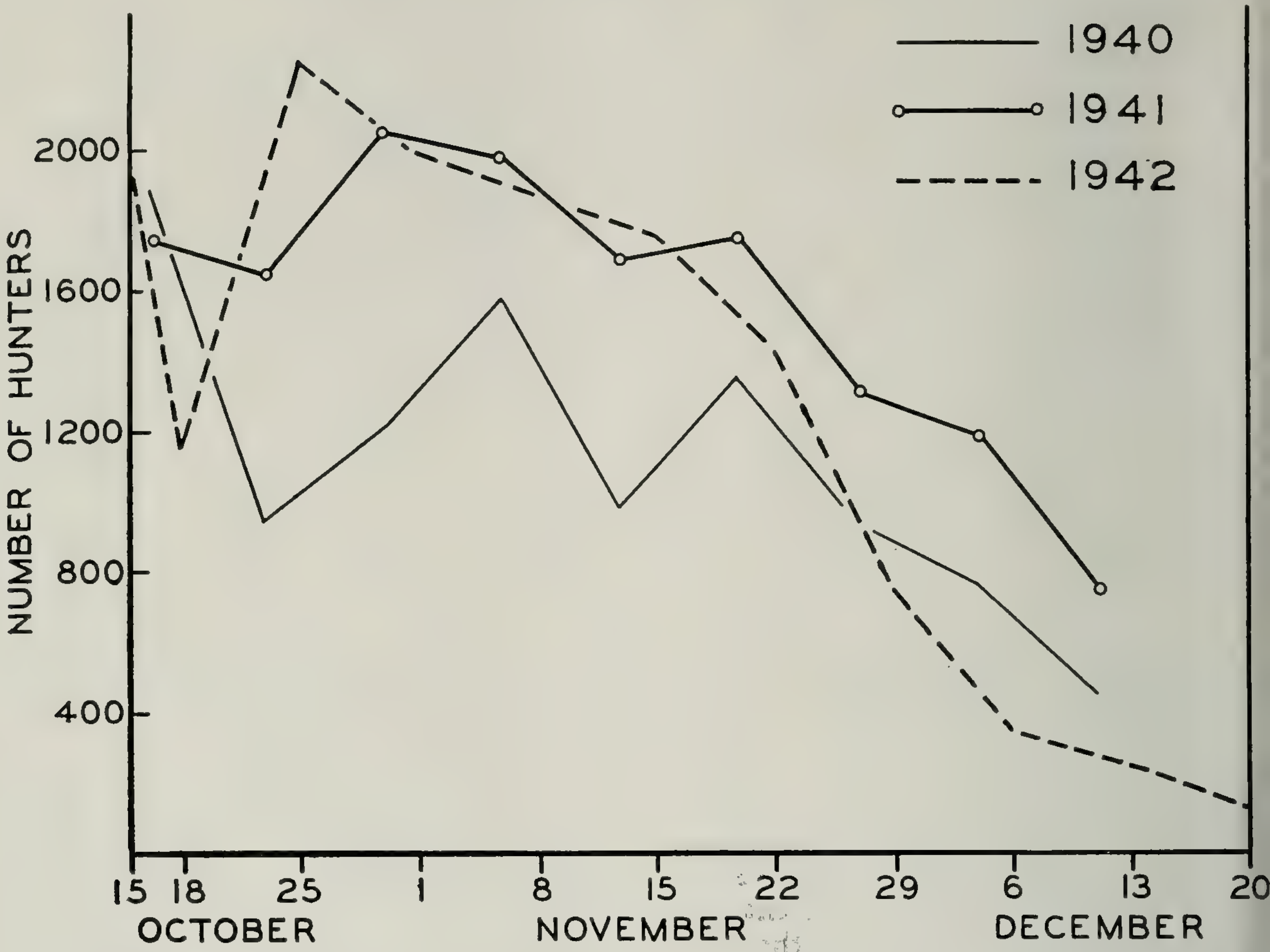

Fig. 16.—Seasonal trend in activity of hunters at Illinois River valley waterfowl hunting clubs, 1940–1942.

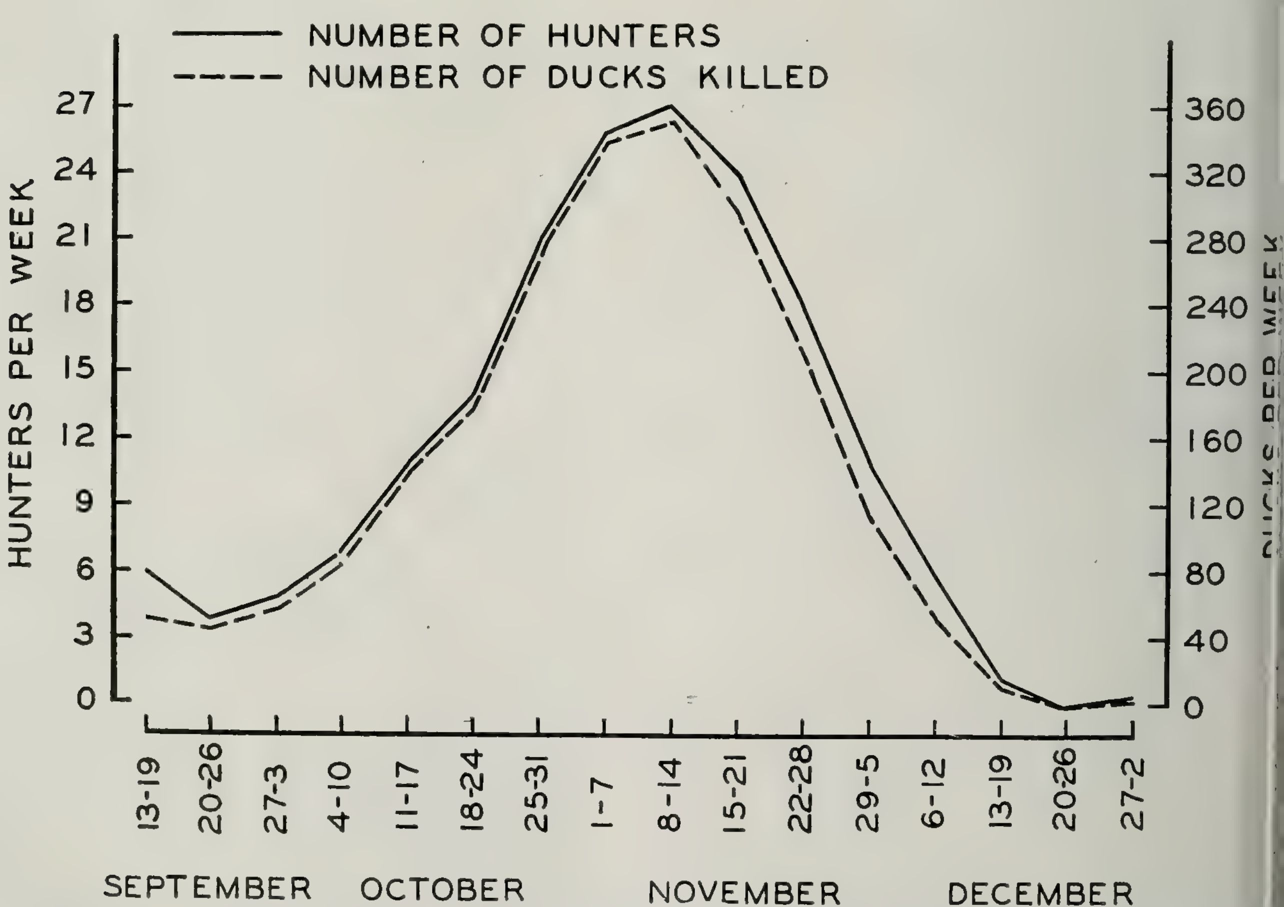

Fig. 17.—Weekly averages of number of hunters in action and ducks killed at Duck Island Preserve over a 23-year period, 1914–1936.

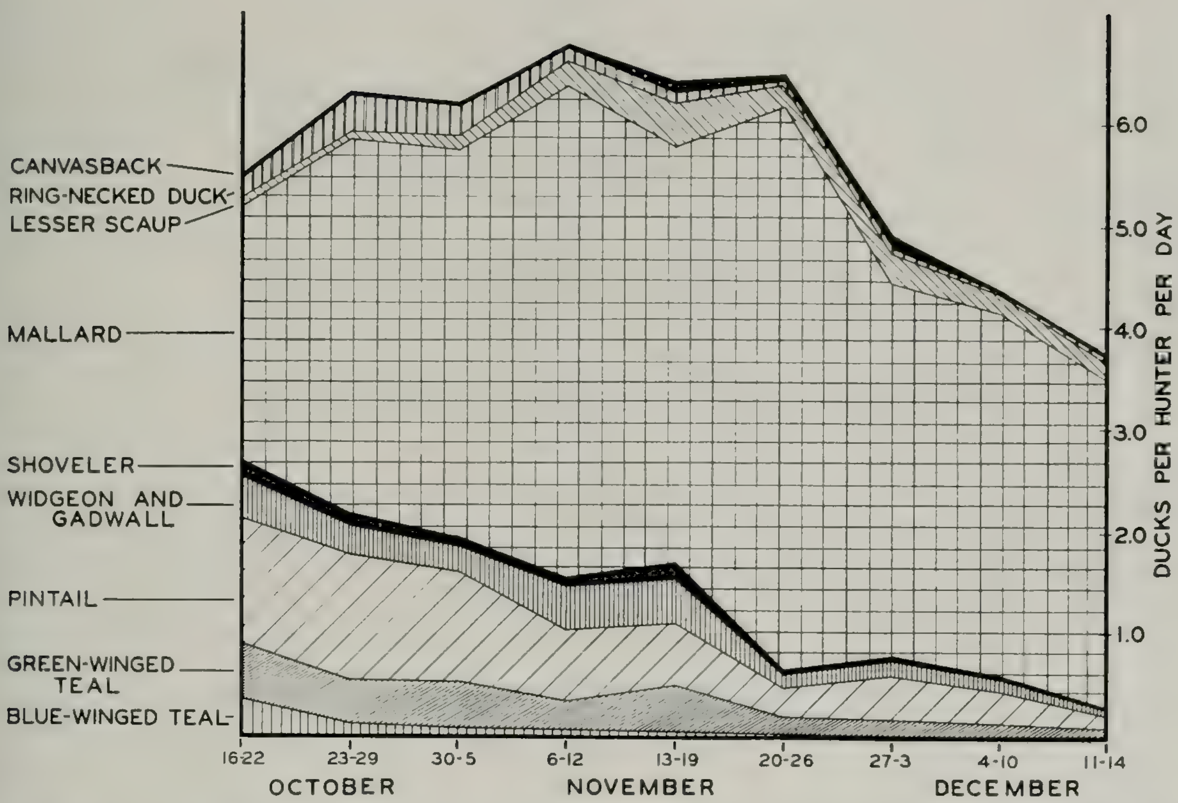

Fig. 18.—Seasonal composition of the duck bag made by Illinois River valley club hunters in 1940.

early part, and so increase the competition for ducks as the season progresses, or (2) that the composition of the flight is such that a large bag is more easily made early in the season than later.

As fig. 16 shows, from 1940 through 1942 more hunters were in action at Illinois River valley duck clubs during the first 2 weeks than during the last 2 weeks of the season, and there was a general decline in number of hunters as the season progressed.

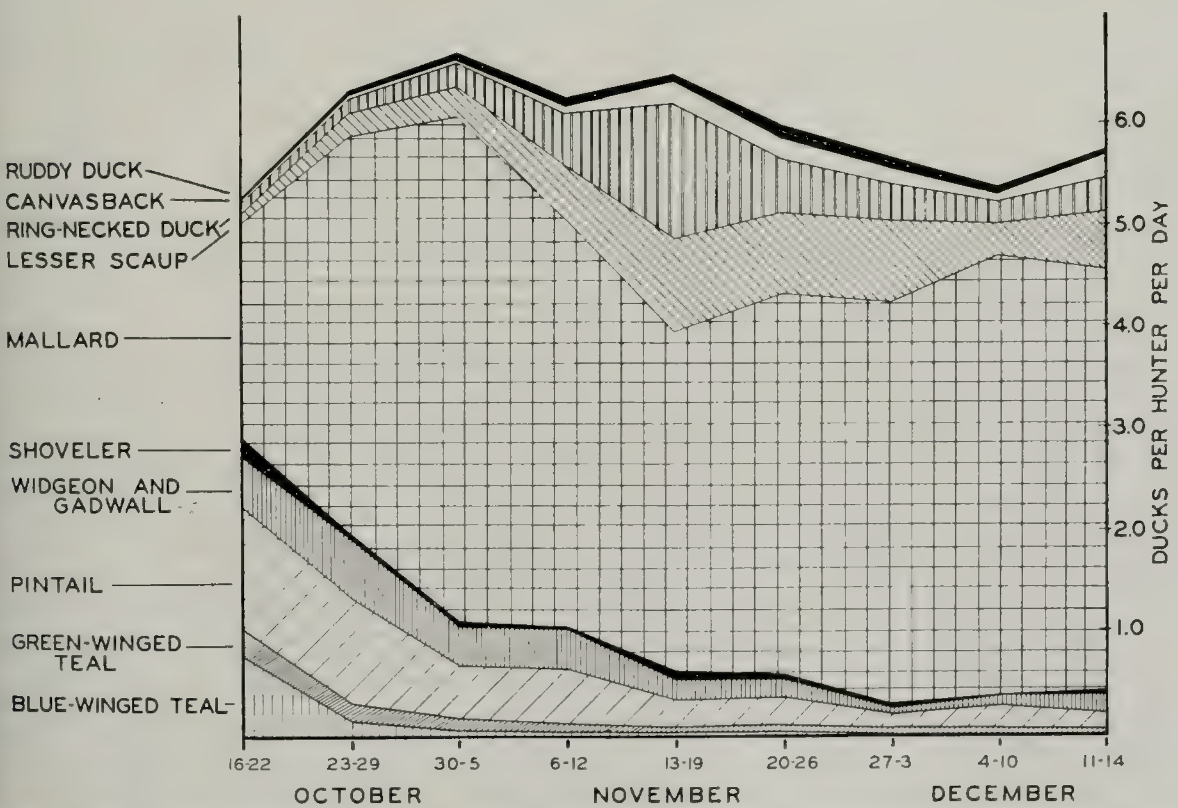

Fig. 19.—Seasonal composition of the duck bag made by Illinois River valley club hunters in 1941.

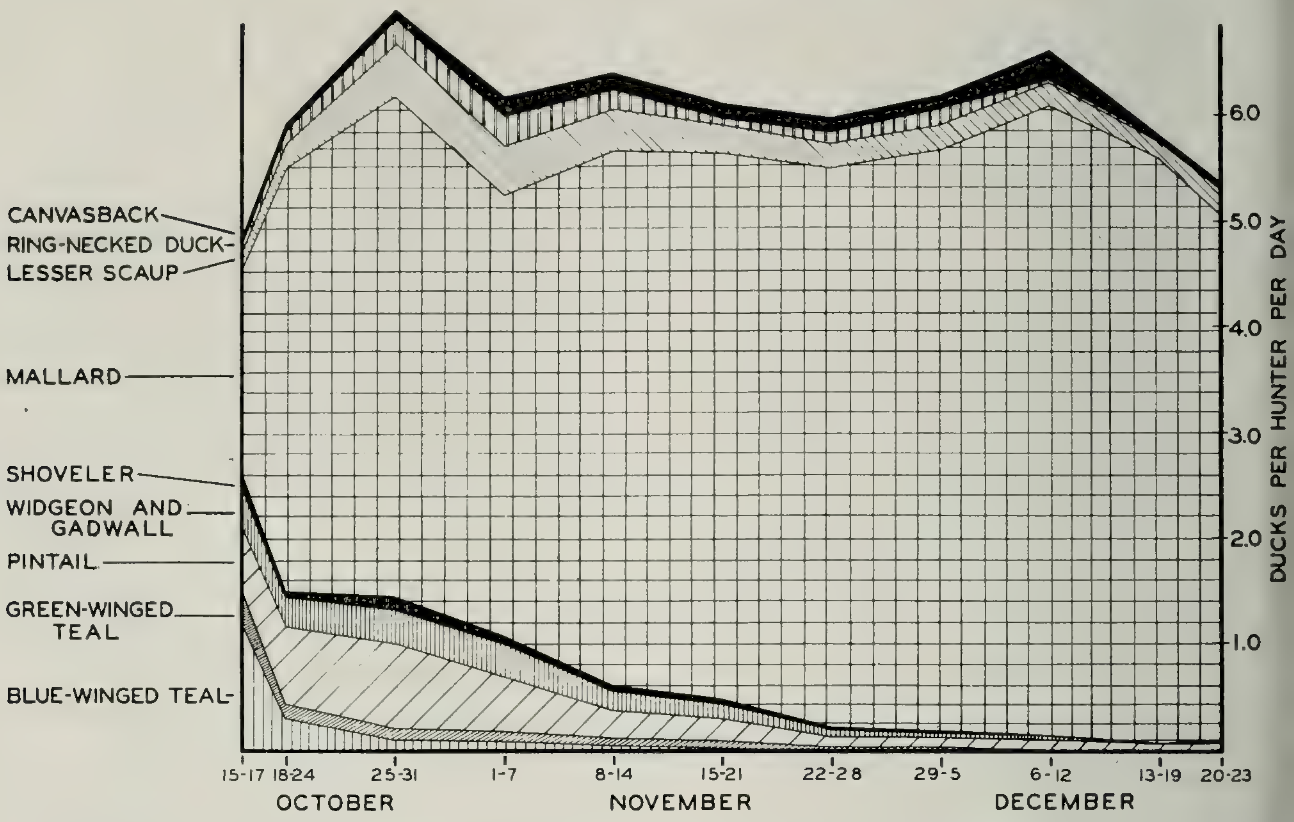

Fig. 20.—Seasonal composition of the duck bag made by Illinois River valley club hunters in 1942.

Fig. 17 shows the seasonal trend in the number of hunters shooting and the number of ducks killed per week over a 23-year period at the Duck Island Preserve. This duck club is not typical of many Illinois River valley clubs in that most of its members reside within 30 miles of the club and are able to respond readily to hunting conditions, as shown by the close correlation between number of hunters in action and number of ducks killed. But even at this club, over a 23-year period, the number of hunters in action early in the season was larger than the number late in the season.

From previous discussion, we know that mallards and black ducks as a group are the most difficult species to bag in Illinois. Figs. 11–15 show that as the season progressed, 1938–1942, these species comprised relatively more of the population. Figs. 18–20 show that as the season progressed, 1940–1942, there was a steady decline in the kill per hunter-day of blue-winged and green-winged teals, pintails, widgeons and shovelers, while there was at least a comparative increase in the number of mallards and black ducks taken per hunter-day. It is evident that the composition of the flight makes for a comparatively high bag early in the season.

Studies made by the Illinois Natural History Survey demonstrate that juvenile ducks are about twice as easy to kill as adults and that, generally, juveniles of a species predominate among the early arrivals of that species. These findings account in part for a greater kill being made in proportion to the population of some species in the early part of the hunting season than later.

Optimum Shooting Dates

A waterfowl hunting season commencing, as it did in the past 6 years, no earlier than October 15 and running into late November or December was probably optimum for these years in Illinois in that it afforded good duck hunting and placed most of the shooting pressure on species best able to take it. From evidence previously presented, it is obvious that, with a season set at such a late date, shooting pressure falls to a greater extent on mallards, black ducks and diving ducks than on the more vulnerable teals, shovelers, pintails and widgeons.

Some hunters believe that the season might well be set earlier. As fig. 16 shows, most Illinois duck hunters prefer to do the greater part of their hunting early in the season, when waterfowl are rather evenly distributed and temperatures are comfortable. While an earlier season of 60 days or more would include a smaller proportion of the waterfowl flight, records of the Duck Island Preserve, table 9 and fig. 17, and figs. 5, 6 and 7 indicate that it would increase the kill of ducks in Illinois. The greater vulnerability of the species and individuals present early in the season more than compensates for the reduced population in Illinois at that time.

Setting the season earlier would enable waterfowl hunters to bag more coots. It is generally agreed among wildlife technicians that a greater kill of coots could and probably should be made, and, since almost half of the coot population of the Illinois River valley is present by the middle of October, an earlier opening would result in a greater kill of that bird.

Although an earlier season might provide a more equitable distribution of the take and more comfortable hunting, it must be realized that in Illinois such a season would tend to increase the pressure on species that are least able to withstand it.

The closing date for the waterfowl hunting season in Illinois should probably be December 10 or earlier. According to records of the Peoria weather station, the average date of closing of the Illinois River by ice (1867–1930) is December 10. In most states of the central zone the mean daily temperature falls below 32 degrees by December 15, fig. 2. While, as fig. 10 discloses, a large percentage of the mallard and black duck populations remain after the freeze-up in the Illinois River valley, winter conditions then usually do not favor duck hunting. The remaining mallards and black ducks concentrate on only a few lakes and, partly because of such local concentrations, only a small percentage of hunters continue hunting, fig. 16. Under such rigorous weather and feeding conditions as occur after the freeze-up, few ducks may be killed, or, occasionally, excessively many. Because most duck hunting ends with the winter freeze-up, there is little reason to extend the season in Illinois beyond December 10 or 15. The same closing dates may be applicable to other states in the central zone.

If, in the future, it is necessary once again to shrink the open season to 30 days, I believe that for Illinois the season should be set from November 1 through 30. This would place most of the shooting pressure on mallards and black ducks, species that are, as already discussed, best able to take it. If conditions were critical enough to warrant a 30-day season, they would almost certainly justify giving greater protection to some species than to others. The ducks in need of greatest protection would probably be the blue- and green-winged teals, shoveler, widgeon and ruddy duck, species that complete a large part of their fall migration through Illinois by November 1.

If the status of waterfowl is such that a 45-day season is desirable, I believe the optimum period for Illinois is from October 22 through December 5. This would place flights of mallards, black ducks, lesser scaups, ring-necked ducks and canvasbacks under shotgun pressure longer than other species less able to withstand this pressure, and it would cover the period in which ducks are most abundant in Illinois.

Should an abundance of waterfowl permit a 60-day shooting season, and most species are sufficiently numerous to be secure, the optimum season for Illinois would be from October 10 through December 8.

Should the continent's waterfowl population justify a 70-day season, then I believe the season, insofar as Illinois is concerned, might best be set at October 1 through December 9.

Recommended dates for an 80-day season are September 26 through December 14; recommended dates for a 100-day season are September 20 through December 28.

Optimum Season Lengths

Does the duck kill increase in direct ratio to the length of the hunting season? Waterfowl investigators have done little to evaluate the influence on the kill of seasons of various lengths.

Fig. 21 shows the influence of open seasons of various lengths on the total yearly kill of three Illinois River valley clubs. While various shooting hours

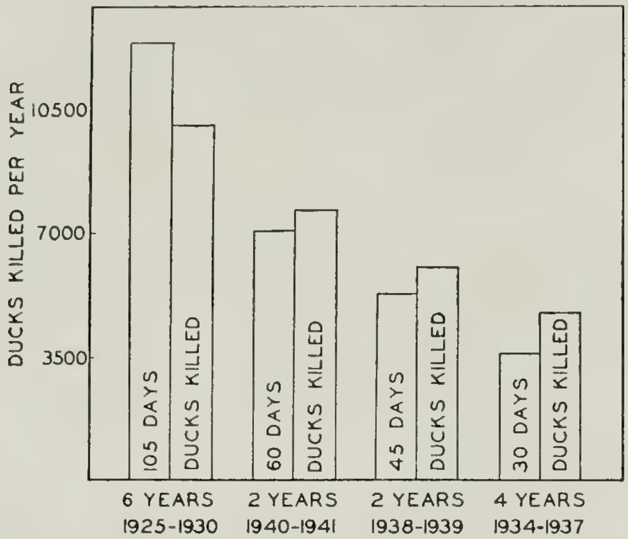

Fig. 21.—Influence of open seasons of various lengths on the total yearly kill of ducks at three Illinois River valley clubs where, even when baiting was legal, little bait was used.

were in effect during the years represented, evidence presented later indicates that these hours had little influence on the kill. Baiting and use of live decoys were permitted during some of the years, but the three clubs studied did little and sometimes no baiting. As the seasons decreased in length there was an increase in the duck kill per day. For example, with seasons of 105 days, the average total kill of the three clubs was 94 ducks per day. With 30-day seasons, it was 151 ducks per day.

Many of the seasons of 105 to 107 days provided proportionally fewer good hunting days than some of the shorter seasons because of the freeze-up and the exodus of most waterfowl long before the closing date. As shown in fig. 16, the greatest hunting intensity occurs during the first half of the season.

Probably a larger daily kill is made in short seasons than in long seasons in most states of the central and northern zones. In the southern zone, it is quite possible that longer seasons may result in average daily kills as large as in short seasons and in total waterfowl kills proportional to the length of the seasons, for the composition and the density of the population are more nearly uniform in that zone during the hunting season than in the other zones. Despite the fact that the duck kill in Illinois is not in direct ratio to the length of the season, altering the length of the season is obviously one of the most expedient ways to regulate the duck kill. It must be remembered, however, that the kill during a 30-day season is apt to be considerably more than half the kill made during a 60-day season.

Optimum Shooting Hours

The daily shooting hours are of great concern to Illinois waterfowlers. This is due to the fact that mallards and black ducks, which over the season as a whole in recent years comprised about 85 per cent of the duck population, have two principal feeding periods during the day. One is early in the morning; the other late in the afternoon. During these periods most of the mallards leave the large rest lakes, flying to cornfields a few hundred yards to 40 miles distant. Some hunters, especially those in the public shooting group, believe they have greatly increased chances of killing ducks in the cornfields. Usually, only on the morning and evening flights or on cold, windy days is cornfield shooting profitable.

Do earlier and later shooting hours appreciably increase the total kill? What has been the effect of altered shooting hours upon the behavior of ducks?

When the 7 A.M. to 4 P.M., Central Standard Time, shooting regulations were in operation, hunters claimed facetiously that mallards carried watches, for in the morning slightly before 7 the birds would leave the cornfields and return to the lakes. The ducks had flown to the fields slightly before or at daybreak. In the afternoon, they would, as a rule, leave the lakes at 4 o'clock to feed in the cornfields until dusk. As the fields became enshrouded in darkness, seemingly endless streams of mallards could be seen winging their way back to the valley rest lakes.

With the return of sunrise shooting in

1940, it was not long until the mallards were flying to the cornfields before daybreak and leaving 15 to 30 minutes later for the rest lakes. Where formerly massed thousands of ducks could be seen streaming back to the lakes in the bright light after sunrise, now entire cornfields appeared to rise into the air as tens of thousands of ducks left with the first streaks of dawn.

In 1942, waterfowl shooting hours were extended from 4 P.M. until sunset. The result was that mallards, after the first few days, would not alight or attempt to alight in cornfields until sunset or shortly thereafter. Consequently, their feeding activities occurred later than under the 4 P.M. closing hour. During cold, blustery weather, when the thermometer was below freezing, mallards forsook their morning and evening routine, feeding throughout the day in fields close to their rest lakes.

In 1943, shooting hours were further extended, the legal starting time being placed at one-half hour before sunrise. This change served no useful purpose to most hunters in Illinois; in fact, it was detrimental to duck hunting in many places. Disturbances caused by hunters in going to their shooting stands at an hour when the ducks were commencing to feed resulted in considerable avoidance of those areas by mallards.

Field observations in 1943 revealed that, because of hunting disturbance during the early morning hours, mallards fed very little in cornfields close to the Illinois and Mississippi rivers until after the end of the open season. The bulk of the population obtained food in the mechanically picked cornfields 20 to 40 miles from the rest lakes. In this vast territory, mallards were able to find fields where there was little hunting disturbance.

Because of the distance they traveled for food, mallards frequently returned from the morning feeding to their rest lakes as late as 10 A.M., Central War Time. The time of return probably depended upon the availability of the

Photo by Bob Becker

Duck club caretaker (left) and Illinois Natural History Survey game technician checking the composition of duck bags at a shooting club in the Illinois River valley.

waste corn. In returning to the lakes, they flew high, out of shotgun range, until over the safety of the open waters.

The evening flight to cornfields commenced at about 5 P.M., C.W.T., almost daily in the 1943 hunting season, and, even though this was before the legal closing time, hunters seldom had targets because the mallards, after leaving open waters, usually flew out of shotgun range. The ducks that arrived at the cornfields before sunset circled over them before alighting until darkness commenced to shroud the fields.

Because of these changes in feeding habits to compensate for changes in shooting hours, the extension of shooting hours apparently did not result in a larger kill of mallards and black ducks in Illinois. Probably the reverse was true, for mallards, in avoiding cornfields near the river (evidently the result of pre-dawn flushing), had more extensive feeding places, and hence were exposed to less intensive shooting pressure.

Mallards and black ducks altered their morning and evening feeding routines even in the baiting days. In an official report, Uhler (1933) states: "By the middle of the hunting season, the ducks became so wary that the major portion of them remained in these rest areas all day, and about 20 minutes after sunset (the close of the legal shooting period) they would start to fly to the surrounding baited pens. Just before dark, literally thousands of mallards could be seen milling over the heavily baited spots, alighting only long enough to fill up on corn and then go back to the rest lakes. On moonlight nights they fed actively all night long. As a result many of the sand hill shooting places fed large quantities of corn but were never able to get much shooting."

A valid objection to permitting waterfowl shooting until sunset is that many shooters—particularly those in the cornfields—defy the law and shoot after sunset, when detection and apprehension are difficult. Hunters are more apt to disregard the sunset closing hour than the 4 P.M., C.S.T., closing hour because of the shorter time from sunset until darkness. Observations in the Sangamon bottoms and Thompson Lake drainage district indicate that shooting after dark in 1942 soon resulted in mallards being "burned out" of certain sections of those areas. Shooting in darkness more than any other disturbance makes ducks avoid or leave areas. Thus, late or pre-dawn shooting not only disturbs the ducks but reacts against the hunters.

At the conclusion of the 1942 waterfowl season, the Illinois Natural History Survey canvassed the opinion of Illinois duck hunters relative to shooting hours. The returns received show the following: Seventy hunters preferred the 1942 regulations, permitting waterfowl hunting from sunrise to sunset. Fifty-two hunters voted for the cessation of hunting at 4 P.M., C.S.T. Twenty-two of these wanted the opening hour kept at sunrise. Thirty hunters voted that waterfowl hunting be permitted only from 7 A.M. to 4 P.M., C.S.T. No canvass of opinion was made following the 1943 hunting season, but the general

Table 10.—Influence of shooting hours on duck kill as derived by comparing the kill during hunting season with the duck population, Illinois River valley, 1938–1942.

Year	Number of Ducks per Acre During Season*	Number of Ducks Estimated Killed	Per Cent of 5-Year Population	Per Cent of 5-Year Kill	Shooting Pressure Index†	Shooting Hours‡
1938	207.39	103,877	15.0	16.3	1.09	7 A.M.–4 P.M.
1939	199.05	100,210	14.4	15.8	1.10	7 A.M.–4 P.M.
1940	216.60	110,000	15.7	17.3	1.10	Sunrise–4 P.M.
1941	390.21	159,400	28.3	25.0	0.88	Sunrise–4 P.M.
1942	367.18	162,500	26.6	25.6	0.96	Sunrise-Sunset

*Sum of weekly averages for season.
†Ratio of per cent of kill to per cent of population.
‡Hours are for Central Standard Time.

expression was that the half hour before sunrise shooting was very detrimental to hunting.

Some hunters who expressed a preference for shooting hours of sunrise to sunset explained that waterfowl occurred on their property only at sunrise and sunset. The principal reason advanced by hunters for ending shooting daily at 4 P.M., C.S.T., was that it kept waterfowl from being "burned out" of a region.

Have longer shooting hours resulted in a greater kill of waterfowl? Shooting hour regulations are difficult to evaluate because of the influence of such other variables as length of season, population, weather and food conditions. Length of seasons has changed with shooting hours; so in order to reduce the influence of varying lengths of seasons, as well as variations in the duck flight, the percentage of the 5-year duck population present during the open season of each year has been compared with the percentage of the 5-year kill, table 10, to give an index of the shooting pressure resulting from various shooting hours. The highest index numbers indicate the greatest shooting pressure and kill.

Because of better hunting conditions in certain years than in others the data are inconsistent, but they show no evidence that larger kills were made in seasons of sunrise or sunset shooting than in seasons of shorter shooting days. The index figure for 1940, when sunrise shooting was permitted, was the same as for 1939, with 7 A.M. shooting, table 10. In 1941 and 1942, with sunrise shooting, the shooting pressure, a measure of the comparative kill, was actually less than that with 7 A.M., C.S.T., shooting in 1938 and 1939.

Effect of Bag Limit

In recent years, several biologists have questioned the value of bag limit as an effective measure in restricting the total game kill.

Fig. 22, based on data assembled by Dr. Yeatter and Dr. Thompson, shows for most years from 1885 through 1938 the average daily bag of Duck Island Preserve members and the observed bag

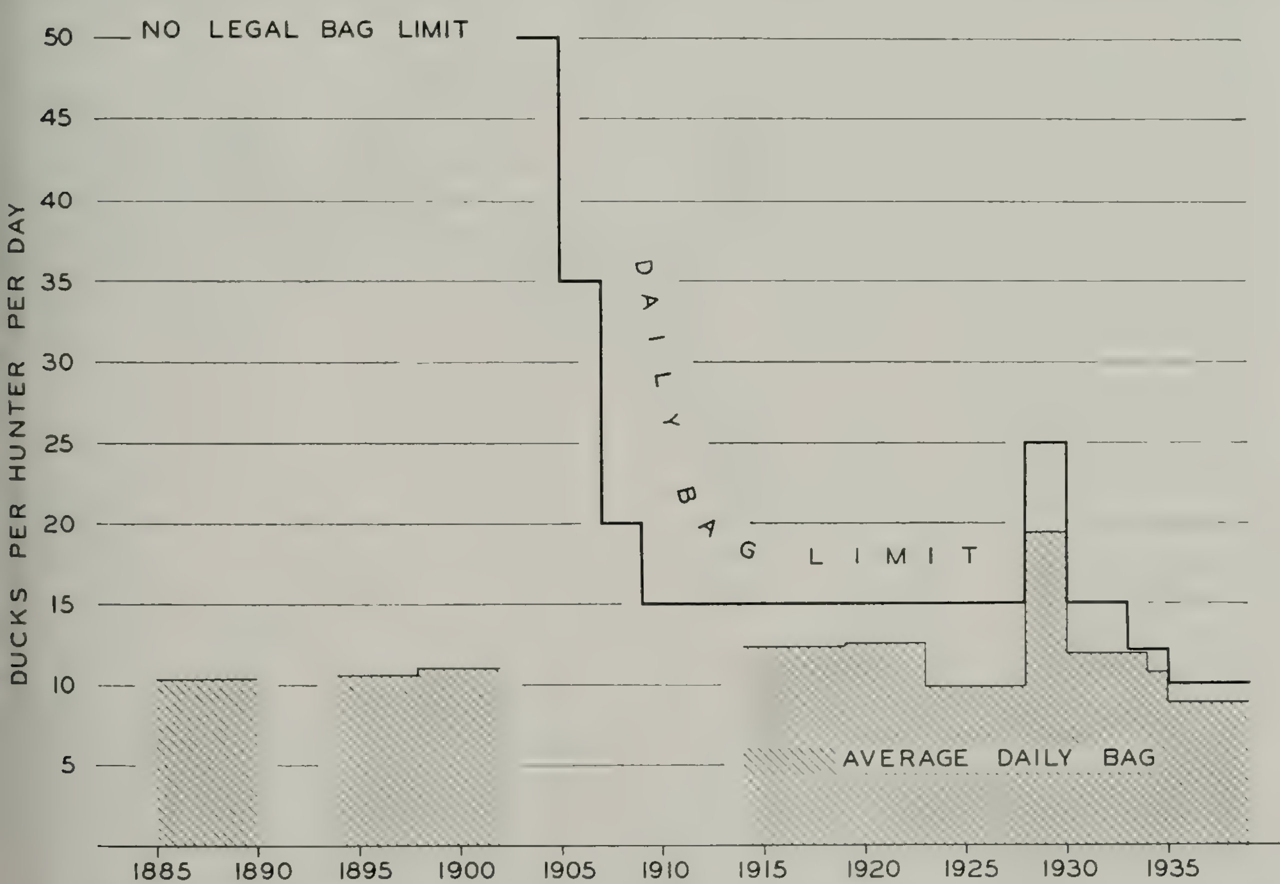

Fig. 22.—Average daily duck bag made by members of the Duck Island Preserve near Banner, Illinois, during certain periods from 1885 through 1938 in relation to the bag limit observed by the club.

limit.* Gaps in the graph are due to missing records. In "the good old days" with no legal restrictions, the kill per shooter per day was little greater than it was in 1938. From 1885 through 1889 and from 1894 through 1901, the kill per hunter-day averaged slightly over 10 ducks. From 1914 through 1927, when the club followed the state legal daily bag limit of 15, club members took an average of about 10 to 12 ducks per day each. In 1928 and the succeeding years the club regulations conformed with the federal limit. When the club elected to observe the federal bag limit of 25 in 1928 and 1929, rather than the state limit, the members' average individual daily bag rose to about 19. But in 1930 through 1932, with the federal limit lowered to 15, the Duck Island Preserve bag dropped to about 12. A further drop in the legal limit to 12, in 1933 and 1934, produced a further decrease in the individual daily kill. In 1935, the legal bag limit of ducks was cut to 10 per day, and again the average daily bag made by individual members of this club dropped.

It is apparent that a legal limit of 50 had little influence on the average daily kill of Duck Island Preserve members. However, as the bag limit decreased, it had increasingly greater influence on the average daily take per hunter. With a bag limit of 25, Duck Island Preserve hunters averaged each about 5 less than the limit; with a limit of 15, they averaged about 3 less; and, with a limit of 10, they averaged about 1 less than the regulations permitted. Since this duck club enjoys better shooting than most clubs in Illinois, the lag of the actual bag below the bag limit is much less than that of the average duck hunter. The better the habitat and the hunter, the more effective is the

Photo by Bob Becker

Bag limits in the lower figures are effective means of preventing overshooting of waterfowl. A mallard and two pintails are shown above.

*Record book made available by Ferd Luthy.

legal bag limit in placing a ceiling on the daily kill per hunter. Few public shooting ground hunters in Illinois are limited in their kill of ducks by the bag limit. But the bag limit is an effective measure in restricting the individual kill of the better hunters at the best Illinois clubs. All evidence points to the probability that in this state it is just as effective in limiting the total kill, for membership in Illinois waterfowl clubs has not materially increased, nor has the hunting intensity increased noticeably as a result of lowered bag limits. The individual daily bag limit ranks next to limitation of length of season as an effective regulatory measure in management of migratory ducks in Illinois.

Laws for Depleted Species

As previously discussed, because of differences in native wariness, feeding, flocking and migrating habits, some kinds of ducks are more readily killed by hunters than others. Some have higher rates of productivity and so can recover more quickly from the effects of heavy shooting, drought or other disaster. Some are affected more than others by adverse weather conditions. Because of differences in numbers or in attractiveness to hunters, as well as in certain habits, some are subject to greater shooting pressure.

Federal regulations of 1938–1940 restricting the daily individual bag of canvasbacks, redheads, ruddy ducks and buffleheads to three alone or in the aggregate of these species were not very effective in reducing the shooting pressure on, or the total kill of, these species in Illinois.

The shooting pressure quotient on the canvasback was 1.65 in 1938, 1.44 in 1939 and 0.63 in 1940, with the restrictions; 1.47 in 1941 and 1.09 in 1942, without the restrictions, table 8. The shooting pressure quotient on the ruddy was 3.07 in 1938, 2.48 in 1939 and 0.57 in 1940, with the restrictions on the take; 0.86 in 1941 and 0.63 in 1942, when there were no such restrictions, table 8. This situation alone does not necessarily mean that in other sections of the United States the restricted limit did not lower the total kill of these species, but it indicates that in states where these species made up only a small part of the population, and where no special effort was made to bag them, such measures had little effect on the kill.

Table 11.—Per cent of bands returned from 11 species of ducks within the first year after being banded. Ducks were banded in the United States and Canada, principally since 1938.*

Species	Number of Banded Ducks	Per Cent of Bands Returned First Year
Wood duck	1,271	5.4
Mallard	48,652	6.4
Pintail	9,072	6.0
Green-winged teal	659	5.2
Blue-winged teal	6,705	2.4
Gadwall	362	10.5
Widgeon	892	6.4
Shoveler	488	8.0
Lesser scaup	1,824	5.3
Ring-necked duck	392	4.5
Redhead	1,629	8.0

*To Richard Griffith and Frederick C. Lincoln of the U. S. Fish and Wildlife Service and to B. W. Cartwright of Ducks Unlimited (Canada) is due the credit for making banding data available.

Although in certain areas the three per bag limit regulation undoubtedly reduced the kill in those species to which it applied, we wonder if it reduced the continental take materially. Despite restrictive regulations on the take of redheads in recent years, this species has suffered high shooting losses, table 11. Recent first season band returns show that a greater percentage of redheads was taken by hunters than of any other species but the gadwall and shoveler, and banding data on these latter species may not be large enough to be significant.

Because the wood duck was in a precarious position in the early part of this century, it was given complete legal protection in some states by the Migratory Bird Act of 1913. This protection was extended to all states under the Migratory Bird Treaty Act of 1918 and was in force until 1941, when one wood duck in possession was allowed in 15 states. In 1942 and 1943 one wood duck was permitted in possession in all 48 states; in 1944 in all states but South Dakota and Massachusetts.

The regulation allowing one wood duck in possession has caused a great deal of controversy among bird lovers, conservationists and duck hunters. Does it permit too high a kill of this species? Will the status of the species once again become critical? In order to answer these questions, at least in a limited way, let us examine the kill records of Illinois duck clubs and ratios of band returns to birds banded.

Relatively few wood ducks were killed in the Illinois River valley in 1942, table 12. While these ducks were relatively numerous, most hunters in this region passed up shots at them to kill other species. Occasionally one was shot to add to a low bag, and birds were shot accidentally in 1942, just as when given complete legal protection. Because the legal 1942 kill of wood ducks in the Illinois River valley was probably little greater than the estimated illegal kill (Hawkins & Bellrose 1939) in the 1938 season, it must not be assumed that the one wood duck law had little adverse effect on the species.

Undoubtedly where other species of ducks were less abundant than along the Illinois River, proportionally more wood ducks were taken by hunters. Kill records from duck clubs along the Mississippi River in 1942 disclose that one-third more woodies were bagged there per hunter-day than along the Illinois River. Harry Maltby, U. S. Game Agent, reporting (letter December 27, 1943) on conditions along the Mississippi River in Iowa during the 1943 season, stated that a larger number of wood ducks were killed in that region in 1943 than in 1942. This was due to the greater scarcity of other species early in the season.

From the first season band returns before and after full legal protection was removed, table 13, it may be possible to evaluate the effect of the regulation allowing one wood duck in possession. Only the bands reported from wood ducks either shot or "found dead" were recorded; the "found dead" woodies are assumed to have been shot, for it is evident, after comparing the proportion of other species reported found dead and after noting the greatly reduced number of woodies reported "found dead" when it was legal to take one, that the "found dead" report was sometimes only a subterfuge on the part of hunters to escape being penalized. Nevertheless, a surprisingly large number of protected wood ducks were actually reported shot. Doubtless some

Table 12.—The numbers and species of ducks killed at 276 clubs in the Illinois River valley, 1942.

Species*	Number Killed
Wood duck, *Aix sponsa* (Linnaeus)	675†
Redhead, *Nyroca americana* (Eyton)	332
Ruddy duck, butterball, *Erismatura jamaicensis rubida* (Wilson)	627
Shoveler, spoonbill, *Spatula clypeata* (Linnaeus)	751
Gadwall, gray duck, *Chaulelasmus streperus* (Linnaeus)	953
Green-winged teal, *Nettion carolinense* (Gmelin)	1,171
Canvasback, can, *Nyroca valisineria* (Wilson)	1,415
Widgeon, baldpate, *Mareca americana* (Gmelin)	1,563
Ring-necked duck, blackjack, *Nyroca collaris* (Donovan)	1,824
Blue-winged teal, *Querquedula discors* (Linnaeus)	2,006
Lesser scaup, bluebill, *Nyroca affinis* (Eyton)	4,161
Pintail, sprig, *Dafila acuta tzitzihoa* (Vieillot)	4,875
Mallard, *Anas platyrhynchos platyrhynchos* Linnaeus; Black duck, black mallard, *Anas rubripes* Brewster	59,545

*Other duck species occasionally seen in Illinois include the bufflehead, *Charitonetta albeola* (Linnaeus), and the American golden-eye or whistler, *Glaucionetta clangula americana* (Bonaparte).

†The actual number recorded killed was 476; however, since there was no designated place for wood ducks on the kill sheets, some club members recorded them in the unspecified duck column. Based upon number classified as unspecified in 1941, it is believed that about 200 wood ducks were so classified in 1942.

bands were not turned in because the hunters finding them feared apprehension.

Data presented in table 13 show that even when wood ducks were given complete legal protection a significant proportion of the population was killed by hunters. There was apparently a decrease in the proportion killed in 1941, although, for the first time since complete legal protection was given the wood duck, one such duck was permitted in the bag in 15 southern states. The lower proportion killed in that year may have been due to improved hunting conditions, causing more hunters to pass up shots at wood ducks for the larger ducks, or to some habitat conditions—such as high water—which favored a low wood duck kill.

In 1942 and 1943, when one wood duck could legally be taken in all 48 states, the ratio of first year band returns to wood ducks banded over the nation rose to 5.4 per cent. This would indicate about two-thirds greater kill in those years than when the species was given complete legal protection.

Has the increased kill resulting from the one wood duck law been too high? Only time and an adequate check on the wood duck population status will provide this answer, but we can compare the relative take of these ducks at present with that of other species, table 11. It is evident that over the nation, even with a one in bag or possession limit, wood ducks suffered a hunting mortality rate comparable to that of most other species.

How the wood duck ranks in productivity with other species has at present not been determined. There can be little doubt that during the past 2 years in many sections of the United States wood duck mortality from all causes exceeded productivity.

In the Illinois River valley, in sections of the Mississippi River valley and in parts of Maine, Arkansas, Iowa and Missouri, wood duck productivity was abnormally low in 1942 and 1943. Floods, combined with excessive raccoon predation, destroyed most of the nests in the Illinois River bottomlands. Raccoons, and also squirrels, raided many nests in the uplands. In Illinois, raccoons were more abundant in 1942 and 1943 than at any other time in the past decade.

The kill of wood ducks in 1942 and 1943, amounting as it did to proportions as great or almost as great as the kill of other species, indicates that this kill may be a serious threat to the species if its reproduction rate is low. A close watch on the population should be maintained, and, if a decline continues, the species should either be placed under complete protection or the hunting

Table 13.—Number of wood ducks reported banded in North America, place of banding and per cent of bands reported recovered from banded birds shot or "found dead" within a year after being banded (first season returns).

Place of Banding	Prior to 1941 (Closed Seasons)		1941 (One in Possession in 15 States)		1942–1943 (One in Possession in All States)	
	Number Banded	First Season Returns, Per Cent	Number Banded	First Season Returns, Per Cent	Number Banded	First Season Returns, Per Cent
Northern Illinois	21	0.0	163	2.5	518	5.2
Central Illinois	62	3.2	51	1.9	303	7.9
Wisconsin	309	3.8	102	2.0	...	0.0
Michigan	328	3.7	128	0.8	104	2.0
New York	63	8.0	...	0.0	228	4.4
Maine	318	2.8	216	2.2	57	8.8
Vermont	...	0.0	...	0.0	61	3.3
British Columbia	142	1.4	...	0.0	...	0.0
North American Average		3.4		2.3		5.4

season adjusted to provide less shooting pressure. In the northern and central zones, a late opening would see most of the wood ducks gone before shooting commences. Census and banding records in Illinois reveal that most of these ducks have departed from this state by November 1.

Effect of Bait and Live Decoys

In the years when baiting was permitted along the Illinois River, there were two diverse types of baited areas. In the bottomlands, bait was placed in small timbered ponds, or at shooting stands in the marshes and on the large lakes. Differing widely from such baited areas were the upland field pens, each of which consisted merely of a pen of decoys, bait and, usually, a small pond of water.

The bottomland areas most successfully baited were small timbered ponds and potholes. For the reason that the region near the mouth of the Sangamon River contained many such areas and was almost devoid of natural foods, it was the scene of the heaviest baiting. Leopold (1931) reports that in that region in 1928 clubs were putting out, on a 20-acre tract, as high as 7,000 bushels of corn per season and that rates per acre ran up to 430 bushels per season.

According to Uhler (1933) field-pen shooting reached its maximum development in Mason County. The success there was due largely to the proximity of three large "rest" lakes—Clear, Jack and Crane—which at the time were not adapted to the growth of first-class duck food plants because of their extreme fluctuation in water levels. Mallards were readily attracted from these lakes to the nearby heavily baited field pens. From a plane, Uhler enumerated 250 field pens in Mason County and in the adjacent part of Tazewell County. Most of these were within 5 miles of the Illinois River bottomlands, but a few were nearly twice that distance from the river.

Uhler's description of a dry-land club is as follows: "A typical field-pen consists of a small artificial pond supplied by water which is usually pumped from a nearby well by means of a portable gasoline engine. The basin of the pond is lined in a variety of ways to prevent seepage. . . . . The pond is equipped with a flock of live decoys and baited heavily with corn on the cob or shelled. Sometimes, the entire pond is enclosed with poultry mesh about four feet high. Other ponds have the decoys confined

Photo by Bob Becker

Corn being scattered at an Illinois River valley shooting stand in the days of baiting, 10 o[r] more years ago. Mallard and pintail silhouettes are shown being used as decoys. The combinatio[n] of baiting and live decoys resulted in a duck kill so high that restrictive measures were inaugurate[d] in an effort to prevent rapid depletion of the population.

to one or more small pens extending into the pond. . . . . Usually from 3 to 5 blinds made of corn stalks, leafy oak branches, or rushes fastened to portable frames surround these ponds. Many dry pens were also noted. These consist of a pen of live decoys placed in some remote field and surrounded with long bands of shelled corn or corn on the cob. The only water involved in this set-up is placed in a trough or other receptacle for the decoys to drink."

Uhler reported that one of the most successful commercial shooting places fed at four field pens from 1,400 to 2,500 bushels of corn per season. He estimated that 6,000,000 bushels of corn were fed by Illinois clubs during the 1933 season. Sixty-seven clubs reported feeding an average of 1,243 bushels of corn and other grains.

What was the influence of baiting and decoy pens on the kill of ducks in Illinois? In addition to Uhler's 1933 report on the estimated duck kill and populations in the Illinois River valley, we have waterfowl kill records from the State Department of Conservation for 2 years in which corn was put out for ducks, 1933 and 1935. Through band returns, we can roughly compare differences in mallard mortality during and after the baiting period.

Besides the 250 field pens enumerated by Uhler in Mason County and an adjoining part of Tazewell County, there were probably 200 others in the vicinity of the Illinois River. Leopold (1931) reports that 4,000 ducks were killed in 60 days on one 40-acre commercial dry-land club. Uhler says that at one commercial dry-land club in 1933 an average of eight shooters per day were assured the limit up to the time of his visit in mid November. That would mean a kill of about 2,400 ducks during the first half of the season. These were among the dry-land places at which the highest kills were made. Reports of local hunters familiar with the situation indicate that an average of 500 ducks were killed at each field pen. If there were 450 field pens, the total annual kill made by these dry-land clubs amounted to about 225,000 ducks.

Photo by Bob Becker

A pen of live decoys in front of a blind, once a familiar scene in the Illinois River valley.

Bottomland clubs were not affected as greatly as upland field-pen clubs by the outlawing of bait and live decoys. However, many clubs in the Sangamon River bottoms disbanded because of the low duck kill resulting from the no-bait, no-live-decoy law. With no bait or live decoys, the kill at several of the large Sangamon River clubs dropped from 7,000 or more to less than 500 per year.

Some indication of the influence of bait and live decoys on the duck kill in

Table 14.—Total reported kill of ducks at Illinois River valley waterfowl hunting clubs; average kill per club and per hunter-day.

Year	Days in Season	Number of Clubs	Total Ducks Reported Killed	Average Annual Kill per Club	Average Kill per Hunter-Day
1933	60½	99	60,467	611	7.50
1934	30	...	......	...	....
1935	30	214	84,733	396	7.18
1936	30	260	56,860	219	6.14
1937	30	289	38,063	132	5.23
1938	45	252	60,102	239	5.51
1939	45	138	36,783	267	....
1940	60	243	66,502	274	6.03
1941	60	308	89,670	291	6.12
1942	70	276	80,339	291	6.25

Illinois may be derived from a study of table 14. In 1933, during a 60½-day season, in which baiting and live decoys were allowed, 99 clubs reported a kill of 60,467 ducks, or 611 per club. During a season of 60 days in 1941, when baiting and live decoys were prohibited, 308 clubs reported a kill of 89,670 ducks or 291 per club. Even in 1935, when no live decoys were permitted, when the season lasted but 30 days and feeding was permitted in sections of the premises not shot over, 214 clubs reported a kill of 84,733 ducks or 396 per club. In two seasons of equal length, 1936 and 1937, in which live decoys and all types of baiting were outlawed, 260 and 289 clubs reported kills of 56,860 and 38,063 ducks in the 2 years, respectively, or 219 and 132 per club.

Uhler estimated the Illinois duck club kill in 1933 at 926,000. This may have been too high since the kill was computed on the basis of 20 clubs that probably had higher than average kills. He estimated the total number of mallards and pintails in baited portions of Illinois at "from 3,000,000 to 4,000,000 birds." During 1941, a season similar to 1933 except for outlawing of bait and live decoys, we estimated the Illinois River valley kill (based on club records and observations in the field) at 175,000. We estimated the mallard and pintail population in 1941 for the same section included by Uhler at 6,175,000. On the basis of Uhler's figures for the first year and our figures for the second, the duck kill in relation to the population was about 8 to 11 times as great in 1933 as in 1941.

A greater proportion of the shooting

Table 15.—Composition of waterfowl bag at Illinois River valley waterfowl hunting clubs, 1933 and 1935–1942. Each figure represents per cent of total bag (all species) in year.

Species	1933	1935	1936	1937	1938	1939	1940	1941	1942
Mallard and black duck	83.80	88.79	79.34	69.28	55.70	61.80	72.10	63.72	74.20
Pintail	6.55	4.01	7.01	13.16	12.60	11.29	11.59	8.60	6.05
Green-winged teal	2.48	1.48	2.81	4.58	9.40	7.16	4.16	1.63	1.46
Blue-winged teal	0.65	1.11	0.56	0.98	3.30	1.53	1.38	2.32	2.50
Widgeon*	0.87	0.60	0.41	0.82	7.16	5.10	2.13	3.12	1.94
Gadwall*	0.59	0.87	1.12	1.83	2.27	2.70	1.13	1.90	1.18
Shoveler	0.40	0.37	2.36	2.05	2.40	1.67	1.08	0.94	0.93
Lesser scaup	2.01	1.24	2.76	3.64	4.40	6.36	3.34	7.85	5.20
Ring-necked duck	1.33	0.65	1.06	0.72	0.59	0.70	1.80	6.62	2.28
Canvasback	0.09	0.08	†	†	0.40	0.35	0.37	1.67	1.76
Ruddy duck	†	†	†	†	0.43	0.52	0.17	0.51	0.78
Other ducks	0.54	0.30	1.34	2.16	....	....	....	0.31	0.41
Coot	0.69	0.50	1.23	0.78	1.35	0.82	0.66	0.81	1.31

*Figures for widgeon and gadwall previous to 1941 calculated from 1941–1942 data for reasons explained in text.

†Given complete legal protection in this year.

pressure resulting from baited areas and live decoys fell upon the mallard and black duck than upon other species. Table 15 shows that, in 1933, 83.80 per cent of the bag was made up of mallards and black ducks. In the 1941 season, of comparable length and dates, only 63.72 per cent of the bag was composed of these species. Even in 1935, when feeding was done in areas not shot over and live decoys were outlawed, the mallards and black ducks comprised 88.79 per cent of the total bag; in 1938, mallards and black ducks formed only 55.70 per cent of the bag. The large proportion of those species in the 1936 and 1937 bags, when baiting and use of live decoys were illegal, was due to the fact that the open season extended from November 1 through 30, a period in which mallards formed over 90 per cent of the waterfowl population.

Banding returns show that baiting and live decoys resulted in heavy shotgun mortality to the mallard. A study of tables in *Returns from Banded Birds, 1920 to 1923* (Lincoln 1924) indicates that 218, or 16.4 per cent, of the mallards banded by Lincoln during the autumn of 1922 near Browning, Illinois, were killed that hunting season in Illinois; a mallard kill rate much higher than in recent years in this state.

From 1939 through 1943, the Illinois Natural History Survey banded about 28,000 mallards at the Chautauqua National Wildlife Refuge, near Havana. As indicated by band returns, the shotgun mortality, the first season, of 27,680 fall banded mallards was 2.9 per cent in 1939; 6.8 per cent in 1940; 2.6 per cent cent in 1941; 7.0 per cent in 1942; and 5.7 per cent in 1943. Lincoln banded his mallards at a gun club, and we banded ours at a wildlife refuge. While this difference contributed to the greater survival of Chautauqua-banded mallards, the kill rate of Illinois mallards in 1922 must have been at least twice as great as it has been since 1939. Returns from 2,452 mallards banded in Canada* show a shotgun mortality, the first year, of only 8.9 per cent in 1940, 5.7 per cent in 1941 and 6.4 per cent in 1942. These mallards had to face shotguns in the northern zone as well as in the central and southern zones and therefore had more time in the season of banding in which to be killed than did those banded by Lincoln near Browning.

Data on duck mortality obtained from Illinois State Department of Conservation kill records, from Uhler's 1933 report and from a comparison of first hunting season band returns indicate that the kill rate under baiting and live decoy conditions was two to three times as great as after their prohibition.

Photo by Bob Becker

Mallard and pintail blocks, or wooden decoys, being picked up in a marsh smartweed area that has yielded large kills of Illinois River valley ducks.

*Information furnished by B. W. Cartwright of Ducks Unlimited (Canada).

In Illinois, the improved survival rate has applied mainly to mallards and pintails; however, all species have benefited from the no-baiting, no-live-decoy regulations, for all species—including canvasbacks, scaups, redheads and ringnecks—were attracted by bait and live decoys.

Credit for the greater survival rate cannot be given entirely to prohibition of baiting and live decoys, for other conservation measures were put in force at about the same time.

However, these prohibitions increased the rate of duck survival more than did shortening the seasons, reducing bag limits or limiting the shooting hours. Because the bans on bait and live decoys were initiated at approximately the same time it was not feasible to evaluate the effectiveness of each of these two separately.

Despite the great reduction in kill following outlawing of the use of bait and live decoys, no catastrophe has befallen either the waterfowl club or the individual hunter. True, the disbanding of all dry-land duck clubs has resulted, but these clubs contributed little to the welfare of the birds. They were parasitic. In some sections, notably near the mouth of the Sangamon River, bottomland waterfowl clubs have passed out of existence, but in other sections they have held their own or even increased in number. In 1941, there were 792 registered waterfowl hunting clubs in Illinois, more than in the last years of the baiting and live decoy era.

The free-lance hunter has materially benefited from the discontinuance of baiting. Where formerly ducks were concentrated in a few private, heavily baited areas, today they are more evenly distributed. Now public hunters may find fair shooting not only on several state-owned public shooting grounds and other waters not under private control, but in cornfields as well.

Ducks have not left the Illinois River valley, as many hunters feared would happen without bait to hold them. Mallards, pintails and black ducks have found a ready source of food in the waste corn left in fields by the mechanical pickers, and they remain in the valley in numbers comparable to those during the baiting era. Natural food resources in the Illinois River valley have increased in recent years because navigation dams have been built on the river and because hunting clubs have made greater attempts to control their water levels. Uhler (1933) estimated that mallards comprised 85 per cent of the waterfowl population of the valley at the time he made his report. Mallards and black ducks, although increasing in numbers, formed a successively smaller part of the total duck population between 1938 and 1942, dropping from 94.61 to 84.98 per cent, tables 3–7. Other species of ducks are forming a greater percentage of the waterfowl population in the Illinois River valley. Improved environmental conditions for diving ducks are largely responsible for this trend.

Effect of Three-Shell Law

Because of lack of specific data, it has been impossible to evaluate the three-shell limit for shotguns. In the days of live decoys and baiting, when pot-shooting on massed ducks was common, the limitation of three shells to a gun would have been an important factor in reducing the carnage at baited pens. However, the three-shell law went into effect in 1935 after live decoys had been banned and outright baiting prohibited.

Ferd Luthy and other veteran Illinois duck hunters are of the opinion that the three-shell law lessens the chance of crippling ducks by reducing the number of out-of-range shots. Since studies we conducted in 1938 and 1939 disclosed that about 3 ducks were crippled and lost for every 10 bagged, it is evident that this loss is serious. If more shells in the gun would result in greater crippling losses, it would appear advisable to retain the present three-shell limit.

Illinois Duck Harvest

What per cent of the duck populations passing through the Illinois River valley in 1938–1942 was harvested by hunters in this state? An answer to this question may be found by comparing the kill with the population, table 16. At present we must base the population figures on peak numbers of each species during the season, without any compensation for turnover of the populations. When banding data are analyzed to the end of showing the rate of movement of ducks through the valley, then we shall be able to determine fairly accurately the number of ducks that actually pass through the Illinois River valley.

Table 16.—The approximate per cent of ducks bagged in the Illinois River valley, 1938–1942.

Year	Calculated Minimum Duck Population	Calculated Minimum Duck Kill	Per Cent of Flight Killed	Per Cent of Bands Returned in Year of Banding*
1938	2,860,000	103,877	3.6	...
1939	2,496,000	100,210	4.0	1.8
1940	3,023,000	110,000	3.6	5.0
1941	6,175,000	159,400	2.6	1.8
1942	4,971,000	162,500	3.3	3.0
Total	19,525,000	635,987		
Average	...	...	3.3	

*Only mallard, black duck and pintail.

The ratio between the number of ducks banded each year on the Chautauqua National Wildlife Refuge near Havana and the number of returns from them in Illinois during the same season should indicate the minimum per cent of kill. Since only the mallard, black duck and perhaps the pintail were banded in sufficiently large numbers to be significant, the band return figures apply principally to those species. The figures indicate a minimum kill ranging from 1.8 per cent of the flight in 1939 and 1941 to 5.0 per cent in 1940, table 16. There is a greater annual variation among the banding ratios obtained than among the figures obtained from a comparison of the population-kill data. This is due probably to the fact that the chronology of banding did not correspond to the chronology of migration. The low per cent of 1.8 in 1939 and 1941 occurred as the result of a disproportionate number of birds being banded late in the season; the banded birds, therefore, received less shooting pressure than the population as a whole.

Population-kill figures for all ducks tend to verify the band recovery data, which were principally for mallards, black ducks and pintails. These figures indicate that during the 1938–1942 period, 3.3 per cent of the ducks of all species in the Illinois River valley were taken by hunters, table 16. The band return data may be too low in some years because of a disproportionate amount of late season banding. After making allowances for inaccuracies in data, we estimate that, in the period of this study, Illinois hunters annually harvested between 3 and 5 per cent of the duck flight passing through the state.

Total Effect of Regulations

The cumulative effect of federal regulations on the continental take of ducks in the past decade may perhaps best be measured by ratios of first-season band returns to birds banded.

A study of data presented by Lincoln (1924) reveals that of about 1,330 mallards banded near Browning, Illinois, in the fall of 1922, approximately 20 per cent were killed before the end of the hunting season. The Illinois Natural History Survey duck banding program was begun almost 20 years later, after important federal restrictions had been placed in force. Banding was done on the Chautauqua National Wildlife Refuge, near Havana, some 20 miles north of Lincoln's station, usually from October until the freeze-up in early December. Notwithstanding the fact that we banded on a refuge, the high proportion of local returns demonstrated that the ducks we banded suffered a high local kill. Yet the same-season band returns over the nation from approximately 28,000 mallards banded on the Chautauqua Refuge, 1938–1943, amounted to only about 5 per cent, approximately one-fourth the proportion recorded by Lincoln near Browning.

Pirnie (1935) reported that 20.5 per cent of 1,607 black ducks banded at the Munuscong Waterfowl Refuge in Michigan's upper peninsula between 1928 and 1934, before drastic waterfowl restrictions were inaugurated, were reported shot the same season as banded. Of 1,251 black ducks banded from 1939 to 1942, inclusive, on the Seney National Wildlife Refuge in Michigan's upper peninsula, only 9.2 per cent were reported shot during the same season as banded (reported by C. S. Johnson to Richard Griffith). This is approximately half the percentage reported by Pirnie for the earlier period from the same region.

According to Phillips & Lincoln (1930) the annual duck mortality up to the time they wrote (as based on first-season band returns from stations scattered over the continent) was about 13 per cent. Banding data supplied by B. W. Cartwright of Ducks Unlimited (Canada) disclose that, in 1940, 6.7 per cent first-season band returns were received; in 1941 the returns amounted to 5.6 per cent; and in 1942 to 7.5 per cent. These figures represent about half the percentage reported by Phillips & Lincoln.

Although these figures are only small samples, their consistency is indicative that regulations in force in the past 10 years cut about in half the rate of kill made by hunters in the previous decade. On the whole, the measures enacted by the federal government to reduce the kill of ducks accomplished their purpose.

Summary

1. In order to manage well the harvest of the continental crop of migratory waterfowl, it is necessary to evaluate as closely as possible the influence each hunting regulation has on the kill and to determine the optimum dates for open seasons. Obviously, a close evaluation covering all of North America is impossible at present, but it is feasible in a smaller area, such as Illinois.

2. All important waterfowl hunting regulations except those relating to territories were made by the individual states until the federal Migratory Bird Act was passed in 1913.

3. The Migratory Bird Act of 1913 and the Migratory Bird Treaty Act of 1918 applied the first major federal restrictions on the taking of waterfowl. However, federal regulations were not very stringent until a shrinking waterfowl population, alarmingly evident by 1933, necessitated a great reduction in the kill.

4. Various restrictive measures imposed on duck hunting, most of them in 1935, included reduction in the open season to 30 days, reduction in the bag and possession limits to 10 birds, limitation of shooting to the hours between 7 A.M. and 4 P.M., prohibition of the use of bait and live decoys, limitation of shells in gun to three or less, and reduced limits or no open season on certain species of waterfowl.

5. It is possible to regulate the kill of certain species of waterfowl in Illinois by opening and closing the hunting season to include all or certain proportions of the flight of these species within the open or closed periods. Species differ in the time of arrival in Illinois, in reaching maximum numbers and in departing.

6. It may be necessary to protect certain species more than others, for each kind of duck varies in vulnerability to the shotgun as well as to natural conditions. Inherent wariness, flight, flocking and feeding habits of ducks and shooting practices of hunters are factors that affect the kill of each duck species.

7. In Illinois, mallards and black ducks, as a group, were found to be the least vulnerable to the shotgun, 1938–1942, followed by lesser scaups, canvasbacks, ruddy ducks, ring-necked ducks, pintails, widgeons and gadwalls, green-winged and blue-winged teals, and shovelers.

8. Recent open seasons in Illinois (1938–1942) have protected blue-winged teals more than any other species. These open seasons have protected other species in the following descending

order: shovelers, green-winged teals, pintails, widgeons, mallards and black ducks, ring-necked ducks, canvasbacks, lesser scaups, ruddy ducks and gadwalls.

9. In general, the duck species that migrate through Illinois during the early part of the fall migratory season are the ones most easily killed. Ducks of many species are most easily killed during the early part of the season, probably because at that time juveniles predominate in the population.

10. The dates for the waterfowl hunting season in Illinois should depend upon what species of ducks need the greatest protection, and whether the hunter or the waterfowl population should be favored. Open dates suggested by this study are as follows: For a 30-day season, November 1–30; for a 45-day season, October 22–December 5; for a 60-day season, October 10–December 8; for a 70-day season, October 1–December 9; for an 80-day season, September 26–December 14; for a 100-day season, September 20–December 28.

11. Although, in Illinois, the total duck bag does not vary proportionally with the number of days in the hunting season, altering the length of the season is one of the most expedient ways to regulate the duck kill.

12. Shooting hours, which were from 7 A.M. to 4 P.M., 1935–1939, from sunrise to 4 P.M., 1940–1941, then from sunrise to sunset, 1942, and from one-half hour before sunrise to sunset, 1943–1944, appear to have affected the flight habits of cornfield feeding ducks more than the kill of those ducks. Mallards, black ducks and pintails feeding in cornfields have changed the time of their daily flights so that they still generally feed before and after shooting hours. To date there is apparently no evidence that changes to earlier and later shooting hours increased the duck kill; probably the changes lowered the kill.

13. Evidence derived from records of the kill of ducks at one Illinois River valley club that furnished good shooting shows a close correlation between legal bag limits in the lower figures and the number of ducks killed per hunter-day. The higher the bag limit, the less it seemed to influence the duck kill; there was much less difference between actual daily bag and legal limit when the limit was 10 than when it was 25. The individual daily bag limit is an effective regulatory measure in management of migratory ducks in Illinois.

14. Special protection has in some years been given through reduced bag limits to several species of waterfowl: canvasbacks, redheads, ruddy ducks and buffleheads. Some doubt exists as to the effectiveness in Illinois of this measure in reducing the kill of species it is intended to protect.

15. While wood ducks were killed in considerable numbers even when given complete legal protection, the regulation permitting one such duck in bag or in possession probably increased the kill as much as two-thirds. The hunting mortality rate of wood ducks in 1942 and 1943 was comparable to the kill of other species of ducks under no special bag restriction. Whether the productivity of the wood duck will keep pace with the increased kill must be determined by closely checking the population.

16. In 1933, when use of bait and live decoys was permitted, the kill of ducks in the Illinois River valley was, it is estimated, 8 to 11 times as great in proportion to the population as in 1941, when use of bait and live decoys was banned. The ban on the use of bait and live decoys eliminated about 450 commercial dry-land pens in Illinois. Most bottomland hunting clubs were not seriously affected by the ban on such practices. In 1941, there were 792 registered waterfowl hunting clubs in Illinois, more than in the last years of the baiting and live decoy era.

17. The three-shell limit on shells in gun appears to be a desirable restriction.

18. In the 1938–1942 period, about 3 to 5 per cent of the migratory ducks passing through the Illinois River valley were taken by Illinois hunters.

19. Restrictive waterfowl regulations enacted in recent years have aided in the survival of migratory ducks in North America. Available data indicate that over the North American continent the proportional kill in the past 10 years was about half that in the previous decade.

LITERATURE CITED

Anonymous

1770. The statutes at large from the first year of King Edward the Fourth to the end of the reign of Queen Elizabeth. Mark Basket, London. Vol. **2**. 723 pp.

1936. A permanent solution to the waterfowl season problem. More Game Birds in America, New York. 6 maps.

Bellrose, Frank C., Jr.

1944. Waterfowl hunting in Illinois: its status and problems. Ill. Nat. Hist. Surv. Biol Notes **17**. 33 pp., 17 figs.

Cottam, Clarence

1935. Waterfowl problems clarified by study of gunning practices. U. S. Dept. Ag. Yearbook **1935**:328–30.

1939. Food habits of North American diving ducks. U. S. Dept. Ag. Tech. Bul. **643**. 139 pp., illus.

Gabrielson, Ira N., and Frederick C. Lincoln

1941. What is behind the waterfowl regulations? Committee Print No. 1, Senate, 77th Congress, 1st Session. 34 pp. 23 figs.

Hawkins, Arthur S., and Frank C. Bellrose

1939. The duck flight and kill along the Illinois River during the fall of 1938. Am. Wildlife **28**(4):178–86.

Kortright, Francis H.

1942. The ducks, geese and swans of North America. American Wildlife Institute, Washington, D. C. 476 pp., illus.

Lawyer, George A.

1918. Federal protection of migratory birds. U. S. Dept. Ag. Yearbook **1918**:303–16.

Leopold, Aldo

1931. Report on a game survey of the north central states. Sporting Arms and Ammunition Manufacturers' Institute, Madison, Wisconsin. 299 pp., illus.

1933. Game management. Charles Scribner's Sons, New York. 481 pp., illus.

Lincoln, Frederick C.

1924. Returns from banded birds, 1920 to 1923. U. S. Dept. Ag. Dept. Bul. **1268**. 55 pp., illus.

Palmer, T. S.

1912. Chronology and index of the more important events in American game protection, 1776–1911. U. S. Dept. Ag. Biol. Surv. Bul. **41**. 62 pp.

Phillips, John C., and Frederick C. Lincoln

1930. American waterfowl, their present situation and the outlook for their future. Houghton Mifflin Company, Cambridge, Massachusetts. 312 pp., illus.

Pirnie, Miles David

1935. Michigan waterfowl management. Department of Conservation, Lansing, Michigan. 328 pp., illus.

Uhler, Francis M.

1933. Effect of baiting and live decoys on the waterfowl of the upper Mississippi River valley. U. S. Fish and Wildlife Service. (Unpublished report.)

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ILLINOIS NATURAL HISTORY SURVEY

THEODORE H. FRISON, *Chief*

Overfishing in a Small Artificial Lake

Onized Lake Near Alton, Illinois

GEORGE W. BENNETT

Printed by Authority of the

STATE OF ILLINOIS

DWIGHT H. GREEN, *Governor*

DEPARTMENT OF REGISTRATION AND EDUCATION

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NATURAL HISTORY SURVEY DIVISION
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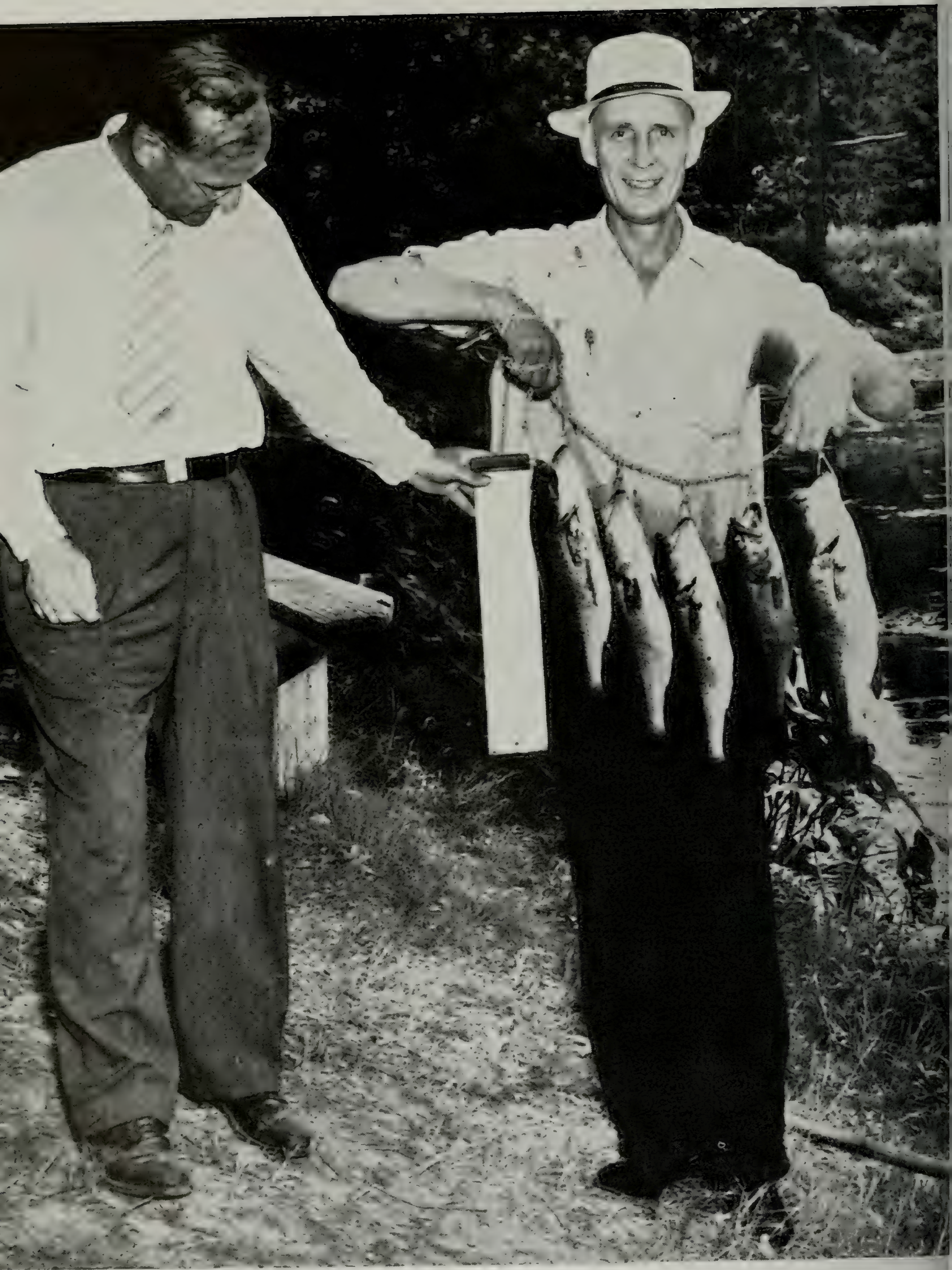


Some of the largemouth bass taken in th
final census of Onized Lake in 1941. W. W
Wood, inspecting fish, and Lyle Walker, hold
ing them, are two of the several members c
the Onized Club who assisted in the census.

Overfishing in a Small Artificial Lake

Onized Lake Near Alton, Illinois

GEORGE W. BENNETT

BEFORE North America was extensively settled, native fish were the staple food for a wide variety of predatory mammals, birds and reptiles, as well as for adult game and other piscivorous fishes. With few exceptions, the natural predators captured small individuals of the various fish species in proportion to the relative abundance of such fish; as the larger individuals were less subject to attack than the smaller individuals, an accumulation of large fish resulted.

Under conditions involving extensive juvenile mortality, the survival of any species of fish depends upon a high reproductive potential, adjusted to compensate for large losses. Most species that exist today have a high reproductive potential. The species that produce comparatively few eggs have unusual behavior patterns that offer special protection to their spawn.

As the human communities have spread to cover the continent, native fishes have been subjected to a different kind of

Onized Lake as seen when looking east from the spillway toward the lower end of the larger bay. The fairly steep banks surrounding the lake are well grassed except where worn by traffic. On the hill above the fishing pier, left, are brick grills, picnic tables and a shelter.

attack. Man has become a selective predator of large fishes. He has waged continual warfare on other fish predators, has passed laws directed at controlling any inclination on his part to take small fish, and has developed an artificial propagation and stocking program to augment the supply of small fish. Because the high reproductive potential of the fishes has remained unchanged, there has been a great increase in the survival of young fish, resulting in added competition for food and space, in overpopulation of waters and in stunting of fish. Intensive interspecific competition among the fishes themselves may be the key factor responsible for eliminating or reducing populations of many of the more desirable game fishes in some waters, because the young of these species are unable to compete with the young of others under crowded conditions.

A common belief among anglers is that, in lakes in which the annual yield of game fish has declined over a period of years, intensive fishing is responsible for the progressively poorer catches. In most instances in which an actual decline may be proved, no data are at hand as to the kinds and quantities of fish that remain in the lake at the time of low production. However, in 22 artificial lakes in Illinois, most of which were censused at a time of low production, only one showed a decline in yield associated with intensive fishing. Whether intensive angling is or has been directly responsible for a reduction in game fish yields of other Illinois lakes, particularly those larger than 25 acres, is subject to question. The efficiency of angling devices is so low, and the patience of the average angler so short, that, long before the population of the selected species has been reduced to the danger point below which it cannot reproduce itself, the fishing for that species has become so uninteresting that it is greatly reduced, or it may even be stopped.

It is not uncommon for populations of desirable fish to become depleted in, or disappear from, waters that are fished very little. This occurrence is frequent in artificial lakes and reservoirs where predators of small fish are at a minimum. Here competition among those desirable species artificially introduced, along with competition from undesirable kinds that gain entrance through feeder streams, eventually crowds out the more desirable species.

The term "overfishing" as it relates to lakes is loosely used by anglers. By some it is applied to a process characterized by the depletion of a single select species, a depletion attributed to more or less intensive fishing (usually an unspecified number of man-hours) for that species. Actually this decrease in yield may result from competition with other fish wherein the select species is gradually replaced by another or several other species, less desirable to anglers. In such a case the water cannot be said to be overfished, for it supports a fish population at least as great in total weight as that when the select species was present in numbers.

In the strict sense, the term *overfishing* involves the entire fish population of a body of water. The yield taken by anglers is not restricted to one or a few species but includes all or almost all in near proportion to their relative abundance. This yield, considered in pounds of fish flesh, is removed at a rate faster than it can be replaced by conversion of available natural food into flesh, and the poundage of fish supported by the water remains below the carrying capacity of that water for all fish. Overfishing as defined here is a condition that is extremely rare because it requires a very great intensity of angling.

The only case of overfishing ever observed in Illinois by Natural History Survey aquatic biologists occurred under conditions favorable for study, 1938-1941. Evidence of overfishing was available from well-kept records of hook-and-line catches for two complete fishing seasons and parts of two others, and from sample catches made with test hoopnets in 1938 and 1940. In 1941 the lake was treated with a plant alkaloid to kill the fish, and a careful census of the fish population was made.

This investigation would have been impossible without the continual interest and cooperation of members of the Fishing Club of the Owens-Illinois Glass Company of Alton, Illinois.

Overfishing in Onized Lake was the result of an intensity of angling far greater than that observed in most waters. Only under conditions of heavy use of a small body of water by a club, community or industry, where fishing is associated with other forms of outdoor recreation, would this intensity of fishing be duplicated.

Acknowledgments

Mr. Bruno von Limbach, Assistant Zoologist with the Illinois Natural History Survey, has given able assistance in many phases of the field work, and is in no small measure responsible for the completeness of the final census. Others to whom I am indebted for assistance are Mr. W. W. Wood, Mr. Austin Vincent and Mr. John Conrad of the Owens-Illinois Glass Company, who helped to make this study possible; Mr. Robert G. Rennels, who assisted in the final census; Mr. Gernon P. Hesselschwerdt, who tabulated the creel census data; and Mrs. Bruno von Limbach, who assisted in growth calculations.

Characteristics of Onized Lake

The Owens-Illinois Glass Company of Alton sponsors an extensive indoor and outdoor recreation program. The outdoor program is centered on a tract of land of 23 acres about 8 miles northwest of Alton. Here facilities are available for picnics, hiking, softball and fishing. The property, leased from C. W. Terry, consists of open flats suitable for ball diamonds and other playgrounds, and steep-sided, well-wooded ravines, attractive for hiking. Several buildings have been erected, which are useful for indoor activities and serve as shelters in case of sudden storms. John Conrad acts as general caretaker during the season the area is open for use.

Onized Lake is located in the northeast part of the tract within 100 yards of the entrance gate, fig. 1. The location of the lake in relation to the entrance and general headquarters for the area makes for convenience in checking fishermen and recording catches.

The lake is a small artificial body of water of approximately 2 acres, built by Mr. Terry in 1933 by damming a steep-sided ravine. It is roughly V-shaped, with the main arm extending northward and

Lotus and pond lilies in the smaller bay of Onized Lake. The lotus plants were started from a few seeds that were thrown into the lake several years ago. They have spread to cover most of the shallow water in this bay and are now a great nuisance to fishermen.

the other extending north-northwest. Surface water entering the smaller arm drains from a cultivated field, and that running into the main arm drains from a pasture and barnlot, the latter located about 200 yards from the lake. The entire drainage area is not more than 15 or 20 acres.

The banks of the ravine in which Onized Lake was built are relatively steep except toward the upper ends of the two arms, resulting in little shallow water along most of the shore line. Soundings indicate a maximum depth of 21 feet in the southwest part of the lake near the dam, and much of the lake is from 10 to 14 feet in depth. The average depth is approxi-

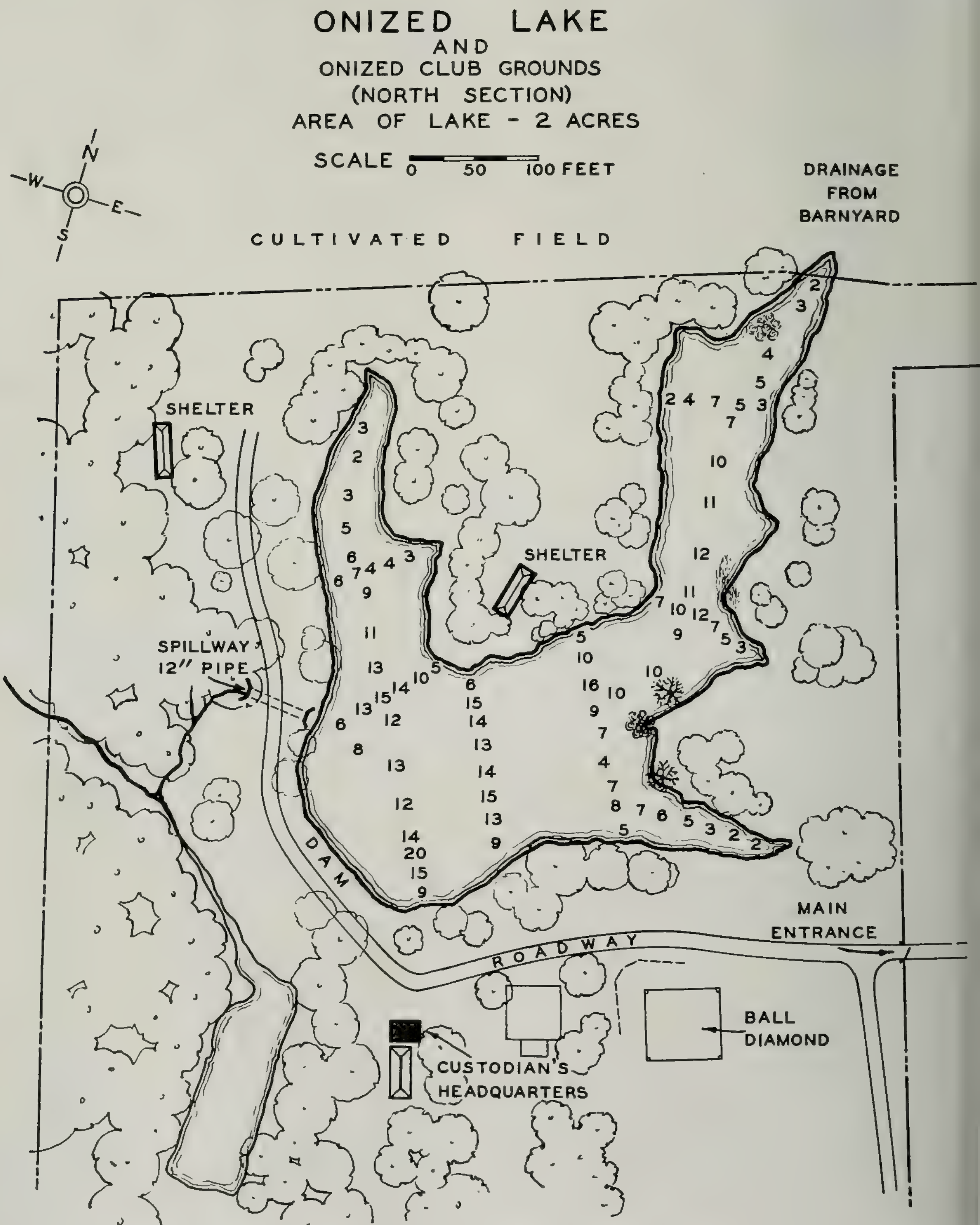


Fig. 1.—Map of Onized Lake and the north section of the recreation area used by the Owens-Illinois Glass Company employees. Fishermen entering and leaving the lake are readily checked by the custodian at his headquarters.

mately 8 feet. Although the drainage area is small, the water level rarely fluctuates more than 2 or 3 feet during the year. A 12-inch tile serves adequately as a spillway.

The area immediately around the lake is used extensively for picnics. Large oaks are scattered over this area, and the shores are well grassed except where heavily shaded or worn by traffic.

Aquatic plants are cattails, *Typha latifolia* L.; pickerelweed, *Pontederia cordata* L.; arrowhead, *Sagittaria* spp.; American lotus, *Nelumbo pentapetala* (Walt.) Fern.,* planted pond lilies of unknown species; coontail, *Ceratophyllum demersum* L.; elodea or waterweed, *Anacharis canadensis* (Michx.) Planch.; and creeping water primrose, *Jussiaea diffusa* Forsk. These plants have encroached upon all of the limited shallow water area.

Table 1.—Vertical series of temperatures and oxygen samples from Onized Lake during very hot weather, 10:00 A.M., August 29, 1938.

Depth, Feet	Temperature, Degrees F.	Dissolved Oxygen, Parts Per Million
Surface	78.0	6.0
1	78.0	5.4
3	75.1	3.0
5	74.2	0.0
7	71.8	0.0
9	67.3	0.0
11	63.5	0.0
13	59.0	0.0
15	58.0	0.0
17	55.4	0.0
19	55.4	0.0
21	54.7	0.0

In many respects, Onized Lake is typical of small deep ponds that are protected from wind action. The waters of these ponds become thermally stratified late in spring and remain so until late fall. Sufficient organic matter is present to produce a high oxygen demand, with the result that throughout most of the summer little or no oxygen is present at depths below 3 or 4 feet.

A series of oxygen samples and temperatures was taken in Onized Lake, August 29, 1938, during a period of very hot weather. These temperatures and oxygen analyses, given in table 1, are probably representative of extreme summer conditions.

Table 2.—Mineral analysis of a sample of water from Onized Lake, collected from the lake surface near the dam on August 31, 1938. Analysis made by J. B. Swartz of the State Water Survey Division.

Analysis		Parts Per Million
Iron (total)	Fe	0.6
Silica	SiO_2	8.0
Calcium	Ca	18.0
Magnesium	Mg	11.2
Ammonium	NH_4	1.7
Sodium and potassium	Na, K	2.5
Sulfate	SO_4	11.9
Nitrate	NO_3	1.8
Chloride	Cl	8.0
Methyl orange alkalinity		76.0
Total hardness		91.5

Water samples showed little oxygen at 3 feet and none at a depth of 5 feet and below. The surface water was warm (78 degrees F.) but at 3 feet the temperature had dropped almost 3 degrees F., and at depths of 5 to 17 feet the samples taken at 2-foot intervals showed drops of 1 degree to more than 4 degrees per interval. Throughout the three greatest depths, 17, 19 and 21 feet, the temperature changed very little.

There is evidence that drainage from the barn lot entering the main arm of the lake adds materially to the fertility of the water, but produces some conditions that are undesirable from a recreational standpoint. Heavy rains in late spring and early summer are frequently followed by a bloom of subsurface algae, or by the appearance of numerous patches of floating bluegreens *(Oscillatoria)*. A large yearly crop of bullfrog tadpoles, *Rana catesbeiana* Shaw, is produced in the lake. These die in large numbers during periods of water bloom, presumably from eating partially decayed bluegreen algae. The appearance and odor, at these times, of putrifying tadpoles and algae are obnoxious to the public. Efforts to control algae by hauling out the floating mats and by

*Nelumbo lutea (Willd.) Pers. of some manuals.

applying copper sulfate have been only partially satisfactory.

A sample of water collected from the lake was analyzed by the State Water Survey, table 2. The presence of 1.7 parts per million of ammonium indicates pollution from barnyard waste. Other parts of this analysis, as compared with similar analyses from many other Illinois ponds, show that the water of Onized Lake is somewhat softer than that of most other ponds.

Further indications of pollution from the barn lot came to light in hoopnet fishing operations in the terminal portion of the main arm in the summers of 1938 and 1940. Most of the fish caught in hoopnets set in the shallow water of this arm, and left overnight, died, while those caught in other parts of the lake, and similarly treated, lived.

No loss of fish has been observed in Onized Lake outside of nets, and it is probable that fish move out of the upper end of the larger arm or bay when periods of oxygen reduction occur. Undoubtedly, the waste from the barnyard has stimulated the growth of fish food organisms and, hence, the fish production of the lake.

Evidences of Overfishing

Onized Lake was stocked with 10,000 fingerling fish in 1934, from the state hatchery near Lebanon. No record is available of the kinds of fish used, but it is believed that largemouth bass and crappies predominated in this group. The next year, 1935, 2,000 fish, species unknown, from the Lebanon hatchery, were placed in Onized Lake, when it was found that the water level in a pond near Brighton, for which they had been intended, was dangerously low. Fishing in Onized Lake was begun in 1937 and it is probable that at that time, with 12,000 fish that had been stocked plus their young of 1935, 1936 and 1937, the lake was overpopulated and the fish already stunted.

L. H. Nicolet of the Owens-Illinois Glass Company estimates that over a 5-year period an average of 125 families fished the lake each year. Fishing permits were issued to about 100 families in 1939, and to a few less in 1940 and 1941. In addition, approximately 95 special passes were issued each year.

Near the end of the fishing season of 1938, the Natural History Survey furnished the Onized Lake caretaker with a creel census record book in which records could be made for each fishing trip, including the date, name of fisherman, number of hours of fishing, kinds of fish caught, numbers caught and their total weight. Mr. Conrad, in charge of the grounds, was much interested in the returns from fishing and checked each fisherman on entering and leaving the area. Fishing was heaviest on week-ends, beginning on Friday and usually reaching a peak on Sunday. Few fishermen appeared on Monday. As the custodian was on duty over the week-end, he was allowed a free day on Tuesday. Although some Tuesday fishermen were interested enough in keeping records to inform Mr. Conrad of catches made on that day, others did not take the trouble to do so; therefore, the Tuesday record is not complete. No attempt has been made to estimate either the total Tuesday catch or the fishing intensity for that day, so that figures listed in the tables dealing with catch and fishing intensity are somewhat lower than if this information could have been included.

The evidence for overfishing originates from three sources: (1) a creel census; (2) hoopnet samples of the population and (3) comparison of the poisoned fish population of June, 1941, with figures from the creel census and the hoopnet sampling.

The first and probably the best evidence of overfishing in Onized Lake is from the creel census. A comparison of the total weight of fish taken by anglers during the fishing seasons of 1939 and 1940, table 3, indicates that a considerable drop in yield occurred in the latter year, after nearly 700 pounds of fish had been removed from Onized Lake in 1939. Apparently the 1939 catch was greater in pounds than could be replaced by the assimilation of the natural food supply. The fact that about 1,000 fewer fish were caught in 1940 than in 1939 does not necessarily mean that the actual number of fish present in the lake had been reduced. No figures are available on the abundance of natural spawn, but a few successful individual broods could easily have replaced the numbers taken. It rather suggests that the number of fish of desirable sizes

Table 3.—Statistics on anglers' catch of fish from Onized Lake, 1938-1941.

Date	Number of Man-Hours of Fishing	Number of Fish Caught	Total Weight of Fish, Pounds	Average Weight of Fish, Pounds	Number of Fish Per Man-Hour	Pounds of Fish Per Man-Hour
1938						
September...	117.00	23	21.50	0.93	0.197	0.184
October.....	17.75	5	4.25	0.85	0.282	0.239
Season......	*134.75*	*28*	*25.75*	*0.92*	*0.208*	*0.191*
1939						
April........	163.25	147	51.38	0.35	0.900	0.315
May........	717.50	834	259.72	0.31	1.162	0.362
June........	847.25	793	246.56	0.31	0.936	0.291
July........	602.50	299	79.75	0.27	0.496	0.132
August......	251.00	40	24.00	0.60	0.159	0.096
September...	135.25	14	27.00	1.93	0.104	0.200
October.....	113.00	33	11.50	0.35	0.292	0.102
Season......	*2,829.75*	*2,160*	*699.91*	*0.32*	*0.763*	*0.247*
1940						
April........	30.50	25	7.60	0.30	0.820	0.249
May........	995.80	370	93.75	0.25	0.372	0.094
June........	947.20	290	76.15	0.26	0.306	0.080
July........	459.00	89	20.83	0.23	0.194	0.045
August......	484.00	328	66.44	0.20	0.678	0.137
September...	343.00	71	17.26	0.24	0.207	0.050
October.....	35.00	2	3.00	1.50	0.057	0.086
Season......	*3,294.50*	*1,175*	*285.03*	*0.24*	*0.357*	*0.086*
1941						
April........	267.30	143	40.75	0.28	0.535	0.152
May........	652.70	255	63.24	0.25	0.391	0.097
June........	347.90	236	37.75	0.16	0.678	0.108
Season......	*1,267.90*	*634*	*141.74*	*0.22*	*0.500*	*0.112*
Grand total..	*7,526.90*	*3,997*	*1,152.43*	*Grand average*	*0.531*	*0.153*

was smaller and that the new broods of young were unable to grow fast enough to reach the size range of interest to anglers. No accurate records were made of the number of small fish returned to the lake by fishermen, but verbal information obtained from persons familiar with the situation suggests that in 1940 many more fish were returned than were taken. Table 3 shows also that the average weight of fish taken in 1940 was considerably less than that in 1939. The fishing intensity actually increased in 1940 over that of 1939 by about 16 per cent.

In both 1939 and 1940, more fish were caught in May and June than during other months, with the exception of August of 1940; also, the fishing intensity was greater in May and June than at other times.

The catch per man-hour was highest during May of 1939 when 1.162 fish were taken per hour of effort. June of 1939 was also a productive month, although the rate dropped to 0.936 fish per man-hour. The unusual August rate of catch in 1940

Table 4.—Hook-and-line yield and fishing intensity per acre of water in Onized Lake, area 2 acres, 1938,* 1939, 1940 and 1941.†

Year	Number of Fish Caught	Weight of Fish, Pounds	Man-Hours of Fishing
1938*.....	14	12.88	67.4
1939......	1,080	349.95	1,414.9
1940......	558	142.52	1,647.2
1941†.....	317	70.87	634.0

*Only September and October in this year.
†Only April, May and June in this year.

of 0.678 fish per man-hour was due to abnormal success in angling for bluegills. The average catch for the period covered by the census was 0.531 fish per man-hour.

Throughout the creel census period there was a gradual reduction in the average weight of fish caught; average weights were 0.92 pound in 1938; 0.32 in 1939; 0.24 in 1940 and 0.22 in 1941. Abnormally high average weights may be observed for September and October of 1938, August and September of 1939, and October of 1940. These were due to the influence of proportionally larger catches of largemouth bass, a fish that averaged heavier than other species.

As a brief summary of fishing at Onized Lake it may be stated that, during the period of study, this 2-acre lake produced a hook-and-line yield of 3,997 fish, weighing 1,152.43 pounds, requiring fishermen to expend 7,526.9 man-hours in return for an average catch of 0.531 fish per man-hour, table 3.

Statistics on fishing intensity and yield from widely scattered investigations are

Table 5.—Analysis of the hook-and-line catch by species, Onized Lake, 1938,* 1939, 1940 and 1941.†

Year	Statistics	Largemouth Bass	Black Crappie	Bluegill	Warmouth Bass	Green Sunfish	Yellow Bass	Bullheads, Black and Yellow	Golden Shiner	Total
1938*	Number..........	13	3	3	3	2		4		28
	Total weight, pounds.........	19.25	0.75	1.00	0.75	0.50		3.50		25.75
	Average weight, pounds.........	1.48	0.25	0.33	0.25	0.25		0.88		
1939	Number	62	502	1,393	14	137	4	48		2,160
	Total weight, pounds.........	106.31	181.19	347.21	5.05	24.90	2.75	32.50		699.91
	Average weight, pounds.........	1.71	0.36	0.25	0.36	0.18	0.69	0.68		
1940	Number..........	29	56	639	54	358	3	23	13	1,175
	Total weight, pounds.........	39.78	22.45	131.85	15.81	55.07	2.50	15.12	2.45	285.50
	Average weight, pounds.........	1.37	0.40	0.21	0.29	0.15	0.83	0.66	0.19	
1941†	Number..........	8	31	398	34	122		14	27	634
	Total weight, pounds.........	13.74	10.25	73.75	11.75	14.75		12.25	5.25	141.74
	Average weight, pounds.........	1.72	0.33	0.18	0.34	0.12		0.88	0.19	
All Years	Total number.....	112	592	2,433	105	619	7	89	40	3,997
	Total weight, pounds.........	179.08	214.64	553.81	33.36	95.22	5.25	63.37	7.70	1,152.43
	Average weight, pounds.........	1.60	0.36	0.23	0.32	0.15	0.75	0.71	0.19	
	Per Cent of Total Number....	2.8	14.8	60.9	2.6	15.5	0.2	2.2	1.0	100.0
	Per Cent of Total Weight.....	15.5	18.6	48.1	2.9	8.3	0.5	5.5	0.6	100.0

*Only September and October in this year.
†Only April, May and June in this year.

Table 6.—Hoopnet catches of fish from Onized Lake, August 28-30, 1938 (9 net-days of fishing), and July 10-15, 1940 (36 net-days of fishing).

Species	Number	Total Weight, Pounds	Number of Fish per Net-Day	Weight of Fish Per Net-Day, Pounds
1938—9 Net-Days of Fishing				
Largemouth bass	8	12.37	0.89	1.37
Black crappie	214	50.60	23.78	5.62
Bluegill	54	15.24	6.00	1.69
Warmouth bass	5	1.15	0.56	0.13
Green sunfish	2	0.32	0.22	0.04
Yellow bass	2	1.40	0.22	0.16
Black bullhead	1	1.90	0.11	0.21
Yellow bullhead	9	3.10	1.00	0.34
Golden shiner	....	....	....	....
Total	*295*	*86.08*	*32.78*	*9.56*
1940—36 Net-Days of Fishing				
Largemouth bass	1	3.15	0.03	0.09
Black crappie	234	43.27	6.50	1.20
Bluegill	99	17.02	2.75	0.47
Warmouth bass	5	1.00	0.14	0.03
Green sunfish	1	0.07	0.03	....
Yellow bass	1	0.09	0.03	....
Black bullhead	1	2.05	0.03	0.06
Yellow bullhead	....	....	....	....
Golden shiner	8	1.57	0.22	0.04
Total	*350*	*68.22*	*9.72*	*1.89*

most easily compared if all data are based upon a common unit; in this case, an acre of lake surface. For this reason table 4 has been introduced, giving the total numbers and weights of the fish caught and the fishing intensity in terms of man-hours, all on the basis of an acre of water surface. The yield per acre in 1939, 349.95 pounds, is higher than that recorded for any single year of hook-and-line fishing in any other artificial lake in the United States.

The anglers' catch from Onized Lake presents several points of interest when broken down by species. This catch was composed of nine species of fish but only three, the largemouth bass, black crappie and bluegill, made up more than 10 per cent each of the total catch by weight. Table 5 lists the hook-and-line yield by species for the years included in the creel census, and also gives the totals and the percentages, for each species, of the total number and weight. Further reference to this table will be found in a later section, where individual species of fish are considered from the standpoint of numbers, growth and age-length distribution.

The second source of evidence for overfishing is from the total numbers and total weights of fish caught in hoopnets during a short period in 1938 and a somewhat longer period in 1940. A comparison of the catch per net-day of fishing for the two seasons gives indication of a reduced population of fish of desirable sizes in 1940.

Hoopnets were fished in Onized Lake, August 28 to 30, inclusive, in 1938 and July 10 to 15, inclusive, in 1940. In the 1938 fishing period, three 1-inch mesh hoopnets were used with leads 40 to 50 feet in length. In the 1940 period, six 1-inch mesh hoopnets were used with leads of essentially the same length as in 1938. Fish caught in each year were measured, weighed and returned to the lake, after a few scales had been removed for age determination. In 1938, 10 crappies and 7 bluegills died in a net set for 24 hours in the upper end of the larger bay. In 1940, 13 crappies and 9 bluegills died in the same location. All other fish were in good condition when released. Twelve bluegills from the 1940 catch were transported to a breeding pond below the lake dam.

The hoopnet catches for the two seasons are shown in table 6. Although the total catch in number of fish was larger in 1940 than in 1938, the total weight of the catch was less; the number per net-day was 3.37 times as great in 1938 as in 1940. Only two species of fish, black crappies and bluegills, were numerous enough in these catches for comparison. Both of these species readily enter the nets. In 1938, crappies were caught at the rate of 23.78 per net-day, while in 1940 the catch was only 6.50 per net-day. In blue-gills the reduction in numbers was not so marked, as the 1938 catch was at the rate of 6.00 per net-day and the 1940 catch 2.75 per net-day. The reduction in weights of these two species from 1938 to 1940, as shown by the catch per net-day, was even greater than the reduction in numbers.

The evidence of a reduced population of fish of desirable sizes in 1940 is not as strong from a comparison of the rate of catch of hoopnets, as from the anglers' records, but both census methods indicate a striking reduction in the numbers of these fish.

Analysis of the Population

On June 24, after Onized Lake had been fished for 3 months in the 1941 season, the fish remaining in the lake were poisoned with the object of making a detailed study of a population supposedly depleted by overfishing. This study was designed to give answers to a number of questions; namely, (1) the weight of fish present in the lake, in pounds per acre, after the removal of a 1939 crop of 349.95 pounds per acre and a 1940 crop of 142.52 pounds per acre; (2) the actual and rela-

Table 7.—Census of all fish in Onized Lake, area 2 acres, June 24-28, 1941.

Fish Species	Number	Weight, Pounds	Average Weight Per Fish, Pounds	Per Cent of Total Weight
		Game Fish		
Largemouth bass	275	108.76	0.395	
Total	*275*	*108.76*		*24.6*
		Other Fine Fish		
Black crappie	22	3.22	0.146	
Bluegill	6,545	232.94	0.036	
Warmouth bass	1,638	28.63	0.017	
Green sunfish	245	6.49	0.026	
Yellow bass	4	3.11	0.778	
Total	*8,454*	*274.39*		*62.1*
		Catfish		
Yellow bullhead	347	37.00	0.107	
Black bullhead	2	2.77	1.385	
Total	*349*	*39.77*		*9.0*
		Rough Fish		
Carp	1	12.00	12.000	
Common sucker	1	0.05	0.050	
Total	*2*	*12.05*		*2.7*
		Forage Fish		
Golden shiner	90	7.18	0.080	
Blunt-nosed minnow	1	0.02	0.020	
Total	*91*	*7.20*		*1.6*
Grand total	*9,171*	*442.17*		*100.0*
Average per acre	*4,586*	*221.09*		

Table 8.—Fish of desirable sizes* in Onized Lake at the time of the final census, June 24-28, 1941.

Species	Number	Per Cent of Total Number of Named Species	Weight, Pounds	Per Cent of Total Weight of Named Species
Largemouth bass	47	17.1	101.8	93.6
Black crappie	7	31.8	2.2	68.3
Bluegill	325	5.0	55.6	23.9
Warmouth bass	13	0.8	2.3	8.0
Green sunfish	9	3.7	1.6	24.6
Yellow bass	4	100.0	3.1	100.0
Black bullhead	2	100.0	2.8	100.0
Yellow bullhead	36	10.4	10.7	28.9
Carp	1	100.0	12.0	100.0
Golden shiner	37	41.1	4.2	58.5
Total	*481*	*5.2*	*196.3*	*44.4*

*Arbitrarily set at 10 inches for largemouth bass, 8 inches for black crappies, 7 inches for yellow bass, bullheads and golden shiners, and 6 inches for bluegills, warmouth bass and green sunfish.

tive numbers of fishes of desirable* sizes then remaining in the lake; (3) the individual ability of various species present to withstand overfishing; and (4) the effect of overfishing on the growth rates of all species.

A careful census was made during the period of June 24 to 28, inclusive, and data on a small number of dead fish found after June 28 were tabulated by Austin Vincent and John Conrad of the Owens-Illinois Glass Company. Table 7 lists the kinds of fish collected and gives details as to numbers and weights. The lake contained a total population of 9,171 fish weighing 442.17 pounds, or, on the basis of an acre, 4,586 fish weighing 221.09 pounds. It is of interest to note that the 1939 yield in pounds per acre was greater than the weight of all fish per acre at the time of the complete census in 1941. All species of fish that were taken in the creel census were present in the final census. In addition, there were one carp, one common sucker and one blunt-nosed minnow; these probably represented escaped bait. Fishermen were allowed to use "minnows" in fishing, but were asked to deposit them with the caretaker after fishing, rather than release them in the lake.

Of the 9,171 fish collected in the final census, 481 or 5.2 per cent were of desirable sizes. However, these fish represented 44.4 of the weight of all fish. Listed in table 8 are the number and weight of the fish of desirable sizes of each species; also, the percentage of each species, by weight and by number, in the desirable size class. All the yellow bass were of desirable size. On the other hand, only 5.0 per cent of all bluegills present were of desirable size; their weight was 23.9 per cent of the weight of all bluegills. The number of bluegills of desirable size, 325, was much larger than that of any other species; also the bluegills of all sizes were more numerous than fish of other species. Although only 17.1 per cent of the largemouth bass were of legal size, the weight of these fish was 93.6 per cent of the total weight of all largemouth bass.

*Desirable size is arbitrarily set as at least 10 inches for largemouth bass, 8 inches for black crappies, 7 inches for yellow bass, bullheads and golden shiners and 6 inches for bluegills, warmouth bass and green sunfish.

Effects of Overfishing

No fish population analysis may be considered complete unless the age composition of that population is known. In fishes, where the pattern of growth may vary a great deal with the amount of available food, the length of the growing season, and the potential size and age for a selected species, the scale method of age determination and its corollary, the calculation of growth from scale measurements, is invaluable.

Samples of scales were taken from many fish collected in the final, or poison, census of 1941. Because the accuracy of growth calculations depends, among a number of other factors, upon the accuracy of length measurements, fish badly

Table 9.—Number of fish used in a study of the growth of Onized Lake fish.

Kind	Final Census 1941	Hoopnets 1938	Hoopnets 1940
Largemouth bass	81	8	0
Black crappie	21	98	234
Bluegill	189	53	99
Warmouth bass	101	0	5
Green sunfish	98	0	1
Yellow bass	4	2	1
Carp	1	0	0
Golden shiner	87	0	8
Total	*582*	*161*	*348*

mutilated or decayed were discarded. Most of the larger fish were measured and "scaled," and random samples were taken from among the other, more numerous individuals of all species, so that the scale collections are believed to represent fairly all broods of all species then present. In this, as in other scale collections, the scales from a small number of fish had to be discarded, because all these scales were regenerate, or the age determinations were uncertain. The fish that were used in this study are listed in table 9.

A monograph on the growth of an individual species of fish should show the relationship between the growth increments of body (length) and the growth increments of a selected scale measured in a designated manner, in order to expose any disproportionate growth increments of scales that may require correction of body lengths calculated from scale measurements. This time-consuming process is hardly applicable to gross population studies involving many kinds of fish, particularly where the fish are killed with poison and must be handled in the least possible time to prevent loss from spoilage. All calculated lengths given in this study are direct proportions based upon measurement of the anterior radius of the scale and the total length of fish. Even though errors are introduced through this method, they are probably of small magnitude, and calculated lengths of fish from various waters, when handled in this way, are believed to be comparable.

Tables showing the age-length frequencies for each of the more abundant kinds of fish in Onized Lake at the time of the poison census are included with the following discussion. As the actual ages were determined on random samples, rather than on all fish, a description of the procedure is given below. When the poisoned population was handled, fish of legal lengths (bass) or of desirable sizes (other species) were carefully separated from the more numerous smaller individuals. Because of the relatively small numbers of large individuals, scales were taken from a high percentage of them. Scales were

Table 10.—Fish recovered from Onized Lake in the final census, June 24-28, 1941, and groupings used in the construction of age-length frequency tables.

Species	(1) Fish Measured and Aged	(2) Fish Measured but Not Aged	(3) Fish Not Aged or Measured	Total
Largemouth bass	81	194	0	275
Black crappie	21	1	0	22
Bluegill	189	254	5,877 from 3.0 to 5.7 inches 235 from 5.8 to 7.5 inches	6,545
Warmouth bass	101	114	1,423 from 2.0 to 5.7 inches	1,638
Green sunfish	98	32	115 less than 5.7 inches	245
Yellow bullhead	0	89	258 from 4 to 7 inches	347
Golden shiner	87	3	0	90

taken from a random sample of smaller fish measured individually, and individual length measurements were taken on many more fish. Finally, if a large number of a given kind of fish still remained after these samples were taken, they were sorted to size, weighed collectively and counted. Thus, the age-length frequency tables are based on data derived from (1) 577 fish, measured individually, the ages of which were determined from scales; (2) an additional number of fish, also measured individually, sorted into age groups on the basis of measured lengths; and finally (3) unaged fish, unmeasured individually but of known length range, sorted into age groups on the basis of age-length relationships. Table 10 lists the numbers of the various kinds of fish in each of the above groups.

The status of the population of each species of fish present in Onized Lake at the time of the final census was influenced by fishing pressure and by the ability of that species to reproduce successfully, as well as to compete with other species of fish. In the following discussion, individual species of fish are considered separately in an attempt to integrate the information furnished by the creel census, hoopnet sampling, the final census, age determinations and growth rates.

Largemouth Bass

Huro salmoides (Lacépède)

The largemouth bass population at Onized Lake was, at the time of the final census in 1941, one of the best observed in 22 artificial lakes in Illinois (Bennett 1943), not only from the standpoint of number and weight per acre of lake surface, but also with reference to rates of growth and range of sizes. This population contained individuals belonging to six annual broods (one brood spawned each season, 1936-1941), and the lengths of fish recovered ranged from 1½ to 22 inches. Forty-seven bass, or 17.1 per cent of the 275 present, were of legal lengths, tables 7 and 8; Onized Lake contained over 23 legal-sized bass per acre in spite of very heavy fishing from 1939 through part of 1941. The greatest catch of bass occurred in 1939 when 62 individuals of legal sizes were taken, table 5; 29 were taken in the season of 1940 and 8 in 1941 from May 15 to June 24. These, and 13 others taken in September and October of 1938, make a total of 112 captured during the period of the creel census. While the hook-and-line catch of largemouth bass made up only 2.8 per cent of the total number of fish removed by anglers, their combined weight was 179.1 pounds, or 15.5 per cent of the weight of all fish caught, table 5. Possibly all of the legal-sized bass in Onized Lake had become "educated" to avoid both artificial and natural baits offered by fishermen. The lake is so small that an experienced bait caster may cover the entire water area from the shore in about an hour. The fact that the lake still contained 47 bass of legal sizes in 1941, including 12 fish that ranged from 3 to 6 pounds in weight, suggests that factors other than angling may be responsible for low populations of bass in many Illinois waters less intensively fished.

The lengths and ages of the bass collected from Onized Lake are shown in table 11. The smallness of the number of bass in the 0 group (spawned in May, 1941) is due partially to predation at the time of poisoning. Small fish are affected by the treatment first, and all carnivorous fish of larger sizes quickly feed upon them, as they are readily captured at this time. Also, many small fish sink to the bottom of the lake as they die and are eaten or torn to pieces by crayfish and turtles. A fish census made by the poisoning method is inaccurate in the numbers of small fish of all kinds.

The natural spawn and survival of young bass in Onized Lake is considered to have been adequate to maintain the population of this fish at a high level—much higher than is usual in artificial lakes containing several species of fish (Bennett 1943). As largemouth bass are known to spawn successfully in mud-bottomed ponds, it seems likely that low populations in many lakes are the result of loss of eggs through silting, through the roiling of waters by fish (bullheads, carp and other bottom feeders), or through the nest raiding activities of sunfish and other species when they are overly abundant (Swingle & Smith 1943).

The growth rate of largemouth bass in Onized Lake was faster than in most Illinois waters. Average calculated lengths by years of life of 81 fish measured and "scaled" during the fish census of June 24-28, 1941, table 12, indicate that these fish reached legal length (10 inches) during the second summer of life and continued to grow rapidly throughout their life span. Fig. 2 shows a growth curve of Onized Lake largemouth bass, based on calculated lengths from scale measurements, with a similar growth curve for the bass in Sportsmen's Lake, a small section of the gravel pit lakes near Lincoln, Illinois (Thompson & Bennett 1939).

At the time of the poison census of Sportsmen's Lake, May 20, 1938, that

Table 11.—Age-length frequencies of the 275 largemouth bass collected from Onized Lake in the census of June 24-28, 1941. The census was made about 1½ months after the spawning season, and the lengths shown for each age include the growth increment for the early part of the 1941 season.

Length in Inches	Age in Years					
	0	1	2	3	4	5
1						
½	3					
2						
½						
3	13					
½	16	96				
4	1	64				
½		15				
5		2				
½		5				
6		2				
½		3				
7		2				
½		2				
8		1				
½		1				
9		2				
½						
10	—Legal Length—					
½						
11						
½			1			
12			4			
½			5			
13			6			
½						
14			6	1		
½			2			
15						
½				1	1	
16				1		
½				1	1	1
17				1	2	
½				1	1	1
18				1		
½				1	1	1
19					1	
½						3
20						1
½						
21						
½						
22						1
Total	*33*	*195*	*24*	*8*	*7*	*8*

Table 12.—Average calculated total lengths in inches of 81 largemouth bass collected from Onized Lake in the census of June 24-28, 1941.

Brood	Number of Fish	Average Calculated Length by Years of Life					Average Total Length at Time of Collection
		1	2	3	4	5	
1936	8	1.68	9.40	13.21	16.24	18.56	19.15
1937	7	4.81	10.32	14.04	16.75		17.32
1938	7	3.93	10.83	14.90			16.64
1939	17	4.07	11.15				12.78
1940	42	3.07					4.79
Total	*81*						
Average		*3.37*	*10.58*	*14.01*	*16.48*	*18.56*	

body of water contained a bass population that comprised 13.2 per cent of the weight of all fish present.

In comparing the growth curves of largemouth bass in these two lakes, fig. 2, it is of interest to note that bass growth in Onized Lake was relatively poor during the first summer, but rapid in subsequent growing seasons, and that the Onized Lake fish reached legal length when almost a year younger than those of Sportsmen's Lake. Slow first season growth is also indicated for Onized Lake in fig. 3, where the growth curve of bass in this Illinois lake is shown with that of 618 bass from Wisconsin and 30 from Louisiana (Bennett 1937). The first season growth of bass in Onized Lake was less than the growth of the Louisiana bass and about equal to that of the Wisconsin bass. The Illinois fish exceeded the Wisconsin fish in size after the first year and approached the Louisiana bass in size in the second and third years of life, falling short of the southern fish during the fourth and fifth years. The explanation of poor first year growth seems to relate to severe competition among young fish of all species in Onized Lake. The continually large catch of adult fish reduced predation on the young to the extent that an entire growing season was required to decimate their numbers. Meanwhile, because of food competition among these young fish,

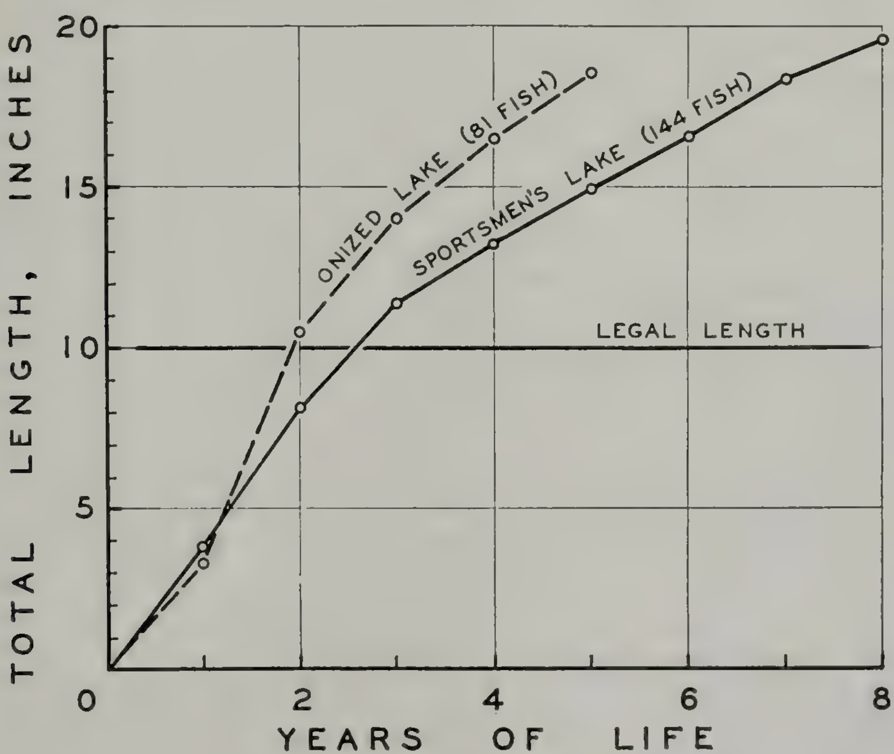


Fig. 2.—Average rate of growth of largemouth bass taken from Onized Lake in the 1941 census, and from Sportsmen's Lake (old gravel pit) near Lincoln, Illinois.

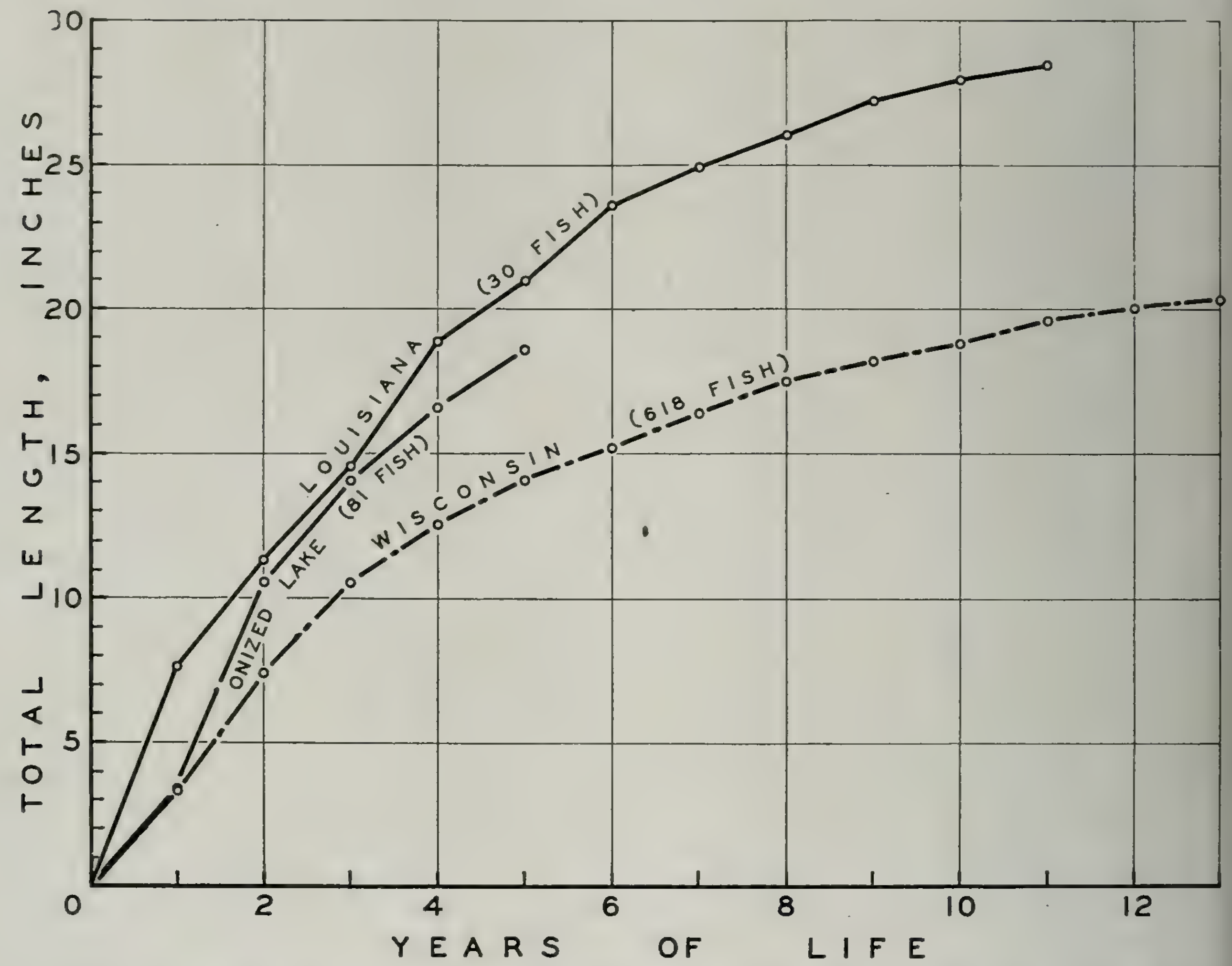


Fig. 3.—Average rate of growth of largemouth bass taken from Onized Lake, from Wisconsin and from Louisiana. The Onized Lake bass averaged about the same size as the Wisconsin bass in the first year and approached the size of the Louisiana bass during the second and third years.

their growth rate was slow. Once the young bass became large enough to prey on other fish, they began to grow rapidly.

Black Crappie

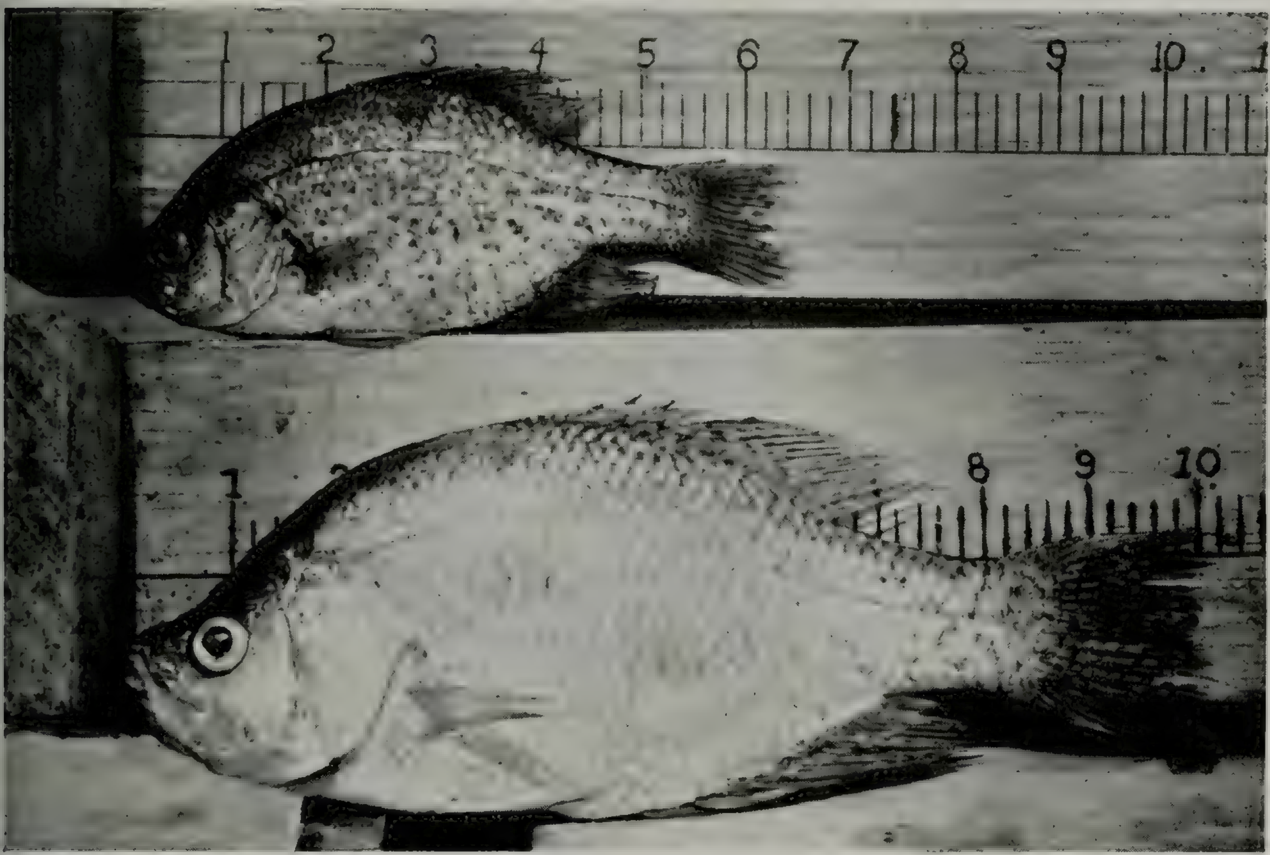
Pomoxis nigro-maculatus (Le Sueur)

The black crappie population at the time of the 1941 census had become reduced to 22 fish. Information gathered from net fishing in 1938 and 1940, and from the catch of black crappies made by fishermen in 1939, 1940 and 1941, indicates that the lake contained a large crappie population at the beginning of the 1939 fishing season and a somewhat larger population in 1940 than was taken in the 1941 census.

The lengths of the 22 crappies taken in the 1941 census are recorded in table 13. Only seven were large enough to interest fishermen; the others were second summer fish of small size. Although a few small fish undoubtedly belonging to the 0 group (spawned in 1941) were seen when the poison was applied, none were collected, and it is probable that they were eaten by fish, turtles and crayfish, or were lost among the mats of vegetation.

It is impossible to say whether the crappies could have returned to their former population level in Onized Lake in competition with the other species of fish present. Certainly the number taken in the final census was sufficient to replenish this population with a single successful spawn, if the young were able to survive predation from a strong bass population.

Studies of crappies in other lake census work in Illinois (Bennett 1943) indicate that the black crappie is rarely as numerous as the white crappie, *Pomoxis annularis* Rafinesque, in small artificial lakes. Not only were there more stunted populations of white crappies than black in the lakes censused, but in 14 lakes where both species were present the white crappies were more abundant in all but 2.



Black crappies taken in hoopnets from Onized Lake in 1940. These crappies were 1½ and 2½ years old.

Scales and total length measurements from crappies taken from hoopnet collections in 1938 and 1940, and from 21 of the 22 fish taken in the final census, were used in calculating the lengths shown in tables 14, 15 and 16.

The lengths of black crappies collected from Onized Lake are plotted in fig. 4. No crappies older than four summers are known to have been taken from the lake during this study. Calculated lengths of the 1938 and 1941 crappie collections showed relatively slow growth rates for the first year, and a marked increase during the second growing season. The 1940 collection included 226 crappies in their second summer of life (1939 brood) that averaged 4.02 inches for calculated first year growth, or about a half more than the first year lengths for the other collections. Most of the fish of the 1940 collection were spawned in the year of the greatest hook-and-line yield, and their rapid growth may have been related to an abundant food supply resulting from the removal of many fish. Growth stimulation caused by an increased amount of available food brought about by one of several possible situations has been observed in

Table 13.—Age-length frequencies of the 22 black crappies collected from Onized Lake in the census of June 24-28, 1941. The census was made about 1½ months after the spawning season, and the lengths shown for each age include the growth increment for the early part of the 1941 season.

Length in Inches	Age in Years 0	1	2
3		2	
½			
4			
½			
5			
½		9	
6		4	
½			
7			
½			
8 ——Desirable size——			3
½			3
9			
½			1
10			
Total	*0*	*15*	*7*

Table 14.—Average calculated total lengths in inches of 98 black crappies collected with hoopnets from Onized Lake, August 29-31, 1938.

Brood	Number of Fish	Average Calculated Lengths by Years of Life 1	2	3	Average Total Length at Time of Capture
1935	1	2.72	9.00	11.38	12.30
1937	97	2.35			7.48
Total	*98*				
Average		*2.35*	*9.00*	*11.38*	

fish many times (Beckman 1941; Bennett, Thompson & Parr 1940; and others). It lasts until natural reproduction supplies a sufficient number of individuals to cause severe competition for food. In the case of Onized Lake, in which the increased growth rate observed in the 1940 collections did not persist, it must be assumed that, as the population of crappies was not being replaced adequately by natural reproduction, some other species (possibly young bluegills or warmouth bass) offered sufficient competition to the young crappies to reduce their first year growth rate to about that of the 1937 brood.

A few growth studies made on the black crappie supply some information on the yearly length increment of this fish in waters of other states. Eschmeyer & Jones (1941) include the black crappie in their study of the growth of game fish in Norris Reservoir, and Schoffman (1940) gives data on black crappie growth in Reelfoot Lake. Material from these sources, along with calculated lengths of black crappies from Onized Lake, 1940 collection, has been used in the drafting of fig. 5. The growth curve for Norris Reservoir is based on age group III of the 1940 collection, which, with the exception

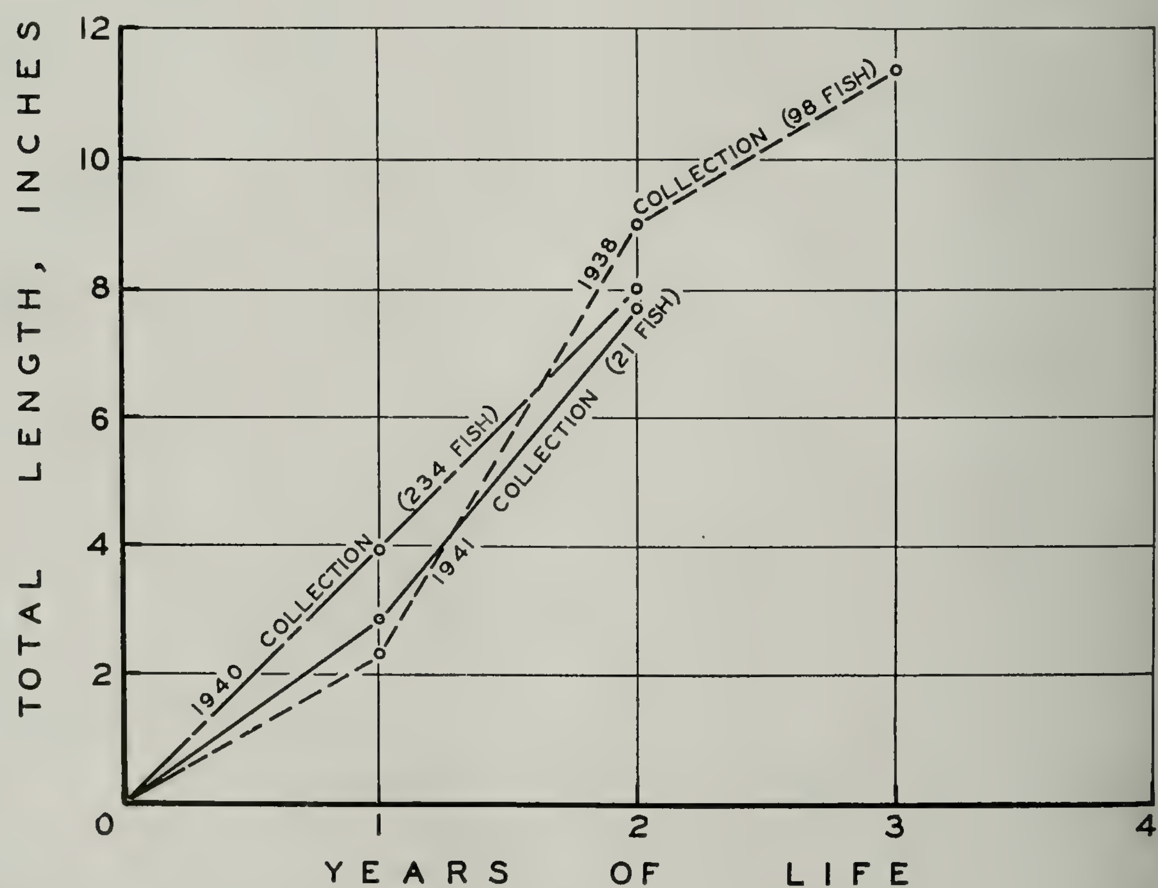


Fig. 4.—Average rate of growth of black crappies taken from Onized Lake as shown by 1938, 1940 and 1941 collections. Crappies spawned in 1939 (1940 collection) showed unusually rapid first year growth.

Table 15.—Average calculated total lengths in inches of 234 black crappies collected with hoopnets from Onized Lake, July, 1940.

Brood	Number of Fish	Average Calculated Lengths by Years of Life 1	2	Average Total Length at Time of Capture
1938	8	2.24	8.03	10.55
1939	226	4.02		6.87
Total	*234*			
Average		*3.96*	*8.03*	

Table 16.—Average calculated total lengths in inches of 21 black crappies collected from Onized Lake in the census of June 24-28, 1941.

Brood	Number of Fish	Average Calculated Lengths by Years of Life 1	2	Average Total Length at Time of Collection
1939	6	3.48	7.82	8.62
1940	15	2.66		5.29
Total	*21*			
Average		*2.89*	*7.82*	

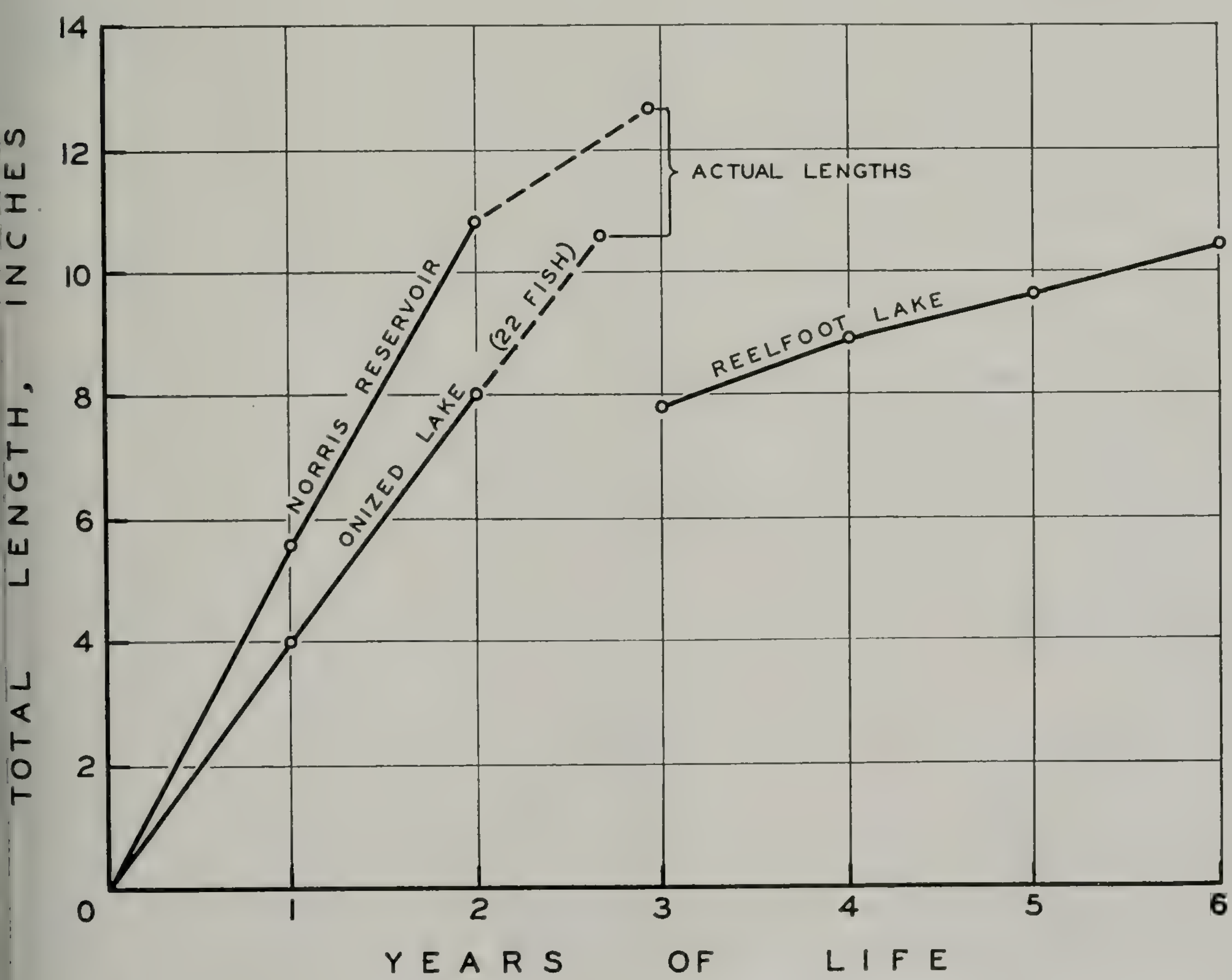


Fig. 5.—Average rate of growth of black crappies in Onized Lake as shown by 1940 collection, in Norris Reservoir and in Reelfoot Lake.

of age group II of the 1939 collection, shows the largest first-year growth. Schoffman's data are based on the average actual lengths of fish on which ages were determined. Points at the extremities of the Norris Reservoir and the Onized Lake curves represent average actual lengths of fish at the time of capture. As shown in fig. 5, the growth curve of the black crappies from Onized Lake lies between the other two, indicating that the Onized Lake fish grew faster than those of Reelfoot, but less rapidly than those of Norris Reservoir.

The excessive cropping of Onized Lake resulted in an unusually rapid rate of growth of black crappies. Schoffman (1940) in his study of Reelfoot Lake black crappies suggests that the minimum legal length of crappies in Tennessee be increased from 8 to 9 inches, in order to give them greater protection and "since the greatest weight per length is reached in the 8th summer." An assumption of this kind is not valid, because fish growth, within limits, is a reflection of food abundance.

Bluegill

Lepomis macrochirus Rafinesque

Bluegills apparently thrive under conditions of intensive fishing. Not only did this species make up 60.9 per cent of the number and 48.1 per cent of the weight of all fish taken by fishermen from Onized Lake, 1938-1941, table 5, but, in the final fish census, bluegills represented 71.4 per cent of all fish present, and their weight was 52.7 per cent of the weight of all fish. As recorded in the creel census, the average weight of 2,433 bluegills caught was 0.23 pound, table 5; a fish of this weight has a length of slightly more than 6 inches. The largest bluegill recorded by the custodian weighed approximately 1 pound. Bluegills caught and recorded in the creel census of 1939 averaged larger, weighing 0.25 pound each, than in succeeding years; in 1940, the average weight was 0.21 pound and, in 1941, 0.18 pound, table 5. Table 17 gives the age-length frequencies of the bluegills taken in the 1941 census. As many of these fish were not accurately aged or measured, but sorted into age groups on the basis of their size range, this table is an estimate of the actual age-length distribution of the population. No fish in the collections were much more than 3 years (in fourth summer) of age.

As in similar tables for other species, the number recorded for 1941 brood bluegills does not represent the actual number in the lake at the time of poisoning. The 1941 brood probably exceeded the 1940 brood in number of individuals. The number of individuals of desirable sizes listed in table 8 represents an accurate

Table 17.—Age-length frequencies of the 6,545 bluegills collected from Onized Lake in the census of June 24-28, 1941. The census was made about 1½ months after the spawning season, and the lengths shown for each age include the growth increment for the early part of the 1941 season.

Length in Inches	Age in Years 0	1	2	3
2	55			
½	145	54		
3	36	1,248		
½		741		
4		868	236	
½		347	579	
5		91	974	
½		16	830	
6 ——Desirable Size——		3	173	11
½		1	47	11
7			14	36
½			4	25
Total	*236*	*3,369*	*2,857*	*83*

count; great care was taken in sorting out individuals of 6 or more inches in length. The ratio of bluegills of desirable sizes to those smaller was 1:19; that is, the number of bluegills of desirable sizes represented about 5 per cent of the total number of bluegills. Because an accurate count of the 1941 brood could not be made, the calculated percentage of large fish was much larger than the actual percentage.

Tables 18, 19 and 20 show calculated lengths of bluegills taken in the hoopnet collections of 1938 and 1940, and in the census of 1941. Growth curves based on these lengths, fig. 6, show some variation in growth rates of bluegills represented by each of these three collections. Unlike the black crappies, bluegills spawned in 1939 apparently made no abnormal growth increment during that year. Abnormal growth in bluegills spawned early might be obscured by the growth figures of those spawned in July and August; it also seems that the growth of bluegills was less stimulated by the results of heavy fishing than was that of most other species.

Other sources of information relative to bluegill growth in Illinois are available.

Table 18.—Average calculated total lengths in inches of 53 bluegills collected with hoopnets from Onized Lake, August 29-31, 1938.

Brood	Number of Fish	Average Calculated Lengths by Years of Life				Average Total Length at Time of Capture
		1	2	3	4	
1934	2	1.89	4.78	6.43	7.44	8.00
1935	10	1.35	5.38	6.59		7.20
1936	30	0.93	5.17			6.86
1937	11	2.50				6.13
Total	*53*					
Average		*1.37*	*5.20*	*6.56*	*7.44*	

Table 19.—Average calculated total lengths in inches of 99 bluegills collected with hoopnets from Onized Lake, July 9-15, 1940.

Brood	Number of Fish	Average Calculated Lengths by Years of Life			Average Total Length at Time of Capture
		1	2	3	
1937	9	1.46	4.36	6.38	6.99
1938	68	2.04	5.05		6.44
1939	22	2.85			4.63
Total	*99*				
Average		*2.17*	*4.97*	*6.38*	

Table 20.—Average calculated total lengths in inches of 177 bluegills collected from Onized Lake in the census of June 24-28, 1941.

Brood	Number of Fish	Average Calculated Lengths by Years of Life			Average Total Length at Time of Capture
		1	2	3	
1938	19	1.65	4.85	6.55	7.06
1939	143	1.78	4.28		5.22
1940	15	2.55			4.25
Total	*177*				
Average		*1.83*	*4.35*	*6.55*	

Measurements of 1938 brood bluegills taken from Fork Lake during 1939 (Bennett, Thompson & Parr 1940) indicate that under uncrowded conditions this species may grow rapidly to useful sizes. Table 21 gives the numbers and average total lengths of 1938 brood bluegills collected from Fork Lake throughout the 1939 growing season.

Table 21.—Numbers and average total lengths in inches of 1938 brood bluegills collected, March through November, 1939, from Fork Lake near Mount Zion, Illinois.

Month	Number	Average Total Length, Inches
March	33	3.61
April	37	4.32
May	24	4.96
June	174	5.24
July	116	5.41
August	77	5.81
September	197	5.99
October	87	6.30
November	28	6.30
Total	*773*	

Schloemer (1939) included in his study of bluegill growth the uncorrected calculated lengths of bluegills taken in hoopnet collections from five Illinois lakes. Most of these collections were furnished, 1930-1938, by Dr. Donald F. Hansen of the Natural History Survey. The collections were from Grass and Pistakee lakes (glacial), in northern Illinois, Senachwine and Chautauqua lakes (bottomland lakes adjacent to the Illinois River) in the central part of the state, and Horse Shoe Lake (old Mississippi River oxbow) in the extreme southern end. The calculated lengths of bluegills from each of these lakes were averaged to give the growth rate shown in table 22.

The average growth of bluegills in Onized Lake (1941 census) and in Fork Lake is compared in fig. 7 with the average growth in the five Illinois lakes studied by

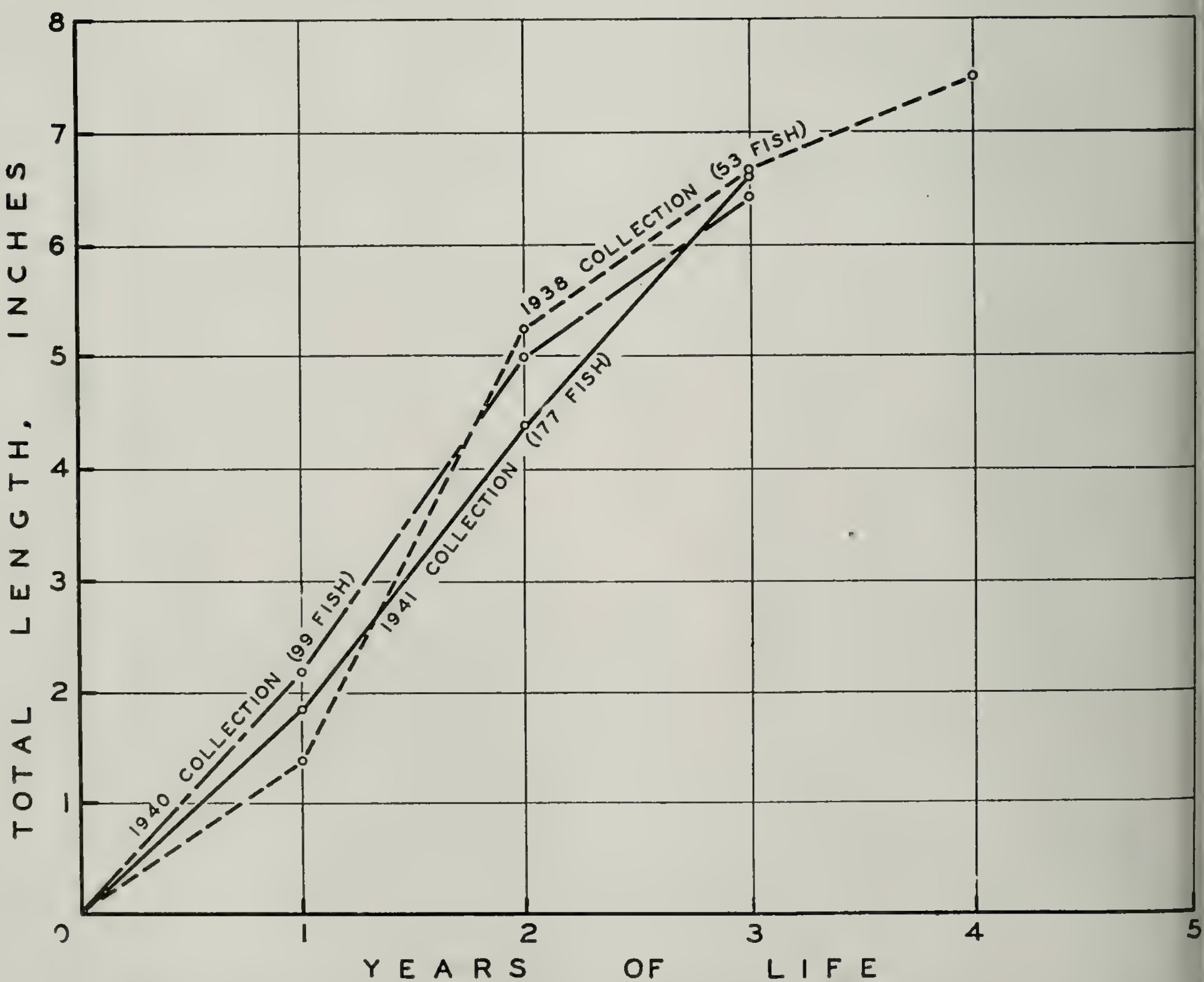


Fig. 6—Average growth rate of bluegills in Onized Lake collections, 1938, 1940 and 1941.

Table 22.—Average growth of bluegills in Illinois, based on growth in five large bodies of water representing northern, central and southern locations, and three types of lakes.

Average Total Length in Inches at End of Growing Season							
First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth
1.3	3.5	4.9	6.0	6.8	8.0	8.2	8.0

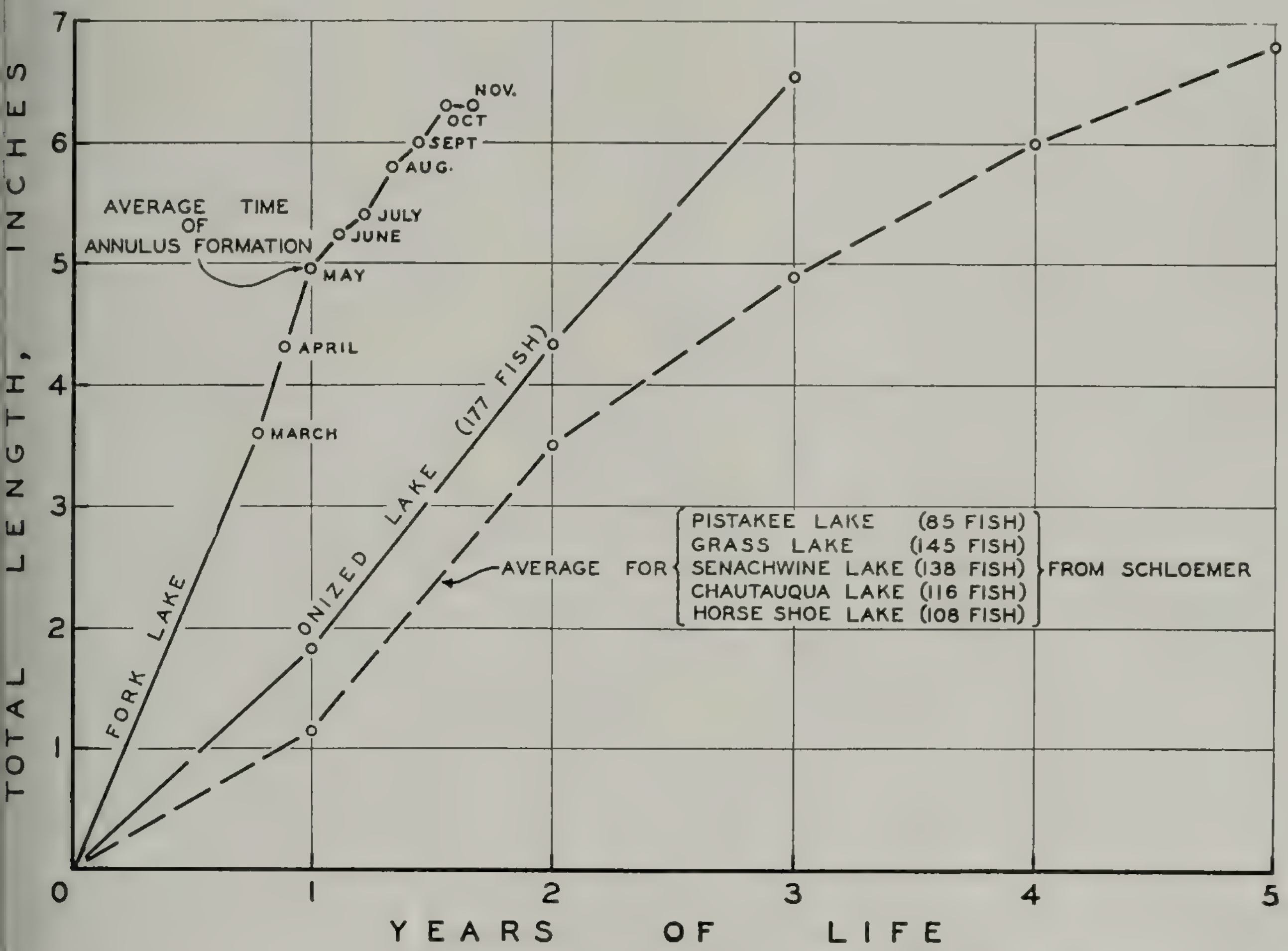


Fig. 7.—Average rate of growth of bluegills in Onized Lake (final 1941 collection), in Fork Lake (1938 brood) and in five large natural lakes in Illinois (1930-1938).

Schloemer. Bluegill growth in Onized Lake was considerably faster than that in the five lakes, but much slower than the growth in Fork Lake, where the population was not crowded because the lake had been newly stocked the preceding year and there was little competition for food.

Warmouth Bass

Chaenobryttus gulosus (Cuvier)

Warmouth bass were of little value to the fishermen of Onized Lake. Although 1,638 of these fish were collected in the final census (1941), their total weight was only 28.6 pounds, and only 13 were large enough to interest fishermen, tables 7 and 8. In the yield taken by fishermen (1938-1941), 105 warmouth bass weighing 33.4 pounds were recorded, table 5.

Table 23 gives the length and age distribution of the warmouth bass collected in the 1941 final census of Onized Lake. None of the 1941 spawn were seen or collected, but it is probable that because of their small size they were not observed when the treatment was first applied.

Calculated lengths based on scale studies were determined for 101 warmouth bass, which included most of the larger individuals, table 24.

In fig. 8, the growth curve of warmouth bass from Onized Lake is compared with a growth curve constructed from Schoffman's data (1940) on the warmouth bass in Reelfoot Lake. In Onized Lake the

Table 23.—Age-length frequencies of the 1,638 warmouth bass collected from Onized Lake in the census of June 24-28, 1941. The census was made about 1½ months after the spawning season, and the lengths shown for each age include the growth increment for the early part of the 1941 season.

Length in Inches	Age in Years 0	1	2	3
2		33		
½		555		
3		474		
½		56	8	
4		47	64	
½			169	
5			179	
½			40	
6	—Desirable Size—		2	2
½			3	3
7			1	1
½				1
8				
Total	*0*	*1,165*	*466*	*7*

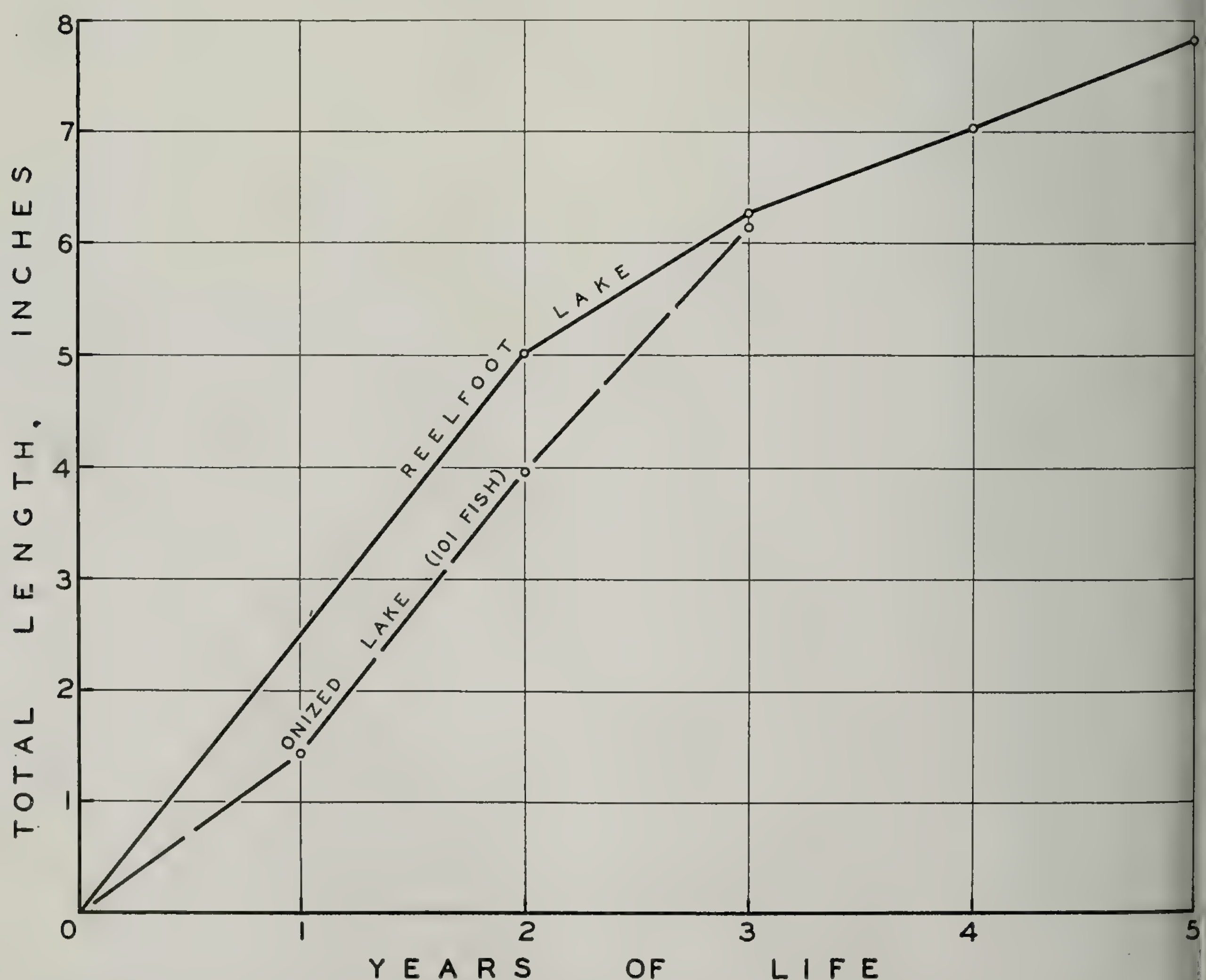


Fig. 8—Average rate of growth of warmouth bass in Onized Lake and in Reelfoot Lake. The warmouth bass in Onized Lake grew at approximately the same rate as the green sunfish, fig. 9, and neither of these species was of great importance in the hook-and-line catch.

Table 24.—Average calculated total lengths in inches of 101 warmouth bass collected from Onized Lake in the census of June 24-28, 1941.

Brood	Number of Fish	Average Calculated Lengths by Years of Life			Average Total Length at Time of Capture
		1	2	3	
1938	7	2.13	4.35	6.12	6.61
1939	63	1.19	3.91		4.87
1940	31	1.77			2.88
Total	*101*				
Average		*1.43*	*3.95*	*6.12*	

growth rate was slower than that in Reelfoot during the first 3 years of life. Only a few of the warmouth bass in Onized Lake had survived to begin the fourth summer.

The warmouth bass may have some potential value as a fish for managed ponds, but it seems unable to produce usable fish in combination with other species in unmanaged small lakes.

Green Sunfish

Lepomis cyanellus Rafinesque

Green sunfish were more important than warmouth bass in the creel census from Onized Lake, but they failed to make up as much as 10 per cent by weight of the fishermen's catch, 1938-1941, table 5. In the 1941 census, green sunfish were greatly outnumbered by warmouth bass and bluegills, table 7.

Table 25 gives the age-length frequencies of green sunfish. With the exception of one fish of the 1937 brood, the green sunfish collected in the 1941 census belonged to the 1938, 1939 and 1940 broods. The 1941 brood was lost in the process of censusing.

The age distribution pattern of green sunfish was nearly identical with that of the warmouth bass, tables 23 and 25. Only 9 of the 245 green sunfish were 6 inches or more in length. The average weight of this fish in the 1941 census was 0.026 pound, while that of the bluegill

Table 25.—Age-length frequencies of the 245 green sunfish collected from Onized Lake in the census of June 24-28, 1941. The census was made about 1½ months after the spawning season, and the lengths shown for each age include the growth increment for the early part of the 1941 season.

Length in Inches	Age in Years				
	0	1	2	3	4
2					
½		10			
3		71			
½		49			
4		43	10		
½		12	15		
5		2	24		
½					
6	Desirable Size			3	1
½				2	
7				2	
½					
8					
½				1	
Total	*0*	*187*	*49*	*8*	*1*

Table 26.—Average calculated total lengths in inches of 95 green sunfish collected from Onized Lake in the census of June 24-28, 1941.

Brood	Number of Fish	Average Calculated Lengths by Years of Life				Average Total Length at Time of Collection
		1	2	3	4	
1937	1	0.91	4.67	5.36	5.86	6.20
1938	6	1.95	4.42	6.16		6.80
1939	21	1.61	4.12			4.63
1940	67	2.16				
Total	*95*					
Average		*2.01*	*4.20*	*6.05*	*5.86*	

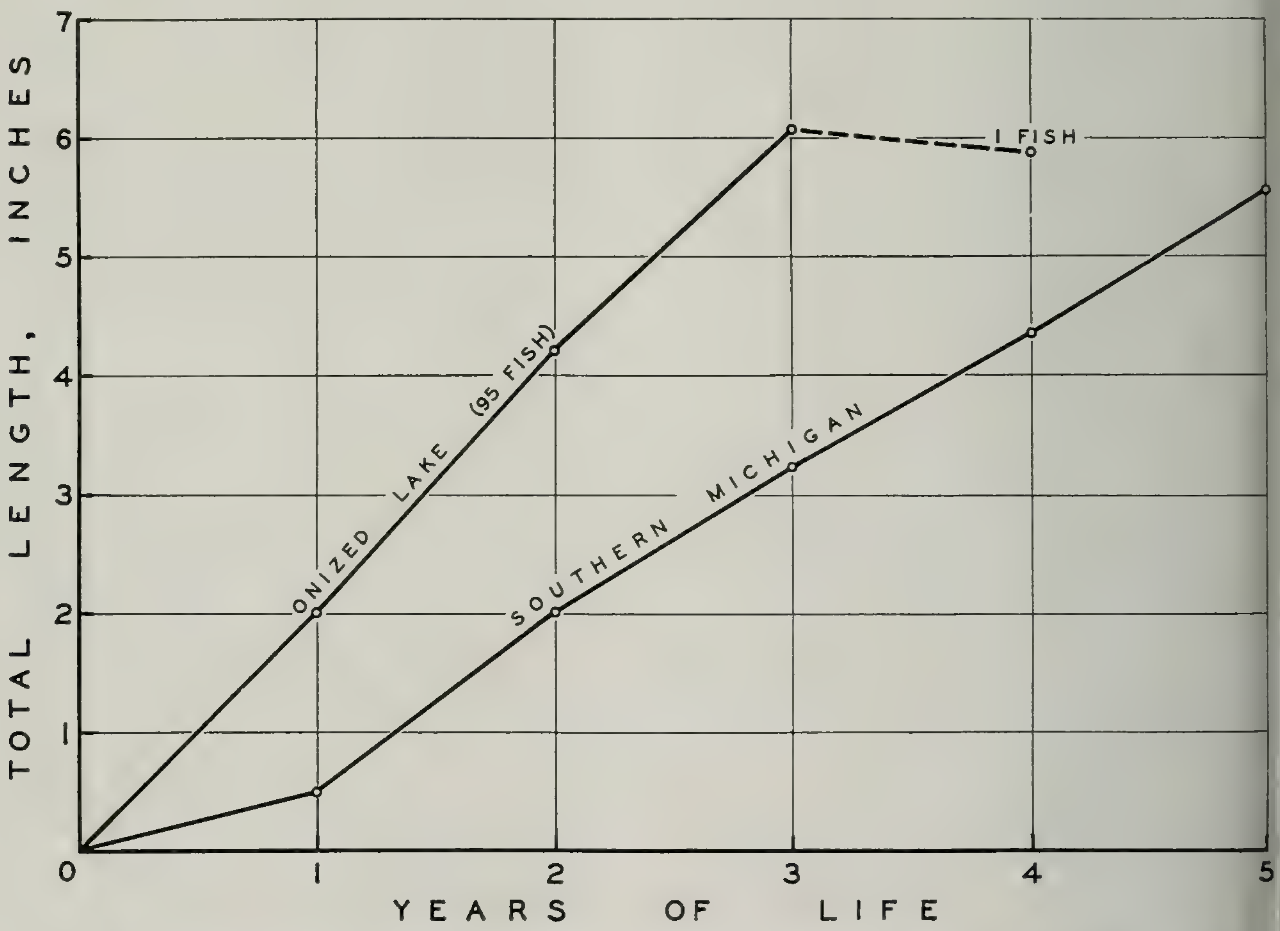


Fig. 9.—Average rate of growth of green sunfish in Onized Lake and in southern Michigan.

was 0.036 pound and of the warmouth bass 0.017 pound, table 7.

The average calculated total lengths of 95 green sunfish are given in table 26 and a growth curve constructed from these lengths is shown in fig. 9. Also in fig. 9 is shown a growth curve of this species from southern Michigan, based on the data of Hubbs & Cooper (1935). Apparently in Michigan a combination of stunting and a short growing season limits the number of green sunfish that reach usable size. Hubbs & Cooper state, "only one fish in thirty-two from the southern zone is of legal size" (6 inches). In Onized Lake, only 1 fish in 27 had reached a length of 6 inches at the time of the 1941 census, tables 7 and 8.

Yellow Bass

Morone interrupta Gill

Four yellow bass were collected in the final Onized Lake census of 1941, table 7. Their lengths were 11.1, 11.4, 11.5 and 11.5 inches and their weights, 0.50, 0.88

Table 27.—Average calculated total lengths in inches of two yellow bass collected from Onized Lake in 1938, one in 1940 and three in the final census of June 24-28, 1941.

Brood	Number of Fish	Average Calculated Lengths by Years of Life					Average Total Length at Time of Collection
		1	2	3	4	5	
			1938 Collection				
1935...........	1	1.57	7.27	9.16			9.80
1936...........	1	2.14	8.56				10.80
Total...........	*2*						
Average.........		*1.86*	*7.92*	*9.16*			
			1940 Collection				
1936...........	1	1.89	8.61	10.23	10.95		11.40
			1941 Collection				
1936...........	3	1.87	8.29	9.97	10.75	11.15	11.50

0.90 and 0.83 pound, respectively. All the scales collected from the smallest fish were regenerated; ages determined for the other three fish indicate that they belonged to the 1936 brood, and it is probable that the fourth fish in the collection was of the same age. The total number of yellow bass taken by fishermen in the creel census of 1938-1941 was seven, table 5. Scales from two yellow bass caught in hoopnets in the 1938 fishing period and from one in the hoopnet catch of 1940 are available for study. One of the two fish caught in nets in 1938 was spawned in 1935, and the other belonged to a brood that was spawned in 1936. The one yellow bass taken in a net in 1940 also belonged to the 1936 brood. Calculated total lengths of yellow bass from Onized Lake are shown in table 27.

Table 27 indicates that the growth rate of yellow bass in Onized Lake was uniform. Stocking records show that fish were put in Onized Lake in 1934 and 1935, and a few yellow bass may have been spawned in the lake in 1936. There is no evidence of a successful spawn since that date. In a study of the fish populations of 22 artificial lakes (Bennett 1943), yellow bass were present in 7, including Onized Lake, but young fish of this species were found in only 1, indicating that the yellow bass is unable to maintain its numbers in most small waters in Illinois.

The growth of yellow bass in Onized Lake was slow during the first season, very rapid during the second and less rapid in subsequent seasons; as increase in length represented a progressively greater increase in weight of these fish.

Bullheads

Ameiurus melas melas (Rafinesque)
Ameiurus natalis natalis (Le Sueur)

Only two black bullheads were taken in the final census of the fish of Onized Lake; one of these was a small fish of 0.56 pound and the other weighed 2.21 pounds. In the hoopnet catches of 1938 and 1940, one black bullhead was recorded for each season. Each of these fish weighed 2 pounds (or perhaps the same fish may have been caught in each year).

In recording the hook-and-line catch, no distinction was made between black and yellow bullheads. A total of 89 bullheads were caught, weighing 63.4 pounds, table 5. These represented 2.2 per cent of the number and 5.5 per cent of the weight of all fish caught. In view of the apparent scarcity of black bullheads, it is probable that nearly all of these fish were yellow bullheads.

In the final census of 1941, 347 yellow bullheads were collected, table 7. Age determinations on bullheads can be made by studying sections of bones and spines, but the process is so slow as to be impracticable in handling a large number of fish. When the numbers of bullheads of various lengths were tallied, all of the fish fell into three general length groups: the smallest from 4 to 7 inches, the next from 8½ to 10½ inches and the largest from 12 to 14 inches. As these groups were distinct,

Table 28.—Hypothetical age-length distribution of the 347 yellow bullheads collected from Onized Lake in the census of June 24-28, 1941. Ages have been assigned on the basis of length. The census was made about 1½ months after the spawning season, and the lengths shown for each age include the growth increment for the early part of the 1941 season.

Length in Inches	Age in Years			
	0	1	2	3
4		22		
½		53		
5		98		
½		58		
6		53		
½		27		
7 —Desirable Size—		22		
½				
8				
½			1	
9			2	
½			5	
10			2	
½			2	
11				
½				
12				1
½				
13				
½				
14				1
Total	*0*	*333*	*12*	*2*

they suggest three age groups. Young bullheads are spawned during May in Onized Lake, and it is unlikely that any of the 4-inch fish taken in the census belonged to the brood of the 1941 season. Therefore, it is assumed that the 4- to 7-inch group represented the 1940 brood; the 8½- to 10½-inch group the 1939 brood; and the 12- to 14-inch group the 1938 brood (possibly the 14-inch fish belonged to the 1937 brood, although this seems unlikely, as bullheads are readily caught). The assumption of these various age groups has a validity it would not possess if the ranges of length in this species had overlapped.

Table 28 shows the age-length frequencies of yellow bullheads, sorted according to their hypothetical ages determined on the basis of their lengths.

Onized Lake is probably a poor habitat for bullheads, because of the steep slope of its basin and its limited shoal water. These characteristics, coupled with the complete absence of oxygen in the deeper waters in summer, result in a limited habitat for bottom-living species such as the black and yellow bullheads.

Golden Shiner

Notemigonus crysoleucas auratus (Rafinesque)

Golden shiners are not usually considered hook-and-line fish, but Onized Lake fishermen caught and kept them in 1940 and 1941. Certainly, desirable sizes of these fish cannot be less than 7 inches. The creel census records show 40 golden shiners, weighing a total of 7.7 pounds, table 5. In the 1941 final census, 90 shiners were collected, of which 37 were 7 or more inches long, tables 7 and 8. The age-length distribution is given in table 29. This table shows that these golden shiners in Onized Lake made rapid growth and reached comparatively large sizes for minnows. Only fishermen and the larger bass could utilize the larger shiners.

Calculated lengths based on scale measurements of 87 golden shiners are given in table 30. These lengths are plotted as a growth curve in fig. 10.

Table 29.—Age-length frequencies of the 90 golden shiners collected from Onized Lake in the census of June 24-28, 1941. The census was made about $1\frac{1}{2}$ months after the spawning season, and the lengths shown for each age include the growth increment for the early part of the 1941 season.

LENGTH IN INCHES	AGE IN YEARS 0	1	2	3
1	1			
½				
2	4			
½	2			
3				
½	1			
4		3		
½		1		
5		18		
½		14		
6				
½		1	6	1
7	Desirable Size		19	1
½			9	1
8			3	1
½			1	1
9				1
Total	*8*	*38*	*38*	*6*

Table 30.—Average calculated total lengths in inches of 87 golden shiners collected from Onized Lake in the census of June 24-28, 1941.

BROOD	NUMBER OF FISH	AVERAGE CALCULATED LENGTHS BY YEARS OF LIFE			AVERAGE TOTAL LENGTH AT TIME OF COLLECTION
		1	2	3	
1938	5	2.76	6.28	7.51	7.76
1939	36	4.24	6.82		7.19
1940	38	3.31			5.25
1941	8				2.20
Total	*87*				
Average		*3.70*	*6.75*	*7.51*	

Table 31.—Size frequencies for each group of female golden shiners taken from the Huron River at Ypsilanti, Michigan, May 19, 1934 (from Cooper 1935, rearranged).

AGE IN YEARS	NUMBER OF FISH	AVERAGE STANDARD LENGTH		AVERAGE TOTAL LENGTH, INCHES*
		Millimeters	Inches	
1	127	70.7	2.78	3.48
2	83	93.4	3.68	4.60
3	37	104.3	4.11	5.14
4	10	120.8	4.76	5.95
5	2	126.5	4.98	6.23

*Standard length converted to total length by the formula $\frac{\text{T.L.}}{\text{S.L.}} = 1.25$. The formula is based on measurements of Illinois golden shiners.

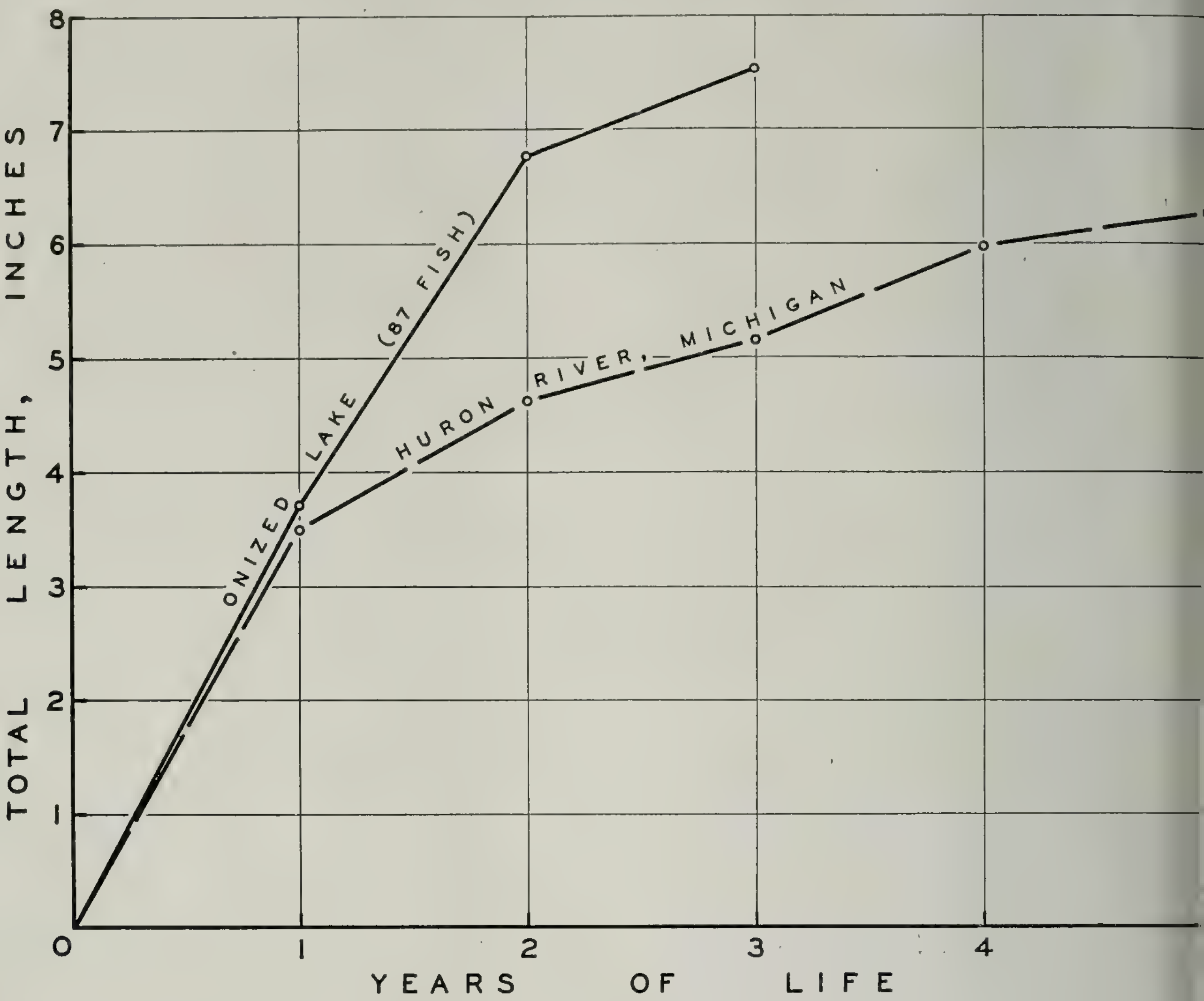


Fig. 10.—Average rate of growth of golden shiners in Onized Lake and in the Huron River at Ypsilanti, Michigan.

Also in fig. 10 is shown a second curve based on female golden shiners collected and aged by Cooper (1936). These fish were taken from the Huron River at Ypsilanti, Michigan, May 19, 1934. Cooper's data, summarized in table 31, offer evidence that the females of golden shiners live to a greater age and grow somewhat faster than males, and suggest that females predominated among the larger shiners in Onized Lake.

In Onized Lake, the first-year growth rate was essentially the same as in the Michigan collection of Cooper. However, Onized Lake shiners continued to grow at a rapid rate during the second year, while the rate of growth of the Michigan fish was much slower. Probably because of competition with other young fish, Onized Lake shiners grew less rapidly in their first year than might normally be expected in the southern part of Illinois.

The origin of the Onized Lake golden shiners is unknown. Possibly they were stocked as forage for bass. Or they may represent escaped bait.

Miscellaneous Fish

One carp, one common sucker and one blunt-nosed minnow were taken in the 1941 census.

This miscellaneous assortment of rough and forage fish probably represents bait that escaped the hooks of fishermen. Onized Lake is some distance from other water containing a variety of fish, and it is improbable that these fish were carried to the lake by fish-eating birds.

Age Distribution of Fish

The overfished population of Onized Lake was of particular interest from the standpoint of its age composition. As may be seen from table 32, overfishing tended to limit the life span of the fishes to the

Table 32.—Age composition of the fish population of Onized Lake; census of June 24-28, 1941.

SPECIES	AGE IN YEARS						
	0	1	2	3	4	5	TOTAL
Largemouth bass	33	195	24	8	7	8	275
Black crappie		15	7				22
Bluegill	236	3,369	2,857	83			6,545
Warmouth bass		1,165	466	7			1,638
Green sunfish		187	49	8	1		245
Yellow bass						4	4
Black bullhead			1	1			2
Yellow bullhead		333	12	2			347
Carp					1		1
Common sucker		1					1
Golden shiner	8	38	38	6			90
Blunt-nosed minnow		1					1
Total	*277*	*5,304*	*3,454*	*115*	*9*	*12*	*9,171*

approximate length of time that was required for them to reach desirable sizes. These sizes were attained by most species during the latter part of the second growing season. Some fish escaped being caught during the third season, but only a few remained to begin the fourth or fifth. Of these, the largemouth bass is the most notable and its survival is believed to hinge upon the probability that, of all species represented, it is the most wary and best able to learn from experience. Moreover, the life span of the largemouth is normally somewhat longer than that of other Illinois lake fishes.

Lines representing a pyramid of numbers of Onized Lake fish have been superimposed upon lines representing a similar pyramid for a theoretical fish population (Bennett 1943), fig. 11. This figure

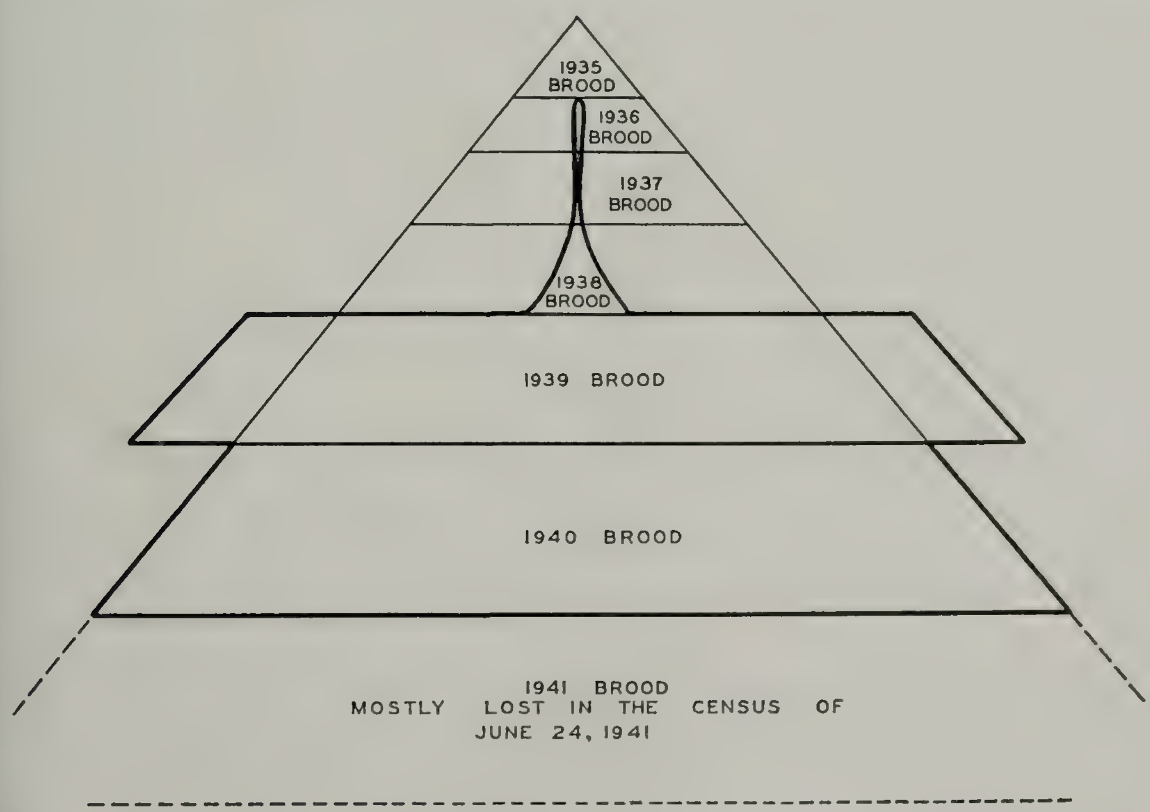


Fig. 11.—Diagram representing the age-frequency distribution of Onized lake fish, final 1941 census, superimposed upon a pyramid of numbers representing a theoretical fish population. This diagram suggests that overfishing tends to remove most of the older and larger fish, but has little effect upon the production of adequate broods of young.

illustrates the tendency of overfishing to remove the larger and older fish. The 1941 census was made shortly after completion of the 1941 spawn, and, as the 1941 brood was composed of very small fish, most of which were lost in the census, this brood is represented as the pyramidal base enclosed in dotted lines. When quadrilaterals representing the 1940 and 1939 broods are superimposed upon the theoretical pyramid, with the lines for the 1940 brood coinciding with the limits of the theoretical quadrilateral for 1940, the lines for the 1939 brood extend beyond the limits of the theoretical quadrilateral for the corresponding year. The figure representing the 1938 brood shows that this brood was only a small fraction of the size of the 1939 brood and much smaller than the theoretical quadrilateral for 1938; the effects of overfishing are thus indicated. Older broods are represented by a spearhead extending toward the apex of the theoretical pyramid.

Discussion

All sources of evidence point to the hypothesis that Onized Lake was severely overfished. Yet every species of fish known to be once numerous in the lake was present in the final census, perhaps due to the fact that fishing pressure drew its quota from all kinds of fish present, rather than from one or two of the more desirable species. The many fishermen using the lake represented a cross section of anglers, their fishing gear running the gamut from willow-pole to flyrod. The fish in this lake were presented with a variety of baits and hook sizes, attractive to all but the smallest.

It is possible that if the fishing intensity had been directed toward a certain species, to the exclusion of others, that species might have been entirely eliminated. This could be expected to occur, not directly through intensive fishing, but indirectly through the inability of reduced numbers of spawn or young of the selected species (because of fewer breeding adults) to compete with the more numerous young and adults of other species not affected by fishing. For all practical purposes, the lake would have become "fished out" for the selected species before all of the adults had been caught, but it is rather unlikely that the few remaining could have produced enough young to compete with young of the more numerous species. In the 1941 census, the black bullheads and yellow bass were only a few in number, but in view of the fact that the hook-and-line catch was made up of only small numbers of yellow bass and bullheads, and the hoopnet collections of 1938 failed to indicate abundant populations of these fish, the conclusion must be reached that some factors other than heavy fishing kept them from becoming numerous.

The black crappies of Onized Lake were nearer extermination than any other species known to be numerous in the past. However, the creel census does not indicate that particularly large catches of these fish were made, fig. 5. Only during 1939 were appreciable numbers taken. In that year the crappie catch ranked second to the bluegill in numbers and well ahead of any other species. In 1940, the total hook-and-line catch of crappies was only 56; yet hoopnets set during July of that year caught 234 black crappies, more than twice the number of bluegills and many times the numbers of other fish caught, table 6. The fact that only 56 crappies were taken by anglers in 1940, and 31 in 1941, following a catch of 502 in 1939, suggests a natural die-off of the older fish during the latter half of the summer of 1940. The only other evidence for the natural die-off assumption is that large numbers of crappies were not present in the final census.

All species of fish in Onized Lake from which scales were studied showed poor growth during the first season, and all but one, the warmouth bass, grew at an exceptionally rapid rate throughout later years of life. This situation can be explained by assuming that the constant drain on the adult fish population through heavy fishing allowed increased success in spawning and greater survival of young fish. Thus, foods suitable for small fish were at a premium, and early growth was slow. However, once the young fish reached sizes large enough to allow them to feed upon larger food organisms, they grew rapidly, because the constant take of adults eased the food competition in this size range.

The fishing intensity at Onized Lake during the period of this study was so great that most of the fish were caught before they reached the age of 3 years; a few managed to escape for two more summers. None had completed the sixth year of life.

The hook-and-line yield of 349.95 pounds per acre in 1939, table 4, is judged to be about three-fourths of the carrying capacity of Onized Lake for the species of fish then in the lake. The carrying capacity, on the basis of that found in other similar ponds, is believed to lie between 450 and 500 pounds of fish per acre, as the average for Onized Lake and 21 other small Illinois lakes censused was 446.5 pounds per acre (Bennett 1943). In the final census of 1941, the total weight of fish in Onized Lake was only 221.09 pounds per acre, table 7, plus a few pounds for the numerically abundant 1941 brood that was not recovered. The number of fish collected per acre was 4,586. In the 21 other small lakes mentioned above, which were censused in a manner similar to the census of Onized Lake, the numbers of fish per acre ranged from 10,119, where a large number of minnows were present, to 1,124; the average number per acre was 3,434. The fact that Onized Lake contained more than the average number of fish per acre, although overfished, indicates that numerically the population was maintaining itself (in spite of no additional stocking), and that, with reduced fishing pressure, the population would have increased rapidly in total weight, until it approached the carrying capacity of the lake.

Much of the angling at Onized Lake is done by families or other small groups that use the club grounds for picnics. Because fishing is incidental to other uses, the angling pressure on this body of water is less closely related to the catch of fish than on most other lakes.

Summary

1. Onized Lake, a small pond of 2 acres, offered an excellent opportunity to study overfishing because it was fished intensively and a creel census was made of the catch.

2. The creel census covered September and October of 1938, the fishing seasons

of 1939 and 1940, and April, May and June of 1941. The fishing intensity was light in 1938 (end of the season), but for the 1939 season it was 1,414.9 man-hours per acre; for 1940, 1,647.3 man-hours per acre; and, for April, May and June of 1941, 634.0 man-hours per acre. Hook-and-line fish yields were, for 1939, 349.95 pounds per acre; for 1940, 142.5 pounds per acre; and, for 3 months of 1941, 70.9 pounds per acre. Hoopnet sampling of August 28-30, 1938, compared with catches made with nets July 10-15, 1940, indicated a reduction in the population of large-sized fish between these two sampling periods.

3. A poison census was made on June 24, 1941. At this time the lake contained 9,171 fish weighing 442.17 pounds. The kinds of fish present were largemouth bass, black crappies, bluegills, warmouth bass, green sunfish, yellow bass, black bullheads, yellow bullheads and golden shiners, as well as one carp, one common sucker and one blunt-nosed minnow.

4. Fish were relatively stunted during the first year of life, but most species grew at an exceptionally rapid rate during later years. The oldest fish were in their sixth summer of life, and nearly all of these were largemouth bass. Most of the fish were taken when in their third summer.

5. A large population of black crappies had been reduced to 22 fish by the time of the final census. This reduction was apparently not due to hook-and-line fishing. Largemouth bass and bluegills remained numerous, although they had made up an important part of the hook-and-line catch.

6. In spite of heavy fishing, the natural spawn of fish was obviously sufficient to insure replacement of those fish removed, and under reduced fishing intensity the lake would have returned to its former carrying capacity.

LITERATURE CITED

Beckman, William C.

1941. Increased growth rate of rock bass, *Ambloplites rupestris* (Rafinesque), following reduction in density of the population. Am. Fish. Soc. Trans. **70**:143-8.

Bennett, George W.

1937. The growth of the large mouthed black bass, *Huro salmoides* (Lacépède), in the waters of Wisconsin. Cope. **1937**(2):104-18. 6 figs.

1943. Management of small artificial lakes, a summary of fisheries investigations, 1938-1942. Ill. Nat. Hist. Surv. Bul. **22**(3):357-76. 7 figs.

Bennett, George W., David H. Thompson and Sam A. Parr

1940. Lake management reports. 4. A second year of fisheries investigations at Fork Lake, 1939. Ill. Nat. Hist. Surv. Biol. Notes **14**. 24 pp., 10 figs., 4 pls.

Cooper, Gerald P.

1936. Age and growth of the golden shiner *(Notemigonus crysoleucas auratus)* and its suitability for propagation. Mich. Acad. Sci., Arts and Letters Papers **21**:587-97. 3 figs.

Eschmeyer, R. W., and Alden M. Jones

1941. The growth of game fishes in Norris Reservoir during the first five years of impoundment. N. Am. Wildlife Conf. Trans. 6, **1941**:222-40. 4 figs.

Hubbs, Carl L., and Gerald P. Cooper

1935. Age and growth of the long-eared and green sunfishes in Michigan. Mich. Acad. Sci., Arts and Letters Papers **20**:669-96. 5 pls.

Schloemer, Clarence Louis

1939. The age and rate of growth of the bluegill, *Helioperca macrochira* (Rafinesque). Doctoral Dissertation, University of Wisconsin.

Schoffman, Robert J.

1940. Age and growth of the black and white crappie, the warmouth bass, and the yellow bass in Reelfoot Lake. Reelfoot Lake Biol. Sta. Rpt. **4**:22-42. 9 figs.

Swingle, H. S., and E. V. Smith

1943. Factors affecting the reproduction of bluegill, bream and largemouth black bass in ponds. Ala. Ag. Exp. Sta. Circ. **87**:1-8.

Thompson, David H., and George W. Bennett

1939. Lake management reports. 3. Lincoln Lakes near Lincoln, Illinois. Ill. Nat. Hist. Surv. Biol. Notes **11**. 24 pp., 8 figs.

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Volume 23, Article 4   Urbana, Illinois   August 1945

BULLETIN
of the
ILLINOIS NATURAL HISTORY SURVEY
THEODORE H. FRISON, *Chief*

Wetwood of Elms

J. CEDRIC CARTER

Printed by Authority of the
STATE OF ILLINOIS
DWIGHT H. GREEN, *Governor*

DEPARTMENT OF REGISTRATION AND EDUCATION
FRANK G. THOMPSON, *Director*

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NATURAL HISTORY SURVEY DIVISION
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Volume 23 BULLETIN Article 4

Wetwood of Elms

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URBANA, ILLINOIS

August 1945

This paper is a contribution from the Section of Applied Botany and Plant Pathology.

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PREFACE

THE results which Dr. J. Cedric Carter reports in this article of the BULLETIN OF THE ILLINOIS NATURAL HISTORY SURVEY are the outcome of six consecutive years, 1939 through 1944, of study in the field, greenhouse and laboratory of a complex of disease manifestations in the American elm. The elements of this complex, singly and in various combinations, have puzzled both practical and scientific tree experts for many years.

Dr. Carter has demonstrated that there is a direct relationship between an obscure disease of the heartwood of living elms, commonly called wetwood, and certain forms of twig and branch dieback, "bleeding" from crotches and wounds, and the two conditions known to tree experts as internal slime flux and external slime flux. He has isolated a species of bacterium, apparently heretofore undescribed and unnamed, which can produce elements of this disease complex upon being inoculated into healthy trees.

Although supporting material and observations were gathered in many places in Illinois, the major part of the field work connected with this investigation was done in the Village of Hinsdale, in Du Page County, Illinois. Much of the equipment necessary for some of the studies and certain materials, such as fertilizers, were furnished by the Village, along with labor and other help, as occasion demanded. Many of the illustrations in this paper show phases of these Hinsdale studies.

Mr. Robert S. Hopkins, Commissioner of Public Works for the Village, furthered the work in all possible ways. With his approval, Mr. William Ellsworth Rose, as Forester, took an enthusiastic interest in the work from 1939 through 1941, and Mr. Joseph F. Shafer, Assistant Commissioner of Public Works, showed an equal interest from 1942 through 1944. These men gave generously of their time, assisting personally and assigning men employed under them to various tasks as need arose. Among such tasks may be mentioned the collecting of wood, gas and sap samples for laboratory testing, the felling and cutting up of certain trees, the periodical recording through 2 years of the readings of gauges installed in trees, the feeding of several trees and the setting up of a number of experiments. Also, through their reports to the Village President and Board of Trustees, Mr. Rose and Mr. Shafer kept the officials and citizens of Hinsdale informed regarding the progress of the investigation.

To acknowledge all of this help is a pleasure. The elements of personal and public interest did much to make Dr. Carter's study complete and exact in many details. Moreover, the cooperation between officials of the Village of Hinsdale and scientists of the Illinois Natural History Survey, cordially maintained throughout, provides an example showing how communities in Illinois can proceed toward the solution of tree problems requiring the services of highly specialized scientists.

T. H. FRISON, *Chief*
Illinois Natural History Survey.

CONTENTS

American elm on the University of Illinois campus.

The American elm, *Ulmus americana* L., unsurpassed in beauty and grace, is the most popular and widely planted shade tree in the Middle West.

Wetwood of Elms

J. CEDRIC CARTER

THE investigation of wetwood reported in this paper is the outgrowth of studies of an unusual wilt observed on a large number of American elms in the Village of Hinsdale, Illinois, in July and August, 1939. As studies of the wilt progressed, it became apparent that this wilt was a secondary manifestation of disease intimately related to slime flux, a chronic bleeding at crotches and wounds, to abnormally high sap pressure in the trunk, and to wetwood, a water-soaked, darkly discolored condition of the heartwood. The investigation has shown that all of these conditions—wilting, high sap pressure and water-soaked, discolored wood—are phases of the wetwood disease, and that a bacterium, described as a new species, can cause wetwood in elms.

Acknowledgments

The author wishes to express his sincere appreciation to all those who have assisted in any way during the course of this investigation. Special recognition is given to the Village of Hinsdale foresters—Mr. W. E. Rose through 1941 and Mr. J. F. Shafer since 1942—for their assistance with the portion of the investigation that was carried out at Hinsdale. Elms affected with wetwood on Hinsdale parkways were used in parts of this investigation. Permission to use these trees was arranged with the government of the Village of Hinsdale through Mr. Robert S. Hopkins, Commissioner of Public Works, and much of the labor, equipment and material used in treating and examining them was furnished by the Village. Dr. O. W. Rees and Dr. G. C. Finger, chemists of the Illinois State Geological Survey, gave many suggestions in regard to methods of analyzing sap and gas taken from affected elms. Some gas samples were analyzed by Mr. C. D. Lewis, Assistant Chemist of the Illinois State Geological Survey. Dr. F. M. Clark, Assistant Professor of Bacteriology at the University of Illinois, made many helpful suggestions in connection with the identification of the bacterium associated with wetwood. Preliminary analyses of sap from wetwood-affected elms were run by Dr. F. F. Weinard, Associate Professor of Floricultural Physiology at the University of Illinois. Mr. O. T. Lay, in charge of the city office of the United States Department of Commerce Weather Bureau at Chicago, furnished the monthly meteorological summaries for Chicago. Photographic illustrations for the frontispiece and for figs. 19, 20, 21 and 22 were prepared by Mr. Ray R. Hamm, Manager of the University of Illinois photographic and blueprinting laboratory. Mrs. Lucile Rogers Carter assisted in many ways in the preparation of this manuscript. The author is indebted to Dr. L. R. Tehon, head of the Section of Applied Botany and Plant Pathology of the Illinois Natural History Survey, for suggestions made during the course of this investigation.

Review of Literature

A bacterial vascular disease of Lombardy poplar, *Populus nigra italica* Muenchh., was described by Hartley & Crandall (1935). Crandall, Hartley & Davidson (1937) called this disease wetwood and described it as "a water-soaked condition of the central wood." They reported wetwood in species of *Abies, Morus, Platanus, Populus, Prosopis, Prunus, Quercus, Salix, Tsuga* and *Ulmus,* and also *Elaeagnus* cuttings.

Crandall, Hartley & Davidson (1937) mentioned that slime flux, in several species, appeared to be a pathological phenomenon of wetwood. Dodge (1937), in a discussion of slime flux, stated, "A tree should not be diagnosed as suffering from slime flux unless there is a 'wet wood' condition of the heartwood and unless the bleeding of moisture from the tree issues from this heartwood." He pointed out that, in general, moisture is under pressure throughout the heartwood of such an affected tree. However, in a few cases he found pressure to be present only in isolated sections of the heartwood. May (1942) showed that bleeding or fluxing from the heartwood of elms affected with wetwood was independent of sap flow in the sapwood. He considered slime flux to be one of the manifestations of wetwood. Crandall (1943), working with winter-injured *Platanus acerifolia* Willd. in 1934, found a bacterial infection to be present in wetwood-affected trunk wood. He suggested that the frost cracks that were present in the trees affected with wetwood had developed during periods of low temperature. The affected trees fluxed freely through these cracks. Large (1944) described a flux of tung tree as alcoholic flux or white slime flux and stated that the disease was confined to the cambial region. He found bacteria and an Actinomycete-like fungus associated with this type of flux.

Most of the work on slime flux before 1935 was concerned mainly with the visible manifestations of the disease on the outside of trees. Ludwig (1886, 1888, 1890) described alcoholic flux or white slime flux of oak, birch, poplar and maple, and brown slime flux of apple, elm, birch, horse chestnut, poplar and oak. He stated that in brown slime flux the sap or slime formed in the wood and broke through the bark, and both the bark and wood soon decayed. He associated *Endomyces magnusii* Ludw. with white slime flux, and *Micrococcus dendroporthos* Ludw. with brown slime flux.

Following Ludwig's early work, slime flux was investigated by Hansen (1889) in Denmark, by Holtz (1901) and Stautz (1931) in Germany, by Massee (1897, 1907) and Ogilvie (1924) in England, and by Stone (1916) and Cook (1918) in the United States. These investigators, with the exception of Ogilvie (1924), believed that slime flux was caused by parasitic organisms. Massee (1897) produced slime flux of apple and plum trees by inoculating them with *Micrococcus dendroporthos* Ludw. Stautz (1931) pointed out that no fungus hyphae were found in affected wood but that bacteria were present in drops of the sap. Tubeuf & Smith (1897), Ward (1901) and Ogilvie (1924) believed that slime flux was not a parasitic disease but an abnormal physiological bleeding associated with normal or abnormal pressures in the tree.

Guba (1934, 1942), after reviewing the literature, concluded that slime flux was not a parasitic disease but that it developed because of artificial environment and other mechanical or physiological conditions.

Hosts and Distribution

In Illinois, wetwood has been found in American elm, *Ulmus americana* L., including the varieties Moline and Littleford, slippery elm, *Ulmus fulva* Michx., English elm, *Ulmus procera* Salisb., and Siberian elm, *Ulmus pumila* L. Trees affected with this disease have been found in 40 towns and 21 counties, as follows: Quincy in Adams County; Champaign and

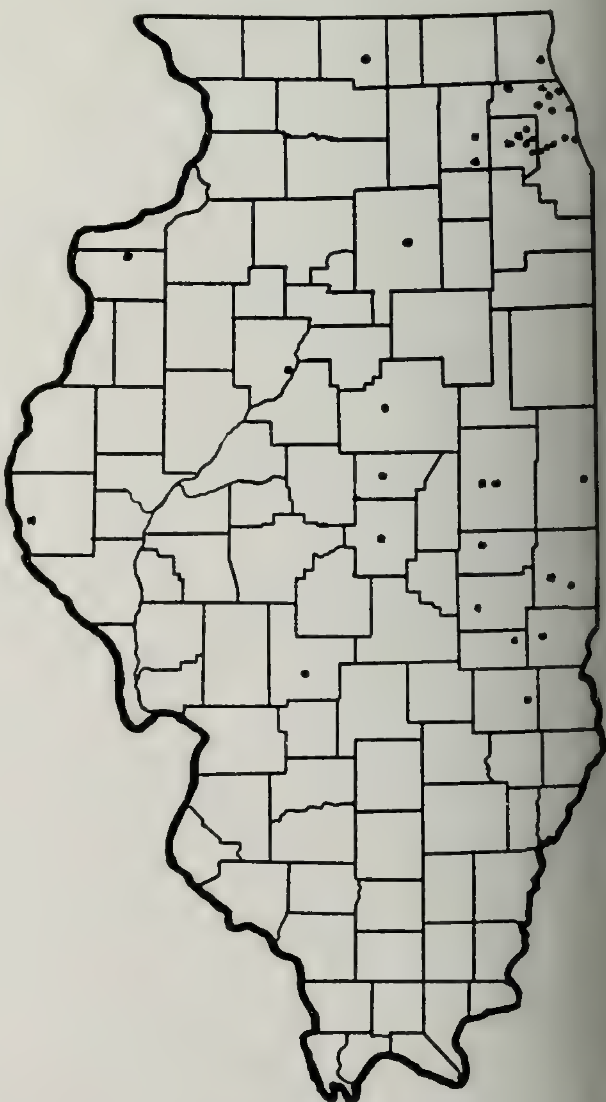

Fig. 1.—The black dots indicate the location of towns in which wetwood-affected elms have been found.

Urbana in Champaign County; Martinsville in Clark County; Mattoon in Coles County; Barrington, Brookfield, Chicago, Des Plaines, Evanston, Glencoe, La Grange, Northbrook, Oak Park, Park Ridge, Techny and Western Springs in Cook County; Timothy in Cumberland County; Clinton in De Witt County; Tuscola in Douglas County; Addison, Elmhurst, Glen Ellyn, Hinsdale, Lombard and Villa Park in Du Page County; Paris and Redmond in Edgar County; Willow Hill in Jasper County; Aurora and St. Charles in Kane County; Lake Forest in Lake County; Ottawa in La Salle County; Decatur in Macon County; Bloomington in McLean County; Hamlet in Mercer County; Hillsboro in Montgomery County; Peoria in Peoria County; Danville in Vermilion County and Rockford in Winnebago County. Distribution of the 40 towns is shown in fig. 1.

Trunk Pathology

Wood Discoloration.—Wetwood in elms is characterized by dark brown discoloration that may appear in current-season trunk wood as streaks or broken bands or in several annual rings as narrow to broad streaks or broken bands, fig. 2. The discoloration sometimes extends beyond the current-season wood into the cambial region and phloem, fig. 3. There it is grayish brown and appears as short streaks or irregular, elongate patches. Discolored wood appears water-soaked. When it is cut, sap oozes out.

Fig. 2.—Section of elm trunk affected with wetwood, showing discoloration of inner wood and brown streaks in current-season wood.

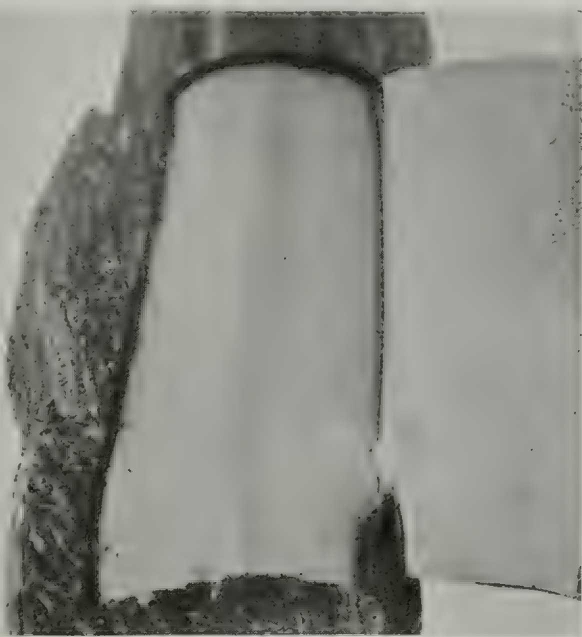

Fig. 3.—Wetwood discoloration can sometimes be found in the cambial region and phloem of elms, where it is grayish brown and shows as short streaks or elongate patches.

Fig. 4.—Fluxing through a wound made in the removal of a large branch. Toxicity of the flux from wetwood-affected elm prevents callus formation at the base of the cut.

Fig. 5.—Fluxing through branch crotches is common in elms affected with wetwood. The flux on this tree, invaded by air-borne organisms, has coated the bark below the crotch with slime.

In most elms, wetwood is confined to the inner sapwood and heartwood, and there is very little or no streaking in the outer sapwood and no discoloration in the cambial region or phloem. However, in those affected elms that exhibit wilting of twigs and branches, grayish brown discoloration can be found in the outer sapwood and occasionally in the cambial region and phloem as well as in older wood.

Gas.—In wetwood-affected tissues, gas is produced in large amounts by the action of the fermenting bacteria on carbohydrates and other materials in the trunk. This gas, confined in the trunk, causes abnormally high sap pressures to develop. Pressures up to 60 pounds per square inch have been recorded.

Sap.—Sap accumulates in abnormally large amounts in affected wood. Because of the abnormally high pressure caused by the gas produced by fermentation, sap frequently is forced out of the trunk

Fig. 6.—This elm is fluxing through a crack in the trunk, which originated as a frost crack during the preceding winter. Fluxing through the crack in the bark became apparent by June.

through wounds made by the removal of branches, fig. 4, through cracks in crotches, fig. 5, and trunks, fig. 6, and through other trunk injuries. This exuding of sap is commonly called fluxing. The sap or flux as it oozes out of diseased wood is colorless to tan but turns dark upon exposure to air. When abundant bleeding occurs, the flux flows down the trunk, wetting and soaking large areas of bark, figs. 5 and 6. When it dries, it leaves a light gray to white incrustation on the bark, fig. 7. Ogilvie (1924), who worked

Fig. 7.—Dried flux showing on the bark of an elm after the trunk crack from which it came had closed.

Fig. 8.—Crack in elm trunk wood around which a pocket formed between bark and wood. Such pockets develop when sap and gas seep out through cracks in the wood.

in England on elm and other trees, suggested that fluxing sap contains calcium carbonate and forms a white incrustation on the bark upon drying. In some cases, especially when fluxing is prolific or long continued, air-borne bacteria, yeasts and fungi contaminate the oozing sap, ferment it, and produce the malodorous material commonly called slime flux. Hence slime flux, in the common sense, is the material resulting from an entirely external putrefactive condition which develops only after bleeding has occurred.

The wetwood flux, when it exudes from the tree, is toxic to the extent that it is capable of retarding or preventing callus formation, and it frequently kills back the cambium at the base of a cut where a

Fig. 9.—Cross section of trunk showing a crack that extends from wetwood-affected heartwood through the bark. Also visible are cracks radiating from the center of the heartwood. Cracks in the wood aid in spread of sap and gas in wetwood-affected trees.

branch has been removed, fig. 4, and around trunk cracks through which it flows, fig. 8. Young shoots directly above fluxing regions may wilt. Foliage and young shoots, and also the grass at the base of an affected tree, may be killed if the flux drips on them.

At Hinsdale, in June and July of 1943, several affected elms having splits or cracks in the trunk bark were examined. Fluxing made the bark cracks on these trees conspicuous, fig. 6. When the cracked bark was removed, corresponding cracks were found in the wood beneath, out of which sap had been oozing, fig. 8. Cross cuts of these trunks showed the cracks in the wood to extend inward into wetwood-affected tissues, fig. 9. Cracks in the heartwood radiated from the center and extended through several woodrings, fig. 9. Most of these cracks did not reach the cambial region; therefore, they did not flux, although they may possibly have permitted more rapid and greater internal movement of sap and gas.

Cracks probably develop in the wood during the winter months, at times when the temperature falls rapidly to very low points. Toxic sap from the wetwood-affected heartwood kills the cambium for some distance around the cracks in the wood. The bark separates from the wood, forming oval to elongate pockets, fig. 8. Cracks in the bark with flux oozing through them become apparent in June or July. Many such cracks callus over during the same growing season, fig. 10. In studying *Platanus acerifolia* Willd. which had developed frost cracks, Crandall (1943) found only wetwood-affected trees

Fig. 10.—Callus formation that developed over a crack in the trunk of a wetwood-affected elm. The crack developed during the previous winter and flux became apparent during the spring and early summer.

Fig. 11.—Split stump of a wetwood-affected Moline elm. Wetwood does not, as a rule, spread into roots of grafted elms but is confined mainly to the heartwood of the trunk.

to show cracks. He observed that the sap from wetwood prevented callusing.

Root Pathology

Roots of affected trees usually show very little discoloration. However, in seed-

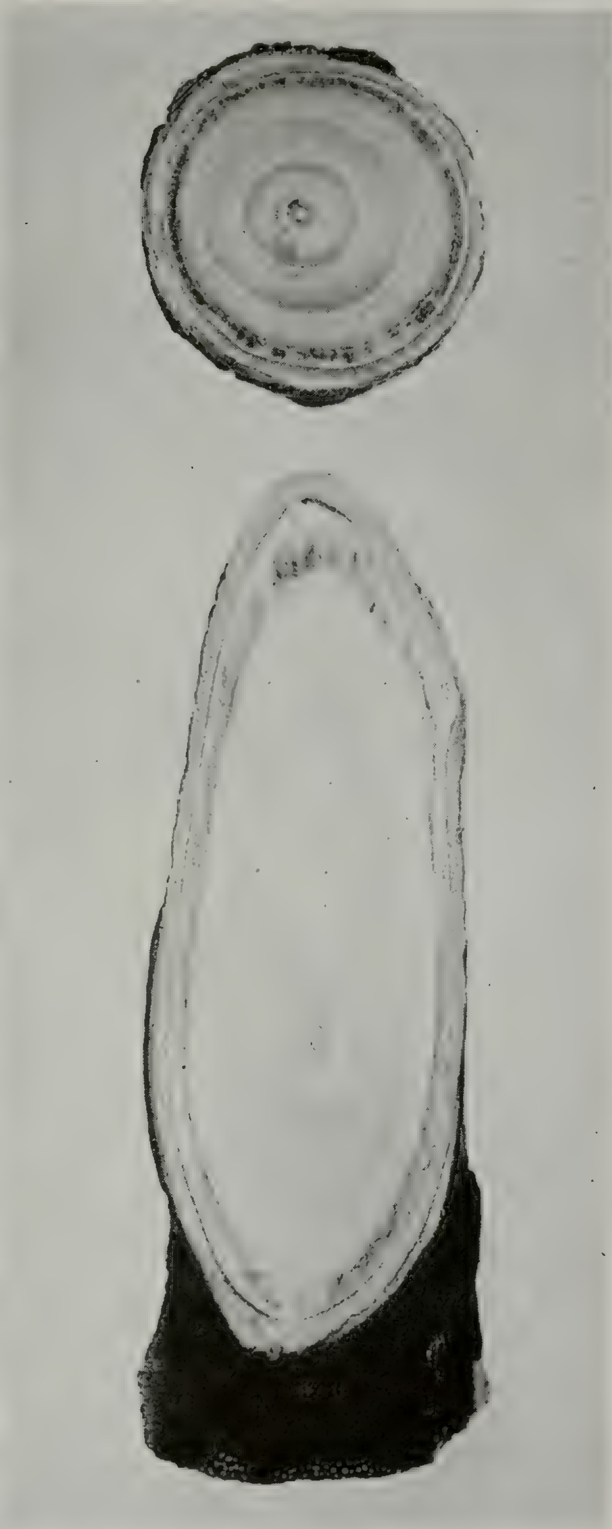

Fig. 12.—Sections of an elm branch that wilted because of wetwood. Grayish brown streaks form in the current-season wood, principally in the spring wood. When freshly cut, the discolored wood appears to be water-soaked.

ling trees and in some grafted trees brown streaks may extend from the diseased trunk into the heartwood and occasionally into the sapwood of the roots. In most of the grafted trees examined, the brown discoloration was confined to the trunk wood above the region of grafting, fig. 11, with no evidence of disease in the roots of these trees.

Branch Pathology

Branches that wilt on wetwood-affected trees show, in the current-season wood,

Fig. 13.—Branch dieback on a wetwood-affected elm on which wilting occurred several years in succession.

grayish brown streaks that are especially noticeable in the spring wood, fig. 12. These streaks originate in the trunk and spread out into the branches. However, they usually do not reach the branch tips. Where grayish brown streaks are abundant, they may appear as solid brown rings in the wood of one or more seasons, but usually only in current-season wood, which usually appears water-soaked when freshly cut. Branches so affected may die, fig. 13. In some trees affected with wetwood, very few branches die. In others, scattered branches die, a few each year, and the

Fig. 14.—Wetwood-affected elm, which shows general decline, especially of lower branches.

trees show gradual decline, as in the elm pictured in fig. 14.

Heartwood in the basal portions of some branches, especially large branches, is discolored brown, as in wetwood-affected heartwood of the trunk shown in fig. 2. This discoloration in branch heartwood is a continuation of the wetwood-affected heartwood in the trunk.

Foliage Pathology

Wilt occurs on elms affected with wetwood when sufficient quantities of the toxic sap that has accumulated in the trunk wood is carried into the branches. First, affected leaves curl upward along their margins, then the petioles become flaccid and finally the leaves droop. Curl and droop are followed by wilt, fig. 15. Some leaves that wilt rapidly may drop from the trees while still green. Other leaves that wilt rapidly may take on a dull, greenish brown or somewhat bronzed appearance by the time they fall. Leaves that wilt slowly may turn yellow or brown before they fall. Many of the brown leaves may remain on the affected branches for several weeks. Leaves on some trees may droop and turn yellow but not wilt, while those on others may turn dull greenish brown between the veins, fig. 16. Many leaves that turn yellow or dull greenish brown may abscise prematurely during July and August.

Fig. 15.—The wilt which occurs sometimes in elms affected with wetwood is evident on branches at right.

Wilting as the result of wetwood in the trunk has been observed on trees as much as 10 inches d. b. h., but most frequently on trees 3 to 6 inches d. b. h. Elms more than 10 inches d. b. h. affected with wetwood usually do not wilt but frequently develop yellowing and browning of the foliage, followed by leaf drop and branch dieback. General decline may occur in these larger trees affected with wetwood.

Many large elms affected with wetwood are characterized by the dying, year after

Fig. 16.—Leaf discoloration produced experimentally by injecting elm seedling with toxic sap from wetwood-affected elms. The toxic sap caused the leaves to turn dull greenish brown between the veins and along the margins.

year, of scattered branches. This type of branch dying is evident in the Hinsdale elm pictured in fig. 14.

Dissected Elm

An American elm, variety Littleford, that wilted during late July and early August of 1943 was cut up for examination. This tree had two trunk cracks near its base. Both cracks had developed during the previous winter and before the growth of 1943 wood. Both had fluxed earlier in the summer but were callused over by August. One crack, fig. 10, had a 12-inch-long bark callus which extended upward from a point 4 inches above the ground. The inner face of the bark and the wood callus which formed beneath the bark are shown in fig. 17. Fig. 18 shows the crack in the trunk wood after most of the 1943 wood adjacent to it had been chiseled off. This trunk crack, approximately 18 inches long, extended into the 1938 wood.

The second trunk crack, fig. 9, was covered by a 2-foot-long bark callus which extended upward from a point about 2 feet above the ground. This crack was directly beneath the branches which wilted in the upper part of the tree. Wood callus had developed only in the 1943 woodring of the crack. A cross section of the trunk through the crack, fig. 9, shows wetwood-affected heartwood, which includes most of the 1941 and 1940 woodrings and all older woodrings. Sap which had spread out through the crack from the infected wood into the 1942 woodring and the spring wood of the 1943 ring was carried from the crack up the trunk through 1943 spring wood and into the branches, which soon wilted. There was some lateral spread of the sap as it traveled up the trunk. The sap caused brown streaks to form in the

Fig. 17.—A wetwood-affected elm with a trunk crack which had callused over. Callus was formed by both the wood and bark.

1943 spring wood through which it passed. However, the streaks in the branches did not extend to the branch tips. Other cracks, which were confined within the heartwood, are shown radiating out from the center of the trunk in fig. 9. The sap in this tree was under a pressure of 13.5 pounds before the tree was cut. Wetwood-affected tissue extended only to the junction of roots and trunk, fig. 11.

Isolations

Samples from 346 elms—American, Moline, Littleford, slippery, English and Siberian—were cultured in the laboratory, 1939-1943. Several types of bacteria were isolated from 239, or approximately 69 per cent, of the trees sampled. Of the 346 trees, 292 had wilted during one or more growing seasons. Many of the remaining 54 trees, which were affected with wetwood but which had not wilted, showed flux. As preliminary tests showed that the various bacterial isolates would grow abundantly in nutrient broth and on potato dextrose agar, these two media were used throughout this investigation, except where otherwise stated.

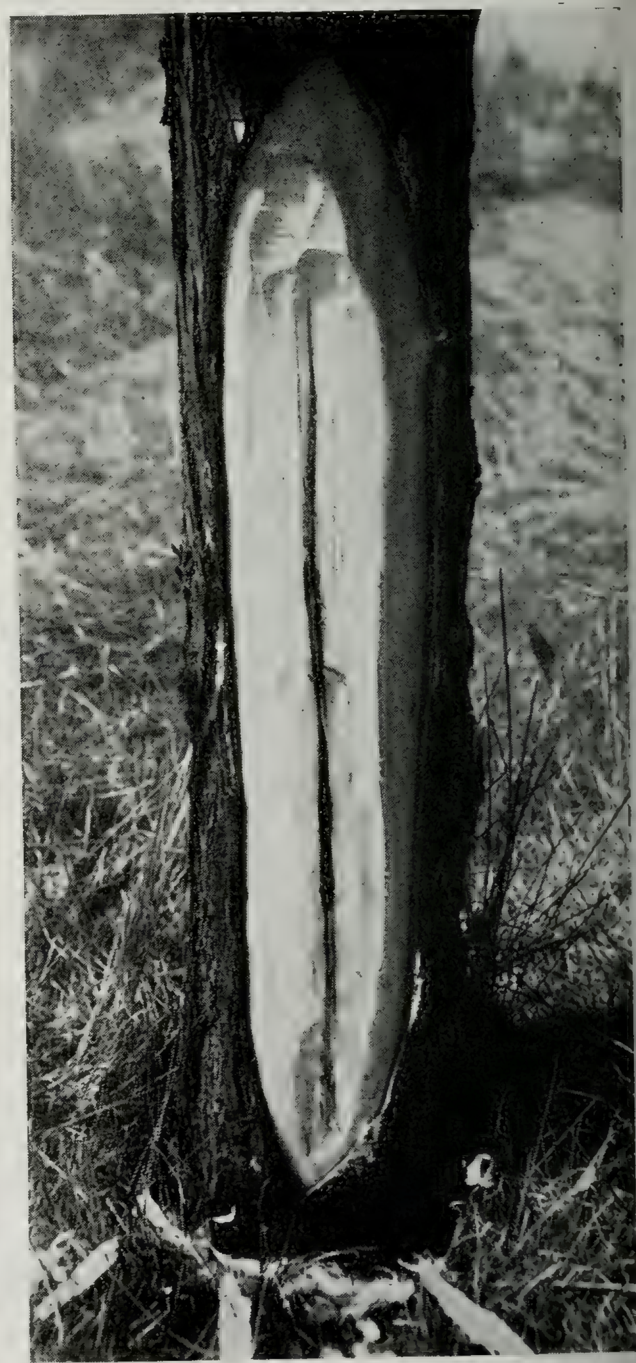

Fig. 18.—The trunk crack shown in fig. 17 with the current-season wood removed. Grayish brown discoloration formed in the wood along the crack.

Table 1.—Summary of isolations obtained from 346 elms which showed wetwood.

Material Sampled	Portion of Tree Cultured	Number of Samples Cultured	Number of Samples From Which Bacteria Were Isolated	Per Cent of Samples From Which Bacteria Were Isolated
Branch	Sapwood	261	95	36.40
	Heartwood	22	14	63.64
Trunk	Sapwood	232	181	78.02
	Heartwood	30	28	93.33
	Cambial region	6	0	0.00
	Phloem	3	1	33.33
Sap from trunk	Sap	23	23	100.00

In all of the branch and trunk samples cultured, the diseased condition was indicated by brown streaks or other abnormal brown discoloration. The number and type of samples cultured, the number of bacterial isolates obtained and the per cent of samples from which bacteria were isolated are given in table 1.

The types of materials samples, listed in table 1, were branch sapwood and heartwood, trunk sapwood, heartwood and phloem, and sap from wetwood-affected trunk wood. Isolates of bacteria were obtained more frequently from heartwood than from sapwood and from a greater per cent of the trunk samples, approximately 77 per cent, than of the branch samples, approximately 39 per cent. Bacteria were present in all sap samples tested, indicating that sap of wetwood-affected trunk wood is constantly infested with bacteria. These data indicate that bacteria are more abundant in the trunk wood, where they live over from year to year, than in the brown discolored branch wood. Crandall (1943) found that, in *Platanus acerifolia* Willd., fermenting bacteria were limited mainly to the innermost rings, and he concluded that these bacteria usually did not readily attack the healthy tissues of well-established trees.

Histology

Histological studies were made on tissues from 11 elms affected with wetwood. The tissues examined included branch xylem, root xylem, trunk xylem, trunk cambium and trunk phloem. Many vessels affected with wetwood, especially those of the trunk xylem, contained tyloses, bacteria and gumlike materials. Some vessels, fig. 19, were filled with large, thin-walled tyloses while others had small tyloses which covered only the inner vessel walls. Tyloses were formed by August in current-season wood of wetwood-affected elms which wilted during July. They appeared to be sufficiently abundant in some vessels to retard and possibly prevent the flow of sap.

Masses of bacteria were present in scattered vessels and ray cells. Bacteria were more abundant in trunk xylem than in branch xylem. The limited occurrence of bacteria in the branch xylem explained why they were not isolated so frequently from branch samples as from trunk samples. There was no evidence of tissue disintegration in the infected wood.

Light brown deposits of what appeared to be gum were observed in a few scattered vessels and ray cells. Occasionally cells appeared to be filled with this gum, but most frequently the gum appeared to be deposited on the cell walls. Ogilvie (1924) reported medullary rays and wood parenchyma of water-soaked elm wood to be filled with a gummy substance, composed partly of tannin and partly of starch, that gave the wood a brown color.

Fungi were not found in any of the wetwood-affected tissues that were examined.

The formation of callus over a trunk incision on a 2-year-old elm seedling submerged in water occurred within 11 days. The callus tissues were laid down by xylem, cambium and phloem. That no callus formed over a trunk incision of

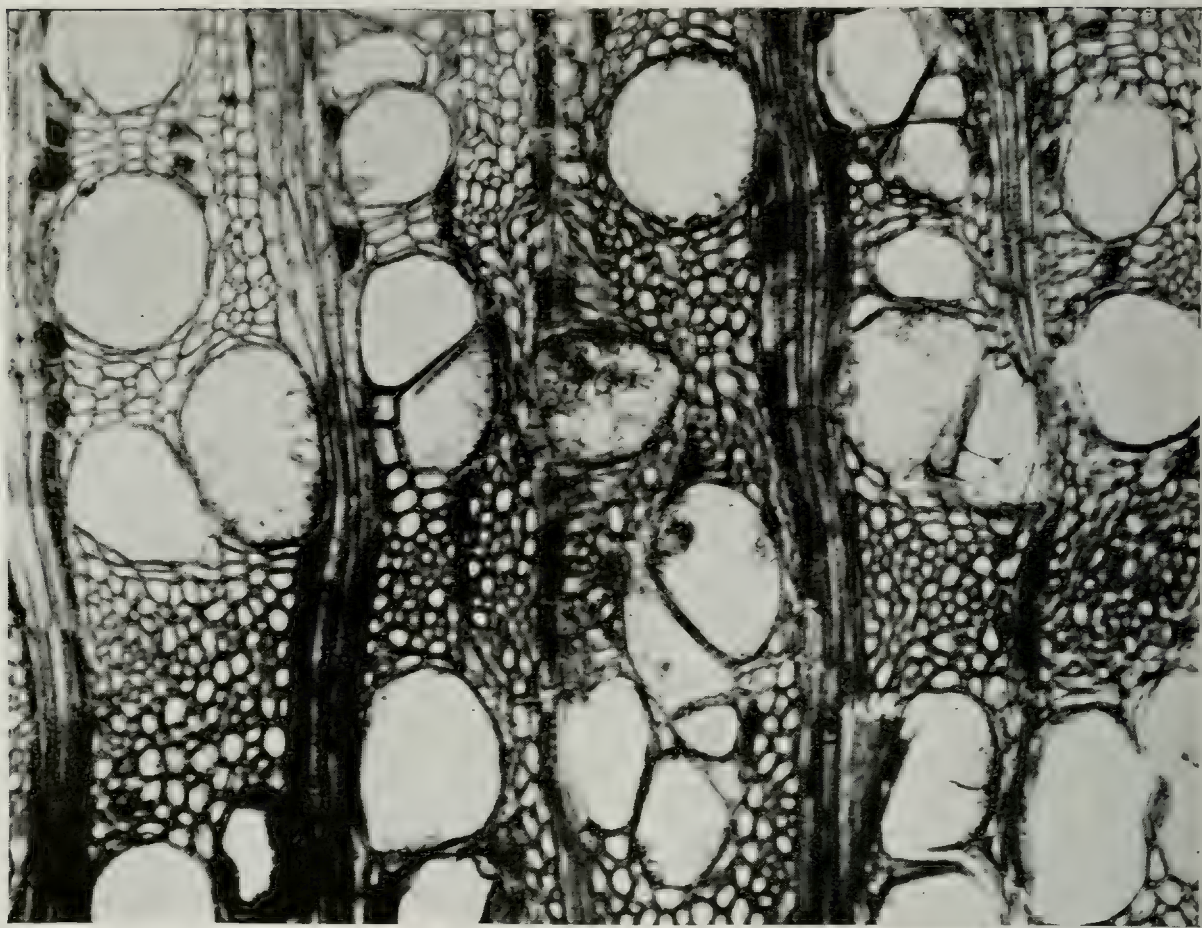

Fig. 19.—Cross section of xylem of elm affected with wetwood, showing tyloses in many vessels. Bacteria are occasionally present in some of the vessels. They are observed most frequently where tyloses are abundant. $\times 130$.

a second 2-year-old seedling when the cut portion of the stem was submerged in sap from a diseased elm indicates that such sap prevents or at least retards the formation of callus. Many of the ray and parenchyma cells near the surface of the trunk incision which was submerged in sap became filled with brown, gumlike material.

The Wetwood Organism

Five bacterial isolates, representative of the numerous isolates obtained from elms affected with wetwood, each obtained from a different elm, were studied for their morphology, cultural characters and biochemical reactions. Isolates 1, 3, 4 and 5 were obtained from wetwood-affected elms which had wilted. Isolate 2 was obtained from a wetwood-affected elm which had not wilted. Isolates 1, 2 and 4 were from parkway trees, while isolates 3 and 5 were from nursery trees.

Morphology.—These five isolates are believed to represent a single species of bacterium. The organism is a short rod with rounded ends and occurs singly or, rarely, in pairs or chains, fig. 20. Cultures on potato dextrose agar (pH 6.8) incubated at 24 degrees C. for 48 hours produced cells measuring $0.68–2.00 \times 0.34–0.68\mu$ mostly $0.68–1.35 \times 0.34–0.68\mu$. This organism is Gram-negative, motile, not acid-fast, and has up to six peritrichiate flagella measuring up to 11μ long, fig. 21. Capsules and spores were not observed.

Cultural Characters.—Growth in nutrient broth appears in 24 hours or less and the broth becomes strongly clouded or turbid, with a decided kidney bean odor. The organism usually forms a thin pellicle or flocculent surface growth when undisturbed. Sediment is usually scant and viscid but becomes abundant if cultures are disturbed at frequent intervals. The medium becomes strongly alkaline. Colonies on potato dextrose agar incubated at 24 degrees C. for 24 hours are circular, smooth, entire, flat to slightly raised, and usually opaque (whitish cream) but occasionally somewhat translucent. Growth in streaks on potato dextrose agar is abundant, spreading, glisten-

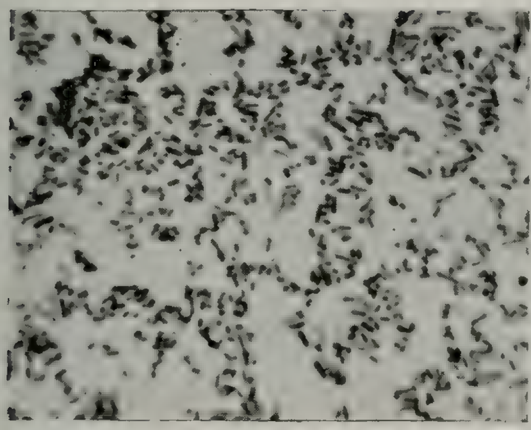

Fig. 20.—The organism that causes wetwood of elm produces cells that are short rods with rounded ends and that occur singly or, rarely, in pairs or chains. ×1,000.

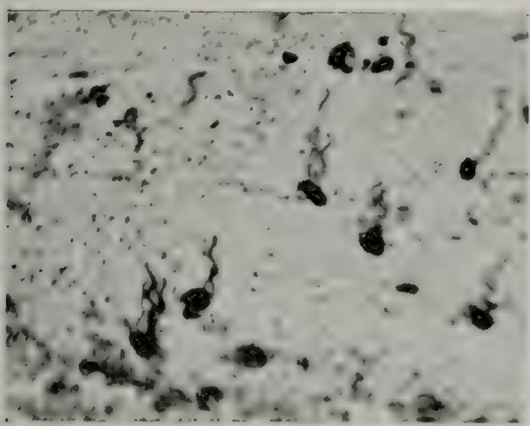

Fig. 21.—Cells of the wetwood organism have peritrichiate flagella. ×1,500.

ing, whitish cream and viscid, and is accompanied by an odor of fermentation. A culture of the organism growing on cabbage infusion agar is shown in fig. 22. Growth in stabs in potato dextrose agar is abundant and is accompanied by the liberation of gas. This gas produces fissures and frequently forces a portion of the agar up against the cotton plug or beyond the mouth of the test tube. At first the colonies are lens shaped to disk shaped. The medium remains unchanged in color. In shake cultures of potato dextrose agar covered with a mixture of paraffin and vaseline, the organism develops abundant growth through the medium and produces sufficient gas within 20 hours to form fissures in the medium and to start raising the paraffin-vaseline seal. Growth on additional agars is as follows: abundant on cabbage infusion; moderate on lima bean and wood decoction;* scanty on bean pod, nutrient broth, corn meal, malt extract, prune, and plain agar plus 1 per cent, 5 per cent and 10 per cent dextrose; hardly visible on wort agar and on plain agar plus 20 per cent dextrose. No visible growth develops on 2 per cent plain agar. Streak cultures on potato plugs produce an abundant, filiform, glistening, dark gray growth that darkens the potato tissue only slightly. The texture of the potato tissue is not visibly affected. Streaks on carrot plugs produce scant growth, consisting of one to a few beadlike glistening cream colonies. Carrot tissue is not visibly affected. No growth develops from streaks on apple plugs. Milk is coagulated in 24 hours at 37 degrees C. and in 13 days at 24 degrees C. There is a separation of acid curd with the production of whey. The milk changes to pH 4.1–5.1 by the end of 15 days. Litmus and bromocresol purple are reduced. Milk is not peptonized. By Conn's

*Wood decoction agar was made by adding 2 per cent agar to distilled water in which normal elm wood had been soaked for several days.

Fig. 22.—Culture of the wetwood organism growing on cabbage infusion agar.

method of rennet production (Society of American Bacteriologists, Committee on Bacteriological Technic, 1939), whey and hard curd are produced in 20 minutes by isolate 4, in 18 hours by isolate 2 and in 40 hours by isolates 1, 3 and 5. In shake cultures, each isolate grows throughout the agar. The least amount of growth develops in the upper quarter inch of medium. On agar in Petri dishes, each isolate grows beneath and beyond both microscope slides and Petri dish bottoms placed on the surface of the medium.

The optimum temperature for growth of the organism is approximately 24 to 30 degrees C., maximum about 37 degrees C. and minimum 5 degrees C. or lower. Potato dextrose agar slant and shake cultures held at –12 degrees C. for 4 days, then incubated at 24 degrees C., produce abundant growth within 3 days, with conspicuous gas production in the shake cultures. The thermal death points for the five isolates are 15 minutes at 55 degrees C. for isolates 1, 3 and 5; 10 minutes at 55 degrees C. for isolate 2 and 10 minutes at 45 degrees C. for isolate 4. The optimum pH range for growth is 6.82–7.50, the maximum is pH 10.00+ and the minimum is pH 4.67.

Biochemical Reaction.—Growth of the organism in gelatin stabs is beaded and most abundant at or near the surface but absent beyond 15 mm. below the surface. There is no liquefaction and the medium is unchanged. Colonies on gelatin are punctiform, convex, entire, smooth and translucent. Nitrates are reduced to nitrites without the formation of gas. Indole is not formed. Hydrogen sulfide is produced. Asparagin stimulates growth without the production of gas in synthetic peptone-free medium (Society of American Bacteriologists, Committee on Bacteriological Technic, 1939). The medium becomes alkaline. Starch is not hydrolyzed. Both the methyl red and Voges-Proskauer tests are positive. Pectin is not fermented by the method described by Elrod (1942).

All fermentation tests to determine the sources of carbon that these five isolates utilize were run in duplicate and in parallel series on nutrient broth and synthetic peptone-free basic media. Both types of basic media were used, since Burkholder (1932) has pointed out that accurate results in carbohydrate fermentation tests frequently are not obtained when strong alkali-producing bacteria are grown in beef-extract-peptone broth. One per cent of each carbon was used except for trehalose, melibiose and cellobiose, where 0.5 per cent was used. These isolates produced both acid and gas from arabinose, rhamnose, xylose, dextrose, fructose, galactose, mannose, lactose, maltose, trehalose, melibiose, cellobiose, mannitol, sorbitol and salicin. They produced slight acid and gas from starch, slight acid but no gas from glycerol in nutrient broth, alkali and no gas from glycerol in synthetic peptone-free medium, and no acid or gas from inulin, dextrin or filter paper. Acid and gas were not produced by these isolates from elm sawdust in nutrient broth or from elm sawdust in synthetic peptone-free medium when the medium was autoclaved after the sawdust was added. However, there was slight acid and no gas production in the synthetic peptone-free medium when the elm sawdust was autoclaved before it was added to the sterile medium. Variable results were obtained with sucrose, raffinose, melezitose and dulcitol. Isolates 1, 3 and 5 produced alkaline reaction, without the formation of gas, from all four carbons. Isolate 2 produced acid and gas from sucrose and raffinose and an alkaline reaction without gas from melezitose and dulcitol. Isolate 4 produced both acid and gas from all four carbons. Variation in ability of these five isolates to ferment sucrose, raffinose, melezitose and dulcitol is not believed to be sufficiently significant to separate them as distinct species.

Taxonomy

The organism constantly associated with wetwood of elm in Illinois is similar in many respects to *Erwinia salicis* Day. However, it reacts differently from *E. salicis* by producing gas from most of the sources of carbon that were tested. In addition, it changes litmus milk, produces hydrogen sulfide and does not produce a bright yellow pigment on potato. Also, it is similar in many respects to *Pseudomonas lignicola* Westerdijk & Buisman (1929), which inhabits the wood of elms in Holland. However, it differs from *P. lignicola* as follows. It produces gas from dextrose and most other sources of carbon tested, whereas *P. lignicola* does not produce gas from glucose, the only source of carbon tested by Westerdijk & Buisman. In addition, it has peritrichiate, not polar, flagella, coagulates litmus milk with the production of acid, reduces nitrates, and does not hydrolyze starch. Because of these differences, as well as because of the complex type of disease it produces in elms, the wetwood organism is believed to be a new species and is so described below. It is associated with the production of wetwood, wilt, dieback, premature leaf drop and flux of elm—American, Littleford, Moline, slippery, English and Siberian. Affected trees flux through trunk wood exposed by the removal of branches, through cracks in crotches, cracks in trunks, and other types of injuries that penetrate to wetwood-affected tissues. The organism inhabits mainly heartwood and inner sapwood and is especially likely to invade elms through pruning wounds, crotch injuries and wounds made during surgical treatment, transplanting and cultivation in the nursery. The wetwood organism was isolated from dark brown diseased trunk sapwood and heartwood and occasionally from brown-streaked branch wood.

*Erwinia nimipressuralis** New Species

The organism is a short rod with rounded ends, $0.68-2.00 \times 0.34-0.68\mu$, mostly $0.68-1.35 \times 0.34-0.68\mu$, arranged singly or, rarely, in pairs or chains; motile, with up to six peritrichiate flagella; capsules and spores not observed; anaerobic, Gram-negative and not acid-fast.

On potato dextrose agar, colonies are circular, smooth, entire, flat to slightly raised, and usually opaque (whitish cream). Growth in streaks on potato dextrose agar is spreading, glistening, whitish cream and viscid. Growth in stabs in potato dextrose agar is abundant, with liberation of gas. In nutrient broth, growth is abundant with a thin pellicle or flocculent surface growth, and sediment is scant and viscid. In gelatin stabs, growth is beaded and most abundant near the surface, and the medium is unchanged. Gelatin is not liquefied; nitrates are reduced to nitrites without the formation of gas; hydrogen sulfide is formed; no indole is formed; starch is not hydrolyzed; pectin is not fermented; milk is coagulated; litmus and bromocresol purple are reduced. Methyl red and Voges-Proskauer tests are positive. Optimum temperature for growth, 24—30 degrees C., maximum 37 degrees C., minimum 5 degrees C. or lower; thermal death point, 45—55 degrees C. Optimum pH for growth, 6.82—7.50, maximum pH 10.00+, minimum pH 4.67.

The organism produces both acid and gas from arabinose, rhamnose, xylose, dextrose, fructose, galactose, mannose, lactose, maltose, trehalose, melibiose, cellobiose, mannitol, sorbitol and salicin; slight acid and gas from starch; no acid or gas from inulin, dextrin or filter paper; variable results from sucrose, raffinose, melezitose, dulcitol, glycerol and elm sawdust.

The organism is pathogenic in trunk wood of elms, *Ulmus americana* L., *U. pumila* L., *U. fulva* Michx. and *U. procera* Salisb.

*Etymology: Latin; *nimis* = too much; *pressuralis* = pertaining to pressure; literally, pertaining to too much pressure.

Inoculations

Inoculation experiments were started in 1940 to determine the pathogenicity of the bacterial isolates obtained from diseased elms in Hinsdale that wilted in 1939. Two hundred nine inoculations were made on opening buds, leaves, shoots, branches, trunk phloem, trunk cambium and trunk current-season wood of American elms in our experimental nursery. None of these inoculations produced what were believed to be typical infections or resulted in wilt. Limited browning in trunk wood was produced in inoculated heartwood and older sapwood but was not at first believed to represent infection. However, later experiments showed this browning in trunk wood to represent infection and early development of wetwood. Patch grafting of discolored inner bark from diseased elms in Hinsdale on 28 healthy American elms in our experimental nursery did not produce infection or cause wilt.

American Elm, Greenhouse Inoculations.—Eight American elms, 1.0–1.5 inches d. b. h., grown in a greenhouse pit, were used for this experiment, begun in 1941. Six of the trees were inoculated with *Erwinia nimipressuralis* by use of a hand syringe, fig. 23—three on July 21 and three on August 5. Each tree was inoculated by injecting 50 ml. of bacterial culture in nutrient broth plus dextrose into the trunk through a three-quarter-inch hole. In each trunk the injection hole, about 14 inches above the ground, was bored at a downward slant and it extended three-fourths of the way through the trunk. Each injection hole was closed with a sterilized cork stopper. Two of the eight trees were used as checks. One check tree was injected with 50 ml. of sterile nutrient broth plus dextrose and the other was untreated.

Presence of infection of trunk wood in the inoculated trees was determined by culturing wood samples obtained with an increment borer. One of the six trees inoculated with bacteria was sampled April 21, 1942, two were sampled November 13, 1942, and three were sampled April 10, 1943. The untreated tree was sampled November 13, 1942, and the tree injected with sterile nutrient broth plus dextrose was sampled April 10, 1943. The trunk wood samples obtained with an increment borer from the six inoculated trees showed dark brown streaks in the heartwood. This discoloration was comparable to the streaking in elms naturally infected with wetwood. Fermenting bacteria which produced both acid and gas in nutrient broth plus dextrose were isolated from the wetwood tissues of these six inoculated trees. These bacterial isolates were similar to the original inoculum. The untreated tree and the tree injected with nutrient broth plus dextrose showed no dark brown discoloration in the heartwood typical of wetwood. Fermenting bacteria were not isolated from wood of these two check trees. None of the eight trees had wilted by February, 1945, when they were removed from the greenhouse.

Siberian Elm, Greenhouse Inoculations.—Eight Siberian elms, *Ulmus pumila* L., 2 to 3 inches d. b. h., grown in a greenhouse pit, were used for a second experiment which, like the first, was begun in 1941. Three of these eight trees were inoculated, each with 50 ml. of inoculum—culture of fermenting bacteria in nutrient broth plus dextrose—on October 10, 1941. This inoculum was injected by the use of the hand syringe method described above. As a check, another tree was injected with nutrient broth plus dextrose. The four remaining trees were untreated.

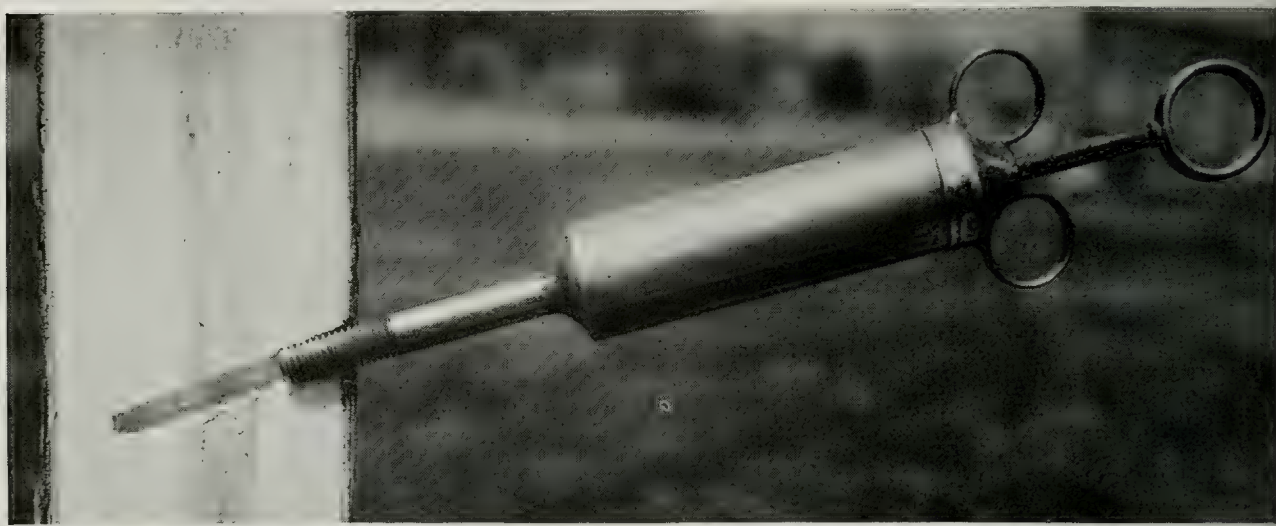

Fig. 23.—Apparatus used for injecting bacterial suspension and other materials into the trunks of elms. The material is injected into the tree through a hole bored in the trunk to within about 1 inch of the bark on the opposite side.

The four untreated trees and one of the three inoculated trees were cut up and examined on April 13, 1942. In three of the four untreated trees, the 1938 and all older wood was light brown, while the 1939 and all younger wood was white. Brown heartwood and white sapwood are believed to be normal for healthy Siberian elm. Bacteria were not isolated from the trunk wood of these three trees. The other untreated tree was fluxing through cracks in crotches and through a crack in the trunk. The trunkwood showed normal white 1942 and 1941 wood. The 1940 wood was gray and water-soaked and turned light brown upon exposure to air. The 1939 and older wood was dark brown and showed an infection of wetwood. Fermenting bacteria, which produced both gas and acid, were isolated from the dark brown 1939 wood but not from the grayish, water-soaked 1940 wood or the white 1941 and 1942 wood.

The inoculated tree which was examined on April 13, 1942, had normal white

1942 and 1941 wood. Its 1940 summer wood was white, but its 1940 spring wood and all older wood was dark brown and water-soaked. Isolates of fermenting bacteria similar to the original inoculum were obtained from the brown 1940 spring wood.

With an increment borer, trunk wood samples for culturing were taken April 10, 1943, from the remaining three trees, two inoculated with bacteria and one treated with sterile nutrient broth plus dextrose. Isolates of fermenting bacteria similar to the original inoculum were obtained from the two inoculated trees. Bacterial growth was not obtained from the trunk wood of the tree injected with nutrient broth plus dextrose.

Toxicity Tests for Wilt

Numerous toxicity tests were conducted to determine why wilting occurs on elms affected with wetwood. These tests were made on cut shoots of both elm and tomato and also on potted elm seedlings.

Laboratory Tests on Cut Shoots.—Cut shoots of elm and tomato were placed in test tubes, one of each in each tube, containing the solutions to be tested. Observations were made on the time required for the shoots to wilt. The materials tested and the times required for the elm and tomato shoots to wilt in the various solutions are given in table 2. All samples of sap were from elms in Hinsdale affected with wetwood. Neither filtering nor autoclaving, nor both, destroyed the toxicity of the sap. The elm shoots wilted in 1.5 to 4.0 hours, the tomato in 8.5 hours. The results indicate that filterable and thermostable toxins were present in the sap.

Water-soluble materials toxic to elm shoots but not to tomato shoots were obtained from normal elm heartwood when it was soaked and also when it was autoclaved in distilled water. The water in which normal heartwood was autoclaved was much more toxic than that in which it was soaked. It caused elm shoots to wilt in 1.5 hours, while water in which heartwood was soaked caused shoots to wilt in 9.5 hours.

No apparent correlation existed between the amount of liquid taken in and the number of hours before the shoots wilted. However, the total amount of material taken in may have been influenced by the size of the shoots, injury to tissues when

Table 2.—Results of toxicity tests with sap from infected wood of wetwood-affected elms; sap tested for toxicity on shoots of elm and tomato. All tests were run for 10 hours.

Material Tested	Hours Required to Wilt		Milliliters of Liquid Taken In	pH of Liquid
	Elm	Tomato		
Air	1.0	1.5	—	—
Tap water	No wilt	No wilt	8.0	7.16
Sterile distilled water	No wilt	No wilt	7.6	6.40
Sterile nutrient broth plus 1 per cent dextrose	No wilt	No wilt	2.1	6.38
24-hour culture of isolate 41–173	1.5	No wilt	0.2	5.55
24-hour culture of isolate 41–173, autoclaved	1.5	No wilt	3.3	4.65
Filtrate of 24-hour culture of isolate 41–173	No wilt	No wilt	3.5	5.13
Filtrate of 24-hour culture of isolate 41–173, autoclaved	No wilt	No wilt	2.1	4.96
Sap from diseased elm No. 4–7	4.0	8.5	4.4	7.06
Sap from diseased elm No. 6–7	3.5	8.5	1.5	7.15
Sap from diseased elm No. 42–43	3.5	8.5	3.7	7.28
Sap from diseased elm No. 42–43, autoclaved	1.5	8.5	0.6	8.14
Filtrate of sap from diseased elm No. 42–43	1.5	8.5	3.0	6.35
Filtrate of sap from diseased elm No. 42–43, autoclaved	1.5	8.5	2.2	6.36
Water in which normal elm heartwood was soaked	9.5	No wilt	1.8	5.70
Water in which normal elm heartwood was soaked, autoclaved	1.5	No wilt	2.4	4.96

the stems were cut, and the presence or absence of bacteria in the solutions tested. The amount of solution (0.2 ml.) from the 24-hour culture of isolate 41–173 taken in by the shoots may have been limited in part by mechanical plugging of vessels by bacteria. However, the tomato shoot in this solution did not wilt, even though the elm shoot in the same test tube wilted in 1.5 hours. Filterable and thermostable toxins were not produced in nutrient broth plus dextrose by isolate 41–173. The hydrogen ion concentrations of the solutions used, which ranged from pH 4.65 to 8.14, appeared to have no effect on the elm and tomato shoots.

Field Tests on 2-Year-Old Elms.—In this experiment, six 2-year-old potted seedlings of American elm were connected by rubber and glass tubing to six large wetwood-affected elms in Hinsdale to test the toxic effect, on seedlings, of sap from wetwood trees. Two additional potted seedlings were maintained as check trees. Four of the six large elms had wilted in previous years. Sap from the large trees was carried to the seedlings through rubber tubes and improvised glass containers. A glass tube, 29 mm. in diameter, about 3.5–4.0 inches long, was placed around the stem of each seedling to be treated, care being taken not to injure the foliage as the tube was slipped down over the seedling. Rubber stoppers, with holes cut to fit, and split to the outside, were fitted around the stem and inserted in each end of the glass tube. The upper stopper had two additional holes into which two glass tubes were inserted. One of these tubes, plugged with sterile cotton, served as a vent. To the other tube was attached rubber tubing which extended to a piece of one-half inch threaded pipe fitted into a hole bored in the diseased tree trunk. The whole apparatus was arranged in such a way that sap from the wetwood-affected heartwood of the large tree flowed into the glass container around the stem of the seedling.

On each of four of the eight seedlings, a transverse incision was made by removing a V-shaped piece of stem. Three of these seedlings were attached by tubes, as described above, to elms affected with wetwood. The fourth, used as a check, was not attached to a tree; its glass container was filled with sterile distilled water.

Each of three of the remaining seedlings was attached, as described above, to an elm affected with wetwood and, when the glass container was full of sap, a transverse incision was made at a downward slant in the stem beneath the surface of the liquid. A similar incision was made in the stem of the single remaining seedling, whose glass container was filled with sterile distilled water.

The two seedlings which received water grew normally throughout the experiment. The three seedlings given sap through V-shaped incisions did not wilt.

Fig. 24.—Apparatus used in supplying wetwood sap and other materials to potted elms.

One of them, however, showed some browning of the interveinal tissues of the leaves on the side of the tree directly above the incision. In all of them, grayish brown streaks typical of wetwood developed in the last-formed spring and early summer wood, extending 4 to 9 inches up the stems and 3 to 6 inches down the stems from the incisions.

The three seedlings which had incisions made in their stems under sap developed wilt. A dull brown or water-soaked condition of the interveinal leaf tissue, similar to that pictured in fig. 16, developed within 24 hours after treatment was started, and was followed in another 24 hours by curling and wilting of the leaves. Each seedling developed grayish brown streaks similar to the streaks found in current-season wood of trees naturally affected with wetwood. These streaks appeared in the last-formed wood, mainly in the spring wood, and extended up the stems from 8 to 24 inches above the incisions and down the stems 4 to 10 inches below the incisions.

Greenhouse Tests on 2-Year-Old Elms.—The toxicity of sap collected from wetwood-affected elms in Hinsdale and of the materials listed below was tested on 2-year-old greenhouse-grown seedlings of American elm. The materials tested and the number of trees that received each material were as follows: (1) sterile distilled water, as check, 7 trees; (2) unsterilized distilled water, as check, 2 trees; (3) unsterilized sap from diseased elms, 4 trees; (4) filtrate of sap from diseased elms, 4 trees; (5) sap from diseased elms, autoclaved, 4 trees; (6) filtrate of sap from diseased elms, autoclaved, 8 trees; (7) precipitate of sap from diseased elms—precipitate obtained by acidifying the sap with sulfuric acid, filtering, then resuspending the precipitate in alkalized water—2 trees; (8) sterile distilled water in which healthy wood was soaked 1 year, 2 trees; (9) water acidified (pH 2.62) with hydrochloric acid, 4 trees; (10) water alkalized (pH 9.5+) with sodium hydroxide, 4 trees; (11) suspension of living wetwood bacteria in sterile distilled water, 1 tree; (12) filtrate of nutrient broth staled by growth of the wetwood organism, autoclaved, 4 trees; (13) filtrate of nutrient broth plus dextrose, staled by growth of the wetwood organism, autoclaved, 2 trees; (14) suspension of ash from sap in distilled water—suspension obtained by evaporating the liquid and burning out the organic materials—2 trees; (15) filtrate of ash suspension from (14), 2 trees.

The stem of each tree to be treated was fitted with a glass container similar to that shown in fig. 24. The material to be tested was supplied to this glass container through the thistle tube. A piece of small bore glass tubing, bent in a V shape, was placed in the upper stopper to serve as an air vent. After the container had been filled, the upper stopper was lifted sufficiently to permit insertion of a sterile chisel, and an incision was made in the stem beneath the surface of the liquid; this incision was made across the stem at a downward slant through one-third to one-half of the stem. The stopper was then replaced and sufficient amounts of material were added at intervals to keep the level of the material above the incision and to prevent air from getting into the conductive tissues. The tests were run at different times during the period from July 30 to October 22, 1943, and all were run in duplicate, except that for material (11), suspension of living wetwood bacteria in sterile distilled water. Most tests were terminated at the end of 5 days.

The trees treated with the distilled water, sterile distilled water, acidified water, alkalized water, water in which healthy wood was soaked, precipitate from wetwood sap, water suspensions of living wetwood bacteria, ash from wetwood sap, and filtrate of ash from wetwood sap, maintained their foliage and grew normally throughout the experiment. Data obtained with the other materials, including the check materials, are given in table 3.

Trees treated with wetwood sap—unsterilized, autoclaved, filtered, and filtered and autoclaved—with filtrate of staled nutrient broth, and with filtrate of staled nutrient broth plus dextrose, showed varying degrees of leaf discoloration, curl and wilt. In general, filtrate of wetwood sap caused the most rapid leaf discoloration, curl and wilt. Bacteria in the wetwood sap did not increase the amount or affect the type of wilt. Filtered sap was absorbed in greater quantities than unfiltered sap. In one test, sap that was filtered and autoclaved, table 3, caused browning of interveinal tissues within 6 hours. In the same test, leaf curling or an early stage of wilt developed within 22 hours. This browning and curling occurred during clear weather in August. With most of the materials listed in table 3, browning of interveinal tissues developed in 8 to 36 hours; leaf curl and wilt developed in 22 to 70 hours.

These tests show that toxic materials in the abnormal sap that accumulates in

Table 3.—Results of toxicity tests with sap from infected wood of wetwood-affected elms; sap tested for toxicity on 2-year-old greenhouse-grown elm seedlings. Most tests terminated at the end of 5 days.

Material Tested	Tree No.	Number of Hours for Browning and Wilt of Leaves to Appear		Milliliters of Material Taken Up
		Browning	Wilt	
Sap untreated	1	8	70	27
	2	8	70	31
	3	27	48	20
	4	27	48	24
Sap autoclaved	1	36	96	31
	2	36	69	42
	3	None	None	18
	4	23	48	79
Sap filtrate	1	8	70	30
	2	8	70	71
	3	21	27	37
	4	21	27	39
Sap filtrate, autoclaved	1	28	69	88
	2	28	69	66
	3	24	40	92
	4	24	66	79
	5	72	None	31
	6	6	22	75
	7	96	96	24
	8	22	46	54
Staled* nutrient broth filtrate, autoclaved	1	21	28	28
	2	21	28	39
	3	30	45	68
	4	None	None	8
Staled* nutrient broth plus dextrose filtrate, autoclaved	1	45	144	21
	2	21	45	20
Sterile distilled water	1	None	None	72
	2	None	None	39
	3	None	None	33
	4	None	None	26
	5	None	None	45
	6	None	None	34
	7	None	None	57
Distilled water	1	None	None	60
	2	None	None	43

*Staled medium is a medium in which bacteria have been grown for some time.

tissues affected with wetwood can cause wilt and that, for the production of wilt, *Erwinia nimipressuralis* need not be carried into the branches and leaves.

The first evidence of leaf discoloration, as shown in the greenhouse tests, is a faint dull browning of the subepidermal cells in the interveinal tissues. Visible only when the leaf is held up to the light, the discoloration is followed within a few hours by more pronounced browning of the upper and lower epidermal cells that spreads toward the lateral veins, fig. 16. This leaf browning, which is similar in appearance to a type of midsummer leaf scorch commonly seen in Illinois on large fluxing elms, continues to spread until the whole leaf margin is brown, and it is followed by curling or wilting of the leaf. Frequently the brown tissues are bordered by a yellow band. Leaves usually are brown and dead within 3 to 6 days from the time the sap is introduced. Such affected leaves abscise easily.

The treated trees were examined for internal symptoms. A water-soaked appearance in the current-season wood, together with brown streaks typical of wetwood, developed only in the trees given wetwood sap through incisions. However, not all of the trees that received wetwood sap showed both of these symptoms. In trees treated with acidified and alkalized water the current-season wood was water-soaked but had no typical brown discolorations. The water-soaked appearance of the wood depends upon the amount of moisture present and can occur in healthy as well as wetwood-affected trees. Wetwood sap, however, is brown in color and it makes the wood it affects appear darker than healthy wood. Cut ends of stems or branches affected with wetwood lose this water-soaked appearance after drying.

Grayish brown streaks appeared in current-season wood of trees given unsterilized and autoclaved wetwood sap and its filtrate. They did not appear in the wood of the trees given the autoclaved filtrate or the water suspension of living bacteria. A brown flocculent precipitate was formed when the filtrate was autoclaved. The filtrate was much lighter brown or tan after the precipitate was removed. This indicates that streaking in current-season wood is largely dependent upon the amount or intensity of color in the wetwood sap that passes through it.

Wilt did not occur in trees given acidified (pH 2.62) or alkalized (pH 9.5+) water, indicating that the pH reaction (pH 7.5 to 10.0) of wetwood sap has no relation to the production of wilt. The toxic material in wetwood sap was not removed by precipitation, but it was destroyed when the sap was reduced to ash by burning. Trees treated with an ash suspension did not wilt.

From this experiment it appears that a toxic agent is produced by *Erwinia nimipressuralis* grown in nutrient broth and in nutrient broth plus dextrose. However, the cut shoot experiment described earlier indicates that very little toxic material was produced in nutrient broth plus dextrose. In the earlier experiment, cut shoots of elm placed in wetwood sap wilted in 1.5 hours, while those placed in the filtrate of staled nutrient broth plus dextrose did not wilt in 10.0 hours.

Greenhouse Tests on 7- to 12-Foot Elms.—An experiment was carried out to determine whether wetwood sap and other materials listed below would be readily taken in through elm leaders one-fourth to one-half inch in diameter and whether any of these materials would cause wilt. Seven American elms, 7 to 12 feet tall, growing in 14-inch flower pots in the greenhouse were selected for this experiment. Each tree was treated with a different material. The materials tested were (1) sterile distilled water, used as a check, (2) wetwood sap, (3) filtrate of wetwood sap, autoclaved, (4) fermenting wetwood bacteria in nutrient broth culture, (5) filtrate of nutrient broth staled with fermenting wetwood bacteria, autoclaved, (6) fermenting wetwood bacteria in sterile distilled water and (7) fermenting wetwood bacteria in sterile distilled water, autoclaved.

A leader of each tree was bent over and fastened in such a position that when a bottle containing the material to be introduced was slipped over the cut end of the leader the liquid would not run out. Before the leader was cut, bark on the portion of the stem to be immersed in the solution was disinfected with 70 per cent alcohol and then rinsed with sterile distilled water. After the stem end was immersed in the solution, sterile cotton was packed in the bottle mouth around the leader. Each cut leader remained in its respective solution for 5 days. As each bottle was removed, the cut end of the leader was wrapped with rubber tape to prevent the wood from drying out.

Filtrate of wetwood sap, of which 291 ml. were taken up in 5 days, caused browning and wilt of foliage on the two upper branches nearest the cut end of the treated leader; the two branches were, respectively, 9 and 12 inches below the cut. Browning appeared within 24 hours, wilt within the next 24 hours. Leaves near the base of the two branches turned brown and wilted 24 hours before the leaves at the tips. All of the leaves, 50 in number, on these two branches wilted and turned brown within 72 hours, and abscised within 10 days. In 45 days the treated leader had died back 8 inches, to within 1 inch of the uppermost lateral branch. Additional dieback had not occurred at the end of 3 months. On subsequent examination a light tan water-soaked condition was found in the current-season wood, especially noticeable in the spring wood; this condition extended down the stem 30 inches.

Wetwood sap, of which 41 ml. were absorbed in 5 days, caused slight browning of leaves on the first lateral below the treated leader. However, none of the foliage wilted. The treated leader died back 5 inches in 45 days.

The wetwood organism, *Erwinia nimipressuralis,* in nutrient broth, in sterile distilled water, and autoclaved in sterile distilled water, did not cause any browning or wilting of leaves. Filtrate of nutrient broth staled with fermenting wetwood bacteria did not cause wilt but prevented callus formation on the end of the cut leader.

Callus developed normally on the cut leaders immersed in sterile distilled water and nutrient broth culture of *Erwinia nimipressuralis* after a slight initial killing of the cut bark had occurred. It is possible that bark on the leader immersed in water was killed by mechanical injury when the leader was cut. Callus formation was not retarded on the cut leaders which were immersed in water suspensions of living and autoclaved *E. nimipressuralis.*

In this experiment, browning and water-soaked appearance of the wood was not characteristic of any one treatment. A water-soaked condition developed when wetwood sap, its filtrate, nutrient broth culture of fermenting wetwood bacteria and its filtrate were used. Fine brown streaks developed in current-season wood of the cut leaders when they were immersed in sterile distilled water, a nutrient broth culture of *Erwinia nimipressuralis,* its filtrate, and a suspension of it in sterile distilled water, but this streaking was not characteristic of that found in wetwood-affected trees in the field. The trees treated with sterile distilled water, a nutrient broth culture of *E. nimipressuralis,* its filtrate, a suspension of it in sterile distilled water, and an autoclaved suspension of it in sterile distilled water, continued to grow normally throughout the experiment, except for the lack of callus formation at the cut on each leader, as pointed out above.

Pressures in Affected Elms

Field Studies.—In these studies, the presence of gas and sap under pressure in tree trunks was first noticed in 1941 while increment borings of the diseased trunk wood of wilting elms were being taken. From some trees, a considerable amount of gas and sap flowed out through the increment borer tube (auger) and continued to flow out of the hole in the tree trunk after the increment borer was removed. This flow was accompanied by bubbling and fizzing sounds, indicating that gas was dissolved under pressure in the sap.

According to the studies of MacDougal (1932), MacDougal & Working (1933), and Beilmann (1940), pressure in trunks of healthy trees, various kinds, is never great, never as much as 1 pound, and is altered mainly by changes in external air temperature. Stautz (1931), Dodge (1937) and May (1942) have pointed out that abnormally high pressures develop in the trunk wood of trees affected with wetwood.

During 1941, as part of this investigation, the pressures in the trunks of 22 wilting elms that were affected with wetwood were measured with a pressure gauge attached to an increment borer, fig. 25. Pressure readings were taken after the wood core had been removed from the auger and the increment borer had been backed up several turns to allow for the greatest possible exposure of diseased wood adjacent to the hole in the trunk. This procedure eliminated errors that might have resulted from compression of the air in the auger. Pressures read in 13 of the 22 trees ranged from 1.0 to 16.5 pounds. No apparent relation existed between the pressures read and the amounts of branch wilt observed. The higher pressure readings were obtained from trees which either were not fluxing or were fluxing only slightly through cracks in crotches, pruning wounds and other external wounds. However, those trees which gave high pressure readings fluxed strongly through the holes made by the increment borer. All cores obtained with the increment borer from trees giving high pressure readings were discolored dark brown, especially noticeable in the older sapwood and heartwood, and they had a fermentation odor.

Fig. 25.—Apparatus used for measuring pressure in trunks of elms affected with wetwood. The gauge is attached to the outer end of the increment borer auger. Pressure is recorded by the gauge when the auger enters the wetwood-affected wood, but pressure readings are taken only after the wood core has been removed from the auger. (See text, pages 430 and 431.)

Pressures recorded in wetwood-affected trees in 1941 were so abnormally high in comparison with the pressures found in healthy elms that additional readings were taken in 1942 and 1943. On April 1, 1942, gaugecock connections were installed, fig. 26, on eight elms at Hinsdale. Readings were taken at irregular intervals during 1942 and 1943.

In 1942, pressures greater than could be accounted for by changes in the outside air temperature or barometric pressure began to develop during April. These pressures continued to increase and reached a peak in August. After they had reached the peak, they gradually declined and had reached zero by February, 1943.

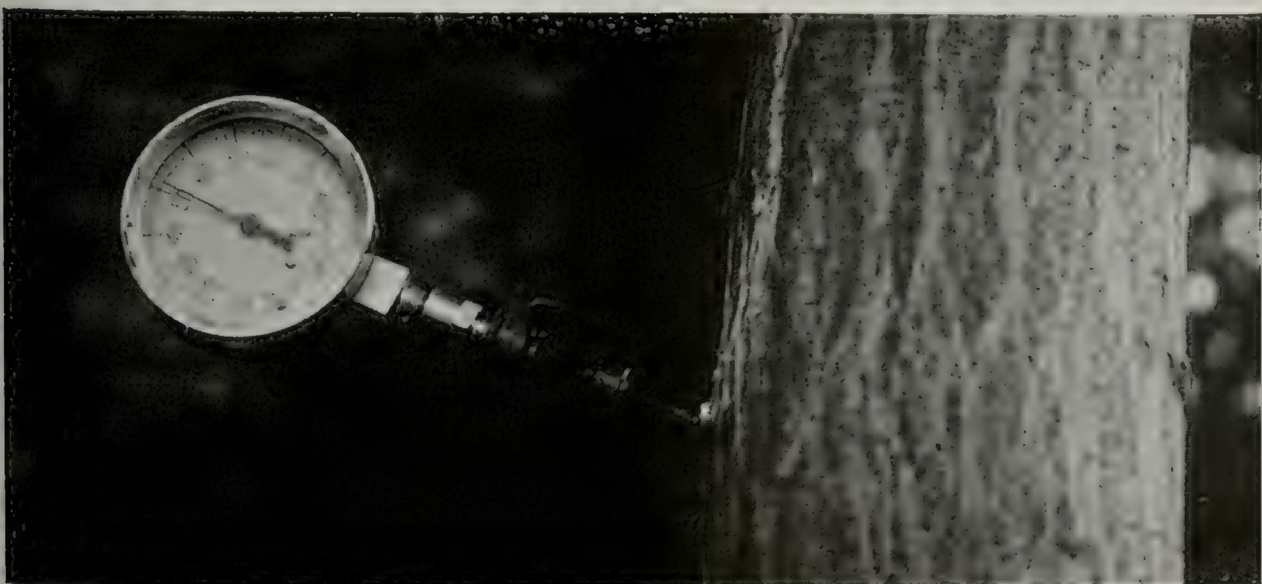

Fig. 26.—Gauge and gaugecock connection used to obtain pressure readings of elms affected with wetwood. This type of gaugecock connection made it possible to obtain pressure readings at will without the escape of gas and sap from the trunk.

Pressure changes of fractions of a pound, probably induced largely by changes in external air temperatures, were obtained during February and March of 1943. Pressures definitely higher than normal became apparent in April, 1943, and increased until early September, when they reached a peak, following which they gradually declined, dropping to zero by January, 1944.

The relation between the pressure curve and the air temperature curve for the 2 years is shown in fig. 27. The pressure curve represents the average mean monthly pressure readings from two non-fluxing elms in Hinsdale. In shape it is very similar to the mean temperature curve. However, the peaks of the pressure curve occurred in August in 1942 and in September in 1943, while the peaks of the temperature curve occurred in July in both years. The similarity of these two curves indicates that the period of the year when the wetwood organism is most active is in general the period of the year during which high temperatures occur—July, August and early September. The period during which maximum fermentation occurs in the trees, as indicated by maximum pressure readings, is mainly in August when the mean maximum air temperature—22 to 30 degrees C. or 71.6 to 86.0 degrees F.—coincides with the optimum temperature for the organism: 24 to 30 degrees C., or 75.2 to 86.0 degrees F. Although the mean maximum temperature for June falls within this range, pressure readings are not then at the maximum, perhaps because of the limited amounts of carbohydrates and other materials available at that time for fermentation in the infected wood. Possibly at that time much of the food of the tree is being used in wood growth. According to Priestly (1930), Beilmann (1935) and MacDougal (1936, 1938), xylem growth in several species of trees is most rapid during late April, May and June. MacDougal (1938) reported that cambial activity of elm ceases about August 1 in New York state.

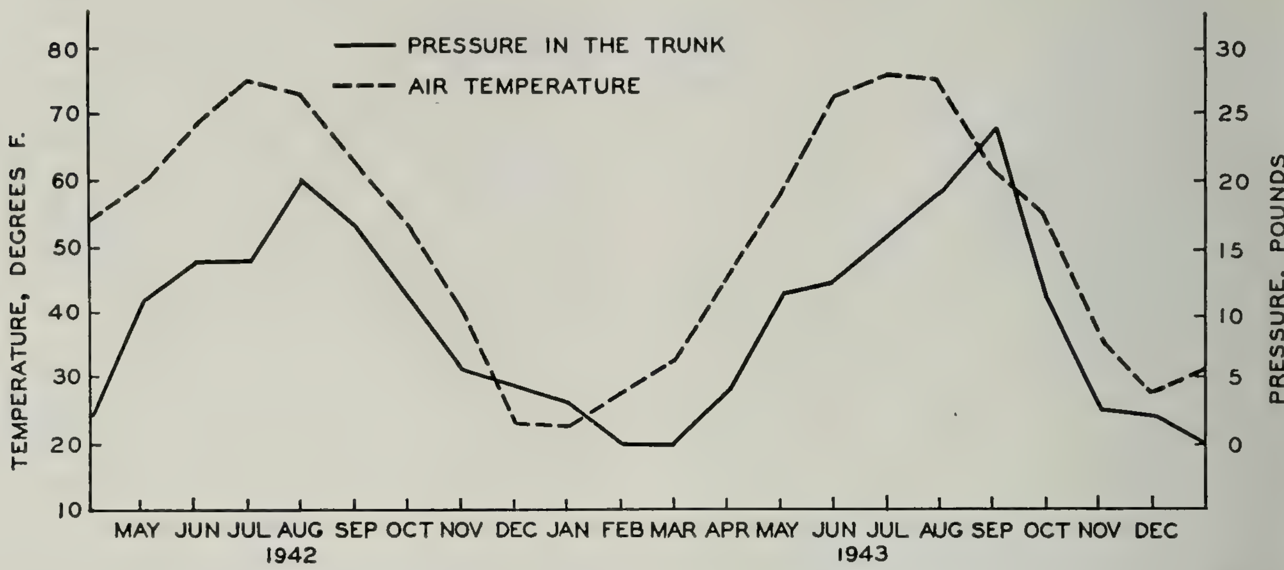

Fig. 27.—The average monthly air temperature and pressure in two non-fluxing wetwood elms in Hinsdale; record covers 22 months. The temperature and pressure curves are similar in shape. However, the peak of the temperature curve occurred in July in each year, while the peak of the pressure curve occurred in August in 1942 and in September in 1943.

A pressure of 60 pounds per square inch, recorded for one elm tree in Hinsdale on June 20, 1942, is quite remarkable when it is compared with pressures recorded by MacDougal (1932) and Beilmann (1940) for healthy trees of various species. MacDougal found internal maximum trunk pressures of 20 mm. of mercury and Beilmann 18 mm. of water. MacDougal & Working (1933, page 85), who studied gas pressures of the pneumatic system of trees, reported positive pressures of not more than 20 mm. of mercury (approximately 0.3868 pound) ". . . and never more than a few millimeters less than barometric." The elm in Hinsdale which developed 60 pounds of pressure in 1942 had wilted during 1941. A gaugecock was installed in this tree on

April 1, 1942, and pressure readings, taken periodically, increased from 1 pound on April 14 to 60 pounds on June 20, 1942. The reading was 51 pounds on June 18, as recorded on the gauge, fig. 26.

On June 20, after the 60-pound reading had been made in this Hinsdale tree, the gaugecock started to leak, allowing sap and gas to escape. The next day, June 21, the pressure had dropped to 40 pounds. The pressure continued to decrease during the remainder of June and through most of July, and had decreased to 11 pounds on July 29. After the installation of a new gaugecock on July 29, trunk pressure again increased, and readings were obtained of 28 pounds on July 30, 42 pounds on July 31 and 46 pounds on August 4. Pressure then decreased until it reached 1 pound on January 8. During February and March of 1943 the pressure in this tree was too low to register on the gauge being used. A pressure of 2 pounds was read in May of 1943, and on June 2 this tree was fluxing through a trunk crack which apparently had developed the previous winter. The tree continued to flux through the trunk crack until October. So long as the trunk continued to flux, pressure readings varied between 1 and 2 pounds. On October 6 the trunk crack was found to have callused over, and the pressure registered on that day was 12 pounds. Subsequent pressure readings were 14.2 pounds on October 12, 16 pounds on October 27 and 2 pounds on November 30. On December 11, there was not sufficient pressure to register.

Greenhouse Studies.—The pressures developed in two elms artificially infected with wetwood and one elm not infected, all grown in the greenhouse, were recorded from November, 1942, through February, 1944. The infected trees had been inoculated with *Erwinia nimipressuralis* in 1941 and had developed typical wetwood symptoms in the trunk wood during 1942. The non-infected tree was used as a check. Gaugecocks were installed in the trunks of all three trees on November 13, 1942. In the two wetwood-affected trees, pressures developed which were greater than those normal for healthy elms and similar to those found in naturally infected elms. In one tree a maximum pressure of 8 pounds occurred on June 26 and again on July 3, 1943. In the other tree a maximum pressure of 14.8 pounds was recorded on August 30, 1943. In the check tree no pressure that could be measured with the gauge developed. A water manometer was connected to the check tree on October 4, 1943, and a maximum reading of 21 mm., approximately 0.03 pound, was recorded on October 21.

The curve in fig. 28 shows the monthly average of the pressure readings obtained from one of the infected trees

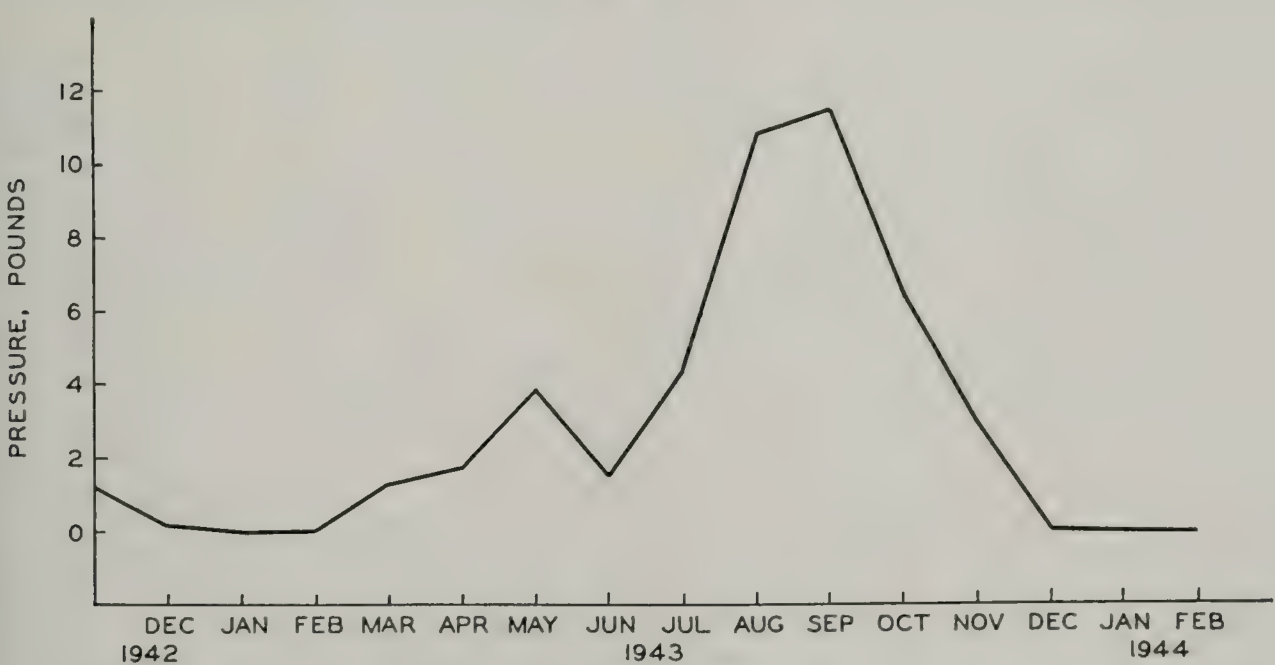

Fig. 28.—The average monthly pressure recorded during 16 months in one greenhouse-grown elm, artificially infected with wetwood. In the greenhouse, just as in the field, an annual pressure cycle occurs, with the peak pressure in September and low pressures in winter.

for the period November, 1942, to the end of February, 1944. The maximum pressure in this tree occurred in September, 1943. Diseased elms under observation in Hinsdale this same year also produced maximum pressures in September.

The low pressure of 1.5 pounds which occurred in June was recorded while the tree was fluxing through a crack in a branch crotch 3 feet above the gaugecock. To test the effect of drainage on fluxing, the gaugecock was left open from June 7 until the crotch stopped fluxing on June 11. Then the gaugecock was closed, and fluxing began again on June 15. The gaugecock was reopened at once and the crotch stopped fluxing on June 17. Thereafter the gaugecock was kept closed, and the amount of fluxing was not sufficient from that time on to prevent the formation of callus. The crotch crack was sealed with callus on July 18, and fluxing ceased.

Pressure in the trunk of this wetwood-infected tree was found to follow a diurnal cycle as well as an annual cycle. Both pressure and air temperature readings during a period of 2 days and 1 night were recorded on August 3–4 and August 12–13, 1943, fig. 29. On August 3, when the air temperature did not go much above the optimum temperature range for the wetwood organism, the maximum pressure occurred at 1:15 P.M. On August 4, 12 and 13, when the air temperature had risen above the optimum temperature for the organism by 9:00 A.M., the maximum pressure occurred between 8:30 and 11:00

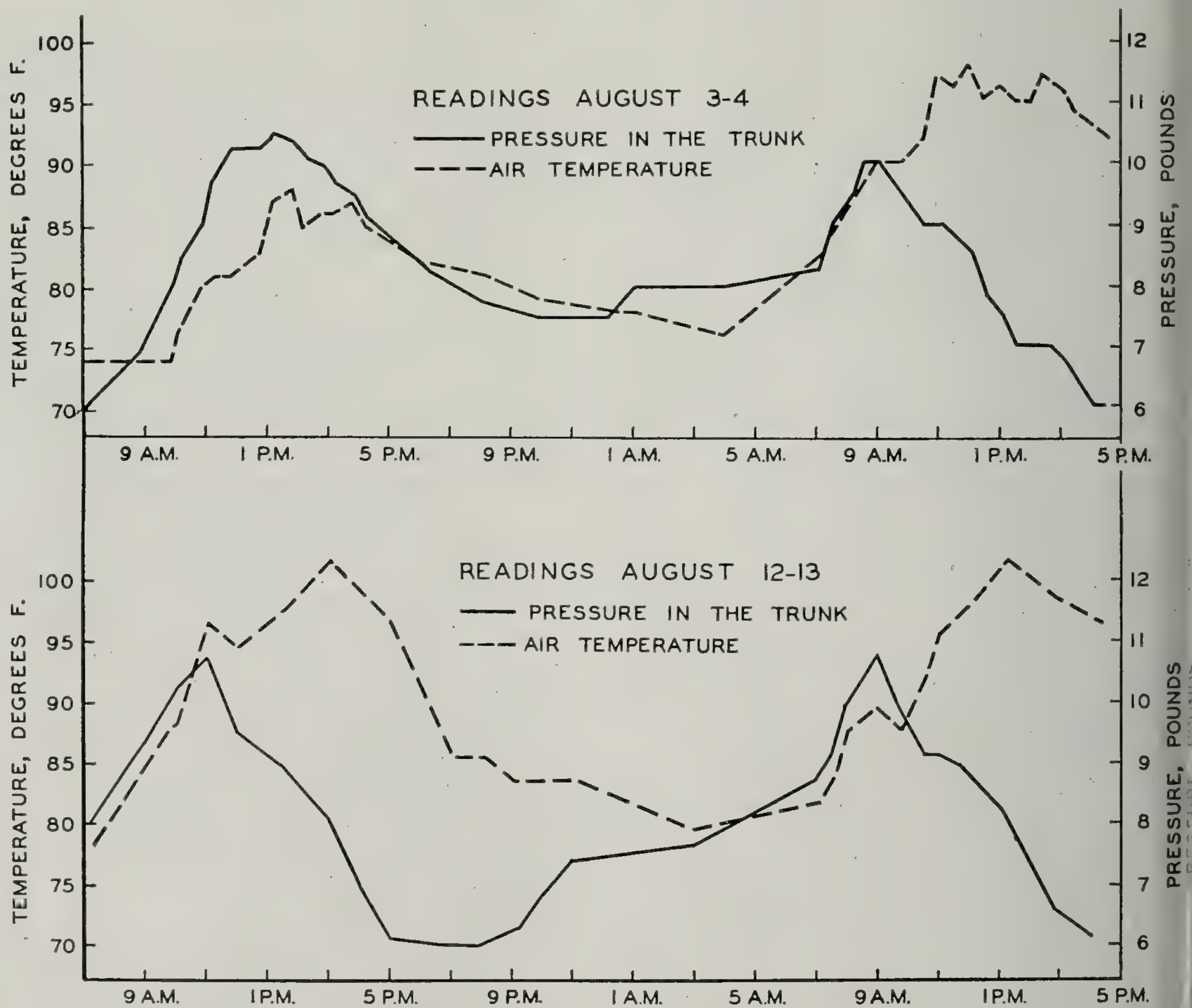

Fig. 29.—Air temperatures and pressures in one greenhouse-grown elm artificially infected with wetwood were recorded during two 34-hour periods. Pressure in the greenhouse tree followed a diurnal cycle. When the air temperature did not go much above the optimum temperature for the wetwood organism, maximum pressure occurred at 1:15 P.M. When the air temperature had risen above the optimum temperature for the organism by 9:00 A.M., maximum pressures occurred between 8:30 and 11:00 A.M. Minimum pressures occurred between 7:05 P.M. and 12:10 A.M.

A.M. The minimum pressure occurred between 10:00 P.M. on August 3 and 12:10 A.M. on August 4 and between 7:05 and 8:00 P.M. on August 12. These observations indicate that the diurnal pressure maximum pressures and maximum temperatures occurred most often at 1:00 P.M. These data show, as did the temperature and pressure curves for August 3 and 12, that pressure reaches its maximum at

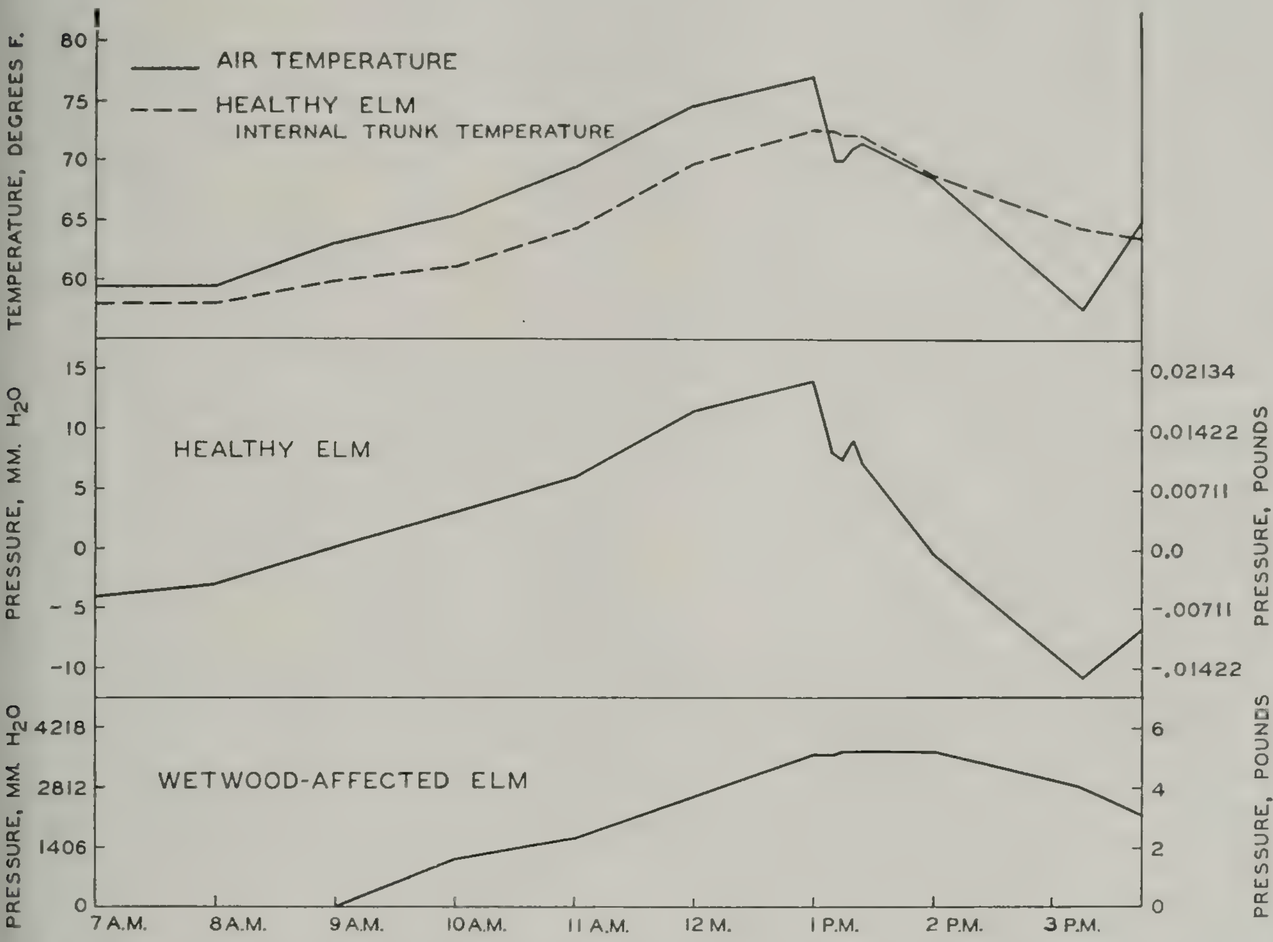

Fig. 30.—Air temperatures, internal trunk temperatures in a healthy tree, and pressures in a healthy tree and in a wetwood-affected tree, all three trees greenhouse-grown; recorded on November 16, 1943. The trunk temperature curve and the pressure curve for the healthy trees are similar in shape to the air temperature curve. A rapid drop in air temperature between 1:00 and 1:10 P.M. did not cause a similar drop in pressure in the wetwood-affected tree. Pressure in the diseased tree did not decrease until the air temperature dropped below 68.5 degrees F. Zero represents atmospheric pressure.

cycle in wetwood-affected trees is not influenced by changes in air temperature, as long as the air temperature is in the optimum range for the organism. However, air temperatures above and below the optimum range for the organism apparently influence the rate of fermentation and thus affect pressure.

Pressure and air temperature readings were taken at 15-, 30- or 60-minute intervals on 17 days between August 2 and September 1 and on 15 days between September 29 and November 16, 1943. For the 17 days, maximum pressures occurred most often at 11:00 A.M., while maximum temperatures occurred most often at 1:00 P.M. For the 15 days, both

about 11:00 A.M., when the maximum air temperature is above the optimum temperature range for the wetwood organism. However, when the maximum air temperature is not above the optimum temperature range of the organism, pressure and temperature both reach their maxima at about 1:00 P.M. The pressure cycle does not reach a second peak during any one day, regardless of the variations in air temperature. This experiment indicates, as did the previous one, that the diurnal pressure cycle is not influenced by changes in air temperature so long as the air temperature is in the optimum range for the organism.

The relationship between air temperature, trunk temperature in a healthy tree and pressures in a healthy tree and in a wetwood-affected tree was studied from October 5, 1943, to January 13, 1944. Curves in fig. 30, which are typical, show the readings for November 16. Air and trunk temperature readings are given in degrees Fahrenheit, pressure readings from the healthy tree as millimeters of water, and pressure readings from the wetwood-affected tree as pounds per square inch.

The air temperature curve shows a gradual increase from 8:00 A.M. until 1:00 P.M., when the temperature reached 77 degrees F. Opening the greenhouse ventilator between 1:00 and 1:10 P.M. caused the air temperature to drop from 77 to 70 degrees F. This drop was followed by an increase to 71.5 degrees at 1:25; then the air temperature declined to 57.5 degrees F. at 3:15 P.M., after which it increased to 65 degrees at 3:45 P.M. The pressure curve and the trunk temperature curve for the healthy trees are similar to the air temperature curve except that the trunk temperature curve continues to decline between 3:15 and 3:45 P.M. Reynolds (1939) found temperatures in poplar and cottonwood to be influenced greatly by air temperatures. Pressure in the wetwood-affected tree became apparent by 10:00 A.M. and increased until 1:15 P.M. This pressure stood at a maximum of 5.2 pounds from 1:15 to 2:00 P.M., but decreased as the air temperature dropped below 68.5 degrees F.

The average of the maximum air temperature readings taken in the greenhouse was approximately 83 degrees F. in October, 73 degrees F. in November, 66 degrees F. in December and 71 degrees F. in January, while the average of the maximum trunk temperature readings taken was approximately 74 degrees F. in October, 70 degrees F. in November, 68 degrees F. in December and 71 degrees F. in January. As no continuous recording devices were used, the maximum temperatures recorded in many cases may not have been the actual maximum temperatures. Air temperatures of 66 to 73 degrees F. are not sufficiently below the optimum temperature for the wetwood organism (75.2 to 86.0 degrees F.) to stop fermentation. Pressures that could be measured with a gauge were present in the wetwood-affected elm until the tree became dormant about December 1. The average daily maximum pressure was 8 pounds in October and 4 pounds in November, but in December and January the pressure, if any was present, was too low to register on the gauge.

The pressure in the healthy tree did not decrease as did that in the wetwood-affected tree and was not noticeably affected by dormancy. The healthy tree had an average daily maximum trunk pressure of 6.7 mm. in October, 7.9 mm. in November, 4.8 mm. in December and 6.7 mm. in January.

Gas Analysis

Gas produced in wetwood-affected elms was analyzed in the field for carbon dioxide and in the laboratory for carbon dioxide, oxygen, hydrogen, methane, carbon monoxide, illuminants and nitrogen. The gas samples analyzed were from trees ranging from 5 to 12 inches d. b. h. Field analyses for the per cent of carbon dioxide in the gas were made by collecting approximately 24 ml. of the gas in Smith fermentation tubes over water and by absorbing the carbon dioxide with N/5 sodium hydroxide.

The gas samples analyzed in the field were collected in August, October and November, 1942, and in June, July and August, 1943. The analyses tended to show that in August the gas contained more carbon dioxide than it did in preceding or succeeding months. The per cent of carbon dioxide in different trees varied considerably during any one day. There was no correlation between the diameter of the trunk and the per cent of carbon dioxide in the gas. For instance, each of two gas samples collected on August 19, 1943, one from a tree 12 inches d. b. h. and one from a tree 5 inches d. b. h., contained 19 per cent carbon dioxide. Gas was not present in sufficient quantities to be collected for analyzing from December, 1942, to May, 1943.

Samples of gas were analyzed in an Orsat apparatus, July 2, 1943, and found to consist of approximately 46.4 per cent methane, 33.8 per cent nitrogen, 14.3 per cent carbon dioxide, 4.5 per cent oxygen and 1.0 per cent hydrogen. Carbon monoxide and illuminants were not present. The amount of hydrogen recorded (1.0

per cent) is very small—less than the probable error in a combustion analysis. MacDougal (1932) reported that marsh gas, composed mostly of methane, or any other inflammable gas had not been found in normal trees.

No tests were made in the present investigation to determine whether the gas from the wetwood-affected trees was toxic to foliage of elms. Crocker (1931), Crocker, Zimmerman & Hitchcock (1932) and Krone (1937) pointed out that natural gas, which contains about 80 per cent methane, is not highly toxic to trees and other plants.

Gas was produced in abundance when the wetwood organism was grown in nutrient broth plus dextrose. The carbon dioxide content of six samples of this gas was determined by absorption with N/5 sodium hydroxide and the hydrogen content by passage of the gas through a palladium tube. The samples contained approximately 44.7 per cent carbon dioxide and 2.4 per cent hydrogen. However, it was found that the amount of carbon dioxide contained in the gas varied with the age of the culture and with the rate of fermentation. More carbon dioxide was produced in young cultures, when the rate of fermentation was most rapid, than in old cultures.

Sap Analysis

Sap from the trunk wood of elms affected with wetwood was analyzed for calcium, chlorides, copper, iron, magnesium, manganese, phosphate, potassium, sulfates, zinc, nitrates, nitrites, ammonia, starch, reducing sugars, indole and erythrodextrin. Also, different quantities of distilled water in which healthy tissue and wetwood tissue had been soaked were analyzed for the materials listed above. The methods used in analyzing for these different materials were those given in publications of the Society of American Bacteriologists, Committee on Bacteriological Technic (1939), Merck and Company, Inc. (1940) and Connors & Tiedjens (1941). Many of these methods were supplemented by recommendations of Dr. O. W. Rees, Chemist, Illinois State Geological Survey.

Sap that accumulates in large amounts in elms affected with wetwood can be collected by tapping the trunks of affected trees. In all healthy elms tapped during this experiment, sap was not present in the wood in sufficient quantities to be collected. Analyses were made of distilled water in which wood samples from healthy trees and from wetwood-affected trees had been soaked. Sapwood and heartwood samples of both healthy and diseased trees were tested separately. The water in which the wood had been soaked, and which contained the water-soluble materials of the wood, is referred to below as *leach.*

All analyses of sap and leach were run in duplicate and most of them were repeated two or more times. Ash of the sap of diseased elms was obtained by evaporating the liquid and burning out the organic material over low heat. This ash was resuspended in distilled water and used as a test material. Also, filtrate of the ash suspension was used as a test material.

The sap—untreated, filtered, and filtered and autoclaved—and the ash suspension filtrate contained a moderate amount of phosphate. In the ash suspension, phosphate was abundant. Only small amounts of phosphate were present in the leaches from wetwood and healthy heartwood. Potassium was abundant in the sap—untreated, filtered, and filtered and autoclaved—and in the ash suspension. There was possibly a trace of potassium in the leach from wetwood tissue but none in the leaches from healthy sapwood and heartwood. Magnesium was not present in any materials tested except for possibly a trace in the ash suspension. No nitrites were found in sap from wetwood tissues or in the leach from healthy heartwood. There appeared to be traces of nitrites in the leaches from healthy sapwood and from wetwood tissues. In our analyses, no calcium, chlorides, copper, iron, manganese, zinc, nitrates, ammonia, starch, indole or erythrodextrin were found in any of the materials tested. The ash suspension contained carbonates but it did not contain bicarbonates or hydroxides. It would seem from this fact that potassium and phosphorus were present as carbonates in the materials tested.

No reducing sugars were detected in sap or in the leaches from wetwood tissues, healthy sapwood or healthy heartwood. There appeared to be traces of reducing sugars in the leaches produced by autoclaving healthy sapwood and healthy heartwood. Ogilvie (1924) found no sugar, or only traces of it, in the clear fluid from "water-soaked wood" of elm.

The pH of Sap

To compare the pH of sap from wetwood-affected elms with the pH of water-soluble materials in the wood and bark of healthy trees and in the wood of trees affected with wetwood, each of the tissues named was soaked in distilled water and the resulting leach, containing water-soluble materials, was tested for its pH. Ten samples of sap and 10 samples of wetwood leach were alkaline, pH 7.9, when tested with indicators in the field. Five samples of leach from healthy wood and five samples of leach from healthy bark were acid, pH 6.3. The distilled water used in these tests was neutral to slightly acid.

The pH values of wetwood sap and of wetwood leaches, and of healthy wood and healthy bark leaches, were determined with the Youden apparatus in the laboratory on several occasions and are given in table 4. Both sap and leach from wetwood-affected elms were alkaline, averaging pH 7.67 and 7.39, respectively. The leaches from healthy wood and bark were acid, averaging pH 6.35 and 5.89, respectively. These data indicate that sap in healthy elm wood and bark is acid, while sap in wood affected with wetwood and also the water-soluble materials from wood affected with wetwood are alkaline. This is in general agreement with the findings of Ogilvie (1924), who reported the brown and red flux from elm to have a pH of 9 or above, and of Crandell, Hartley & Davidson (1937), who found wetwood-affected tissues of elm and other trees to have a higher pH value than either live sapwood or true heartwood.

Additional pH tests were made on fil-

Table 4.—The pH of wetwood sap and of leaches of wetwood, healthy wood and healthy bark of elms. The readings were obtained with the Youden apparatus, with platinum electrodes.

Date Collected	Tree No.	pH Value			
		Wetwood Sap	Wetwood Leach	Healthy Wood Leach	Healthy Bark Leach
July 23, 1941	1	7.43			
	2	7.36			
	3	7.80			
	4	8.34			
August 15, 1941	5	....	7.33	6.55	
	6	....	7.80	6.53	
	7	7.56	7.06	6.33	
	8	....	7.73	6.60	
	9	7.11	7.12		
November 12, 1941*	10	7.87	7.28	6.11	5.91
	11	7.31	7.24	6.26	5.94
	12	....	7.56	6.26	5.75
	13	7.62	7.51	6.18	5.86
	14	7.36	7.29	6.35	6.01
	15	7.70			
August 11, 1942	16	8.55			
	17	8.00			
	18	7.40			
Average pH	....	7.67	7.39	6.35	5.89

*The materials collected on November 12, 1941, were tested with indicators as well as with the Youden apparatus. All wetwood sap and wetwood samples tested approximately pH 7.9, while healthy wood and bark samples tested approximately pH 6.3.

tered and autoclaved sap from wetwood-affected elms. For these tests a sample of sap was divided into four portions. One portion was untreated, one was autoclaved at 15 pounds for 20 minutes, one was passed through a Berkefeld filter and one was filtered and then autoclaved. The untreated sap had a pH of 7.40, the autoclaved sap a pH of 8.09, the filtered sap a pH of 6.26 and the filtered and autoclaved sap a pH of 6.33. Autoclaving resulted in an increase in the pH of both the unfiltered sap and the filtered sap. When samples of unfiltered and filtered sap were autoclaved, a brown, fluffy precipitate was formed, which settled to the bottom of the container upon standing. The formation of this precipitate may have accounted for the differences in the pH readings obtained before and after autoclaving.

Sap collected from the diseased tissues of a wetwood-affected tree is alkaline. Supposedly it is, or contains, the products of the long-continued fermentation of fermentable materials present in the tree. In the laboratory, nutrient broth plus dextrose eventually becomes strongly acid (p. 422) as the result of fermentation by *Erwinia nimipressuralis.* The difference in pH between fermented sap and fermented medium appears inconsistent. However, Conner, Peterson & Riker (1937) have shown that the crown gall bacterium, *Phytomonas tumefaciens,* brings about an acid condition when it is grown with glucose as the main source of energy but an alkaline condition when grown in a medium that does not contain glucose. The wetwood organism likewise brings about an alkaline condition when it is grown in nutrient broth without dextrose. It would seem, therefore, that fermentation as it occurs in the tree goes on when no sugar or only traces of sugar are present. The validity of this assumption is further emphasized by our failure to obtain tests for reducing sugars in any of the sap samples, or in any of the leach samples (p. 437) until after they had been autoclaved.

Control Studies

Control studies, which were started in 1940, included injection of chemicals into trunk wood, fertilization, and installation of trunk drains. The chemicals injected were *Helione,* mercuric chloride, copper sulfate, silver nitrate, and 8-hydroxyquinolin sulfate. The fertilizers used were 10-8-6 commercial fertilizer and urea.

***Helione* Injections and Feeding in 1940.**—Twenty elms, 3 to 10 inches d. b. h., were selected for this experiment. Nine of these trees had wilted in 1939 and all 20 in July, 1940. The 20 trees were treated as follows: (1) Eight trees were injected with *Helione*—2 trees with a 1:200 dilution, 2 with a 1:500 dilution, 2 with a 1:750 dilution and 2 with a 1:1,000 dilution—and each received 250 ml. of solution. (2) Eight trees were injected with *Helione* in the same manner as in (1) but were also fed 10-8-6 fertilizer. (3) Four trees were fed 10-8-6 fertilizer but were not injected with *Helione.*

Helione injections were made during August and September, 1940. Fertilizer was applied during September and October by the punch bar method in amounts of 25, 35 and 40 pounds to 3–4-, 6- and 8-inch trees, respectively.

Subsequent to treatment, seven of the eight trees injected with *Helione,* but given no fertilizer, wilted in 1 or more years: three in 1941, two in 1942 and three in 1944. One of the three trees that wilted in 1944 had wilted in 1941 also. None of the eight trees injected with *Helione* and given fertilizer wilted in 1941, but five of them wilted in 1942 and one of these five wilted also in 1943 and 1944. Wilt occurred in all four of the trees which were given no injections but were given fertilizer, two in 1941, one in 1942 and one each year, 1941–1944. Only one of the eight injected trees and three of the eight trees that were injected and fed did not wilt during the 4 years following treatment. Under the conditions of this experiment, injecting with *Helione,* feeding with 10-8-6 fertilizer or combining both treatments did not appear to be effective in preventing wilt.

Urea Feeding in 1941-42.—Urea was fed by the punchbar method to 10 elms, 3 to 5 inches d. b. h. Five of these trees were fed 15 pounds of urea each and five were fed 25 pounds of urea each. Each tree received half of its dosage of urea in October, 1941, and the other half in April, 1942. Previous to treatment, eight of the 10 trees had wilted in 1941, one in 1939 and one in both 1939 and 1941.

Subsequent to treatment, only three of the trees wilted, 1942–1944, one in 1942 and 1944, one in 1943 and 1944 and one in 1944 only. The tree which wilted in 1942 and 1944 had received 25 pounds of urea; the other two had received 15 pounds of urea each.

Drains Installed in 1942.—Drains were installed in 10 affected elms, 4 to 6 inches d. b. h, to determine whether provision of an artificial outlet for the abnormally produced sap and gas in the trunk would prevent wilt. In eight trees the drains were installed on March 24, in one tree on May 13 and in one on June 17. Holes were bored into the trunks at an upward slant to within about 1 inch of the cambium on the opposite side. Sections of pipe were then driven into the holes far enough to be firmly held, but an effort was made not to drive them into the wetwood-affected tissue.

Only three of the trees fitted with drains wilted, 1942–1944. One wilted in 1942 and again in 1944, the other two in 1943. The tree which wilted in both 1942 and 1944 fluxed through cracks immediately above and below the drain, and the bark adjacent to these cracks was killed. In the other two trees, it is possible that cracks in the wood, concealed beneath the bark, permitted seepage of toxic sap into current wood, whence it was distributed to branches and leaves, causing wilt.

Injections in 1941 and 1942.—In August of 1941, 10 elms affected with wetwood were selected for this experiment. All 10 trees were wilting but none of them had wilted in 1939 or 1940. Five of them were injected with mercuric chloride and five with copper sulfate. The five trees injected with copper sulfate were 4 to 6 inches d. b. h. and each tree received 100 ml. of a 1 : 1,000 dilution. The five trees injected with mercuric chloride were 3 to 10 inches d. b. h. One 3-inch tree received 50 ml., one 4-inch and two 5-inch trees received 100 ml. each, and one 10-inch tree received 200 ml. of a 1 : 1,000 dilution. Each injection was made with a hand syringe, fig. 23, through a hole bored in the tree to within 1 inch of the cambium on the opposite side. One to four such holes were bored in each trunk, the number of holes depending upon the size of the tree: e. g., one hole in a 3-inch tree, four holes in a 10-inch tree. The total dosage for any tree with more than one hole was divided equally among the several holes.

From the results of bactericidal tests made in 1942, the amounts of mercuric chloride and copper sulfate injected into these 10 elms in August, 1941, were estimated to have been inadequate. The 1942 tests were made during February, March and April, and the following concentrations of materials were found to kill the wetwood organism: mercuric chloride, 1 : 150,000; copper sulfate, 1 : 1,000; silver nitrate, 1 : 50,000; and 8-hydroxyquinolin sulfate, 1 : 9,000. On the basis of this information, the elms injected in 1941 were reinjected with the same chemicals—mercuric chloride and copper sulfate—in June, 1942. Also, additional elms were selected for injection with silver nitrate and 8-hydroxyquinolin sulfate.

The amount of material to be injected into each tree was determined in the following manner. First, a wood core or boring was obtained with an increment borer, and the diameter of the wood affected with wetwood was measured on the core. Then the probable height of the affected wood in the tree was estimated. With these figures, the volume of affected wood was roughly calculated. The amount of chemical injected into each tree was sufficient to give a concentration that would kill the wetwood organism in a volume of water equal to the estimated volume of affected wood. Four elms—three which had wilted in 1940 and 1941 and one which had wilted in 1939 and 1941—were injected with a 1 : 500 dilution of silver nitrate; two of these trees were each given 200 ml., the third was given 300 ml. and the fourth 500 ml. Three elms which had wilted in 1940 and 1941 were injected with a 1 : 200 dilution of 8-hydroxyquinolin sulfate; one of these trees was given 300 ml., the second 800 ml. and the third 1,000 ml. After the injections were made, the holes were closed with iron set-screws sterilized with 70 per cent alcohol.

The five trees injected with mercuric chloride in 1942 did not wilt in that year, in 1943 or 1944. The five trees injected with copper sulfate and the four injected with silver nitrate did not wilt in 1942 or

1943, but two trees injected with copper sulfate and two injected with silver nitrate wilted in 1944. Two of the three trees injected with 8-hydroxyquinolin sulfate did not wilt in 1942, 1943 or 1944, but the third tree wilted in 1942 and again in 1943.

These tests might be interpreted as indicating that mercuric chloride, copper sulfate, silver nitrate, and 8-hydroxyquinolin sulfate may be of value in controlling wilt. However, it must be borne in mind that of 284 trees in Hinsdale that wilted, 1939–1943, only 73 wilted in more than 1 year. Also, the wetwood organism was isolated repeatedly, 1942–1944, from the wetwood-affected trunk wood of the trees which had received injections in 1941 and 1942, indicating that the organism was not killed throughout the affected wood by any of the materials injected. Later experiments indicated that most of the material injected went into the younger sapwood, especially the current-season wood, and not into the heartwood or older sapwood.

Injections of mercuric chloride and copper sulfate made in August, 1941, caused the cambium to die back 0.5 to 1.5 inches around many of the injection holes. Most of these injured areas callused over in 1942. Cambial injury following the injections made in 1942 was negligible, since care was taken to prevent the solutions from coming in contact with the cambium around the injection holes.

Miscellaneous Experiments

Injections of Toxic and Stimulatory Materials.—An experiment was started on July 29, 1942, to determine whether materials toxic to the wetwood organism, as determined by bactericidal tests, would inhibit or kill bacteria in wetwood-affected trunk wood and subsequently reduce the pressure in the trunk. Also, materials known to stimulate fermentation were injected into other trees to see if pressure could be increased. The toxic materials injected were mercuric chloride, 1 : 500, copper sulfate, 1 : 200, silver nitrate, 1 : 500, 8-hydroxyquinolin sulfate, 1 : 200 and *Elgetol,* 1 : 40. The stimulatory materials injected were 5 per cent dextrose and nutrient broth plus 1 per cent dextrose. Sterile distilled water was injected as a check material. Each material was injected into a single tree.

A one-half inch hole was bored through the heartwood of each tree to be treated, to about 1 inch from the cambium on the opposite side. A gaugecock was installed in each hole. All injections were made with a hand syringe, fig. 23. After the solutions were injected, the gaugecocks were closed to keep these solutions in the trees. Pressures registered immediately before and immediately after the injections were made and during the remainder of the growing season of 1942 and the season of 1943 are shown in table 5.

Following the injection of each material, including distilled water, pressure temporarily increased. However, the pressure in most trees had returned to approximately the initial point within 9 hours after the injections were made. Trunk pressures increased during August and September of 1942 in all trees except the one which was injected with 5 per cent dextrose. Pressure readings obtained from each tree followed the normal pressure curve from June to mid October of 1943. Failure of the toxic materials to reduce pressure suggested that these materials either had not become distributed throughout the bacteria-infected wood, that through some chemical change they were not toxic to the bacteria after being injected into the wood or that the quantity of materials was not sufficient to produce the desired result.

Distribution of Malachite Green in Elms.—Malachite green was used to study the distribution of materials injected into elms. These tests were made August 31, 1943, on 8-year-old American elm trees growing in our experimental nursery. Methods of supplying the dye were (1) through a hole bored under dye in the trunk, dye being held against the trunk in a cuplike container that kept the hole submerged while it was being bored and for 10 minutes afterwards; (2) by the hand syringe method, fig. 23; (3) by cutting the tree and immersing the cut trunk base in the dye; (4) by cutting the leader and immersing the cut end in the dye; and (5) by cutting a branch and immersing the cut end in the dye. Two trees were subjected to each method of treatment.

Penetration of malachite green through a hole in the trunk submerged below the surface of the dye was not extensive but was similar in both trees. In one tree the dye extended in its upward spread from 0.3 inch in 1938 wood to 16 inches in 1943 wood. It extended in its downward spread from 2 inches in 1941 wood to 5 inches in 1943 wood. The dye did not penetrate 1937 and older wood above the hole or 1940 and older wood below the hole. It spread laterally beyond the hole 0.1 inch in 1943 to 1941 wood.

With the injection method, penetration of the dye was more extensive than in the test described in the preceding paragraph. The dye in one tree extended in its upward spread from 24 inches in 1939 wood to 36 inches in 1942 wood. It extended in its downward spread from 6 inches in 1938 wood to 12 inches in 1942 wood. It spread only in the midsummer and late summer portions of the 1938 wood, and laterally beyond the injection hole from 0.1 inch

Table 5.—Pounds pressure per square inch registered by elms injected with various materials.

Date of Pressure Readings	Sterile Distilled Water 300 Milliliters	Five Per Cent Dextrose 300 Milliliters	Nutrient Broth Plus 1 Per Cent Dextrose 300 Milliliters	Mercuric Chloride 1:500 200 Milliliters	Copper Sulfate 1:200 500 Milliliters	Silver Nitrate 1:500 200 Milliliters	8-Hydroxyquinolin Sulfate 1:200 50 Milliliters	*Elgetol* 1:40 300 Milliliters
1942								
July 29								
Before injection	1.0	3.0	0.0	6.0	3.0	7.0	16.0	1.0
After injection	14.5	10.5	3.0	18.0	21.0	24.0	30.0	11.0
3 hours later	4.0	0.5	—	11.0	7.0	—	24.0	2.0
9 hours later	4.0	1.0	0.0	10.0	3.0	10.0	—	2.0
July 30	5.0	1.0	1.0	11.0	5.0	11.0	—	2.5
31	4.0	0.5	1.0	12.0	6.5	11.0	30.0	2.5
August 4	4.0	0.0	2.0	6.0	12.0	9.5	27.0	1.5
7	3.0	0.0	8.0	15.0	8.0	11.0	30.0	3.0
12	6.0	2.0	9.0	10.5	11.0	8.0	15.0	1.5
20	7.0	3.0	13.0	12.0	12.0	10.0	24.0	1.0
September 4	6.0	1.0	11.0	12.0	13.0	8.0	21.0	1.5
25	1.0	4.5	8.5	7.5	7.5	5.0	13.5	0.5
November 18	—	—	−1.5	3.5	1.5	1.0	−1.0	−1.0
1943								
June 3	2.0	17.0	15.0	10.0	11.0	4.5	7.0	2.0
4	3.0	14.0	11.5	9.0	8.5	5.5	—	2.0
22	11.0	15.0	20.0	10.5	13.5	5.5	—	—
23	9.0	14.0	18.0	11.0	13.0	7.0	6.5	2.0
24	11.0	15.0	20.5	12.5	15.0	7.0	7.5	2.0
25	11.0	—	—	13.0	16.0	7.0	7.5	3.0
July 7	10.0	—	24.5	12.0	17.0	6.0	6.0	—
8	11.0	12.0	23.0	11.0	16.0	6.5	7.0	3.0
20	11.0	14.0	20.0	11.0	16.5	5.5	6.0	4.7
21	12.0	11.5	20.5	10.5	16.5	5.5	8.0	4.5
22	9.5	14.0	22.0	11.0	14.0	5.7	6.5	4.5
23	10.2	11.5	22.5	11.0	11.5	—	8.0	—
August 17	8.5	14.0	25.0	11.8	17.5	10.5	6.8	2.0
18	9.0	12.0	26.0	12.5	18.0	12.0	7.5	2.0
19	9.5	12.5	25.2	12.8	17.8	13.6	7.7	2.0
September 2	12.5	14.0	20.0	12.5	18.5	19.5	—	2.0
3	11.0	14.0	23.5	12.1	17.2	22.0	8.5	—
October 12	6.0	12.5	—	8.4	11.0	5.5	2.0	—

in 1938 wood to 0.5 inch in 1942 wood. It did not penetrate 1943 or 1937 and older wood. However, 1943 wood was blocked off by the screwed-in syringe.

Penetration of malachite green was most extensive in the two trees that had their trunk bases submerged in dye for 3 hours. Both trees were about 18 feet tall. The dye spread to the top of the trunk and into some branches in the 1943 spring and early summer wood but only 9 feet up the trunk in the 1943 late summer wood. It spread upward 8 feet in 1942 wood, 7 feet in 1941 and 1940 wood, 6 feet in 1939 wood and 4 feet in 1938 late summer wood. The dye did not penetrate 1937, 1936 or 1935 wood, or 1938 spring and early summer wood. Evidently, the 1935–1937 wood had become inactive. The 1943 or current-season wood, especially the spring and early summer wood, was the most active in carrying the dye to various parts of the tree.

From the cut leader submerged in malachite green for 3 hours, the dye spread down the trunk 60 inches in 1943 spring wood, 42 inches in 1942 and 1941 wood and 36 inches in 1940 and 1939 wood; 1939 wood was the oldest in this portion of the trunk. The dye spread into branches through the 1943 spring and early summer wood and reached the branch tips and penetrated the leaf petioles. These branches were within 4 feet of the cut on the leader and measured 6 inches to 5 feet long.

Penetration of malachite green in a 5-year-old branch, cut 30 inches from the trunk and immersed for 3 hours, was mainly in 1943 wood. The dye spread from 22 to 24 inches back from the cut in 1942–1939 wood. In 1943 wood, mainly in the spring and early summer wood, it spread from the base of the immersed branch down the trunk 1 foot and up the trunk 6 feet. The dye, as it spread up the trunk, was carried out into lateral branches through the 1943 spring and early summer wood.

With all methods of injection except the hand syringe, the distances to which malachite green penetrated were greatest in current-season wood, especially that formed in spring and early summer. The dye failed to penetrate heartwood, because, as MacDougal, Overton & Smith (1929) found, the heartwood of certain trees is under pneumatic, not hydrostatic, pressure. The failure of the dye to penetrate heartwood suggests that when dextrose, nutrient broth plus dextrose, mercuric chloride, copper sulfate, silver nitrate, 8-hydroxyquinolin sulfate and *Elgetol* were injected, as described for an earlier experiment, they also failed to penetrate heartwood and on that account could have only temporary effect on fermentation and development of pressure.

Table 6.—Analysis of Hinsdale, Illinois, parkway soil in which elms affected with wetwood were wilting.

Samples	pH	Nitrates (Pounds Per Acre)	Phosphates
Sample 1			
Topsoil..	8	5	Low
Subsoil..	8	5	Doubtful
Sample 2			
Topsoil..	8	15	Medium
Subsoil..	8	10	Medium
Sample 3 (Peat soil)			
Topsoil..	6	10	Low
Subsoil..	7	25	Low
Sample 4			
Topsoil..	8	10	Medium
Subsoil..	8	20	Doubtful

Soil Tests.—One topsoil sample and one subsoil sample were collected in September, 1939, from each of four parkway areas in Hinsdale where elms affected with wetwood were wilting. These samples were tested for pH with a Youden apparatus and for nitrates and phosphates with an Urbana soil-testing kit. The analyses are shown in table 6. Only in the peat soil area, sample 3, was the soil neutral to acid, pH 6 to 7; both topsoils and subsoils of the other areas were highly alkaline, pH 8. In all samples, nitrates and phosphates were medium to low. Much of the parkway soil in Hinsdale, like that of many other villages and cities, contains considerable quantities of fill, which includes clay, gravel and cinders mixed with loam topsoil. This type of soil, as shown by analyses, is not the most favorable for vigorous tree growth, especially since the optimum pH range for American elm is pH 6.0 to 7.5, according to Spurway (1941).

Elm Seeds.—Seeds were collected from 10 wetwood-affected elms in Hinsdale and planted in the spring of 1941 to ascertain if the disease was transmitted through the seed. Nine of these trees had wilted previous to 1941, three in 1939, one in 1940 and five in both 1939 and 1940. *Verticillium* had been isolated from the three trees which wilted in 1939 and from the one tree which had not wilted. The seedlings that were obtained grew normally.

Growth Associations.—Growth of the wetwood organism in association with four fungi—*Verticillium albo-atrum* R. & B., *Dothiorella ulmi* V. & M., *Coniothyrium* sp. and *Alternaria* sp.—was studied because these fungi were found occasionally in trees affected with wetwood. Each fungus to be tested was planted at the center of a Petri dish of potato dextrose agar, and each test was run in duplicate. Four days later, the wetwood organism was planted in streaks along two sides and about 20 mm. beyond each growing fungus colony. The plates were held 30 days for observation.

The wetwood organism was inhibitory to growth of *Verticillium* and *Dothiorella* upon contact. However, this inhibition was overcome in 12 days, and thereafter both *Verticillium* and *Dothiorella* grew slowly over the bacterial colonies and spread over the agar beyond. The wetwood organism produced only a slight, temporary inhibition of growth of *Coniothyrium* and *Alternaria.* This inhibition occurred when the fungus and bacterial colonies were in contact with each other. Both *Coniothyrium* and *Alternaria* grew through and over the bacterial colonies, and the bacteria spread along the hyphae of both fungi. In each test, the bacterial colonies spread more rapidly from the fungus colony than toward it.

Conclusions

From wetwood-affected elms in Illinois a bacterium was isolated, and with it the wetwood disease was reproduced experimentally. The bacterium is quite similar to *Erwinia salicis* Day, the watermark disease bacterium, and to *Pseudomonas lignicola* Westerdijk & Buisman (1929), but because of certain differences it is regarded as a separate species and has been named *Erwinia nimipressuralis,* new species.

Erwinia nimipressuralis inhabits mainly the heartwood and older sapwood of the trunk. Fermentation by this organism in the infected wood liberates gas which, if it does not escape, produces high pressure. Sap accumulates in the infected wood and produces the water-soaked condition which gives rise to the name wetwood. Much of the abnormal gas and sap can be drained out of the affected wood by the installation of drains. Radial cracks may occur, probably during the winter months, in wetwood-affected trees. These cracks may or may not reach the cambial region. If they extend to the cambial region, they serve as avenues of escape for the sap and the gas generated in the infected wood. Sap and gas flow out through the trunk cracks, killing the surrounding cambium and forming pockets between the bark and wood. The bark external to these cracks may split; then the sap and gas seep out, and the sap flows down the trunk. In many trees, cracks form in branch crotches, and sap and gas escape through these cracks. Likewise, wounds caused by the removal of branches may allow the sap and gas to escape. The flowing out of the sap and gas through these vents is commonly called fluxing, and the escaping sap and gas are known as flux.

Wilt develops wherever sufficient quantities of the wetwood sap are taken up in the current-season wood and carried to the branches. The severity and extent of wilt appear to depend largely upon the amount of toxic sap that is carried into the branches. Some trees show yellowing of leaves and premature leaf drop in July and August without the development of wilt. Trees that wilt may show symptoms any time during July and August; occasionally they show symptoms in late June and early September also. Although wilting branches may lose all of their foliage, if no twig or branch dieback occurs they may produce a new crop of foliage within 3 weeks. If, however, severe wilt occurs, not only do the leaves wilt and fall but the twigs and branches die back to larger laterals.

There is very little spread of wetwood into the roots of elms, and usually it does not spread below the region of grafting in Moline or other grafted types of elms.

In the experimental work reported here, buds, leaves, branch and trunk phloem, trunk cambium and current trunk sapwood inoculated with the wetwood organism did not become infected. Trunk heartwood and older sapwood inoculated with fermenting bacteria became infected, and typical wetwood was produced. However, the trees in which the heartwood became infected did not wilt during the 3 years they were under observation.

In the trunks of elms affected with wetwood, high pressures develop, whether the trees wilt or not. These pressures commonly reach 5 to 30 pounds per square inch, and are highest in trees that do not flux. In trees which flux freely, there usually is very little or no pressure. A pressure of 60 pounds per square inch was recorded in one elm in 1942. This tree fluxed freely in 1943 and, while fluxing, developed a pressure of only 1 to 2 pounds. Pressure is absent in February and March but begins to develop in April and early May. It increases until August or September; then decreases until late December or January. Pressures recorded in artificially infected greenhouse elms followed the general annual pressure cycle observed in naturally infected elms and were too low to be measured with a gauge when the trees were dormant.

In artificially infected greenhouse elms, a diurnal pressure cycle was observed. The maximum pressure occurred about 11:00 A.M. in June, July and August and about 1:00 P.M. in October, and the minimum pressure occurred usually between 7:00 P.M. and 11:00 P.M. The amount of pressure that developed in the greenhouse trees was influenced by air temperature. When the temperature fell much below the optimum temperature range of the wetwood organism—23 to 30 degrees C. or 75.2 to 86.0 degrees F.—pressure in the trees decreased. The pressure recorded in a greenhouse elm not affected with wetwood never exceeded 21 mm. of water, approximately 0.03 pound per square inch, as measured by a water manometer, but the maximum pressure recorded in one greenhouse tree affected with wetwood was 14.8 pounds. The diurnal rise and fall of the pressure curve for a normal tree, of the trunk temperature curve and of the air temperature curve corresponded closely.

Samples of gas from wetwood-affected elms contained approximately 46.4 per cent methane, 33.8 per cent nitrogen, 14.3 per cent carbon dioxide, 4.5 per cent oxygen and 1.0 per cent hydrogen. Carbon monoxide and illuminants were absent.

Samples of sap from wetwood-affected elms contained phosphates and an abundance of potassium. Although tests were made for them, the following elements and compounds were not found: calcium, chlorides, copper, iron, magnesium, manganese, sulfates, zinc, nitrates, nitrites, ammonia, starch, reducing sugars, indole and erythrodextrin.

The sap and diseased wood of wetwood-affected elms are alkaline, while both sapwood and heartwood of normal trees are acid in reaction.

Erwinia nimipressuralis has an optimum temperature range of 24 to 30 degrees C., 75.2 to 86.0 degrees F., a maximum temperature of 37 degrees C., 98.6 degrees F., and a minimum temperature of 5 degrees C., 41 degrees F., or less.

Summary

1. Our investigation of wetwood of elms was started in 1939. In Hinsdale, 1939–1943, 284 elms wilted because of wetwood infections in their trunks. None of the 284 elms which wilted died, and only 73 wilted in more than 1 year.

2. Wetwood infection has been found in the American elm (*Ulmus americana* L.) and its cultivated varieties Moline and Littleford, and in the slippery elm (*Ulmus fulva* Michx.), the English elm (*Ulmus procera* Salisb.) and the Siberian elm (*Ulmus pumila* L.). Samples from 346 elms located in 21 counties of Illinois were cultured, and the wetwood organism was isolated from 239 of them. Of the 346 trees, 292 showed wilt at the time the samples were taken.

3. Histological studies show the wetwood bacterium to inhabit principally the vessels and ray-cells of the trunk. It does not grow in sufficient abundance to cause general clogging of the conducting tissues and it does not cause disintegration of the tissues it inhabits.

4. Wetwood and flux were produced by trunk wood inoculations with this bacte-

rium. Wilt was not produced by these inoculations, nor by inoculations of buds, leaves, shoots or branches. Infection was not obtained by patch grafting with discolored inner bark taken from diseased trees.

5. Sap from wetwood caused young trees to wilt when it was introduced into their current-season wood. It appears that grayish brown streaks in the current-season wood are caused by the discolored sap and not by the wetwood organism. The bacterium was not often isolated from wilting branches.

6. Trunk pressures in wetwood-affected elms commonly reached 5 to 30 pounds per square inch, and were highest in trees that did not flux. A pressure of 60 pounds per square inch was recorded in one tree in 1942. Pressures in wetwood-affected elms began to develop in April and early May, increased until August or September and then decreased until late December or January. Pressures were not detected in February and March. In artificially infected greenhouse trees, pressures followed a diurnal cycle with a maximum between 11:00 A.M. and 1:00 P.M. and a minimum between 7:00 and 11:00 P.M.

7. Gas from affected elms contained methane, carbon dioxide, oxygen, hydrogen and nitrogen.

8. Sap from affected elms contained phosphates and potassium.

9. The pH determinations showed the sap and discolored wood of wetwood trees to be alkaline, the wood of healthy trees to be acid.

10. The bacterium which causes wetwood is a fermenting facultative anaerobe of the genus *Erwinia*. It is named *Erwinia nimipressuralis*, new species.

11. Control measures tested included feeding with 10-8-6 fertilizer and urea, installation of drains in trunks, and the injection of mercuric chloride, copper sulfate, silver nitrate, 8-hydroxyquinolin sulfate and *Helione*. Neither the use of fertilizers nor the injection of any of the chemicals appeared to be effective. The installation of drains, however, gave at least temporary control of flux.

LITERATURE CITED

Beilmann, August P.

1935. The use of instruments in tree diagnosis. Natl. Shade Tree Conf. Proc. **11**: 18-26.

1940. An attempt to record internal tree-trunk pressures. Mo. Bot. Gard. Ann. **27**(3): 365-70.

Burkholder, Walter H.

1932. Carbohydrate fermentation by certain closely related species in the genus *Phytomonas*. Phytopath. **22**(8): 699-707.

Conner, H. A., W. H. Peterson and A. J. Riker

1937. The nitrogen metabolism of the crown gall and hairy root bacteria. Jour. Ag. Res. **54**(8): 621-8.

Connors, Charles H., and Victor A. Tiedjens

1941. Chemical gardening for the amateur. Wh. H. Wise and Company, New York. 225 pp.

Cook, Mel. T.

1918. Common diseases of shade and ornamental trees. N. J. Ag. Exp. Sta. Circ. **98**. 27 pp.

Crandall, Bowen S.

1943. Bacterial infection and decay of the inner wood of winter-injured young London plane trees. Phytopath. **33**(10): 963-4.

Crandall, Bowen S., Carl Hartley and R. W. Davidson

1937. Wetwood. (Abstract.) Phytopath. **27**(2): 126.

Crocker, William

1931. The effect of illuminating gas on trees. Natl. Shade Tree Conf. Proc. **7**: 24-34.

Crocker, William, P. W. Zimmerman and A. E. Hitchcock

1932. Ethylene-induced epinasty of leaves and the relation of gravity to it. Boyce Thompson Inst. Contrib. **4**(2): 177-218.

Dodge, A. W.

1937. Slime flux. Arborist's News **2**(7): 1-2.

Elrod, R. P.
1942. The *Erwinia*-coliform relationship. Jour. Bact. 44(4): 433-40.

Guba, E. F.
1934. Slime flux. Natl. Shade Tree Conf. Proc. **10**: 56-60.
1942. Slime flux of trees. Arborist's News 7(3): 17-8.

Hansen, Emil Chr.
1889. Ueber die in dem Schleimflusse lebender Bäume beobachteten Mikroorganismen. Centbl. f. Bakt. u. Parasitenk. **5**(19): 632-40, (20): 633-7, (21): 693-6.

Hartley, Carl, and B. S. Crandall
1935. Vascular disease in poplar and willow. (Abstract.) Phytopath. **25**(1): 18-9.

Holtz, Wilhelm
1901. Beitrag zur Kenntnis der Baumflüsse und einiger ihrer Bewohner. Centbl. f. Bakt., Parasitenk. u. Infektionskrank. Abt. II, 7(4): 113-28, (5, 6): 179-89, (7): 229-38, (8): 274-81, (9, 10): 338-50.

Krone, Paul R.
1937. The reaction of greenhouse plants to gas in the atmosphere and soil. Mich. Ag. Exp. Sta. Spec. Bul. **285**. 35 pp.

Large, John R.
1944. Alcoholic flux or white slime flux of tung trees. U. S. Dept. Ag. Pl. Dis. Rep. **28**(1): 35-6.

Ludwig, F.
1886. Ueber Alkoholgährung und Schleimfluss lebender Bäume, verursacht durch Endomyces Magnusii n. sp. und Leuconostoc Lagerheimii n. sp. Hedwigia **25**(5): 168-72.
1888. Der braune Schleimfluss. Centbl. f. Bakt. u. Parasitenk. 4(11): 323-4.
1890. Zwei parasitologische Mittheilungen. II. Eine profuse Gummose der Eichen. Centbl. f. Bakt. u. Parasitenk. 8(14): 424-5.

MacDougal, Daniel T.
1932. The pneumatic system of trees. Carnegie Inst. Wash. Yearbook **31**: 192-3.
1936. Studies in tree-growth by the dendrographic method. Carnegie Inst. Wash. Pub. **462**. 256 pp.
1938. Tree growth. Chronica Botanica Company, Leiden, Holland. 240 pp.

MacDougal, Daniel T., J. B. Overton and Gilbert M. Smith
1929. The hydrostatic-pneumatic system of certain trees: movement of liquids and gases. Carnegie Inst. Wash. Pub. **397**. 99 pp.

MacDougal, Daniel T., and Earl B. Working
1933. The pneumatic system of plants, especially trees. Carnegie Inst. Wash. Pub. **441**. 87 pp.

Massee, George
1897. Slime flux. Kew Bul. Misc. Inf. **132**: 423.
1907. Additions to the wild fauna and flora of the Royal Botanic Gardens, Kew. Saccharomycetaceae. Kew Bul. Misc. Inf. **6**: 240.

May, Curtis
1942. A note on slime-flux in American elm. Arborist's News 7(7): 52-3.

Merck and Company, Inc.
1940. The Merck Index. Fifth edition. Merck and Company, Rahway, New Jersey. 1,060 pp.

Ogilvie, Lawrence
1924. Observations on the "slime-fluxes" of trees. Brit. Mycol. Soc. Trans. **9**: 167-82.

Priestly, J. H.
1930. Studies in the physiology of cambial activity. III. The seasonal activity of the cambium. New Phytol. **29**(5): 316-54.

Reynolds, Ernest S.
1939. Tree temperatures and thermostasy. Mo. Bot. Gard. Ann. **26**(3): 165-255.

Society of American Bacteriologists, Committee on Bacteriological Technic
1939. Manual of methods for pure culture study of bacteria. Leaflets **2**: 3-15; **4**: 3-23; **5**: 2-20. Seventh edition. Society of American Bacteriologists, Geneva, New York.

Spurway, C. H.
1941. Soil reaction (pH) preferences of plants. Mich. Ag. Exp. Sta. Spec. Bul. **306**. 36 pp.

Stautz, Walter
1931. Beiträge zur Schleimflussfrage. Phytopath. Ztschr. 3(2): 163-229.

Stone, George E.
1916. Shade trees. Mass. Ag. Exp. Sta. Bul. **170.** 264 pp.

Tubeuf, Karl Freiherr von, and William G. Smith
1897. Diseases of plants induced by cryptogamic parasites. Longmans, Green and Company, New York. 598 pp.

Ward, H. Marshall
1901. Diseases in plants. The Macmillan Company, New York. 309 pp.

Westerdijk, Johanna, and Christine Buisman
1929. De Iepenziekte. Rapport over het Onderzoek Verricht op Vorzoek van de Nederlandsche Heidemaatschappij. Nederland. Heidemaatsch. te Arnhem. 78 pp.

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Volume 23, Article 5 Urbana, Illinois September 1945

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THEODORE H. FRISON, *Chief*

Fox Squirrels and Gray Squirrels *In Illinois*

LOUIS G. BROWN

LEE E. YEAGER

Printed by Authority of the

STATE OF ILLINOIS

DWIGHT H. GREEN, *Governor*

DEPARTMENT OF REGISTRATION AND EDUCATION

FRANK G. THOMPSON, *Director*

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NATURAL HISTORY SURVEY DIVISION
THEODORE H. FRISON, *Chief*

Volume 23 | BULLETIN | Article 5

Fox Squirrels and Gray Squirrels

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URBANA, ILLINOIS

September 1945

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CONTENTS

Squirrel hunting is highly prized by those who participate in it, both for its recreational value and because it means "meat on the table." Illinois hunters kill approximately 1,400,000 squirrels annually, of which about 70 per cent are fox squirrels.

Fox Squirrels and Gray Squirrels

*In Illinois**

LOUIS G. BROWN
LEE E. YEAGER

Since the passing of big game in Illinois, fox squirrels and gray squirrels have never ranked lower than second among game mammals of this state in importance to hunters. First place is now a toss-up between these tree squirrels and cottontail rabbits, with the latter declining in public esteem because of recent epidemics of tularemia (Yeatter & Thompson 1943), a disease more commonly associated with rabbits than other game.

Despite the long-standing importance of squirrels, very little information has been available upon which to base Illinois hunting regulations, management and restoration measures relating to them. Laws in regard to hunting seasons have been varied, and at times grossly unsound biologically. The most common problem pertaining to seasons is that of mid- or late-summer hunting. Such hunting is demanded by many hunters, particularly in the southern part of the state. The Illinois squirrel season for the biennium of 1939-41 opened, in this area, on July 15. The date was set back to August 1 in 1941, but again advanced to July 15 in 1943.

These early opening dates, as would be expected, resulted in numerous complaints from conservation organizations and from some sportsmen. Lawmakers and administrative personnel, in coping with the situation, were greatly handicapped by the lack of specific information, despite recent investigations in Ohio, Michigan and other states. In particular, information on squirrel breeding was scarce, and it was feared that such as was available was not fully applicable to Illinois conditions. A season similar to that in Ohio or Michigan, considered sound, would retard the opening date in Illinois 2 months or more; and Illinois hunters, to whom summer squirrel shooting is traditional, could be expected to oppose strongly and in good faith such a restriction on their sport. For educational purposes as well as for administrative use, therefore, a fact-finding study was needed in Illinois.

The Federal Aid Project on which this report is based was proposed jointly by the Illinois Natural History Survey and the Illinois Department of Conservation. Formally known as "Squirrel-Raccoon Investigation and Management in Illinois, Project 14-R," the study was initiated on July 1, 1940, and terminated as a project on June 30, 1942, although some field work, in connection with other projects, was continued through 1944. Early in the investigation it was found that, despite the similarity in some squirrel and raccoon habitats, the two phases of the study could not be carried on adequately at one time by one man; only the senior author was available for field work during the greater part of the investigation. Accordingly, the raccoon phase was dropped except for observations that could be made incidentally or as a part of regular squirrel studies.

OBJECTIVES OF PROJECT

The project had two main objectives, as follows:

1. Determination of squirrel breeding seasons and related biology, the information derived to be used in recommending biologically sound squirrel hunting seasons.

*Illinois Federal Aid Publication No. 4.

2. Determination of the environmental requirements of Illinois squirrels, the information on this subject to be used in management and restoration practices.

METHODS OF STUDY

Illinois, with a north-south length of 385 miles, is subject to greater seasonal variations than any other midwest state. In the formulation and administration of fish and game laws, these variations are partially compensated for through the division of the state into the northern, central and southern zones, fig. 1, each comprising about one-third of the state and each representing a difference in season of 6 or 7 days.

The necessity for determining seasonal variations in squirrel breeding and related phenomena in each of the three zones was recognized at the beginning of the project.

Fig. 1.—Map of Illinois showing the three zones on which the game and fish code of the state is based.

It appeared, therefore, advisable for the senior author to spend the first 10 days of each month in the southern zone, the second 10 days in the central zone, and the last 10 days in the northern zone, collecting and studying during each period a sufficiently large number of fox and gray squirrels to determine seasonal differences in reproduction. Because such a plan, however sound theoretically, was expensive in travel time, only the first year was given to this periodical study by zones. During this time the zonal differences in the seasons of reproductive activity were determined approximately. The second year was devoted to intensive field study on representative central zone areas, on which both fox and gray squirrels occurred.

In general, data on breeding and other seasonal phases of this study relate to the central zone, except where otherwise stated, and practical utilization of the information in the northern and southern zones necessitates appropriate allowance in time.

Sample material yielding information on squirrel biology consisted of freshly shot, steel-trapped and live-trapped specimens. Study of dead specimens was carried on mainly in several improvised field stations, although some material was examined in Natural History Survey or University of Illinois laboratories. Live-trapped squirrels were examined in the field, usually at the site of capture. Both fox and gray squirrels were available for study every month for the duration of the project, although it was of course impossible to obtain equal numbers of squirrels each month, either in species or sex. Fox squirrels far exceeded gray squirrels in number, amounting to about 70 per cent of the total examined.

Each collecting method has its advantages. Over much of the study period guns and steel traps were employed simultaneously. Hunting was most effective during the main mast-feeding months, from mid or late August into October. Trapping was particularly successful during the winter and early spring, when corn was readily taken as bait. Traps were set, uncovered, on logs and each was baited with a half ear of corn, usually impaled on a nail a few inches above the trap. Twenty-five to 50 traps were employed, and they were visited at least daily, and, as often as possible, twice daily. The most serious disadvantage of this trapping method was that of taking animals other than squirrels. These included skunks, foxes, raccoons, opossums, woodchucks, cottontail rabbits and a variety of birds. Since No. 1 traps were used, practically all mammals caught except squirrels and rabbits were uninjured and were released at the point of capture. Most birds caught in the traps were dead when found. Blue or red corn was found to attract fewer birds than yellow corn, but it appeared to be somewhat less attractive to squirrels.

Live trapping, which was conducted in three wooded areas in Pike County, involved both fox squirrels and gray squirrels. Shelled corn was used for bait. Fifty live traps of the type described by Baumgartner (1940) were used, fig. 2. Squirrels so taken were not killed, but were examined in the field for evidence of breeding, pregnancy and lactation. Many squirrels were taken repeatedly. This phase of the study supplied information on species ratio, sex ratio, population density, movements and home range, in addition to breeding and related data. Various animals, including woodchucks, cottontail rabbits, skunks and opossums, and a few birds, were captured in the live traps. These were unharmed and were released. The period of continuous trapping was from October 16, 1941, to August 7, 1942.

Fig. 2.—Live trap, baited with shelled corn, in a typical set location. Fifty live traps, used in three Pike County areas, yielded useful information on squirrel populations and life history.

Prior to each of the two hunting seasons, 1940 and 1941, covered by this project, copies of a questionnaire were distributed throughout the main squirrel hunting regions of the state. This questionnaire contained blanks to be filled by hunters before the copies were returned to the project leader. It was hoped that from the returned forms information pertaining to kill, distribution, species ratio and population trends could be obtained. A total of 3,300 forms were distributed during the 2 years, of which only 236, or 7 per cent, were returned. The writers consider that the most valuable information yielded by the questionnaire pertained to population trends and hunters' opinions of squirrel seasons.

Data pertaining to breeding were obtained directly from examination of squirrels of all age classes and of both species. Such information was recorded systematically under appropriate headings, as shown in fig. 3. For males, the information particularly sought was size and weight of testes and size of Cowper's glands; for females, evidence of oestrus, pregnancy, lactation and placental scars. The age of all specimens was determined with as much accuracy as possible, and, throughout the study, special efforts were made to develop aging criteria. Weights and general measurements were taken of nearly all specimens. Other records related to locality and date of collection, condition of pelage, parasites, disease and stomach contents. Supplementing these data were detailed observations on foods and feeding habits, activity, behavior, habitat requirements and other matters of ecological interest.

Unfortunately, no fully satisfactory technique has been developed for censusing squirrels. That such a tool is important is obvious because the first information needed in management relates to the number of animals present on each study unit. This information is most useful when it supplies numbers at a definite time; for example, population in the fall. In the absence of standardized methods for determining squirrel numbers, it becomes necessary to make the best estimates possible. These estimates are generally made by rules-of-thumb, or by using one or more of the various techniques that have been described. The result is often expressed in reference to the population by such terms as "plentiful," "common," "scarce," or "heavy," "medium," "light."

Dice (1931) proposed, as the best method of determining mammal abundance, the listing of individuals observed in each ecological unit of the habitat. This

ILLINOIS NATURAL HISTORY SURVEY
Urbana, Illinois

Zone________ County__________ Town_________ Location__________

Ecology______________________________

Food Types____________________________

Date	Species	Sex	Weight	Body Length	Total Length	Hind Foot	Molt	Mange	Testes			Cowper's Glands	Age			Oestrus	Pregnant	Nursing	Stomach Contents	Comments
									Length	Width	Weight		2nd	1st	Ad.					

Fig. 3.—Field form used for recording biological data, Illinois squirrel study, 1940–1943.

method gives more properly an index of relative abundance in the various units rather than a true census. Later, Dice (1941) summarized various census techniques, some of which were applicable directly or indirectly to squirrels. Leopold (1933) discussed census methods for both game birds and mammals. Like Dice, he suggested techniques that could be used in squirrel census.

Goodrum (1940) developed three census techniques for gray squirrels in Texas, which probably would be equally applicable to fox squirrels. These methods were as follows:

1. Time-area counts, using number of squirrels observed during definite time period on random plots of known size in each ecological type.
2. Nest counts in each ecological type, multiplied by a factor of two.
3. Hunting with dog, using number of squirrels treed per hour.

The first method is based on the average distance a squirrel can be seen, and thus the size of the territory that may be observed from a stationary position. Goodrum, using three-fourths of this territory as the unit that could be watched effectively, calculated populations in each ecological type by multiplying the average number of squirrels seen per acre on each observation territory by the number of acres in the type represented. The second method involved counting all twig and leaf nests, preferably in the fall and winter, in each ecological type and multiplying by two. The third method, employed only when squirrels were active on the ground, gave the number of animals treed per hour in each ecological type. In each of these methods, the greater the number of counts and the more uniform the vegetational types, the more nearly accurate is the census.

It should be noted that Goodrum's first two methods result, theoretically at least, in a true census; the third, unless several factors not given are known, could not be more than an index of relative abundance. The present writers made limited use of the time-area method and were convinced of its possibilities provided the investigator had time for making a large number of counts. In agreement with Allen (1942, 1943), who worked with fox squirrels in Michigan, we are uncertain of the value of the nest-count method. The hunting-with-dog method was not tried. It is probably significant that Goodrum refers to these census techniques as "... methods found most effective in estimating gray squirrel populations in eastern Texas."

Chapman (1937, 1938*a*) in Ohio, and others, have used data taken directly from hunters as a means of determining trends in populations. This is a rapid and useful method, and, if based on many samples, may indicate trends for large areas, even for a state as a whole. However, most kill data are subject to too many variations to yield more than very general information, thus limiting materially their use.

Baumgartner (1940), Allen (1942, 1943) and the present writers determined, by exhaustive live trapping, and with a relatively high degree of accuracy, squirrel numbers on small study areas. This technique, however, is too time consuming for practical, large scale censuses. Estimates of the population made by less exacting means, if based on experience and judgment, serve many purposes of management; and, if made uniformly year after year, may indicate population trends satisfactorily. Some experienced hunters develop almost uncanny accuracy in judging squirrel numbers on areas with which they are familiar.

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POPULATIONS

During the second year of the investigation, considerable time was given to study of squirrel populations on representative areas in Pike County, in the central zone. From data gathered there, from questionnaires returned by hunters and from kill records supplied by the Illinois Department of Conservation, detailed information on squirrel distribution, kill, sex ratios, species ratios and related subjects was obtained and added to the more general information gathered in the first year.

Distribution

The western fox squirrel, *Sciurus niger rufiventer* (Geoffroy), the northern gray squirrel, *S. carolinensis leucotis* (Gapper), and the southern gray squirrel, *S. c. carolinensis* Gmelin, are listed by Necker & Hatfield (1941) as occurring in Illinois. The fox squirrel has statewide distribution; records for the northern gray squirrel include counties in approximately the northern two-thirds of the state and for the southern gray squirrel several of the southernmost counties, fig. 4. Both subspecies of gray squirrels undoubtedly extend beyond the range given.

The red squirrel, *Tamiasciurus hudsonicus loquax* Bangs, is listed by Necker & Hatfield as still being present in the wild in Illinois, but no observations or other records of it were obtained during the present study. If red squirrels occur here, it is believed that they do so only in reduced numbers and in quite restricted localities. Kennicott (1857) gives a good account of their early abundance in the northern parts of the state.

Fox squirrels are found on farm and forested areas, and in cities and villages. Outside of some urban communities, gray squirrels are restricted to heavily wooded areas, generally those having abundant ground cover and brushy understory.

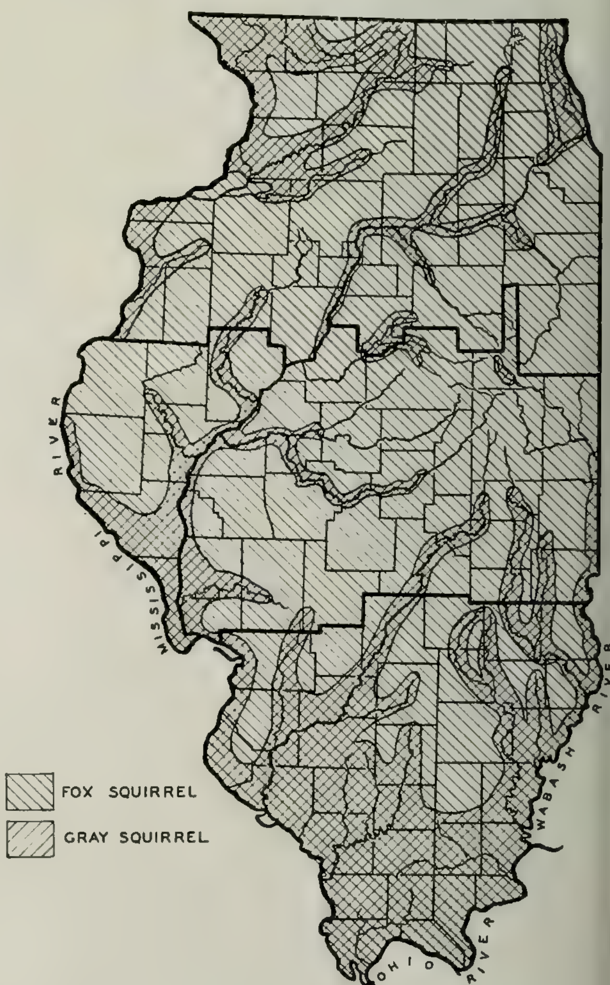

Fig. 4.—Distribution of fox squirrels and gray squirrels in Illinois.

Woodland of this type is found in Illinois principally along the main river valleys and in the southern and southwestern parts of the state, fig. 4. Further discussion of the preferences of the two species are given under "Illinois Habitats."

Density

During this study squirrel population density was determined with a high degree of accuracy on only one area. This area, however, was typical of the large region of good squirrel habitat in southern and southwestern Illinois, where both squirrel species often occur in mixed populations. On three other areas, all representative of extensive Illinois habitat types, rough estimates of the population were obtained. Population estimates of the four areas are presented in table 1 and are discussed below.

Great differences in population density were found in Illinois fox squirrel habitats. Comparable data are not available for the gray squirrel. This species, however, is known to occur in varying densities, although not in the extremes found in the fox squirrel. The lack of extremes is due probably to relative uniformity in the habitat occupied by gray squirrels, which, as stated previously, is mainly heavily wooded areas. The populations given per acre for the Harshman and Urbana Township areas, table 1, probably represent the highest and lowest densities for fox squirrel habitats likely to be encountered in the state. On the Mason County area, which is of the black oak type, composed of all ages and degrees of stocking, it was found that fox squirrels may occur in varying densities in the same general habitat. The censused populations in 16 black oak stands in this area ranged from 0.02 to 2.20 squirrels per acre.

Although many areas were found where both species were present, as well as many areas carrying only fox squirrels, none were encountered that held gray squirrels alone over a relatively large tract. Local concentrations of gray squirrels were often seen. The junior author counted 16 of these animals late in the afternoon of October 16, 1942, on an area of less than 3 acres. All were foraging in an oak-hickory stand that bordered a young river-bottom forest in Coles County. It was known that fox squirrels frequented this site. The figure of 1.49 individuals per acre for the Wade area, table 1, probably represents for gray squirrels the upper density limit found on the better Illinois range.

The figure of 2.23 fox squirrels per acre for the Harshman area represents the density on a small, very favorable area. A density of half this figure is considered as probably representative for large areas, even of the better habitats.

No evidence was obtained to show conclusively that either fox or gray squirrels are cyclic in Illinois. Fluctuations in populations from year to year, as long observed by hunters and reflected in kill records, suggest that these squirrels may be cyclic, although the degrees of fluctuation are only minor. If squirrel cycles operate at all in Illinois, they show little of the spectacular nature common in hares and other species in northern regions. Edminster (1937), at least by implication, suggested that the gray squirrel is cyclic in the New England region.

Species Ratios

From data presented in tables 2 and 3, and from general observations throughout the state, it is evident that the fox squirrel is more abundant than the gray squirrel in Illinois.

All of the squirrels listed in table 3 and 86 per cent of the 4,597 animals included in table 2 were obtained by hunting. Because of two differentials associated with hunting, the relative abundance of fox squirrels may be actually somewhat lower than the figures indicate. First, fox squirrels may be easier to kill than gray squirrels; they are so considered by many hunters, although the writers found little difference between the species in this respect. Second, there is a small difference in the accessibility of habitat preferred by the two species, that for the gray squirrel being, in general, the more remote and the more difficult and time consuming for hunters to reach.

On areas harboring presumably typical populations of fox and gray squirrels, both steel trapping and live trapping showed a preponderance of fox squirrels in the catch, table 2; in live trapping the difference was small. In view of the first

Table 1.—Squirrel density in four representative Illinois habitats, 1941 and 1942.

Area	County	Number of Acres	Type of Habitat	Date of Census	Populations: Fox Squirrels Number	Fox Squirrels Average per Acre	Gray Squirrels Number	Gray Squirrels Average per Acre	All Squirrels Average per Acre
Wade	Pike	41	Upland oak-hickory, with shaded runs and heavy understory; fox and gray squirrel habitat of high quality.	October, 1941, to August, 1942	35	0.85	61	1.49	2.34
Harshman	Pike	13	Upland oak-hickory, open and parklike; fox squirrel habitat of high quality.	October to December, 1941	29	2.23	0	0.0	2.23
Mason County State Forest	Mason	2,900	Black oak sand plains; fox squirrel habitat of good quality.	February, 1942	1,500*	0.52	0	0.0	0.52
Urbana Township Wildlife Area	Champaign	2,560	Intensively farmed black prairie; fox squirrel habitat of very low carrying capacity.†	December, 1942	40	0.02	0	0.0	0.02

*Population estimated on basis of census by Dr. Jessop B. Low, and on supplementary observations by Frank C. Bellrose, Jr., and the writers.
†Although of low carrying capacity due to the small area suitable for habitation, the squirrels present showed excellent condition and high fecundity.

Table 2.—Species ratio in Illinois squirrels as determined from 4,597 animals, some of them shot by hunters and others collected by the writers, 1940, 1941 and 1942.

How Taken	Fox Squirrels		Gray Squirrels		Total	
	Number	Per Cent	Number	Per Cent	Number	Per Cent
Hunters (throughout Illinois)						
1940 (over-all season, July 15–November 15)	955	62.3	577	37.7	1,532	100.00
1941 (over-all season, August 1–November 15)	1,413	75.8	452	24.2	1,865	100.00
Collected specifically for study						
Shooting (all zones represented)	381	67.7	182	32.3	563	100.00
Steel traps (all zones represented)	341	66.6	171	33.4	512	100.00
Live traps (Pike County)	64	51.2	61	48.8	125	100.00
Total	*3,154*	*68.6*	*1,443*	*31.4*	*4,597*	*100.00*

hunting differential discussed in the paragraph above it is suspected that the figures yielded by steel trapping, which was conducted in all three zones and in many areas, are a somewhat more reliable indication of the relative abundance of the species than the data derived from hunters' questionnaires. Of the steel-trapped squirrels, 66.6 per cent were fox squirrels and 33.4 per cent were gray squirrels. Live trapping gave a percentage of 51.2 for fox squirrels and 48.8 for gray squirrels, but the figures upon which these percentages were based are believed to be too small for reliability.

Fox squirrels, table 3 indicates, were much more numerous than gray squirrels in the northern and central zones, but not in the southern zone when the survey was made; fox squirrels averaged more than 85 per cent of the kill in these first two zones in the 1940–1941 period. In the southern zone, the two species were taken in about equal numbers, indicating populations of nearly equal density. Reports received from hunters chosen for their reliability indicate that, for the state as a whole, fox squirrels made up two-thirds or slightly more of the annual kill. These ratios are roughly in proportion to the acreages of fox squirrel and of gray squirrel habitat in the three zones, fig. 4.

Table 3.—Species ratio in Illinois squirrels, by zones, as determined from questionnaires returned by hunters, 1940 and 1941.

Zone	Fox Squirrels						Gray Squirrels					
	1940		1941		1940–1941		1940		1941		1940–1941	
	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent
Northern	92	73.6	268	88.0	360	86.1	33	26.4	24	12.0	57	13.9
Central	472	84.7	758	89.1	1,230	87.4	85	15.3	93	10.9	178	12.6
Southern	391	46.0	387	53.6	778	49.5	459	54.0	335	46.4	794	50.5
Total	*955*	*64.6*	*1,413*	*75.8*	*2,368*	*69.7*	*577*	*35.4*	*452*	*24.2*	*1,029*	*30.3*

Sex Ratios

The sex of 4,651 squirrels, 3,197 fox squirrels and 1,454 gray squirrels, as determined during the investigation is shown in table 4. These data were derived largely from hunters' questionnaires, and were therefore subject to whatever differentials there may have been in bagging the sexes.

It appears that Illinois squirrel populations either have a preponderance of males, or that males are more easily bagged by hunters, who invariably shoot at squirrels in the order of their appearance until the limit is reached or the hunt is over. Fox squirrel males and females were taken in steel traps in approximately the ratios in which they were shot; gray squirrel males and females were steel trapped in more nearly equal numbers, but with males predominating, table 4. Live trapping, for which the samples are too small for reliability, yielded in both fox and gray squirrels more females than males, but in gray squirrels the numbers were nearly equal for the sexes. Litter counts, on the basis of a very few samples, showed slightly more males than females in both species. A summary of figures listed in table 4 showed a preponderance of males in both species, giving a male to female ratio of roughly 60 to 40.

The sex ratio of 17 litters of fox squirrels, totaling 43 young, recorded during the spring of 1941 was 105 males to 100 females, table 4. Of 179 first-season or spring juvenile fox squirrels taken by the writers and by hunters from May through November 15, 62 per cent were males and 38 per cent were females; of 109 second-season or summer juveniles taken during September and October, 57 per cent were males and 43 per cent were females. The sex ratio of all juvenile fox squirrels for which records were obtained, including litters, 195 males and 136 females, was 144 to 100.

In gray squirrels, the sex ratio of 3 litters, totaling 11 young, was 120 males

Table 4.—Sex ratio in Illinois squirrels as determined from sample litter counts and from animals shot, steel-trapped and live-trapped, 1940–1943.

How Taken	Number		Total Number	Per Cent		Sex Ratio Male: Female
	Male	Female		Male	Female	
Fox Squirrel						
Litters (all zones represented)	22	21	43	51.2	48.8	105:100
Shot (throughout Illinois; including writers' kill)	1,631	1,118	2,749	59.3	40.7	146:100
Steel traps (all zones represented)	202	139	341	59.2	40.8	149:100
Live traps (Pike County)	28	36	64	43.7	56.3	78:100
Total	*1,883*	*1,314*	*3,197*	*58.9*	*41.1*	*143:100*
Gray Squirrel						
Litters (all zones represented)	6	5	11	55.5	44.5	120:100
Shot (throughout Illinois; including writers' kill)	734	477	1,211	60.6	39.4	154:100
Steel traps (all zones represented)	89	82	171	52.0	48.0	109:100
Live traps (Pike County)	30	31	61	49.0	51.0	97:100
Total	*859*	*595*	*1,454*	*59.1*	*40.9*	*144:100*

to 100 females, table 4. Of 60 spring juveniles taken by the writers and by hunters, 55 per cent were males and 45 per cent were females; of 38 summer juveniles collected in late September and October, 58 per cent were males and 42 per cent were females. The sex ratio of all juvenile gray squirrels for which records were obtained, 61 males and 48 females, was 127 males to 100 females.

Fig. 5.—Juvenile (left) and adult male fox squirrels. Note smoothed, blackened appearance of scrotum in adult and the smaller, less conspicuous scrotum in juvenile. Piatt County, late January, 1944. Gray squirrels of the same ages show the same characteristics.

The actual sex ratio of Illinois squirrels may be more nearly equal in both species than shown in table 4. It seems that males, because of somewhat more active habits, offered hunters more opportunities for shots than did females, and probably for the same reason proportionately more males were taken in steel traps.

Fig. 6.—Juvenile (left) and adult female fox squirrels, Mason County, August 15, 1944. Juvenile was first-season young; adult had weaned a first-season litter, but was neither pregnant nor lactating. Note the inconspicuousness of the mammary glands of the juvenile, and the prominent, blackened nipples of the adult.

Age Classes

No simple, yet infallible, method of determining age classes in fox and gray squirrels has been reported. Such techniques are much needed, not only for squirrels but for many other animal groups. The nearest approach to a workable method for aging squirrels requires the use of a number of criteria introduced by several workers, and validity of the method is somewhat conditioned by the experience of the user. For fox squirrels, Allen (1942, 1943) and Baumgartner (in letter to writers) placed some value on comparative growth stages, skin texture, and development of pigment and hair on various parts of the body, particularly on the scrotal sac of the males and on the ventral region of females. Chapman (1938*a, b*) working with gray squirrels, found a correlation of age and weight classes.

In both species males were the more difficult of the sexes to age. Juvenile males born in late winter or early spring were easily confused with adult males by the October and November following; and by December, when weights and measurements of the two groups were approximately equal, they could scarcely be differentiated. In adult males the scrotal sac is more pendent, and is blackened and less nearly clothed by hair on the ventral surface, fig. 5. In December, appearance of the teeth, and of hair and skin on the soles of the feet, is very similar in the two age groups. Some juvenile males born in the summer remain distinguishable from adult males until about May of the following year.

In females, the teats offer the best means of determining age classes. In individuals that have never bred, these structures are small, light in color, and with the entire gland more or less hidden in the growth of hair. Mature females, after breeding and nursing, have much larger and more conspicuous mammary glands, the nipples of which, in both species, are dark in color, fig. 6.

The criteria found useful in aging squirrels in this study are listed in table 5. Collectively, and when used by an experienced observer, they are believed to be reliable for most individuals of both species. No single criterion was found applicable to all individuals of a given species or sex, and in some individuals age could not be determined with complete satisfaction when all criteria were used.

Hunters distinguish young from adult squirrels by several criteria other than appearance. The skinning test is perhaps most common, young squirrels being "easy" to skin and old squirrels "tough." Young squirrels remain "easy" to skin well into the fall or into the following spring, according to time of birth. The ease with which the leg bones may be snapped when the animals are being dressed is another criterion sometimes used by hunters.

Squirrels may properly be classed as adults after they reach breeding condition, and on this basis first-season young, born in late winter or early spring, become

Table 5.—Criteria for distinguishing between adult and juvenile fox and gray squirrels.

ADULTS	JUVENILES
MALES	
1. Ventral surface and posterior end of scrotum blackened, and generally free of hair.	1. Posterior end only of scrotum with smooth skin, brown to black and free of hair.
2. Cowper's glands one-half inch or more in diameter from November to following July (in other months about same size as in juveniles).	2. Cowper's glands undeveloped.
FEMALES	
1. Mammary glands large and noticeable, not hidden by hair growth; teats (in bred fox squirrel females) black tipped.	1. Teats inconspicuous, more or less hidden in growth of hair.
2. Uterus contracted in posterior position of coelom, horns about 2 mm. wide and flattened.	2. Uterus threadlike, extending forward toward kidneys.
MALES AND FEMALES	
1. Body length (tip of nose to anus) over 280 mm. for fox squirrels and over 250 mm. for gray squirrels.	1. Body length (tip of nose to anus) under 280 mm. for fox squirrels and under 250 mm. for gray squirrels.
2. Tail rectangular, block shaped; sides parallel or nearly so.	2. Tail pointed, triangular; sides not parallel.
3. Tips of guard hairs on tail rufus to red (fox squirrels only).	3. Tips of guard hairs on tail silvery until first tail molt in fall (fox squirrels only).

Table 6.—Age classes of squirrels shot or steel-trapped by the writers in Illinois, by months, 1940, 1941 and 1942.

Age Class	Number													Per Cent												
	January	February	March	April	May	June	July	August	September	October	November	December	*Total*	January	February	March	April	May	June	July	August	September	October	November	December	*Total*
Fox Squirrel																										
Adults	72	36	32	25	46	25	26	53	34	16	17	35	*417*	79.1	67.9	68.1	83.3	73.0	54.3	53.1	39.0	48.6	30.2	48.6	71.4	*57.8*
Spring juveniles	0	0	0	0	17	21	23	83	32	13	4	0	*193*	0.0	0.0	0.0	0.0	27.0	45.7	46.9	61.0	45.7	24.5	11.4	0.0	*26.7*
Summer juveniles	19	17	15	5	0	0	0	0	4	24	14	14	*112*	20.9	32.1	31.9	16.7	0.0	0.0	0.0	0.0	5.7	45.3	40.0	28.6	*15.5*
Gray Squirrel																										
Adults	17	19	14	22	35	15	17	25	14	13	16	24	*231*	73.9	73.1	73.7	84.6	79.5	62.5	53.1	59.5	43.8	43.4	59.8	85.7	*65.4*
Spring juveniles	0	0	0	0	9	9	15	17	18	7	4	0	*79*	0.0	0.0	0.0	0.0	20.5	36.5	46.9	40.5	56.2	23.3	14.8	0.0	*22.4*
Summer juveniles	6	7	5	4	0	0	0	0	0	10	7	4	*43*	26.1	26.9	26.3	15.4	0.0	0.0	0.0	0.0	0.0	33.3	25.9	14.3	*12.2*

Table 7.—Age classes of squirrels shot or steel-trapped by the writers in Illinois during the hunting seasons of 1940 and 1941.

Age Class	Fox Squirrels											
	Number						Per Cent					
	July	August	September	October	November	*Total*	July	August	September	October	November	*Total*
Adults	26	53	34	16	17	*146*	53.1	39.0	48.6	30.2	48.6	*42.6*
Spring juveniles	23	83	32	13	4	*155*	46.9	61.0	45.7	24.5	11.4	*45.2*
Summer juveniles	0	0	4	24	14	*42*	0.0	0.0	5.7	45.3	40.0	*12.2*

Age Class	Gray Squirrels											
	Number						Per Cent					
	July	August	September	October	November	*Total*	July	August	September	October	November	*Total*
Adults	17	25	14	13	16	*85*	53.1	59.5	43.8	43.4	59.3	*52.2*
Spring juveniles	15	17	18	7	4	*61*	46.9	40.5	56.2	23.3	14.8	*37.4*
Summer juveniles	0	0	0	10	7	*17*	0.0	0.0	0.0	33.3	25.9	*10.4*

adults in December, and second-season, or summer-born, young reach adulthood the following May or later. In this report, the first-season young are referred to usually as spring juveniles.

Age classes of fox or gray squirrels shot or steel-trapped by the writers are given by months in table 6. September, October and November were the only months in which shootable populations contained the three general age classes—adults, spring juveniles and summer juveniles. During the hunting months of August, September and October, spring juveniles were disproportionately represented in the kill, since young animals are more readily taken by hunters than are adults. Summer juveniles did not appear in the kill until late September or early October, after most of the kill had been made.

Data presented in tables 6 and 7 were obtained from squirrels shot or taken in steel traps by the writers. The totals, therefore, are not necessarily representative of the three age classes as taken by hunters. It is unfortunate that the several thousand squirrels reported by hunters could not have been classified according to age, since this sample would have permitted not only more reliable conclusions than the few hundred animals shot and trapped, but would probably have permitted analysis by zones. However, since the writers, after the invariable practice of hunters, shot animals in their order of appearance, the take for July–November, as given in table 7, may be accepted as fairly representative of age classes of squirrels bagged by Illinois hunters. The small number of steel-trapped animals included is believed to induce no appreciable age-class error.

In July and August, during the period of this study, Illinois hunters generally bagged only adult and spring juvenile squirrels. In September a few summer-born fox squirrels were taken, but grays, which have later birth dates, were not usually represented. In October, the kill of second-season individuals was heavy in proportion to the total number of squirrels bagged, but the total was small, since wide-scale hunting ended in September. Very few squirrels were taken by hunters in November. Second-season young, therefore, absorbed comparatively little of the hunting loss in their first season, leaving a large part of this age class for breeding stock. In view of the heavy kill of adult and first-season juveniles, the survival of large numbers of second-season young is important in maintaining the population.

SPECIES COMPETITION

No information was obtained during the squirrel investigation to indicate any appreciable degree of strife between fox squirrels and gray squirrels. The occurrence of one or both species on a given area appeared to be due more to characteristics of the habitat than to interspecific competition or lack of it. Only two or three observations of belligerency, and none of actual fighting between the two species, were obtained, while, on the other hand, both were frequently observed feeding in the same area and sometimes in the same tree. Throughout the Illinois gray squirrel range, hunters often kill both species on the same grounds. In one Pike County area, live trapping revealed a squirrel population composed of 64 per cent gray squirrels and 36 per cent fox squirrels. Only fox squirrels inhabited an open, oak-hickory area a few miles away that was similarly trapped. Both species were collected with gun or steel trap on at least 50 areas throughout the state during the period 1940–1943.

That some competition exists between the two species for available food and cover is probable, but it seems equally probable that little if any more competition results from the presence of two species than from the presence of an equal number of individuals of the same species. The best evidence of interspecific competition at hand is that usually only one species occurs in a given urban community. Seldom were both species found in any one municipality. We observed that about as many urban populations consisted of gray squirrels as of fox squirrels, although the habitat afforded by parks and tree-bordered streets is obviously better suited to the latter.

DAILY ACTIVITY

Throughout the first 2 years of this investigation, squirrels were hunted at least weekly and often daily for the purpose of obtaining study specimens. The record kept of all hunts included the time of hunt (Central Standard), and the place and activity of each animal when seen. A total of 716 hours, 387 in the morning and 329 in the afternoon, were devoted to hunting. Of the 554 squirrels observed, 336 were fox squirrels and 218 were gray squirrels. These data are summarized in table 8.

Activity in both species of squirrels was decidedly greater in the morning than in the afternoon. In the forenoon, the hour between 6 and 7 o'clock, when an hourly average of 0.89 fox squirrel and 0.77 gray squirrel was seen, showed the highest activity figure for both species, table 8. The next highest activity hour in the forenoon was 7 to 8 o'clock for fox squirrels and 5 to 6 o'clock for gray squirrels. The greatest afternoon activity was between 4 and 5 o'clock for fox squirrels and between 5 and 6 o'clock for gray squirrels. Gray squirrels were active both earlier and later in the day than fox squirrels, but fox squirrels were definitely more active during midday hours.

The data in table 8 are not in accord with the observations of Hicks (1942), who found that the peak of activity in Iowa fox squirrels occurred between 8:00 and 10:00 A. M., and that the next highest peak was between 1:00 and 2:00 P. M. Hicks made only a limited number of observations before 8:00 A. M. and after 5:00 P. M. Most other writers discussing this subject have indicated early morning and late afternoon activity peaks.

The daily activity of both species was observed to reach the annual zenith during the mast season. At this time, storing appeared to be the main pursuit other than feeding, and in individual squirrels involved several hours per day. Gray squirrels were observed to be abroad during midday hours more during the mast season than at any other time of the year except at the height of mating in December and January. During the mast season, as at other times, there was more activity in both species during early morning and late afternoon hours than at midday.

Although the effect of various weather conditions on squirrel behavior was not studied in detail, both species were found to be active all year, but least so during unusually cold weather. In hundreds of observations made in winter examinations of wood duck boxes, it was noted that individuals of both species were somewhat sluggish and more or less reluctant to leave nest boxes when the temperature was below freezing. A total of 680 boxes yielded 55 squirrels, 48 of which were fox squirrels; 32 of the fox squirrels showed noticeable reluctance to leave their nests. Many of these individuals, which remained in the boxes after the lids were removed, were observed to be sleeping,

Table 8.—Activity in Illinois squirrels based on 716 hours of hunting in which 336 fox squirrels and 218 gray squirrels were observed, June 1–October 31, 1941 and 1942. Hours specified are for Central Standard Time.

Species	Squirrels Seen per Hour										
	4–5	5–6	6–7	7–8	8–9	9–10	2–3	3–4	4–5	5–6	6–7
Fox squirrels	0.07	0.61	0.89	0.73	0.54	0.22	0.15	0.30	0.34	0.29	0.10
Gray squirrels	0.29	0.47	0.77	0.37	0.18	0.05	0.05	0.05	0.14	0.34	0.15
Total squirrels	0.36	1.08	1.66	1.10	0.72	0.27	0.20	0.35	0.48	0.63	0.25

tightly rolled in a ball with leaves pulled over them. In one box there were three such fox squirrels, stacked one on top of another. In numerous cases two squirrels occupied the same box. Every squirrel showing a state of lethargy could be induced to leave the nest by shaking the box or by gentle prodding with hand or stick. True hibernation, of course, does not exist in fox or gray squirrels, in Illinois or elsewhere.

A few occasions permitted activity observations during periods of deep snow. On January 21, 1940, fox squirrels were seen foraging aggressively in a large oak-hickory-elm woodlot in Pike County when snow was 8 inches deep. The observations were made between 2 and 3 o'clock in the afternoon. The day was clear; the air temperature was about 15 degrees F., and the preceding 20 days had been cold and with much snow. Five squirrels and innumerable tracks were seen. There was much evidence of squirrel digging in the snow for nuts and Osage orange fruits; many of the latter had been eaten on stumps and rail fences, and under trees in hedgerows. The senior writer found that deep snow tended to reduce steel trap and box trap catches, particularly on days of long-continued snowstorms. Both species were observed in mating chases under conditions of light snow or during snow flurries.

Squirrels apparently are affected by heat as well as by cold. Individuals of both species were observed on hot days lying quietly, legs outstretched and relaxed, on tree branches. One young fox squirrel was collected on August 21, 1942, in the early afternoon, while resting on the second highest rail of a fence. Collection was on a very hot, humid day, an hour or so before a rainstorm. This animal seemed to be seeking relief from the oppressive atmospheric conditions.

Rain seemed to have some reducing effect on squirrel activity. Neither fox nor gray squirrels were as active during heavy rains or high winds as at most other times, although both species were often seen during showers and immediately after heavy rainfall. Misty days are favored by some hunters, no doubt partly because of the quietness with which squirrels may be stalked at such times. Many fox and gray squirrels were collected by gun on drizzly days, during light showers, and before and after heavy rains. Occasionally, animals with wet outer hair were taken, indicating activity either during rain or in wet vegetation.

Both fox and gray squirrels were observed swimming. Two gray squirrels were seen deliberately entering water to reach the opposite shore of a slough, and two fox squirrels were observed swimming to shore after falling from dead, loose-barked soft maple trees. The distance these squirrels were seen swimming was not over 10 yards.

SEASONAL MOVEMENTS

Live trapping and general observation offered considerable opportunity for studying squirrel movements. The information gathered is given under "Local Movements," a subject that involves day-to-day travels of squirrels in feeding and other routine activities; "Migration," which considers mass movements of squirrels in a well-defined direction; and "Dispersal," which deals with the phenomenon of spread or "shuffle" in squirrel populations, especially in the fall prior to the breeding season.

Local Movements

Both fox and gray squirrels are usually considered sedentary species, although the latter, according to some authors, are subject to irregular migrations, discussed below. As has been reported by Seton (1928), Baumgartner (1938, 1943*a*), Goodrum (1940) and Allen (1942, 1943), local movements in both species of squirrels appear to be caused mainly by food conditions. In the course of a year, fox squirrels, apparently in foraging, may cross woodland or open fields for a distance of 2 or 3 miles. Gray squirrels, where favored by continuity of forest cover, may travel equal if not greater distances. The homing instinct of this species was studied by Hungerford & Wilder (1941), who reported returns in 6 of 15 animals, the greatest distance being 2.8 miles during a period of 4 weeks.

Squirrels shift readily from one local food area to another. On the Chautauqua National Wildlife Refuge, fox squirrels deserted one area after another as specific foods in other areas became available. They frequented the elm lowlands from late February into July, when elm buds and seeds, and later mulberries, supplied staple foods; they raided adjacent cornfields from midsummer until fall; and they used upland oak-hickory areas as main foraging grounds during the fall and winter. These shifts, however, at no time involved travels of more than a few hundred yards, and in no sense did they take on the usual characteristics of migration.

In one wooded area on the Chautauqua Refuge containing mature oaks, pecans and hickories, in addition to elms, maples and other riverbottom species, seasonal shifts in the squirrel population (all fox squirrels) were much less distinct than those mentioned in the foregoing paragraph. Indeed, day-to-day travel here seemed to be confined to a small area, usually not more than a few acres, and often the vicinity of one or a small group of food trees. The annual range of the resident population covered only about 150 acres.

During the young-rearing period particularly, females seemed to confine their movements to the vicinity of their brood sites, which numbered from one to several. In both species local movements were most extensive during the fall.

When not disturbed by overhunting, fire, drought or lumbering, individual squirrels may spend an entire year or more in the vicinity of a given nest tree. Allen (1942) reported an example of a Michigan fox squirrel female that used a red maple as headquarters continuously from October, 1937, at least until observations were terminated in December, 1939.

Seton (1928) stated that a gray squirrel may live its entire life on a 100-acre plot. Goodrum (1940) considered the home range of this species to be 200 yards or less, but he believed that some individuals may cover 4 or 5 miles during the course of a year. Middleton (1930) intimated that gray squirrels in Great Britain seldom travel more than 100 yards from headquarters, but also stated that the species extended its range 35 miles in 5 years.

Migration

No evidence of migration in fox squirrels was observed in this study. Baumgartner (1938) writes: "General and regular migration of the fox squirrel is unknown." Allen (1943) states: "Fox squirrels have seldom been observed in mass movements similar to those of the gray, which was known in early days as the 'migratory squirrel.' " There are numerous reports of mass movements or migrations of gray squirrels covering considerable distances; in these movements the animals were not deterred even by the formidable widths of the Hudson, Ohio or Mississippi rivers. Seton (1928) associated this phenomenon with food shortage, overpopulation and cyclic influences. Chapman (1936) attributed it mainly to the first two reasons. Jackson (1910, 1921) cited two instances in which numbers of the gray squirrel, in one case possibly because of a food shortage, swam the Mississippi River from Wisconsin to enter Minnesota. Goodwin (1934) reported an extensive migration in the New England states in 1931 and 1933. Osgood (1938) reported a gray squirrel migration of small proportions in Vermont in 1935. According to the reports of numerous authors, the migrations covering the most territory, as well as involving the most individuals, occurred before the twentieth century.

Dispersal

According to Baumgartner (1940), the most extensive and important movement in fox squirrels "is the traveling associated with the annual readjustment of populations. This dispersal movement occurs between August 10 and September 15. The distances traveled at this time average about two or three miles, although two long records of 14 and 8 miles respectively were secured. This movement is responsible for the annual restocking of overhunted areas."

Allen (1943) indicates that a population shuffle occurs in Michigan fox squirrels. He states (1943) that " . . . it appears that increased activity among squirrels begins in late August, rises to a peak in late September, and is over by the middle of December."

Of the reasons for dispersal Baumgartner (1943*a*) writes: "The cause of this movement is controversial. The motivating factor is usually considered to be population pressure correlated with a shortage of food, yet it occurs when the food supply is greatest, almost simultaneously with the maturing of the nut crop. The moving squirrels are more noticeable when the population is high, and the writer believes the movement results from *intra-species intolerance*. This view is partially substantiated by the fact that no record of excessive fox squirrel populations, either in the literature or in the field, could be authenticated. Seven such reports were investigated but none showed more than two squirrels per acre."

Our evidence indicates that in Illinois a dispersal occurs in both fox and gray squirrels during the fall. Continuous and intensive live trapping on the Wade area over a 10-month period prior to August 8, 1942, resulted in the capture and marking of most if not all resident squirrels, since only one unmarked animal, a 1941 summer juvenile (female), was taken either by trapping or hunting during the period between July 12 and October 15, 1942. This individual was trapped on August 5, and it is likely that the squirrel had only recently moved onto the area from a woodland to the east. On August 8, 1942, the writers shot two fox squirrels (Nos. 11 and 26) and seven gray squirrels (Nos. 1, 5, 9, 13, 26, 33 and 50) on the Wade area. No unmarked animals were among these squirrels. In the period October 15 through 17 the senior writer shot 13 additional specimens, 5 fox squirrels and 8 gray squirrels, of which 1 fox and 2 gray individuals were unmarked. They were 1942 spring juveniles, and therefore subject to trapping and marking had they been present during the last 8 to 10 weeks of trapping. It is believed that these three animals had moved onto the area during the period of August 8 through October 17. Other than these three spring juveniles, six unmarked 1942 summer juveniles (one fox, five gray) were collected in mid October, 1942, but these may have been young born on the area and too small to be taken in live traps prior to August 8.

CONDITION

Weight and length measurements were taken of most squirrels collected, and information on diseases, parasites, deformities and pelage development was recorded when observed in the specimens.

Weight

Weights were obtained for a total of 706 fox squirrels and 317 gray squirrels. The data are given in table 9. In adults, weights were recorded by sex, but in juveniles the weights of the two sexes were lumped.

As indicated in table 9, there were no significant differences in weight between male and female adults in either species. Allen (1942, 1943) found female fox squirrels in Michigan to be slightly larger than males. A point of interest in the present study is that of size in juveniles at the time they began to enter hunters' bags in July. Spring juvenile fox and gray squirrels at that time had an average weight of 1.28 pounds and 0.84 pound, respectively. By late October or November, the spring juveniles of both species had reached approximately average adult

Table 9.—Weights, in pounds, of Illinois squirrels collected by the writers, 1940, 1941 and 1942.

Month	Fox Squirrels								Gray Squirrels							
	Adults				Spring Juveniles		Summer Juveniles		Adults				Spring Juveniles		Summer Juveniles	
	Males		Females						Males		Females					
	Number	Average Weight	Number	Average Weight	Number	Average Weight	Number	Average Weight	Number	Average Weight	Number	Average Weight	Number	Average Weight	Number	Average Weight
January	44	1.77	30	1.74	..	..	19	1.42	12	1.17	5	1.13	..	..	6	0.91
February	17	1.62	19	1.71	..	..	17	1.49	12	1.15	7	1.20	..	..	7	0.92
March	21	1.71	11	1.59	..	..	15	1.43	9	1.09	5	1.10	..	..	5	1.04
April	13	1.67	12	1.68	..	..	5	1.47	8	1.13	14	1.14	..	..	4	0.96
May	30	1.65	16	1.63	17	0.84	..	..	16	1.13	19	1.23	9	0.44	..	..
June	7	1.69	14	1.71	21	1.16	..	..	10	1.24	5	1.17	9	0.65	..	..
July	10	1.73	16	1.71	23	1.28	..	..	1	1.27	2	1.02	5	0.84	..	..
August	29	1.66	24	1.67	83	1.37	5	0.98	10	1.16	15	1.19	17	0.99	..	..
September	17	1.64	19	1.70	32	1.52	7	1.02	6	1.24	8	1.16	18	1.02	7	0.64
October	9	1.71	7	1.77	13	1.66	14	1.13	9	1.27	4	1.28	7	1.27	9	0.77
November	8	1.84	5	1.69	4	1.61	4	1.07	5	1.16	3	1.14	..	..	1	0.78
December	19	1.77	16	1.71	..	..	14	1.41	4	1.29	20	1.17	..	..	4	0.98
Total or Average	*224*	*1.70*	*189*	*1.69*	*193*	*1.34*	*100*	*1.26*	*102*	*1.18*	*107*	*1.18*	*65*	*0.89*	*43*	*0.86*

Table 10.—Lengths, in millimeters, of Illinois squirrels collected by the writers, 1940, 1941 and 1942.

Month	Fox Squirrels												Gray Squirrels											
	Adults						Spring Juveniles			Summer Juveniles			Adults						Spring Juveniles			Summer Juveniles		
	Males			Females									Males			Females								
	Number	Average Body Length	Average Total Length	Number	Average Body Length	Average Total Length	Number	Average Body Length	Average Total Length	Number	Average Body Length	Average Total Length	Number	Average Body Length	Average Total Length	Number	Average Body Length	Average Total Length	Number	Average Body Length	Average Total Length	Number	Average Body Length	Average Total Length
January	44	310	530	30	294	542	..	..	..	19	281	520	12	262	462	5	250	470	..	..	..	6	239	436
February	17	299	535	19	289	534	..	..	..	17	281	531	12	258	459	7	256	479	..	..	..	7	234	437
March	21	298	528	11	291	548	..	..	..	15	281	521	9	267	462	5	256	470	..	..	..	5	239	447
April	13	289	536	12	291	537	..	..	..	5	279	539	8	263	467	14	261	477	..	..	..	4	241	459
May	30	297	523	16	287	530	17	231	461	..	..	..	16	265	464	19	255	477	9	205	389	..	..	..
June	7	299	537	14	293	539	21	265	499	..	..	..	10	263	467	5	245	462	9	225	408	..	..	..
July	10	291	542	16	289	532	23	266	494	..	..	..	1	260	465	2	241	447	5	231	433	..	..	..
August	29	289	526	24	287	537	83	277	514	5	236	470	10	255	463	15	254	469	17	245	454	..	..	..
September	17	282	520	19	288	535	32	275	516	7	240	469	6	260	466	8	257	461	18	247	456	7	209	412
October	9	285	526	7	290	538	13	279	521	14	250	496	9	262	465	4	262	474	7	261	469	9	214	439
November	8	298	529	5	287	536	4	286	534	4	252	513	5	256	464	3	258	471	..	..	..	1	228	443
December	19	294	524	16	291	534	..	..	..	14	267	508	4	268	476	20	258	473	..	..	..	4	245	455
Total or Average	*224*	*296*	*528*	*189*	*290*	*537*	*193*	*270*	*507*	*100*	*268*	*512*	*102*	*263*	*464*	*107*	*256*	*472*	*65*	*238*	*439*	*43*	*245*	*438*

weight, representing gains in weight of about 33 or more per cent since July.

Development of summer or second-litter juveniles approximated that of spring or first-litter young in both species, and, as would be expected, summer-born animals taken the following September and October showed the lowest average weight of any age class in the kill at that time.

Length

Body and total lengths of 706 fox squirrels and 317 gray squirrels were recorded, table 10. All readings were taken in a standard manner (Anderson 1932). Length of the hind foot was taken for a large series, but the differences appeared so insignificant that taking of this measurement was discontinued.

Spring juveniles were first collected in May, at which time the average body length and total length in the fox squirrels were 231 millimeters and 461 millimeters, respectively, and, in the gray squirrels, 205 millimeters and 389 millimeters, respectively, table 10. By mid fall these measurements had increased, respectively, about 17 and 13 per cent in fox squirrels, and about 27 and 21 per cent in gray squirrels. The apparently greater rate of increase in gray squirrels may be accounted for by the 2-week difference in the average breeding dates of the two species, and, consequently, in the proportionally younger age of gray squirrels collected in May.

Summer juvenile fox squirrels, first collected in August, had an average body length of 236 millimeters at the time, and 267 millimeters in December. Summer juvenile gray squirrels were first collected in September. At that time their average body length was 209 millimeters. In December it was 245 millimeters.

Deformities

Only one type of deformity, that of stub tail, was noted in 706 fox squirrels and 317 gray squirrels handled by the writers. Ninety-five, or 13.5 per cent of all fox squirrels, and 39, or 12.3 per cent of all gray squirrels, showed this defect to a greater or less degree. This incidence of stub tail in the two species is considered surprisingly high. The deformity is well known to hunters, who commonly attribute it to fighting between males and the mating chase between males and females. We have no more logical explanation. In no case was the deformity observed to impede travel or any other activity.

Wounds

Six crippled squirrels, four fox and two gray, were collected by the writers.

Fig. 7.—Crippled female fox squirrel collected in Piatt County, February, 1945. The injury was probably caused by a steel trap or a .22 caliber bullet. Despite the injury and a case of mange, this female was pregnant and in good condition as to body fat.

These numbers represented little more than one-half of 1 per cent of the total number of animals collected, but they gave, of course, no true index of crippling loss, which hunters' questionnaires indicate are much higher, table 23. Animals showing imbedded shot but healed wounds, or missing toes probably due to shooting, were not counted among the cripples. In two cases, one in each species, bones of a hind leg were so badly shattered that recovery was improbable. Some seriously wounded squirrels undoubtedly make their way to cavities or nests, from which they probably never emerge. In all except one case, shotgun pellets were the cause of the crippled condition observed. A fox squirrel that recovered from a severe wound is shown in fig. 7.

Molt and Color

Fox and gray squirrels molt once a year, the two species having similar molting characteristics. The molt consists of two phases, the first involving the body and the second the tail. Males molt before females, beginning in the spring and concluding the process during the summer. Females appear to molt at any time between April and September, after their last young of the year have been born. Adult males and spring juveniles ordinarily molt before adult females, especially those producing second-season or summer litters. These adult females usually complete the molt in September.

Molting in both fox and gray squirrels requires 3 to 4 weeks. Progress in the body phase is from nose to tail; on the tail, molting begins at the distal end and progresses anteriorly to the base of the tail. In most individuals there is a definite line of demarkation between the new and old hair. When such a line is not present in molting animals, new hair is being replaced over a relatively wide area, the old and new hair tending to blend.

Few of the color patterns ordinarily found in squirrels were encountered in Illinois during the course of this study. One very reddish female fox squirrel was shot that may have been an example of erythrism. This was a mature animal, taken on August 7, 1942, while "cutting" a hickory nut. She was host to a very large ascarid. No distinct albino or melanistic individuals were taken. However, albino gray squirrels occur in considerable numbers in Olney, where they are said to have increased from an albino pair released some years ago. Melanistic squirrels have been reported from Ogle County and other northern Illinois localities. In an early report, Kennicott (1857) stated that of 50 gray squirrels killed near Rockford, Illinois, all were black. During the pioneer period, black squirrels were common in Michigan (Allen 1943), Indiana (Haymond 1869, Hahn 1909) and in other states. One adult male gray squirrel trapped in Pike County, February 25, 1941, had reddish thoracic hair and black abdominal hair. A juvenile male fox squirrel with blue eyes was trapped in Pike County, February 8, 1942. Baumgartner (1943*b*) reported nine different color patterns in Ohio fox squirrels, including melanistic, near albino, browntail, and variations of black and red or rufus.

PARASITES AND DISEASES

Several papers dealing with the parasites of squirrels, particularly fox squirrels, have been published. Katz (1939) brought most of this information together. Harkema (1936) studied the parasites of 53 gray squirrels in North Carolina, finding one species of tapeworm, one of round worm, three of mites, two of lice and one of flea. Chandler (1942) recently reported on the helminth worms of tree squirrels in southeast Texas; and Graham & Uhrich (1943) published on the external and internal parasites of the fox squirrel in southeastern Kansas. Baumgartner (1940) and Allen (1942, 1943) discussed briefly the parasites and diseases of fox squirrels in Ohio and Michigan, respectively; and Goodrum (1940) reported similarly for gray squirrels in Texas. The most prevalent parasites reported by all these authors were mange mites. No diseases of endemic nature other than mange were reported.

Most squirrels studied during 2 years of field work in this investigation were examined for mange, and for ticks and other external parasites. The same species of parasites were found to occur on both fox and gray squirrels. Mange (caused by *Sarcoptes* sp.) occurred to a noticeable degree in only 0.03 per cent of the 722 fox squirrels and 0.06 per cent of the 353 gray squirrels examined for this condition. Incidence of mange in all squirrels studied was 0.04 per cent. All zones were represented by the animals examined for parasites.

The degree of infestation was negligible in most woodland populations, but in some urban populations of both species a heavier rate prevailed. Woodland squirrels showing evidence of mange were found on only two localized areas, one the pin oak bottoms near Thomson in Carroll County, involving only fox squirrels, and the other near Griggsville in Pike County, involving both fox and gray squirrels. The first area showed an infestation of 47 per cent in a sample of 15 squirrels; the latter, 15 per cent in a sample of 94. The degree of infestation in Pike County was about the same in the two species. In both localities squirrels were collected during the breeding seasons, and in both infested individuals were apparently normally active. A female shot February 26, 1941, on the Thomson area had bare patches of skin on head, neck and back, yet contained three well-developed embryos. Another collected on February 17, 1945, near Monticello, Piatt County, had the left hind foot missing and was practically devoid of hair, due to mange, on the neck and thoracic regions, but this animal, fig. 7, likewise contained three normal embryos. None of the infested squirrels were in poor physical condition.

Practically every squirrel, fox and gray, was host to fleas; many animals carried the common dog tick; less than 1 per cent carried sucking lice. Dr. H. H. Ross of the Illinois Natural History Survey supplied the following notes on ectoparasites.

The same species of ectoparasites occur on both the gray and fox squirrels in Illinois.

Ticks (Ixodoidea)

Dermacentor variabilis (Say).—Taken very commonly on squirrels throughout Illinois. This is the common dog tick and occurs on many other mammals.

Parasitic Mites (Parasitoidea)

Several species of this superfamily of mites have been encountered on Illinois squirrels.

Fleas (Siphonaptera)

Orchopeas howardii (Baker).—Very common and frequently extremely abundant. This species has been found in great numbers in overwintering nests throughout Illinois.

Orchopeas nepos Rothschild.—Taken only rarely in Illinois.

Sucking Lice (Anoplura)

Hoplopleura sciuricola Ferris.—Taken only rarely in Illinois.

In addition to the above, chiggers undoubtedly occur on Illinois squirrels. Although we have no definite records for this state, Roger Williams, while at the University of North Carolina, found chiggers on squirrels. These chiggers belong to the mite genus *Trombicula* and allied genera.

In a small number of squirrels studied for internal parasites, one-third of the animals contained parasitic worms. Identification of these specimens was made by Dr. Lyell J. Thomas of the University of Illinois. The following remarks are quoted from his report.

No. 1.—Female fox squirrel, Thomson, Illinois, collected May 27, 1941: Eight cestode cysts in visceral cavity, identified as *Taenia pisiformis*. These generally occur in rabbits.

No. 2.—Female fox squirrel, Griggsville, Illinois, collected April 19, 1942: Several nematodes from intestine; all females, and identified as *Impalaia* sp., probably new.

No. 3.—Female fox squirrel, Griggsville, Illinois, collected August 7, 1942: One large male nematode from large intestine identified as *Ascaris* sp. (probably *A. lumbricoides*). Has been recorded from East Indian squirrels, but not, to my knowledge, from North American squirrels. Normal hosts are man and pig. Closely allied species occur in skunks and armadillos.

No. 4.—Female gray squirrel, Griggsville, Illinois, collected April 21, 1942: Three male and five female nematodes from intestinal tract identified as *Impalaia* sp., probably new. Two female nematodes from intestinal tract identified as *Mescistocirrcus* sp., probably new.

The four squirrels yielding the above endoparasites appeared to be in normal vigor, although none contained noticeable fat in the body cavity. The female that was host to the ascarid was reddish to the point of erythrism. The uterus showed five placental scars and the mammae contained milk. This squirrel weighed 1.59 pounds, was 544 millimeters in total length, and had about half completed the molt.

A female fox squirrel, too weak to escape, was captured alive near Urbana, Illinois, on April 11, 1941. Diagnosis in the Animal Pathology Laboratory of the University of Illinois revealed a fractured tibia and the presence of hepatic coccidiosis. On August 5, 1943, Dr. R. E. Yeatter of the Illinois Natural History Survey collected near Urbana a very weak female fox squirrel; diagnosis in the University's Animal Pathology Laboratory " . . . revealed the presence of small, circumscribed white foci in the liver and spleen. In view of these lesions and the history of the squirrel having been found sick, we regard the possibility of tularemia in this animal as being quite good . . . cultures were not made." This female had recently nursed young.

The writers and others of the Illinois Natural History Survey staff sometimes found dead squirrels in wood duck nest boxes. Usually these squirrels were so badly decomposed that cause of death could not be determined. The number of squirrels found dead was not great, and the over-all evidence suggests that no appreciable number of these animals die of diseases or the effects of parasitism.

PREDATION

Predation losses in squirrel populations are unimportant in Illinois. There are numerous published reports of squirrels being taken by hawks, owls, dogs and other predators, but the writers found little evidence that such losses reach serious proportions in this state. Extreme agility and a speed that attains a maximum of 12 miles per hour in the fox squirrel (Cottam 1941), and probably an equal speed in the gray squirrel, enable both species to elude most predators effectively.

In January, 1941, in the examination of 680 wood duck boxes, one weak male fox squirrel was found that showed conclusive evidence of having been attacked by a raptoral bird. Talon punctures on the dorsal surface reached to the body cavity. Mange was present under the forelegs and about the hocks. When released, the squirrel appeared dazed and climbed back to the box with difficulty. Two months later another inspection revealed that he had died in the box. No sign of gunshot or other injury could be found.

A northern Illinois coon hunter reported one instance of weasel predation on fox squirrels. This attack was at night. The hunter first heard a squirrel in a tree, then a crash, followed by a struggle on the ground. With the aid of a flashlight the hunter saw the squirrel and weasel plainly. The squirrel escaped, but it is not known how badly it may have been injured.

The senior writer once flushed a feral cat that was obviously trying to stalk a barking fox squirrel. On snow in northern Illinois he observed a red fox stalk a fox squirrel that was busily engaged in eating an Osage orange fruit, but the fox was frightened before reaching a springing position. On another occasion the senior author saw a red fox leap upon and capture a badly wounded fox squirrel, but shouts caused the fox to drop its victim and dash away.

Fox and gray squirrels caught in steel traps were occasionally attacked by hawks, free-ranging dogs and other predators. The red-shouldered hawk and red-tailed hawk were the only raptors actually flushed from trapped animals. A trapped fox squirrel, caught late in the afternoon, was killed during the night by a weasel. Dogs are known to have eaten three fox squirrels and one gray squirrel caught in traps. It is recognized, of course, that trapped squirrels attract the attention of predators and offer easy prey, making them unreliable criteria for measuring predation losses.

BREEDING

The term *breeding* as usually employed in this study includes pre-mating behavior, mating and such physiological aspects of breeding as oestrus, pregnancy, testes development and changes in the Cowper's glands.

During the period of investigation, data on breeding or young rearing were obtained from a total of 4,790 squirrels, which are listed in table 11 by species and according to time and manner collected.

The 1,075 squirrels shot or steel-trapped by the writers and used for detailed

Table 11.—Squirrels counted or collected for study in Illinois, 1940–1943.

How Collected or Counted	Period of Count or Collection	Number: Fox Squirrels	Number: Gray Squirrels	Number: Total
Fetal counts	July 1, 1940, to August 31, 1943	75	12	*87*
Litter counts	July 1, 1940, to April 15, 1942	87	19	*106*
Shot by writers, all zones	July 1, 1940, to October 31, 1943	381	182	*563*
Steel-trapped by Brown, all zones	July 1, 1940, to June 30, 1942	341	171	*512*
Live-trapped by Brown, Pike County	October 16, 1941, to August 7, 1942	64	61	*125*
Killed by hunters throughout Illinois	July 15 to November 15, 1940	955	577	*1,532*
	August 15 to November 15, 1941	1,413	452	*1,865*
Total		*3,316*	*1,474*	*4,790*

laboratory study were taken during every month of the year, table 12.

Breeding Seasons

Numerous workers have reported that both fox and gray squirrels are diestrus, that is, have two breeding seasons annually. Allen (1942, 1943), whose studies of the fox squirrel exceed in both scope and duration those of any other investigator, found that old females of this species (2 years or more) usually produce two litters per year, but that younger females ordinarily produce only one. Females from spring litters usually breed the following December or January, when about 11 months old, giving birth to their first young in late February or March. These young females usually do not breed

Table 12.—Month of collection, species and sex of squirrels studied in laboratory in Illinois, July, 1940, to October, 1942.*

Month	Fox Squirrel: Male	Fox Squirrel: Female	Gray Squirrel: Male	Gray Squirrel: Female
January	53	38	14	9
February	31	22	15	11
March	28	19	11	8
April	18	12	15	11
May	37	26	26	18
June	26	20	13	11
July	26	23	17	15
August	80	56	25	17
September	40	30	17	15
October	31	22	17	13
November	19	16	15	12
December	29	20	15	13
Total	*418*	*304*	*200*	*153*

*Includes 305 fox squirrels and 122 gray squirrels not used in breeding studies, tables 14 and 15.

a second time, that is, during the summer, in their first 18 months after birth. Females from summer litters are usually too immature to breed during the ensuing winter season, at an age of 7 months or less, but they breed during the following summer, at an age of about a year.

The gray squirrel has been found to have breeding dates almost paralleling those of the fox squirrel. Goodrum (1940) in east Texas reported two breeding seasons for the gray species, one beginning about December, with winter pregnancy reaching a peak in January or early February, and the second beginning in late May or early June, with summer pregnancy reaching a peak in August. In Kentucky, Hibbard (1935) also found the gray squirrel to have two breeding seasons.

Data on the two breeding seasons for fox and gray squirrels disclosed by the Illinois investigation, table 13, are in general agreement with the conclusions of Allen for the fox squirrel. In Ohio, Baumgartner (1940) indicates two fox squirrel breeding seasons, one from December to April and another from late May to early October. A logical explanation of the two peaks in the female cycle of Illinois squirrels, fig. 8 and table 15, is found in the fact that most old females, and females born the previous spring, breed during December, January and early February, and that little further breeding ensues until females born the previous summer, and old females producing second-season litters, reach the oestrus condition, usually in May or June.

The annual breeding cycle of males in Illinois was found to coincide approximately with that of females, but the two peaks are less distinct in the males, which appear to be in breeding condition continuously from late fall to midsummer, although a minor decline is apparent in February and March, fig. 9 and table 14. The data indicate that males are in breeding condition earlier than females. Cessation of breeding occurs in midsummer.

Table 13.—Generalized peak mating dates of squirrels in three Illinois zones, based mainly on 2 years of study, July 1, 1940, to June 30, 1942.

SPECIES	FIRST SEASON			SECOND SEASON		
	Southern Zone	Central Zone	Northern Zone	Southern Zone	Central Zone	Northern Zone
Fox squirrel....	December 15–25	December 25–January 5	January 5–15	May 25–June 5	June 5–15	June 15–25
Gray squirrel...	January 1–10	January 10–20	January 20–30	June 15–25	June 25–July 5	July 5–15

Our studies indicate that between the northern and southern limits of Illinois there is a difference of about 3 weeks in the average breeding dates for both fox and gray squirrels, the season being progressively later south to north, as would be expected. The breeding peak for gray squirrels, zone for zone, is about 10 days to 2 weeks later than for fox squirrels. These variations appear to hold roughly, in old squirrels, for both the first and second breeding seasons. In table 13 generalized breeding dates of Illinois squirrels are given.

It should be understood that dates given in table 13 are based on only 2 years of study, and that breeding periods are subject to fluctuation from year to year. Such fluctuation may include dates either earlier or later than the dates given, and, while the extent of fluctuation is not known, it is believed not to exceed one week.

Several criteria were used in arriving at peak breeding dates. As discussed below and illustrated in figs. 10 and 11, these criteria were average testes length, average testes weight, average diameter of Cowper's glands and evidence of oestrus. In the first three characteristics, all peculiar to males, there was close similarity but not exact uniformity in the two species. In both fox and gray squirrels, testes length and weight peaks were reached before or by the time of peak mating. It is evident that none of the criteria based on male organs are fully satisfactory for determining the breeding seasons, and for this reason we have placed greater reliance in the percentage of females showing oestrus, fig. 8, assuming that peak oestrus and mating occur simultaneously, or nearly so. Dates given in table 13 are in general agreement with findings reported by other workers.

The chronology of squirrel breeding data in Illinois, including the earliest, latest and peak dates for various reproductive activities or conditions, are given in table 16. Peak dates are applicable

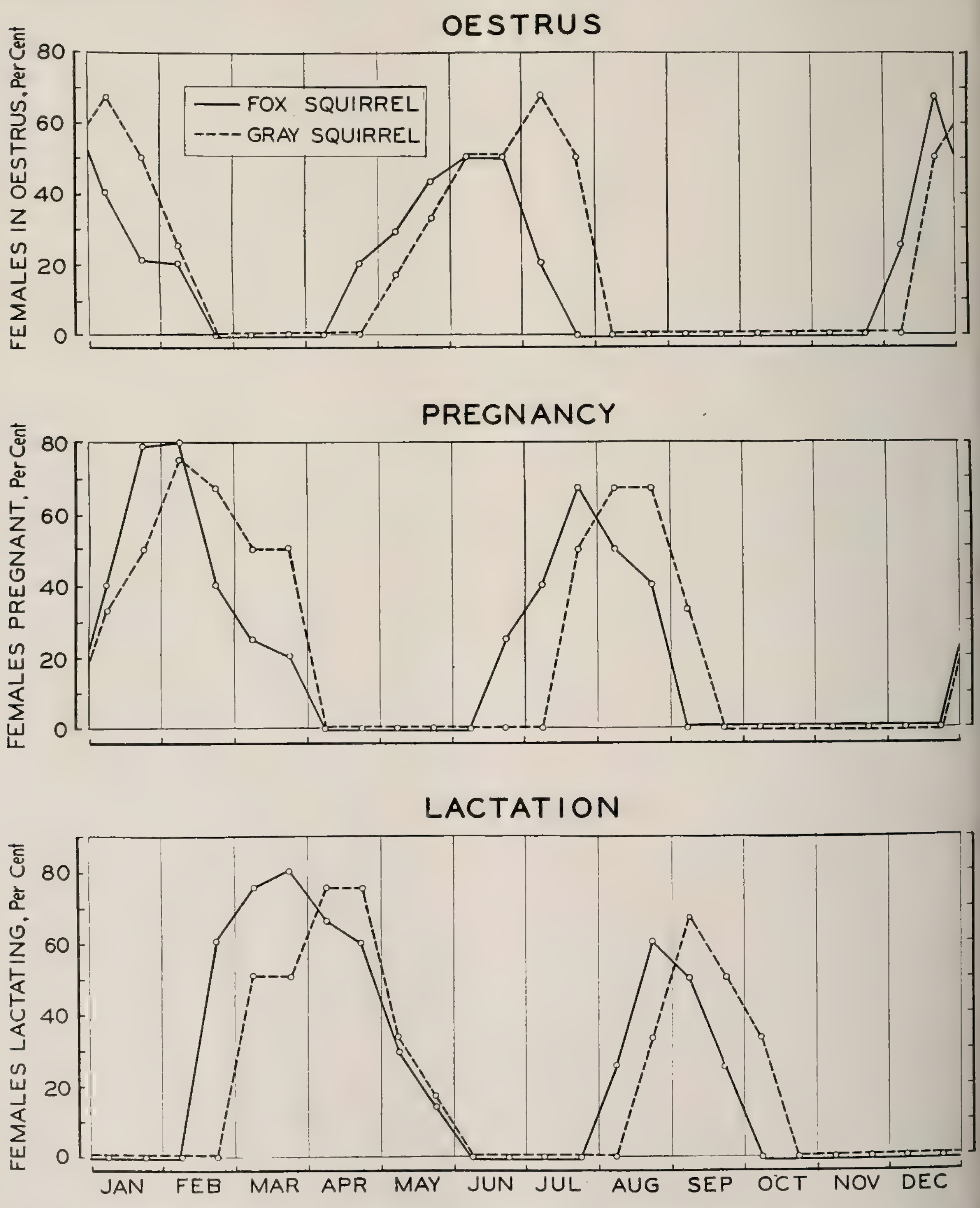

Fig. 8.—Breeding seasons in female squirrels in Illinois, 1940–1942.

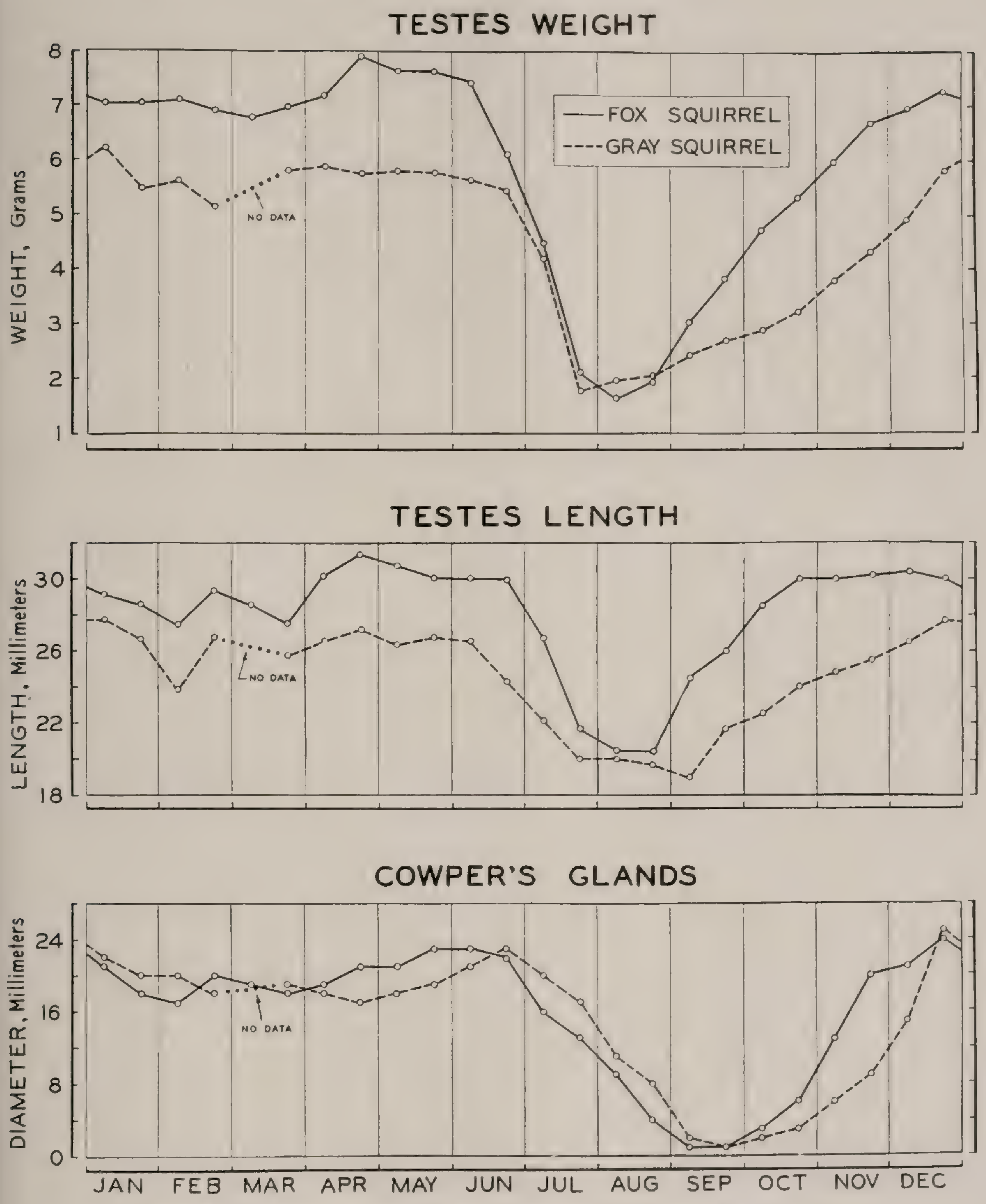

Fig. 9.—Breeding seasons in male squirrels in Illinois, 1940–1942.

particularly to the central zone; in the northern and southern zones, the time of corresponding peaks may, in general, be expected about 6 or 7 days later and earlier, respectively.

Duration of the oestrual period, on the basis of evidence at hand, is approximately 10 days. Peak dates for pregnancy and lactation are less easily established, since gestation requires about 45 days and nursing continues for 8 to 10 weeks. Averages of all data, tables 15 and 16, indicate that pregnancy peaks in fox squirrels were reached about February 1–15 and July 16–31; in gray squirrels, February 10–25 and August 5–20. Lactation peaks in fox squirrels occurred during the months of March and August; in gray squirrels April and September.

Considerable overlap was found in the two breeding and young-rearing seasons. Ending the first season was a lactation

Table 14.—Breeding activity in adult male squirrels in Illinois; data obtained mainly July 1, 1940, to June 30, 1942.*

Breeding Characteristic	January 1–15	January 16–31	February 1–15	February 16–29	March 1–15	March 16–31	April 1–15	April 16–30	May 1–15	May 16–31	June 1–15	June 16–30	July 1–15	July 16–31	August 1–15	August 16–31	September 1–15	September 16–30	October 1–15	October 16–31	November 1–15	November 16–30	December 1–15	December 16–31
Fox Squirrel																								
Males	27	15	9	12	10	9	10	5	12	15	6	8	6	6	12	19	12	7	5	4	5	4	10	11
Adult males	21	12	6	8	7	6	8	4	10	11	2	5	4	2	5	7	6	3	1	2	2	2	7	8
Weight of both testes (adults), average in grams	7.07	7.07	7.19	6.82	6.69	6.88	7.31	7.84	7.68	7.68	7.36	6.21	4.49	2.09	1.64	1.94	3.08	3.78	4.74	5.41	5.92	6.66	6.88	7.38
Length of testes (adults), average in mm.	29.1	28.5	27.4	29.3	28.5	27.5	30.1	31.3	30.7	30.0	30.0	29.9	26.7	21.7	20.5	20.4	24.5	26.0	28.5	30.0	30.0	30.2	30.4	30.0
Diameter of Cowper's glands (adults), average in mm.	21.0	18.0	17.0	20.0	19.0	18.0	19.0	21.0	21.0	23.0	23.0	22.0	16.0	13.0	9.0	4.0	1.0	1.0	3.0	6.0	13.0	20.0	21.0	24.0
Gray Squirrel																								
Males	2	8	7	4	2	6	5	8	5	16	3	4	3	5	7	8	4	2	2	5	5	4	6	7
Adult males	2	5	5	2	0	6	4	6	4	13	2	2	2	1	4	5	2	1	2	1	3	2	4	7
Weight of both testes (adults), average in grams	6.16	5.43	5.56	5.10	.....	5.73	5.80	5.66	5.73	5.73	5.60	5.40	4.20	1.77	1.94	2.10	2.42	2.68	2.86	3.18	3.78	4.42	4.88	5.80
Length of testes (adults), average in mm.	27.7	26.6	23.8	26.7	.....	25.7	26.5	27.1	26.3	26.7	26.5	24.3	22.1	20.0	20.0	19.7	19.0	21.7	22.5	24.0	24.8	25.5	26.5	27.7
Diameter of Cowper's glands (adults), average in mm.	22.0	20.0	20.0	18.0	.....	19.0	18.0	17.0	18.0	19.0	21.0	23.0	20.0	17.0	11.0	8.0	2.0	1.0	2.0	3.0	6.0	9.0	15.0	25.0

*Measurements of testes length to nearest 0.1 millimeter; diameter of Cowper's glands to nearest millimeter; weight of testes (pair) to nearest 0.01 gram.

Table 15.—Breeding activity in adult female squirrels in Illinois; data obtained mainly July 1, 1940, to June 30, 1942.

Breeding Activity	January		February		March		April		May		June		July		August		September		October		November		December	
	1–15	16–31	1–15	16–29	1–15	16–31	1–15	16–30	1–15	16–31	1–15	16–30	1–15	16–31	1–15	16–31	1–15	16–30	1–15	16–31	1–15	16–30	1–15	16–31
Fox Squirrel																								
Females	12	18	7	8	5	8	4	6	8	11	5	6	8	6	10	12	9	6	3	4	4	4	7	7
Adult females	10	14	5	5	4	5	3	5	7	7	2	4	5	3	4	5	2	4	2	1	1	2	4	6
Adult females in oestrus, number	4	3	1	0	0	0	0	1	2	3	1	2	1	0	0	0	0	0	0	0	0	0	1	4
Adult females in oestrus, per cent	40	21	20	0	0	0	0	20	29	43	50	50	20	0	0	0	0	0	0	0	0	0	25	67
Adult females pregnant, number	4	11	4	2	1	1	0	0	0	0	0	1	2	2	2	2	0	0	0	0	0	0	0	0
Adult females pregnant, per cent	40	79	80	40	25	20	0	0	0	0	0	25	40	67	50	40	0	0	0	0	0	0	0	0
Adult females lactating, number	0	0	0	3	3	4	2	3	2	1	0	0	0	0	1	3	1	1	0	0	0	0	0	0
Adult females lactating, per cent	0	0	0	60	75	80	67	60	29	14	0	0	0	0	25	60	50	25	0	0	0	0	0	0
Gray Squirrel																								
Females	5	2	4	4	4	2	4	5	6	8	4	4	4	5	4	6	4	4	4	2	2	5	5	6
Adult females	3	2	4	3	2	2	4	4	6	6	2	2	3	2	3	3	3	2	3	0	0	2	2	4
Adult females in oestrus, number	2	1	1	0	0	0	0	0	1	2	1	1	2	1	0	0	0	0	0	0	0	0	0	2
Adult females in oestrus, per cent	67	50	25	0	0	0	0	0	17	33	50	50	67	50	0	0	0	0	0	0	0	0	0	50
Adult females pregnant, number	1	1	3	2	1	1	0	0	0	0	0	0	0	1	2	2	1	0	0	0	0	0	0	0
Adult females pregnant, per cent	33	50	75	67	50	50	0	0	0	0	0	0	0	50	67	67	33	0	0	0	0	0	0	0
Adult females lactating, number	0	0	0	0	1	1	3	3	2	1	0	0	0	0	0	1	2	1	1	0	0	0	0	0
Adult females lactating, per cent	0	0	0	0	50	50	75	75	33	17	0	0	0	0	0	33	67	50	33	0	0	0	0	0

Table 16.—Chronology of breeding in female squirrels in Illinois; data obtained mainly July 1, 1940, to June 30, 1942. Peak dates are applicable particularly to central zone.

Species	Reproductive Activity*								
	Oestrus			Pregnancy			Lactation		
	Earliest	Peak	Latest	Earliest	Peak	Latest	Earliest	Peak	Latest
First Season									
Fox squirrel	December 11	December 30	January 27	January 1	February 1–15	March 22	February 20	March	May 27
Gray squirrel	December 16	January 15	February 11	January 13	February 16–29	March 29	March 1	April	May 31
Second Season									
Fox squirrel	April 20	June 10	July 11	June 19	July 16–31	August 29	August 4	August	September 22
Gray squirrel	May 5	June 30	July 27	July 5	August 5–20	September 9	August 18	September	October 8

*Peak dates determined by averaging data from first and second breeding seasons in the first 2 years of study. Pregnancy peaks are given for a 2-week, and lactation peaks for a 4-week, period.

record for May 27 in fox squirrels, and for May 31 in gray squirrels. These dates marked the latest that first season lactation was observed in the two species, and came after the earliest observed dates of second-season oestrus, which were April 20 in fox squirrels and May 5 in gray squirrels. Since it is probable that neither the latest nursing nor the earliest oestrus was observed, overlap in the two seasons may be greater than indicated in table 15. This table indicates that completion of summer mating in July was distinct; pregnancy extended into late August in fox squirrels and into September in gray squirrels; lactation continued into September in fox squirrels and into October in gray squirrels.

Table 17.—Dates of first and last reproductive activity and duration of squirrel breeding seasons (all zones) in Illinois; data obtained mainly July 1, 1940, to June 30, 1942.

Species	First Season			Second Season		
	Dates of First and Last Reproductive Activity		Days	Dates of First and Last Reproductive Activity		Days
	Oestrus	Lactation		Oestrus	Lactation	
Fox squirrel	December 11	May 27	168	April 20	September 22	155
Gray squirrel	December 16	May 31	167	May 5	October 8	155

The writers believe that most of the females not breeding during the first or winter season fail to do so because of immaturity or senility. Of the two causes, immaturity is probably the more common. Probably poor physical condition is the most important cause of the failure of some old females to produce the second-season litter.

The first and last dates of reproductive condition or activity observed in Illinois during this study and the apparent season duration are given in table 17. Season length appears to be about the same in the two species.

Mating Chase

The most obvious indication of breeding seasons in squirrels is the mating chase. Fox squirrels appear to be shier than gray squirrels in their mating activities. During the present study, the number of mating chases observed, in proportion to populations, was less in fox squirrels; likewise, the average number of fox squirrels per chase was less. Seldom were more than three fox squirrels observed in a single chase, whereas, in gray squirrels, observations were made on chases of nine and of six animals, and many of five or less. The average mating group, however, even in gray squirrels, involved only three or four animals. Chases were enacted indiscriminately in trees, on logs and on the ground.

In the chase in which nine gray squirrels participated, two of the animals were females, and it is believed that the remaining seven were males, one a juvenile. The two females barked continuously. One female, despite her calling, turned and fought the nearest male when pursued too closely; the other, when chased into isolated positions, such as the smaller branches of a tree, was mounted by several males, but copulation was not observed. One of the females was mounted as she raced up a tree, but she fell upon reaching the top, whereupon the male lost his position. The nearest pursuing male often turned to drive back his rivals. This chase covered an acre of dense undergrowth, lasted about 20 minutes, and was well advertised by continuous barking and noisy quarreling. Chases involving a large number of squirrels sometimes split into two or more separate chases. The chases involving nine and six gray squirrels, respectively, occurred late in the forenoon. Observations similar to the foregoing were made by Baker (1944) in Texas.

In both species, barking or "chatting" was noticed more in December than in any other month, but it was more or less common throughout the summer, fall and early winter. Intermittent barking may occur during any month. Although barking is characteristic of mating behavior, it may, of course, denote alarm, surprise, anger and probably other reactions.

Physiological Aspects

In studying the physiological aspects of breeding, it was necessary, due to limitations of personnel and to field conditions, to rely upon gross laboratory examination rather than the more precise technique of vaginal smears and gonad sectioning with microscopical study.

Mossman, Lawlah & Bradley (1932), who studied the male squirrel reproductive tract, including the Cowper's glands, reported the male reproductive organs in fox and gray squirrels to be similar.

Testes.—In both species the testes, fig. 10 and table 14, began to enlarge in September. In mature males, enlargement was from a flaccid to a turgid condition. For the first breeding season the maximum average testis length, December 1–15, was 30.4 millimeters in fox squirrels, and, December 16–January 15, 27.7 millimeters in gray squirrels. Testis length during the second breeding season was slightly greater than in the first or winter season in fox squirrels, but slightly less in gray squirrels. Following the second season, the testes became much smaller and apparently inactive; the minimum average length in mature males for any 15-day period was 20.4 millimeters in fox squirrels and 19.0 millimeters in gray squirrels. These measurements were reached in late August and early September, respectively. At this time, the testes may have been drawn into the abdominal cavity, and the dormant-like condition have continued until some time in September, when the organs began an increase in size that continued until the winter maximum was reached. Testes measurements for juvenile males were, of course, much smaller than for adults, the difference being greater in the fall than in the spring.

Weight of testes, which may be a somewhat more accurate indication of breeding stage than testes length, showed greater fluctuation during the breeding seasons than the length measurement. In fox squirrels, peak average weights of 7.38 grams and 7.84 grams for the testes were reached in late December and late April, respectively. In gray squirrels, corresponding data, less reliable due to fewer samples, averaged 6.16 grams for the testes early in January and 5.73 in May; the average of a small number of samples in early April was 5.80 grams. Adult and juvenile testes are illustrated in fig. 10.

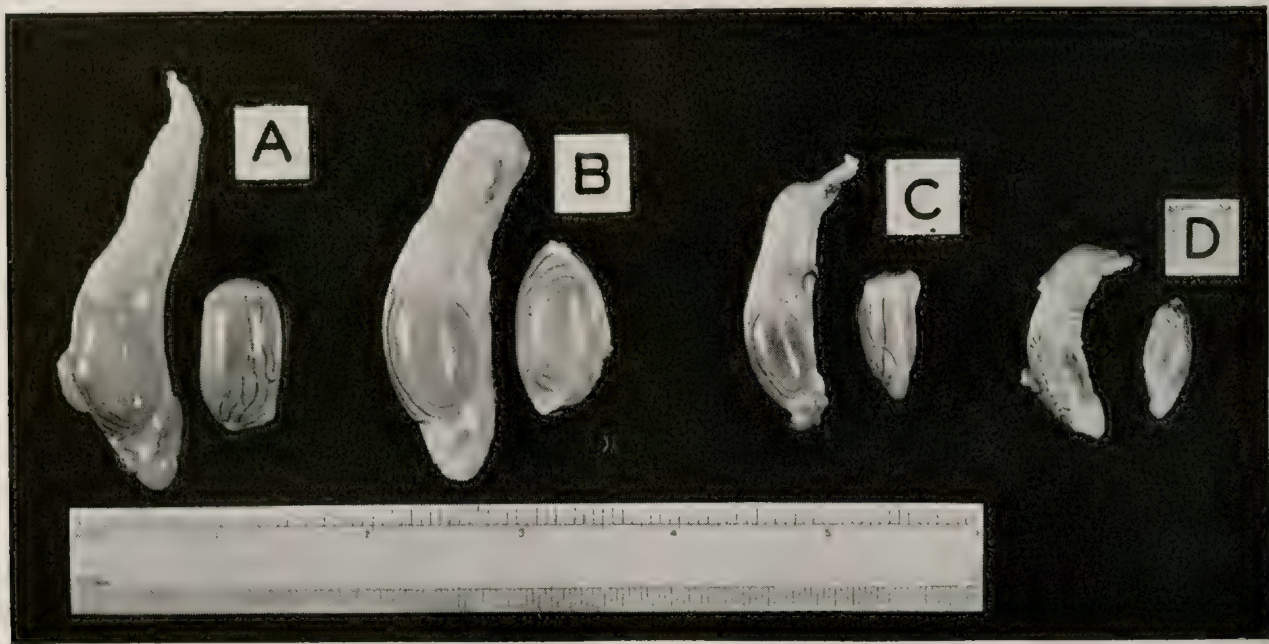

Fig. 10.—Testes of adult and juvenile squirrels. *A*, adult fox squirrel; *B*, adult gray squirrel; *C*, juvenile fox squirrel; *D*, juvenile gray squirrel. Epididymis removed in right example of each pair. Coles and Piatt counties, late January, 1944.

Cowper's Glands.—The location, large size and relationship to breeding activity of the Cowper's glands make them a good criterion by which to judge the sexual condition of males. These glands, fig. 11, are paired, discoid bodies, the function of which is production of sperm-carrying fluid. The glands, coiled like a Polygyra snail shell, are situated one on each side of the rectum. Connection with the penis is by duct. When turgid, these glands extend posteriorly, distending the anal orifice and increasing the average body length by about 10 millimeters.

Enlargement in the Cowper's glands in both species was first observed in October, after which development was rapid. The maximum diameter of the glands in each species was about 25 millimeters, reached during the latter half of December. The spring maximum observed was about 23 millimeters, attained about the end of May in fox squirrels and the last 2 weeks of June in gray squirrels. The number of gray squirrels examined was so small that the data for them may not be representative; comparable data for the fox squirrel indicate that the peak diameter of Cowper's glands in the gray squirrel was reached earlier in June than is shown in table 14. Following cessation of breeding in the summer, these glands became dormant and decreased so greatly in size that, in August, September and October, they were difficult to find, even by dissection of the animals.

Scrotum.—Field observations showed that, as the breeding season progressed, the scrotum became comparatively smooth, and both skin and hair assumed an oily, brown-stained appearance, fig. 5. Following the mating season, in June or later, the scrotum lost this rubbed, blackened appearance through sloughing of the skin and replacement of hair and underfur in the molting process. The new skin of the sac was of lighter pigmentation, as in juvenile males, fig. 5. In old squirrels, the loose saclike condition of the scrotum prevailed, whereas in juveniles, because of the more abdominal position of the testes, the scrotum was less pendent.

Oestrus.—The earliest evidence of first-season or winter oestrus observed in fox squirrel females was December 11 in Alexander County (southern zone), tables 15, 16 and 17. The latest oestrus records for the first season in the southern and central zones were January 27; the two observations were a year apart. In gray squirrels the earliest evidence of winter oestrus was December 16, and the latest was February 11, both observations in the southern zone.

The external indication of oestrus, commonly called "heat," is a swollen, protruding condition of the vulva. During oestrus the uterus is enlarged and congested with blood, by which the vulva is commonly discolored. This condition is easily observed in external examination. Following copulation the congested condition of the uterus clears. The uterus becomes spongy and thick-walled, and fetal nodes, 3 millimeters in length, appear about 10 days after successful coitus.

Pregnancy.—An attempt was made early in the survey to distinguish oestrus and early pregnancy by the use of vaginal smears, but this proved impractical under conditions prevailing in the field. The oestrual period thus was probably not distinguished as precisely as is desirable, and perhaps an unknown number of very early pregnancies were listed under the heading of oestrus. Pregnancy could be determined with some certainty by noting the relaxed and perforated state of the vulva and development of the mammae. Somewhat advanced stages of pregnancy (15 millimeter fetuses) could be detected by palpating the lower abdomen.

The earliest and latest first-season pregnancy records for fox squirrels were January 1 (one animal with 3 fetuses averaging 6 millimeters in length) and March 22 (one animal with 3 fetuses averaging 19 millimeters in length), table 16. The first-season peak of fox squirrel pregnancy, based on 43 adult females, 23 of them pregnant, table 15, came during the first half of February. In gray squir-

Fig. 11.—Glans penis and urethra of adult male squirrel, with Cowper's glands attached in an uncoiled and in a nearly natural position in each case. Left, fox squirrel; right, gray squirrel. Coles County, late January, 1944.

rels, the earliest and latest pregnancy records were January 13 (one animal with 2 fetuses averaging 4 millimeters in length) and March 29 (one animal with 3 fetuses averaging 15 millimeters in length), table 16. Peak gray squirrel pregnancy for the first season, based on 16 adult females, 9 of them pregnant, came about the middle of February, table 15. The earliest and latest second-season pregnancy records were June 19 and August 29 for fox squirrels, and July 5 and September 9 for gray squirrels, table 16. Fox squirrel females taken on August 15 and 29 each contained 2 fetuses; those of the first averaged 20 millimeters in length and those of the second 48 millimeters. Fig. 12 shows embryos at the age of about 15 days in the uterus of a fox squirrel.

Gestation.—Previous writers have reported difficulty in determining exactly the

Fig. 12.—Uterus of pregnant fox squirrel. Right horn contains two normal fetuses and one apparently in process of being resorbed.

Fig. 13.—Lactating gray squirrels, Coles County, September 15, 1944. Note distended appearance of mammary glands and nipples.

gestation period in squirrels. Allen (1942, 1943) and Lyon (1936) indicated that gestation in fox squirrels is probably about 45 days. Since the oestrual peak in this species in Illinois, as determined by the present study, was late in December and early in January, a 45-day term would place the birth peak in February. The oestrus records in table 15 and the birth records in table 18 indicate that the gestation period in Illinois fox squirrels is about 45 days. Seton (1928, 4:44), quoting Powers, gives the gestation period in gray squirrels as 44 days. Goodrum (1940) and Baumgartner (1940) also considered that 44 days was the probable term. The oestrus-mating peak in the small number of gray squirrels observed in the Illinois study was early or mid January, table 15, and the birth peak was early March, table 18, indicating an average gestation period of about that suggested by Goodrum, Baumgartner and other authors mentioned above.

Mammae.—In both fox and gray squirrels, the mammae are eight in number and are arranged in four pairs, occupying the ventral body surface behind the forelegs, fig. 13. Allen (1942) designated the mammae positions as pectoral 1, pectoral 2, abdominal and inguinal. He stated that, in the fox squirrel, the abdominal pair develops first following insemination, and that the usual order of development is abdominal, inguinal, pectoral 2 and pectoral 1. In some cases, however, Allen found that the pectoral 2 and abdominal pairs developed equally, or the former preceded the latter in development. The pectoral 1 pair may not be functional in some cases. Milk can be squeezed from the nipples a few days before the young are born and, in some cases at least, for 2 or 3 weeks after the young are weaned. Thus the glands may contain milk for 3 months or more subsequent to parturition.

The teats and mammary glands of squirrels develop rapidly after pregnancy begins. In both species, the teats swell and become black pigmented. The glandular tissue becomes thickened and spreads to cover the ventral body surface. Hair on the mammae of nursing females becomes worn and matted, and the nipples show an obviously distended and stretched condition, fig. 13. On cessation of lactation the teats become greatly reduced and, in fox squirrels at least, the black pigmented condition of the nipples remains apparent, fig. 6.

YOUNG REARING

In the term *young rearing,* as it is usually employed in this paper, are included the biological phenomena associated with young squirrels.

Birth Dates

In the spring of 1941 birth dates were estimated for 35 litters of fox squirrels and 4 litters of gray squirrels. Most of

Table 18.—Birth dates by 2-week periods for 35 fox squirrel litters and 4 gray squirrel litters in Illinois, all zones, spring, 1941.

Species	February		March		April
	1–15	16–28	1–15	16–31	1–15
Fox squirrel	0	20	11	4	0
Gray squirrel	0	1	2	1	0

Table 19.—Aging criteria for juvenile fox squirrels in Illinois. Data obtained principally from caged animals, which were weaned at the age of about 10 weeks.

Age in Weeks	Condition of Eyes	Condition of Ears	Condition of Incisors		Average Weight in Pounds*	Pelage
			Lower	Upper		
1	Closed	Closed	Not erupted	Not erupted	0.05	Naked, except for bristles on chin and nose; claws well developed; body dark pinkish.
2	Closed	Closed	Not erupted	Not erupted	0.12	Black bristles prominent.
3	Closed	Closed	Showing	Not erupted	0.15	Grayish-brown hair on dorsal surface.
4	Open (milky)	Closed	1 mm.	Not erupted	0.23	Short brownish hair covering body.
5	Open (clear)	Closed	2 mm.	Showing	0.31	Guard hairs on tail ¼ inch or longer.
6	Open	Closed or open	3 mm.	1 mm.	0.36	Brownish hair turning rufus.
7	Open	Open	4 mm.	2 mm.	0.41	Tail beginning to bush out.
8†	Open	Open	5 mm.	3 mm.	0.45	Hair well developed, tail bushed out.

*Average of 7 individuals weighed at weekly intervals.
†Squirrels 9 and 10 weeks old similar in appearance to these in eighth week but larger.

the litters had been born in wood duck nest boxes, but a few of the fox squirrels in leaf nests. The distribution of estimated birth dates by 2-week periods is shown in table 18.

In addition to the fox squirrel births included in table 18 were those involving two nursing females taken on February 20 and another on February 21. In these animals the uterus had returned to approximately normal size and all showed placental scars. Scars do not appear until the uterus has cleared, several days following birth of the young.

The earliest first-season birth date estimated for Illinois gray squirrels (only four litters observed) was February 20 and the latest March 18. One pregnant gray squirrel female, almost to term, was taken March 29, indicating first-season young are born at least through March.

No birth records were obtained for the second season in 1941, or for either the first or second season in 1942. From the numerous records of oestrus, pregnancy and lactation in both species, however, the birth peaks can be approximated.

Birth Sites

Because squirrel dens and leaf nests are discussed later in this report, no details on birth sites are given here. Although young are born in both cavity and leaf nests, it appears that the cavity type is preferred. More litters were found in natural cavities than in leaf nests, and many litters were found in boxes constructed and erected for wood ducks. The senior author checked, on the Mason County State Forest, a total of 89 leaf nests during the first half of April and found only 2 litters of partly grown fox squirrels. Only fox squirrels inhabited this area. Goodrum (1940) states that in east Texas gray squirrels are usually born in hollows of trees, but that they may be transferred to leaf nests. Both species move their young from nest to nest when disturbed. On such occasions the mother grasps the young in her mouth, in the manner of a cat moving her kittens.

Lactation

The young of both fox and gray squirrels nurse for 8 weeks or more. The earliest and latest records of lactation during the first season are for fox squirrels, February 20 and May 27; for gray squirrels, March 1 and May 31, table 16. Most fox squirrel females had finished nursing by May 1; most gray squirrel females by May 15. Lactation data for both species and for both breeding seasons are given by 2-week periods in table 15.

As indicated in table 15, lactation in the Illinois fox squirrels studied was most prevalent in March and August, when 78 and 44 per cent, respectively, of the adult females handled showed this condition. In gray squirrels, lactation was most prevalent in April and September, when 75 and 60 per cent, respectively, of the adult females handled were nursing. In some females the cessation of lactation was found to be delayed. In both species, females showing second-season oestrus still carried first-season milk, which could readily be exuded by pinching the nipples. The young observed during the study were weaned when about 8 or 10 weeks old.

Development of Young

Fox squirrels handled shortly after birth were 50 to 60 millimeters in length and weighed 14 to 18 grams (about one-half ounce). They were dark pinkish, naked, except for vibrissae about the nose and chin, and virtually helpless. The claws were well developed. Both the eyes and ears were closed, and neither the upper nor lower incisors had erupted. The vibrissae grew rapidly, and hair first appeared on the upper dorsal surface at an age of 8 or 10 days. Further growth characteristics are detailed in table 19, data for which were obtained principally from caged animals.

Because of a growth differential between caged and wild specimens, the data in table 19 may vary from corresponding data for wild squirrels by 2 or 3 days. Information relating to pelage is probably subject to wider variation than that pertaining to eyes, ears, teeth or weight.

There was no opportunity during the study to weigh or measure gray squirrels at birth. These animals are smaller and somewhat lighter in color than fox squirrels.

At weaning age, or during late April and May and late August and September

Table 20.—Litter size in Illinois squirrels (all zones) as indicated by nest, fetus and placental scar counts, 1941 and 1942.

Year	Litters*		Fetuses				Placental Scars				Litter Averages					
	First Season		First Season		Second Season		First Season		Second Season		First Season		Second Season		First and Second Seasons	
	Number Litters	Average	Number Litters	Average	Number Litters	Average	Number Litters	Average	Number Litters	Average	Number Litters	Average	Number Litters	Average	Number Litters	Average
Fox Squirrel																
1941	26	2.65	10	2.50	4	2.75	3	2.66	1	3.00	39	2.61	5	2.80	44	2.63
1942	7	2.71	10	2.30	7	2.28	15	2.20	2	3.00	32	2.34	9	2.44	41	2.36
1941–1942	*33*	*2.66*	*20*	*2.40*	*11*	*2.45*	*18*	*2.27*	*3*	*3.00*	*71*	*2.49*	*14*	*2.57*	*85*	*2.51*
Gray Squirrel																
1941	5	3.00	2	2.00	1	3.00	2	2.50	5	2.40	9	2.66	6	2.50	15	2.60
1942	1	4.00	1	3.00	1	2.00	16	2.68	0	....	18	2.77	1	2.00	19	2.73
1941–1942	*6*	*3.16*	*3*	*2.33*	*2*	*2.50*	*18*	*2.66*	*5*	*2.40*	*27*	*2.74*	*7*	*2.43*	*34*	*2.68*

*No second-season records were obtained for post-birth litters; most first-season records were obtained from litters born in nest boxes erected for wood ducks.

for most individuals, fox squirrels were found to average about one-half pound in weight; gray squirrels, on the basis of a very few samples, about one-third pound or somewhat less. By mid June, young fox squirrels handled averaged slightly more than 1 pound, and young gray squirrels about 0.6 pound.

At the time of weaning the pelage in both species, including that of the tail, was well developed. The young animals were active, being able to leave the nest and, with some awkwardness, to forage for buds and other food. Manual dexterity in gray squirrels seemed to develop somewhat more rapidly than in fox squirrels. At or near weaning age the young of both species began to join the adults in travels, and were often observed in litter groups feeding on elm seeds and buds in the spring, and acorns and hickory nuts in the late summer and early fall. It is doubtful, however, if 8- to 10-week old squirrels are fully self-sustaining. Allen (1942, 1943) considers that fox squirrels are not self-sustaining until they are between 3 and 4 months old, a belief shared by the present writers. Development in first- and second-season squirrels appears to be at about the same rate.

Litter Size

The average size of litters in Illinois squirrels was determined by counts of young in nests, of fetuses and placental scars, table 20. As found from study of 85 litters of fox squirrels and 34 litters of gray squirrels, the average size of litters in grays was somewhat larger than that in fox squirrels, but the difference was not significant. Neither was there a great difference in the size of the first- and second-season litters in either species. Gray squirrels showed the larger average in the first season; fox squirrels the larger in the second season.

During the course of this study, interesting data were gathered on the possible effect of food quality on fecundity. The investigation was conducted mainly on the rougher, wooded parts of Illinois, where soil fertility is comparatively low, and where the staple squirrel foods consist principally of nuts, acorns, fruits, berries and buds. Other investigators in Illinois, working on the more fertile agricultural areas where corn is the main staple, found that litter size in fox squirrels there was larger than was found by the writers on wooded range, table 21.

The nutritional value of corn is probably greater than that of the combination of nuts, acorns, buds and fruits of wooded localities, and since, on most Illinois farms, corn is abundant at all seasons, either at cribs or in fields, farmland fox squirrels in this state are well nourished. Most woods-inhabiting squirrels in Illinois appear to suffer no serious food shortages,

Table 21.—Litter size in fox squirrels in two types of Illinois habitat, 1941 and 1942.

Year	Farmland				Oak-Hickory Upland	
	Urbana Township, Champaign County*		Bright Land Farm, Cook County†			
	Number Litters	Average Number Young	Number Litters	Average Number Young	Number Litters	Average Number Young
1941	6	3.66	....	....	44	2.63
1942	4	3.75	15	3.20	41	2.36
1941–1942	*10*	*3.70*	*15*	*3.20*	*85*	*2.51*

*Litter counts by R. E. Hesselschwerdt, leader of Illinois Federal Aid Project 4-R. In March, 1945, the inspection of den boxes in Urbana Township by Dr. Ralph E. Yeatter revealed four litters totaling 14 young, an average of 3.50 per litter.

†Litter counts by Dr. William H. Elder, Assistant Game Technician, Illinois Natural History Survey.

but midwinter supplies are often less abundant in the woodlands than in farm regions. The difference in average litter size in the two habitats, as shown in table 21, is significant. The writers believe that the superior quality and quantity of food characteristic of many farmland habitats may be the main reason for the differential in litter size. No comparative data are available for gray squirrels, but it is of interest that 34 litters found in woodland types averaged 2.68 young, table 20, a number smaller than the average for farmland fox squirrels.

ILLINOIS HABITATS

Forest cover is the basic requirement of fox and gray squirrel habitats, and the kinds, combinations and sizes of the trees, shrubs and brambles they contain, and the density of the stand, to a large extent determine their quality. Since the occurrence and growth of woody vegetation vary with soil, climate and the activities of man and other animals, the types of squirrel habitats in Illinois are many. Although the variations in squirrel habitats are not readily classified, it is possible to include them under two main headings: black prairie and woodlands.

Black Prairie Habitats

The black prairie region of Illinois is overwhelmingly agricultural and is dominated by the production of corn, soybeans and wheat. It contains very little wooded area, and therefore has an acute shortage of den trees. Subtypes making up the squirrel range in this region are woodlots, wooded stream bottoms, hedgerows, and fields and farmyards with scattered trees or groves. The woodlots are predominantly oak-hickory. Walnut plantations are widely scattered and aggregate only a very small acreage. In the bottoms, the main trees are elms, maples, sycamore, white ash and other wet-site species; and on the bluffs, oaks and hickories are the principal trees. The only important hedgerow species is the Osage orange, the older and larger hedges of which are now steadily being pulled. Practically all wooded areas on the black prairie are grazed.

Fig. 14.—Typical farm habitat of fox squirrels on Illinois black prairie type, Champaign County, February, 1941.

Staple squirrel foods in this region, in probable order of importance, are corn,

Fig. 15.—Mature elm-maple river-bottom type, Piatt County. Pin oak through the northern two-thirds of Illinois, and pecan and other hickories in the southern half of the state, add to the quality of many river-bottom squirrel habitats by helping to insure a year around food supply. The pure elm-maple type is rich in squirrel foods during the spring, but low in this respect during other seasons of the year.

acorns, nuts, buds and seeds, especially of elms and maples, and Osage orange fruits. Water is supplied by streams and ditches and probably by such succulent foods as berries and green corn. The fox squirrel exclusively is found in the black prairie, except in towns and in a few heavily wooded and ungrazed bottoms. Fig. 14 illustrates this type.

Fig. 16.—The cypress or cypress-tupelo gum type in the extreme southern tip of Illinois is fair squirrel range. Foods offered by this type are cypress seeds and tupelo gum drupes. Shown here is a tupelo gum bottom, Massac County.

Woodland Habitats

The term woodland, as used here, denotes squirrel habitats other than the woodlot types found on the black prairie. The Illinois woodland habitats contain a vastly larger total wooded area, as well as much larger wooded tracts, than the black prairie. A rough distinction between the two types of squirrel habitat is that black prairie woodlots are surrounded by fields, while woodland range is only irregularly broken by cultivated fields or other open land. Woodland habitats, for convenience, may be divided into two main subtypes: the river bluffs and bottoms and the wooded upland.

River Bluffs and Bottoms.—Constituting this type are the bottoms and contiguous bluffs of the various river systems bordering and within Illinois. The most important wooded areas of this type are along the Mississippi, Illinois, Ohio, Wabash, Rock, Kaskaskia, Embarrass, Big Muddy and Cache rivers and aggregate more than 2,250,000 acres (Case & Myers 1934). The variety of trees and shrubs on this extensive area is great. The principal bottomland trees in the northern half of the state are elms and maples, and in the southern half these species plus oak, hickory and pecan; cypress and tupelo gum swamps are found in a few wet bottoms in extreme southern Illinois. The bluffs in all cases support oaks and hickories, with walnut occurring in many localities. Shrubs are of wide variety and may be considered an important part of the cover.

A bottomland habitat in central Illinois is illustrated in fig. 15. A southern Illinois habitat, principally tupelo gum, is shown in fig. 16.

The river bluffs and bottoms type is found in Illinois in varying densities and stages of maturity. Grazing is the rule, as in black prairie woodlots, but not many of the bottomland areas are seriously injured as squirrel range by this practice. Den trees are generally ample, but extensive lumbering is now seriously reducing both the number of den trees and the number of areas containing such trees.

Staple foods, in probable order of importance, are acorns, nuts, buds and seeds (especially of elms and maples), and corn. Water is amply supplied by streams, lakes and springs. Both fox and gray squirrels are common in this habitat, but the latter are much more restricted than the former in distribution.

Wooded Upland.—The wooded upland possesses many of the qualities of the river bluffs and bottoms type, but contains a larger percentage of oak, hickory, and, in northwestern, central and southwestern localities, of walnut. Fruit-bearing shrubs, wild grapes, bittersweet and brambles supplement the basic food supply of nuts and acorns. Many of the wooded areas border fields of corn, which thus becomes available as staple food, fig. 17. From the standpoint of food, the wooded upland type affords a habitat of higher quality than does the river bluffs and bottoms type, except perhaps in those bottomland situations in which pecans are plentiful. Den trees are not so abundant on the wooded uplands as on the bottoms and bluffs, due both to the presence of large numbers of hickories and other species not given to formation of cavities and to the fact that upland stands have been more continuously and selectively logged, especially of oaks. The residual upland stands, as a result, are younger and more vigorous. Despite this condition there is no pressing

Fig. 17.—Good squirrel country in Effingham County. Oak-hickory woods adjacent to cornfields constitute a habitat with a dependable year around food supply for fox and gray squirrels.

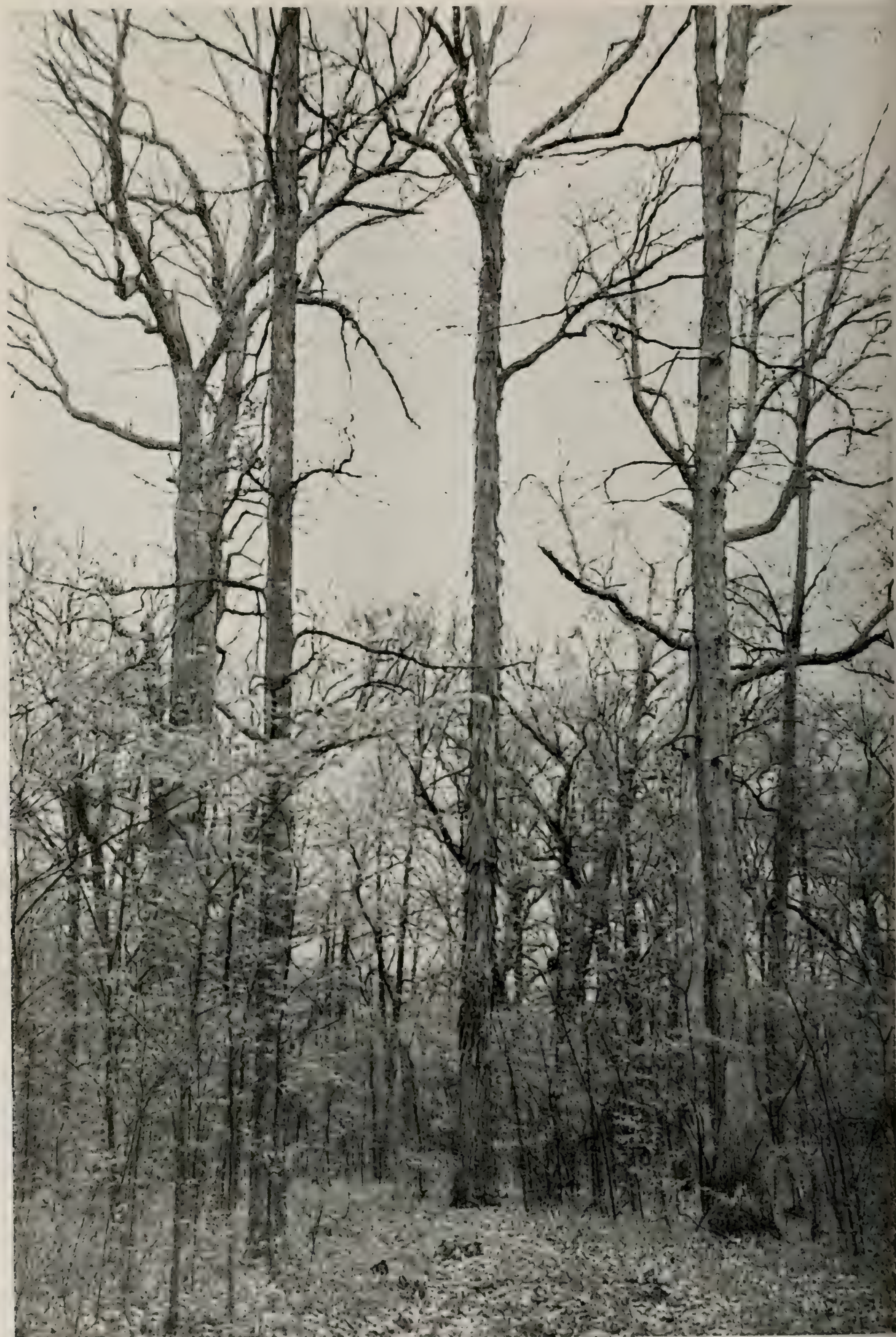

Fig. 18.—Oak-hickory type in Piatt County, a high quality fox squirrel habitat. Here various tree species provide food through most of the year.

den shortage on the wooded uplands. Water is not so plentiful, but in most upland areas is amply supplied by small runs and springs. Grazing is heavier than on the more rugged bluffs. Fire offers a somewhat greater hazard. The cutting of walnut for military use has been more widespread and intensive on the wooded uplands than in any other squirrel habitat in Illinois.

The wooded upland type reaches its best development in several southern and southwestern counties, but there is an appreciable acreage of it in Jo Daviess, Carroll and other northwestern counties. The extensive black oak stands in Mason and Cass counties may be considered a part of the wooded upland type. The aggregate wooded upland acreage is roughly twice that of the river bluffs and bottoms, or about 4,500,000 acres. Both fox and gray squirrels inhabit the upland type, the former occurring throughout, and the latter, as in the case of the river bottoms and bluffs, being restricted generally to areas having heavy forest cover. Wooded upland habitats are shown in figs. 18 and 19.

Miscellaneous Habitats

Throughout Illinois there are habitat types other than those described where squirrels occur in varying numbers. The most common are residence districts of cities and villages, parks, estates, cemeteries and college campuses. There may be some question as to whether urban-dwelling animals are comparable to wild or non-urban populations. Observations by the writers indicate that wild and urban squirrels have identical breeding periods and great similarity in feeding and nesting habits. It is estimated that the adjoining cities of Champaign and Urbana, with a total human population of about 40,000, have 1,000 squirrels, all of which are gray. It is probable that no Illinois municipality is without a squirrel population, and that

Fig. 19.—Dense oak-hickory-hard maple type, Coles County, unpastured and undamaged by fire. A typical and high quality range for both fox and gray squirrels.

200,000 or more squirrels are resident in municipal areas in the state.

Stripmines, which provide an unimportant habitat in the state, are best represented in Vermilion, Perry, Saline and Fulton counties (Yeager 1942), fig. 20. Only in Vermilion County has forest succession in this type of habitat advanced far enough to attract gray squirrels. The cover usually found in stripmine areas is an early stage of river-bottom forest, consisting mainly of cottonwood, sycamore, willows, elms and maples, a combination low in quality as all-year range. Buds, flowers and seeds of trees, and fruits of brambles and wild strawberries offer an appreciable amount of spring and summer forage. Hickory nuts and acorns are seldom represented in these stands. Probably not more than a few hundred squirrels, most of which are fox squirrels, are resident on Illinois stripped lands.

FOODS AND FEEDING

In this investigation no study of squirrel foods based on detailed laboratory analysis of stomach contents was attempted. Through 2 years of field work, however, every opportunity to observe and record squirrel feeding was utilized. Many aspects of the study—particularly those associated with collecting specimens, trapping live animals and making inspections of den boxes—were well adapted to the making of reliable observations. In 716 hours devoted to hunting, several hundred records on squirrel feeding were gathered. Although the nature of the data precludes quantitative evaluation, the writers believe that a good general picture of feeding, based on frequency of observation, was obtained.

In the following discussion, as well as in table 22, no food is listed unless squirrels were observed eating it, or unless other positive evidence of its having been eaten was obtained. Food remains of squirrels were easily distinguished from those of other rodents by the location of "cuttings" as well as by incisor marks on them (Pearce 1938). Only fresh material was used in these determinations. It was impractical to distinguish between fox and gray squirrel food remains, and for this reason, as well as because of great similarity in food habitats, this section of our report is, in general, applicable to both spe-

Fig. 20.—Stripmines, lacking in trees bearing acorns and nuts, are poor year around squirrel habitats. Vermilion County.

Fig. 21.—This Piatt County woodlot of mixed hardwoods, including hickory, black oak, white oak, walnut, elm and soft maple, offers staple foods at all seasons. A nearby cornfield and an Osage orange hedge supplement this food supply. The mature trees contain an ample number of cavities. These characteristics probably represent the optimum in fox squirrel habitat.

cies. Information peculiar to either species is detailed separately.

Food Sources

In table 22, 76 species or groups of squirrel food plants are tabulated. Included are 56 trees and shrubs, 2 groups of vines, 4 brambles, 6 wild herbs, 7 cultivated crops and various fungi. The list is, of course, incomplete; the writers are certain that other plants, particularly herbs, are taken in small amounts. The unlisted foods, however, are of little significance in the squirrel dietary.

Although many items are listed in table 22, the important staple food sources of Illinois squirrels comprise only a half dozen plant groups. There are the hickories, including pecan, and the oaks, walnuts, elms, mulberry and field corn. An imposing list of other foods may be important locally or seasonally. Examples are Osage orange and wild grapes. Boulware (1941) reported local use of eucalyptus by fox squirrels in California, and Dambach (1942) similar use of hawthorn (*Crataegus mollis*) by gray squirrels in Ohio. Woods (1941) reported that a blackberry patch, wild plum thicket or cultivated orchard may furnish the bulk of the food for one or a few squirrels during the few weeks when fruits of such plantings are available. However, no matter how varied and abundant auxiliary seasonal foods may be, most wild squirrels are forced to rely for much of the year on one or more of the staples listed. An environment without a variety of staples may be of little value, and may actually be uninhabitable, except when auxiliary foods prevail. Common examples of such a deficient environment are river-bottom forests of pure elm-maple or extensive cottonwood-willow flats, even those bordering cornfields.

From the standpoint of food, the importance of mixed stands in squirrel habitats is clearly apparent, fig. 21. This factor is discussed by Goodrum (1938). Most of the original forests were of suitable composition, especially those of hardwoods or mixtures of hardwoods and conifers. Most of the larger natural stands now present in Illinois meet the staple food

Table 22.—Plant food sources of Illinois squirrels as observed in field, 1940, 1941 and 1942.

Species	Parts Utilized	Period of Utilization	Stored	Rating* S –Staple SS–Substaple A –Auxiliary E –Emergency
Trees and Shrubs				
Pecan, *Carya pecan*	Nuts	September 1 until exhausted; sometimes all year	x	S
Shagbark, *Carya ovata*	Nuts	August 15 until exhausted; sometimes all year	x	S
Mockernut, *Carya alba*	Nuts	August 15 until exhausted; sometimes all year	x	SS
Pignut, *Carya glabra*	Nuts	September 1 until exhausted; sometimes all year	x	SS
Small pignut, *Carya ovalis*	Nuts	August 25 until exhausted; sometimes all year	x	S
Big shellbark, *Carya laciniosa*	Nuts	September 1 until exhausted; sometimes all year	x	SS
Bitternut, *Carya cordiformis*	Nuts	September 1 until exhausted; sometimes all year	x	SS
Black walnut, *Juglans nigra*	Nuts	September 1 until exhausted; sometimes all year	x	S
Butternut, *Juglans cinerea*	Nuts	September–November	x	A
Red oak, *Quercus borealis maxima*	Buds and acorns	Late April and May; September 1 into winter or later	x	SS
Black oak, *Quercus velutina*	Buds and acorns	Late April and May; July 15 into winter or later	x	S
Pin oak, *Quercus palustris*	Buds and acorns	Late April and May; July 15 into winter or later	x	S
White oak, *Quercus alba*	Buds and acorns	Late April and May; August 1 into winter or later	x	S
Swamp white oak, *Quercus bicolor*	Buds and acorns	Late April and May; August 1 into winter or later	x	A
Bur oak, *Quercus macrocarpa*	Buds and acorns	Late April and May; August 1 into winter or later	x	SS
Chinquapin oak, *Quercus Muhlenbergii*	Buds and acorns	Late April and May; August 1 into winter or later	x	A
Shingle oak, *Quercus imbricaria*	Buds and acorns	Late April and May; September and October or later	?	A
American elm, *Ulmus americana*	Buds and seeds	February and March; April and May	...	S
Slippery elm, *Ulmus fulva*	Buds and seeds	February and March; April and May	...	A
Winged elm, *Ulmus alata*	Buds and seeds	February and March; April and May	...	A
Silver maple, *Acer saccharinum*	Buds and seeds	March and April; late April and May	...	A
Red maple, *Acer rubrum*	Buds and seeds	March and April; late April and May	...	A
Sugar maple, *Acer saccharum*	Buds and seeds	March and April; September and October	...	A

*See footnote, page 501.

Table 22—Continued

Species	Parts Utilized	Period of Utilization	Stored	Rating* S –Staple SS–Substaple A –Auxiliary E –Emergency
Trees and Shrubs—Continued				
Box elder, *Acer negundo*	Seeds	September into winter	...	A
Hackberry, *Celtis* spp.	Berries	July–October	...	A
Beech, *Fagus grandifolia*	Nutlets	Late August into October or later	?	SS
Buckeye, *Aesculus glabra*	Nuts	Sampled in September but not eaten in quantity	...	A
Basswood, *Tilia glabra*	Berries	July 15 to September	...	A
Ironwood, *Ostrya virginiana*	Nutlets	Late August to November	...	A
Red mulberry, *Morus rubra*	Fruit	Mid May to August	...	S
Osage orange, *Toxylon pomiferum*	Fruit	August into the winter	...	SS
Tulip poplar, *Liriodendron tulipifera*	Buds; seeds (in cones)	May; September–December	...	A
Red gum, *Liquidambar styraciflua*	Buds; seeds (in capsules)	May; October–February	...	A
Black locust, *Robinia pseudoacacia*	Seeds	October–December	...	E
Honey locust, *Gleditsia triacanthos*	Pulp of pods; seeds	September–November	...	A
Kentucky coffee tree, *Gymnocladus dioicus*	Pulp of pods	Fall into winter	...	A
Redbud, *Cercis canadensis*	Seeds	Fall into winter	...	E
White ash, *Fraxinus americana*	Seeds	June (so far as observed)	...	A
Pumpkin ash, *Fraxinus profunda*	Seeds	June (so far as observed)	...	A
Cucumber tree, *Magnolia acuminata*	Seeds (in cones)	Fall into winter	...	A
Tupelo gum, *Nyssa aquatica*	Seeds (kernels)	October–February	...	A
Black gum, *Nyssa sylvatica*	Fruit	September and October	...	A
Black cherry, *Prunus serotina*	Fruit	August and early September	...	A
Cypress, *Taxodium distichum*	Seeds (in cones)	October–March	...	SS
Red cedar, *Juniperus virginiana*	Berries	November–March	...	E

*See footnote, page 501.

Table 22—Continued

Species	Parts Utilized	Period of Utilization	Stored	Rating* S –Staple SS–Substaple A –Auxiliary E –Emergency
Trees and Shrubs—Continued				
Persimmon, *Diospyros virginiana*	Fruit	Late September into December	...	A
Pawpaw, *Asimina triloba*	Fruit	August–October	...	A
Hawthorn, *Crataegus* spp.	Fruit	October and November	...	A
Apple, *Malus* spp.	Fruits and seeds	September–December	...	A
Sassafras, *Sassafras officinale*	Fruit	August 15 through September	...	A
Flowering dogwood, *Cornus florida*	Fruit	September and October	...	A
Gray dogwood, *Cornus paniculata*	Fruit	August–October	...	A
Wild plum, *Prunus americana*	Fruit	August and September	...	A
Hazelnut, *Corylus americana*	Nuts	September–January	x	SS
Sumach, *Rhus* spp.	Seeds	December and January	...	E
Serviceberry, *Amelanchier canadensis*	Fruit	Late June and July	...	A
Vines				
Wild grapes, *Vitis* spp.	Berries	September–February	...	A and E
Bittersweet, *Celastrus scandens*	Berries	September–February	...	E
Brambles				
Dewberry, *Rubus* spp.	Fruit	June and July	...	A
Blackberry, *Rubus* spp.	Fruit	July and August	...	A
Raspberry, *Rubus* spp.	Fruit	June and July	...	A
Gooseberry, *Ribes* spp.	Fruit	July and August	...	A

*See footnote, page 501.

Table 22—Continued

SPECIES	PARTS UTILIZED	PERIOD OF UTILIZATION	STORED	RATING* S –Staple SS–Substaple A –Auxiliary E –Emergency
HERBS				
Corn, *Zea mays*	Kernels dry and in milk	July and August; September through winter	...	S
Wheat, *Triticum* sp.	Kernels	July and August	...	A
Rye, *Secale* sp.	Kernels	June and July	...	A
Soy bean, *Soja max*	Beans	September–December	...	A
Bluegrass, *Poa pratensis*	Seeds	July and August	...	A
Squash, *Cucurbita* sp.	Seeds	August–October	...	A
Pumpkin, *Cucurbita*, sp.	Seeds	September and October	...	A
Watermelon, *Citrullus* sp.	Seeds	July–October	...	A
Pokeweed, *Phytolacca decandra*	Berries	September–November	...	A
Burdock, *Arctium lappa*	Seeds	October	...	E
Climbing buckwheat, *Polygonum scandens*	Seeds	September and October	...	A?
Smartweeds, *Polygonum* spp.	Seeds	October–December	...	E
Lotus, *Nelumbo pentapetala*†	Seeds	October–January	...	E
FUNGI				
Agaricaceae and others	Fruiting body	Late spring through summer	?	A

Staple foods are those of most importance, having statewide distribution; *Substaple* foods are preferred foods, important locally, or are thinly distributed over a large part or all of the state; *Auxiliary* foods may be of seasonal importance, use of which is limited by abundance of other foods or other factors; *Emergency* foods are mainly those used during periods of food shortage.

†*Nelumbo lutea* of some manuals.

requirements of both fox and gray squirrels, and many woodlots, supplemented by agricultural crops, particularly corn, meet these requirements for fox squirrels.

The writers found during 2 years of field work only one extensive squirrel habitat showing definite evidence of food shortage. This was the Mississippi River bottoms in Carroll County, where pin oaks furnished the main squirrel fare over a large area. Only fox squirrels occurred there, and they were somewhat underweight, mangy and otherwise in subnormal condition during the late winter of 1940-41. The near failure of pin oak acorns on the area in 1940 is believed to have been the main reason for this situation.

At least one other area was found where serious food deficiency would likely result from mast failure. This was the sand region of Cass and Mason counties, where extensive and nearly pure stands of black

Fig. 22.—Nearly pure black oak stand in Mason County, Illinois. During years of mast failure, pronounced squirrel food shortage may exist in this type due to lack of variety in staple food species. Den boxes, erected for wood ducks, are readily used by fox squirrels.

Fig. 23.—Elm (left) and maple buds and flowers offer the first squirrel food produced each year.

oak occurred, fig. 22. Only fox squirrels inhabited this locality, and during years of poor acorn crops they would be forced to depend mainly on residues of corn, rye and other grains, and such natural foods as wild grapes, bittersweet and miscellaneous seeds and herbage.

In practically every section of Illinois, a general failure of oak mast, and in some sections, especially in southern and southwestern localities, failure of wild pecans in the bottoms and hickories and black walnuts on the uplands might create unfortunate food contingencies during the late winter and early spring. That serious food shortages did not prevail in many instances in 1940–1942 is indicated by the good to excellent condition of the several hundred squirrels examined, some of which were collected during every month of the first 2 years of study.

The nature of the food studies made in this investigation did not permit determination of either the number or importance of animal foods taken by squirrels in Illinois. Numerous writers, however, have called attention to the inclusion of insects and other animal forms in the dietary. Davis (1907, 1924) reported the destruction of acorn weevil larvae (*Balaninus*) and oak apple galls (*Amphibolips confluens*) by gray squirrels. These animals were observed by Hamilton (1943) to feed on caterpillars of the half-wing geometer (*Phigalia titea*). Goodrum (1940) found that in Texas over 3.5 per cent of the food of gray squirrels consisted of insects, mainly lepidopterous larvae. He also presented limited evidence to show that animal food is necessary to successful breeding. Both fox and gray squirrels are said by Seton (1928) to use insects and other animal matter. The evidence is general that animal life, particularly insects, constitutes a small but more or less important food source for tree squirrels.

Brooks (1922) reported the use of chestnut bark and other tree bark by gray squirrels in West Virginia, and Allen (1943) reported use of maple bark by fox squirrels in Michigan. The use of bark by fox squirrels was observed by the junior author in Coles County, Illinois.

The effect of lumbering, fire and grazing on squirrel food sources is discussed in other sections.

Food Succession

Succession in the use of foods by squirrels is somewhat distinct, the Illinois study showed, and the order of succession in this state is approximately the same in both species. The first foods of the late winter or spring season are the buds and flowers of several hardwoods, particularly of elms, maples and oaks, and the buds of sweet gum, ash and other tree species, fig. 23. "Budding," well described in gray squirrels by Nichols (1927), Deuber (1934) and Terres (1939), begins in February in southern Illinois and extends into April. During late April and May, the winged seeds of the American elm are an important item in the diet of Illinois squirrels. From mid May until late July mulberries are utilized in all regions where they occur. Various bramble fruits, as well as wild cherries, wild grapes, wild strawberries and wild plums, are eaten during the summer and early fall as they become available. Corn, in the milk stage, is eagerly sought by both species during July and August, but is much more important to fox squirrels than to gray squirrels because of the wide occurrence of the former in open, agricultural range. Fungi and herbage are taken probably in maximum quantities during the spring and summer; ground feeding, in which fungi and herbage are mainly found, is most prevalent in July and August. It is during this period of extensive ground feeding that squirrels are most difficult to see in the woods.

In Illinois, July and August usher in the principal mast season, the period of greatest food abundance for tree squirrels throughout the northern hemisphere. Although initial use of black oak and probably other acorns may be as early as July 15 in Illinois, most mast species are not used extensively until about mid August. Fruits of oaks, sugar maple and honey locust are commonly eaten in August and later, and are followed by nuts of the hickories and walnuts. Pecans, beechnuts, hazelnuts, fall grapes, Osage orange fruits, pokeberries, ripe corn and numerous other foods are generally used in late August or September and later. In the extreme southern tip of the state, the seeds of cypress and tupelo gum are appreciable food items in late October. Although rare in Illinois, the seeds of various pines are a staple fox squirrel food wherever the range of the trees and the animal coincide.

Fig. 24.—Corn cribs or corn shocks or fields adjacent to squirrel range offer the best feeding stations, and may carry normal squirrel populations through severe food shortages. Pike County.

Following the flush of mast availability in September and October, acorns and nuts supply the bulk of squirrel food during the winter and early spring. Such food is taken both from residues on the ground and from cached supplies. It is after these sources are largely used up, and before the availability of buds, that the food problem of squirrels most often becomes acute. In many farm localities, corn, whether residue, shocked or cribbed, is of great value during this period of deficiency, fig. 24; other emergency foods consist of Osage orange fruits, often dug out of snow, still clinging box-elder seeds, dried grapes, frozen, half-decayed apples and such miscellaneous items as smartweed, climbing buckwheat, burdock and American lotus seeds. In several instances it was found that acorns that had fallen in water were eaten 3 or 4 months later, after the winter drawdown, on areas affected by navigation dams on the Mississippi River, fig. 25. Many other seeds are undoubtedly eaten during the period of scarcity; and various writers have reported greater use of animal foods, particularly insects, during the late winter and spring than at any other time.

Food Preferences

The acorns of every species of oak occurring in Illinois appear to be used by squirrels, but because of their abundance and wide distribution those of pin oak (*Quercus palustris*), white oak (*Q. alba*) and black oak (*Q. velutina*) are the most important food sources. The acorns of bur oak (*Q. macrocarpa*), shingle oak (*Q. imbricaria*), chinquapin oak (*Q. Muhlenbergii*), swamp white oak (*Q. bicolor*) and others are taken where they occur. According to Allen (1943) red oak (*Q. borealis maxima*) acorns are bitter and, in Michigan at least, appear to be used less than the fruit of most oaks. Of the hickories, the shagbark (*Carya ovata*), both because of its statewide distribution and tendency to fruit, is easily first in use among Illinois squirrels. Nuts of the small pignut (*C. ovalis*), occurring most commonly in east-central and southern Illinois, were found to be eaten avidly by both fox and gray squirrels, fig. 26. The mockernut (*C. alba*), pignut (*C. glabra*), big shellbark (*C. laciniosa*) and most other Illinois hickories are of only secondary importance, partly because they are less common than the shagbark and also, perhaps, because they are thicker shelled and therefore more difficult for squirrels to open than are the thin-shelled species. The bitternut (*C. cordiformis*), although thin-shelled, is both bitter in taste and small in size, but appears to be utilized. Pecan (*C. pecan*) is eagerly taken wherever it occurs and represents the most important mast species in the central and lower Illinois River bottomlands and in some southern Illinois localities.

Squirrels show definite preferences when several foods are abundant at one time. During "mast years," when a dozen or more staple or substaple foods, including hickory nuts, walnuts, pecans, acorns, beechnuts, hazelnuts and corn, may be available in quantity from late August through September, hickory nuts (shagbark and the small pignut) seem to rank first in preference with both fox and gray

Fig. 25.—After winter drawdown on area affected by Mississippi River navigation dam, squirrels foraged under ice for pin oak acorns that had lain in water since the previous fall. Carroll County, January, 1941.

squirrels. While these nuts are available, squirrels travel greater distances for them than for any other food and lose to a greater degree their altertness to danger when feeding on them. Pecans and black walnuts also rank high. Among fox squirrels living in farm habitats where nuts are absent, the fruit of the Osage orange seems to rank next to corn as a preferred food, and in numerous instances was taken in winter, even when acorns were available, fig. 27. In the early spring, elm buds and seeds are the most used foods of both squirrel species; in May

Fig. 26.—Two hickory trees, heavily fruited, known to have supplied much of the food of 20 or more Coles County squirrels (both fox and gray) from late August until late September in 1943.

Fig. 27.—Osage orange fruits provide food for fox squirrels from late summer through the winter. Cobs under the tree indicate extensive use of corn from an adjoining field.

and June, mulberries apparently rank first; and, during the early summer, corn in the milk stage is probably highest in palatability rating, at least for fox squirrels.

Because of the well-known adaptability of fox squirrels to open timber and agricultural habitats, this species makes greater use of farm crops than gray squirrels. Of farm-crop foods, corn is of outstanding importance, but wheat, soybeans, oats, apples and other crops are popular. Field crops adjoining woodlots or other timbered areas are used more than those in fields some distance from such areas. Corn is the only cultivated crop used to any considerable extent by gray squirrels in Illinois, and this only where fields adjoin woodland suitable to their requirements. Isolated nut trees, hazel clumps or bramble patches are ordinarily monopolized by fox squirrels.

Failure of any important mast species tends to hasten and increase the use of the species that produce. In 1941, the hickory nut crop was heavy over much of Illinois. Squirrels in the central zone began to use the nuts by mid August, and black walnuts were left untouched until early September. In 1942, hickory mast was scarce in many localities. The small supply was soon exhausted, and in August the squirrels shifted to walnuts, which were still green. Squirrels inhabiting areas short of summer foods, of which heavily grazed woodland is probably the best Illinois example, are often driven to use immature acorns. In the black oak stands in Mason and Cass counties, where the ground cover is mainly grasses, seedlings and second-growth sprouts, immature acorns were taken by the fox squirrels resident there as early as July 15.

Fox squirrels were found to be more tolerant of limited variety in diet than gray squirrels, and on many areas having only one or a very few staple foods it was

Fig. 28.—Sweetgum "balls" stored by a gray squirrel, Horse Shoe Lake Game Refuge, Alexander County, Illinois, December, 1940. This is the only instance of cavity storage noted in tree squirrels in 4 years of field work.

noted that the squirrel population was limited to the former species. This situation was encountered on certain Mississippi River bottoms where pin oaks supply the main food resource; in the sand region of Mason and Cass counties, where black oak supplies the main food staple; and on farm regions throughout the state, where corn is the basis of subsistence. Food, however, is only one criterion for defining the preferred range of the two species. The range appears to be determined by the combination of food, cover, water and possibly space.

In the course of field work it was noted many times that both species of squirrels, even in regions abundantly supplied with food, made limited use of acorns, walnuts, hickory nuts, Osage orange fruits and similar items while they were still quite green. What this use represented—merely a sampling, the activity of juvenile squirrels, an attempt to obtain water—was not ascertained.

Storing and Feeding Habits

Storing or caching appears to be instinctive in squirrels; juveniles are among the first to begin this activity in the fall.

Fig. 29.—Fox squirrel feeding in characteristic manner—sitting on hind legs with nut grasped between forepaws. (Photo by Gordon S. Pearsall.)

Caching in Michigan fox squirrels was well described by Cahalane (1942). The stored foods observed in the present Illinois study were mainly hickory nuts, walnuts, pecans and acorns, which were commonly buried in the ground. Only one instance of cavity storage was found: a gallon or more of sweet gum (*Liquidambar styraciflua*) capsules in the hollow base of a tree of this species, fig. 28. The cache, on the Horse Shoe Lake Game Refuge, Alexander County, was the work of a gray squirrel. In storing, squirrels usually bury only one nut or acorn in a place, carrying each to a point 50 to 100 feet from the food tree by the most direct route.

Storing begins about September 1, and in both 1940 and 1941 it was noticed first in gray squirrels. It seems to be an extension of the forenoon and afternoon feeding periods, and is conducted with fewer-than-usual alerts for danger. Harvesting is rather thorough; once cleaned, the trees are visited only infrequently. In trees nearly stripped, squirrels were observed to go to the uppermost branches and descend in spiral fashion until a nut was found. Acorns and nuts are gleaned later from the ground, but apparently the storing of fallen fruits does not awaken in squirrels the intensity of purpose comparable to that shown early in the season when stores are gathered directly from the trees.

Squirrels seem to have the ability to detect unsound nuts and acorns, usually fruits undeveloped or worm eaten. By what means they make this distinction is not known, but we have many observations of squirrels dropping unsound nuts almost instantly after picking them up. The unhulled nuts they dropped that were examined by us usually showed only one set of incisor marks; the hulled nuts showed little if any "cutting."

Fig. 30.—"Cuttings" on the ground under a hickory tree, Coles County, September, 1943.

In feeding, squirrels ordinarily sit upright on their hind legs, whether on a branch, stump, log or the ground. They possess great skill in handling food with their front paws while eating, fig. 29. Gray squirrels often eat on the spot where they find food, but sometimes, as with fox squirrels usually, they carry the food to a favorite eating place, such as a horizontal branch, a log or stump. Animals of both species leave abundant signs in the form of "cuttings," figs. 30 and 31, and hunters habitually locate them by looking under hickory, walnut, pecan or oak trees to determine the extent and recency of feeding activity. The animals dislodge from trees more fruits than they eat but they usually eat cleanly the nuts and acorns they open.

Neither fox nor gray squirrels take a large number of foods in making any one meal. The writers opened scores of stomachs, but seldom found more than four or five foods in any one stomach, and often only one or two. Items present in stomachs could often be identified by odor or appearance.

Minerals

The mineral requirements of squirrels are not well known. Little information on the subject was gathered in this investigation. As reported previously (Carlson 1940, Coventry 1940), bones are eaten by both species of squirrels, perhaps for the purpose of obtaining minerals. Baumgartner (1939*a*) reported that fox squirrels eat soil to obtain mineral salts. Soil was found in small quantities in some of the stomachs opened by the present writers.

Water

Water apparently is not a requirement of the fox squirrel habitat, but it seems to be a necessity in the habitat of gray squirrels. The tracks of both species are often found in the mud or sand at the edge of streams, ponds and lakes. It was not determined in the present study how often squirrels drink, but observations on animals and study of tracks indicated that during the warmer months gray squirrels, at least, take water daily. A comparison of typical habitats of the two Illinois species leads to the conclusion that the gray squirrel is more exacting in its water requirements than its larger cousin. Gray squirrels were never found at any appreciable distance from open water.

Some evidence is available that mulberries, plums and other succulent fruits serve as water sources for Illinois fox squirrels. Robert E. Hesselschwerdt of the Illinois Natural History Survey did not find that fox squirrels on the Urbana Township Wildlife Area showed a tendency to migrate during the extremely dry summer and early fall of 1940, when all open water within 2 or 3 miles had disappeared. During this period the squirrels made free use of Osage orange fruits and of green corn and apples, from which sufficient moisture may have been obtained. On the Mason County area, wild grapes, blackberries and wild plums probably supplied needed moisture during periods of drought. Other observers, including Allen (1943), have noted the ability of fox squirrels to survive on uplands far from open water. Terrill (1941), working in Missouri, found that extreme drought, resulting in the withering of succulent foods, tended to concentrate both fox and gray squirrels around ponds or other open water sources.

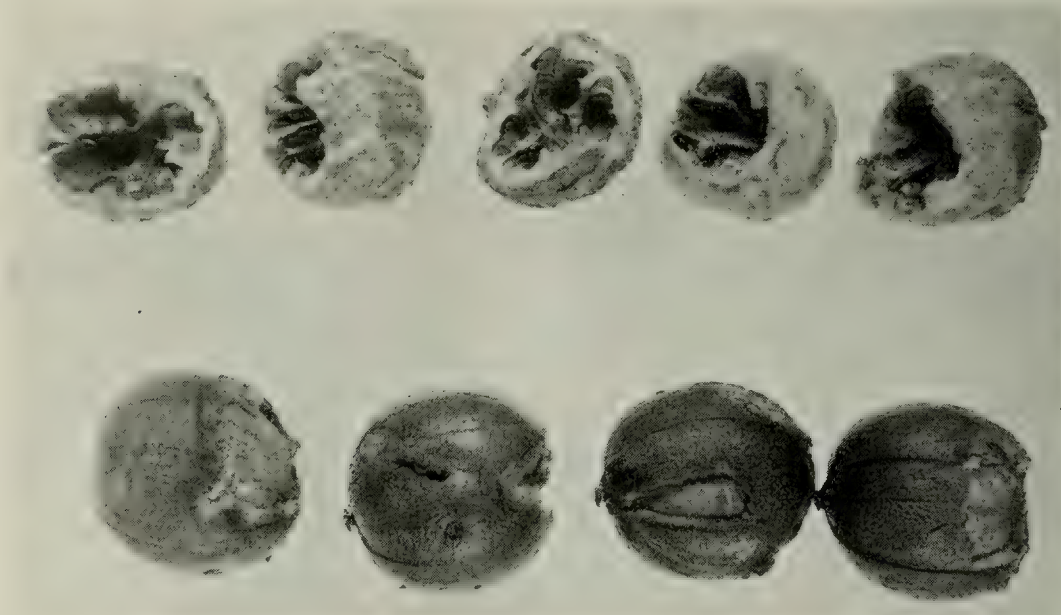

Fig. 31.—Examples of squirrel "cutting" on nuts of the small pignut, *Carya ovalis*. The thin hull and shell of this species, in addition to the sweet-flavored meat, make it highly attractive to both fox and gray squirrels.

NESTING

As has been reported by many writers, fox and gray squirrels throughout their range utilize both leaf and cavity nests.

The degree to which they use each type is determined, at least partly, by the kind and age of the trees in an area. Squirrels were sometimes found by the present writers in young stands, in some cases where cavities were very scarce; but the animals were more common in older, cavity-containing timber. There is no doubt of the superiority of the mature forest range, but the fact that both fox and gray squirrels built leaf nests even where cavities were present suggests that the highest quality habitat must possess the possibility of both types of nest. The writers believe that either type of nest may supply the essential year around nesting requirements of either species.

Dens

On the large expanse of Illinois black prairie, where only the fox squirrel is important, there is an acute shortage of tree cavities suitable for denning purposes. In this region, a few bottoms, occasional woodlots and Osage orange hedgerows supply the main tree cover. The hedges contain very few cavities, and Osage orange leaves are not well suited to nest construction. Although both bottoms and woodlots of the black prairie region contain numerous trees with cavities, the total acreage of such units is so small and their distribution so poor that great inadequacy of dens prevails in the region. In one Illinois study, Hesselschwerdt (1942) demonstrated that boxes made of lumber serve very usefully in meeting the den shortage in the fox squirrel habitat of the black prairie, fig. 32. Use of these boxes is discussed further in the section on "Management."

Many river bottoms and wooded upland areas, particularly in southern parts of the state, are well supplied with den trees. Most cutover areas, as a result of the destructive practice of cutting to smaller diameter limits, have been stripped of

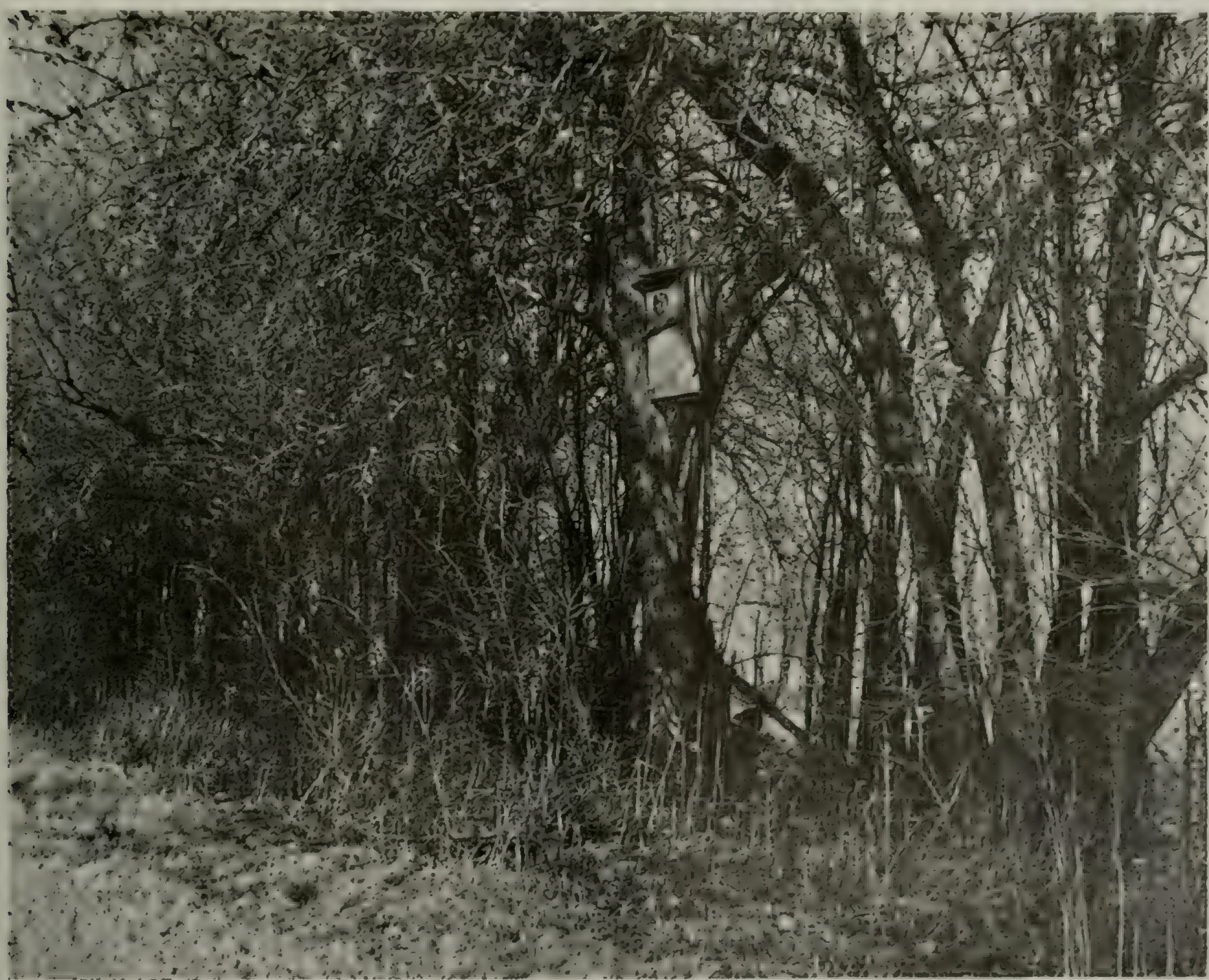

Fig. 32.—Nest box suitable for squirrels in an Osage orange hedge, Champaign County, 1940. A screech owl is sitting in the entrance of the box. An acute shortage of tree cavities suitable for denning purposes exists on the Illinois black prairie.

Fig. 33.—Den tree used by fox squirrels, Piatt County. Cavities are usually higher in trees than the cavity shown here. This den tree is included in the habitat illustrated in fig. 21.

trees with cavities. Selective cutting, especially if light, results in little harm to squirrel range, either temporary or permanent.

The best den trees in Illinois are the oaks, maples, American elm, white ash, beech, sweet gum and, in extreme southern Illinois, cypress and tupelo gum. The inherent soundness of such trees as Osage orange, cottonwood and the hickories, even when mature, eliminates them as important den producers. The oaks, partly because of their abundance and state-wide range, are easily the most important den-tree group, fig. 33.

The physical characteristics of cavities in relation to squirrel denning requirements were not studied by the present writers. Baumgartner (1939*b*) and Allen (1942, 1943) reported in some detail on this subject. Both writers found that squirrels maintain den entrances at a suitable size in growing trees by gnawing the green cambium each year. Allen (1943) found that fox squirrels used almost any size or depth of hollow, sometimes stuffing with leaves those too large for comfort. He also found that certain individuals may establish and use specific dens for long periods, occasionally for the entire life of the animal. Four or five usable cavities per acre are probably ample for any permanent squirrel population. The present writers found considerable evidence that one squirrel, male or female, may use concurrently two or more cavities or nest boxes.

Of the protective value of cavity nests, Allen (1942) aptly states: "From the management standpoint, hollow trees are doubtless desirable even though squirrels can live without them. They protect the animals from hunters, natural enemies, such as raccoons and owls, and severe weather." The present writers, in agreement with Allen, have observed that good tree cavities afford, during storms and extreme cold, a protection that may be

Fig. 34.—Typical fox squirrel leaf nest in oak, Cook County. (Photo by Gordon S. Pearsall.)

Fig. 35.—Fox squirrel nest in white oak tree, Piatt County. Leaf nests may be located in almost any position or height in trees, but most commonly they are situated in branch crotches near the central stem and at heights lower than shown here.

largely responsible for high survival rates of juveniles and of adults in winter.

Leaf Nests

Late summer is the period of greatest nest-building activity in Illinois for both fox and gray squirrels. Stoddard (1920) indicated that the fox squirrel in Indiana and Wisconsin constructs two types of leaf nests, a compact one used for young-rearing, and a larger, more loosely constructed nest used as a summer retreat. Wide variability in the size and shape of nests, in construction materials, and position in trees was observed in the present study. This variability rendered classifying and aging of nests so difficult that the writers were unable to use them as a satisfactory means for censusing squirrels, although a general correlation seemed to exist between the number of nests and the size of the population.

Squirrels in Illinois were found by the writers to exhibit no clearly defined choice of tree species for nest building. Perhaps because they were the most abundant and widely distributed tree group, oaks con-

Fig. 36.—Box elder barked by fox squirrel, Ogle County. (Photo by C. S. Walters.)

tained the largest number of nests. Oak leaves were the most widely used nest material, partly because of abundance, but also, the writers believe, because oak leaves and twigs are highly suited to the type of construction found in squirrel nests, fig. 34. Nests were found in every common Illinois tree species, including cypress and Osage orange. In most cases they were made from leaves of the host tree, but other material also was used. Thus, nests of tupelo gum leaves were found in cypress trees. Crotches of larger limbs were the most common construction sites observed, but there were many sites in forks, between slender branches and, not uncommonly, in the topmost branches of tall trees, fig. 35. Unlike the Bryant fox squirrel, as reported by Dozier & Hall (1940), neither Illinois species was found to choose a characteristic nest position in trees.

Ordinarily, the nests observed by the writers were not lined, but the inner leaves had become frayed and served as lining. Finely shredded bark was at times used for this purpose, and occasionally grass, fine roots, and even rags and paper had been utilized. Some individuals, particularly female fox squirrels, seemed to be addicted to the barking of trees, fig. 36, for the purpose of obtaining nest material, and no doubt for other reasons. The use of bark in tree-cavity nests has been reported previously (Yeager 1936).

HUNTING

Material gathered during the course of the present investigation included information on the method of hunting squirrels in Illinois, on the annual kill and on crippling losses.

Hunters and Hunting Methods

In Illinois, no field sport except rabbit hunting is confined more to rural and small-town populations than that of squirrel hunting. Whereas waterfowl and upland bird shooting draws its devotees largely from urban and professional groups, squirrel hunting is mainly the diversion of farmers, laborers and local business men. This is true particularly in the important southern zone. The sport is highly prized by those who participate in it, both for its recreational value and because it means "meat on the table." To thousands of Illinois citizens, a "mess of young squirrels" is a delicacy annually looked forward to; and to some the resource represents an important and often needed food during the late summer and early fall, fig. 37.

Squirrel hunting tactics are very simple. With experienced hunters, no form of hunting is more likely to result in game bagged, because an understanding of squirrel habits practically insures success. If persistently hunted, however, both fox and gray squirrels become wary, and under such conditions stalking them requires a considerable degree of skill.

Squirrel hunting, except when a dog is used, is primarily a stalking and waiting game. During the mast season, one of the most successful methods is for the hunter to sit or stand quietly near hickory, walnut or oak trees currently being "worked" by squirrels. Often hunters reach such feeding sites by daybreak and shoot the animals as or soon after they emerge from nests in the vicinity, or approach from outlying territory. Under such conditions the killing of one squirrel does not result in cessation of feeding by other squirrels for more than a short time, often only a few minutes. Indeed, limits of five squirrels are often killed at a single site, and sometimes from a single tree. The writers have several records of five squirrels killed from one tree in the space of a few minutes. In such cases, the hunters shot the feeding animals before they could escape into surrounding cover. It is not uncommon for bags made under such conditions to be composed of both fox and gray squirrels.

Stalking is a favorite method of hunting when conditions permit. During dry periods, leaves and twigs are noisy when walked upon, making stalking difficult or impossible. When such conditions prevail, hunters advance from point to point, remaining quietly for a time at each. Points that offer a good view of the surrounding territory are usually selected. Thus, the end of a ridge, especially when bordered by a narrow valley and with timbered slopes beyond, offers a favorable waiting site. When quiet stalking is possible, such as after a rain or early in the morning, hunters walk slowly through the woods, either overland or along trails, pasture fences or dry creek beds, taking advantage of all cover en route. This method permits maximum coverage of hunting territory. A summary of hunting success of 236 Illinois hunters in 1940 and 1941 is given in table 23.

Dogs, which are not widely used in squirrel hunting in Illinois, are perhaps most common in the southern zone; they are most effective after the leaf fall, when squirrels can be easily seen. The 1944 season, closing November 15, October 30 and October 15, in the northern, central and southern zones, respectively, when leaves were still on the trees, virtually eliminated the use of dogs in the southern zone, and permitted only limited use in the

Fig. 37.—A limit typical for central or southern Illinois—three gray and two fox squirrels. hotguns are used by many Illinois squirrel hunters.

central and northern zones. It is said that squirrel dogs were more widely used in Illinois when the season closed later than in 1944.

The writers believe that the data presented in table 23 are too few and selective to be accepted at their face value. There is reason to suspect that they are based on returns made by the more successful hunters. The strikingly uniform bag of slightly more than one squirrel per hour in all zones and for both years represents a very high index of hunting success. The writers suspect that the true index of success falls between 0.5 and 1.0 squirrel bagged per hour.

The uniformity in success per unit of effort in the three zones may be explained by the relationship that exists between the number of hunters and the number of squirrels in each zone. Just as there is a progressive decline in the acreage of squirrel range, and consequently in squirrel numbers, south to north, there is likewise a decline in the number of squirrel hunters. This circumstance would make for more or less equal hunting pressure and consequently success, as is indicated by the data.

It is not known how accurately crippling losses are indicated in table 23. On the basis of the writers' observations and the opinions of many experienced hunters, the figures are conservative. The greatest source of error probably lies in the number of animals hit but giving no indication to hunters of having been wounded. Such cases are not listed in the tabulations. There is evidence based on skulls and bones found in tree cavities that an appreciable number of wounded squirrels reach their dens and die there.

The habit of shooting into leaf nests is more or less common in Illinois. Allen (1940, 1943) in Michigan has shown this to be a wasteful and altogether undesirable

Table 23.—Average number of squirrels bagged, hours of hunting, squirrels bagged per hour and crippling losses, as reported by 236 Illinois hunters, 1940 and 1941.

Zone	Number of Hunters Reporting	Average Number			Cripples Not Bagged* (Per Cent of Total Known to Have Been Hit)	
		Squirrels Bagged per Hunter per Year	Hours of Hunting per Hunter per Year	Squirrels Bagged per Hour	Fox Squirrel	Gray Squirrel
1940						
Northern	18	14.8	13.2	1.2	8.1	10.5
Central	30	18.4	16.7	1.1	12.6	12.8
Southern	110	19.7	17.9	1.1	12.6	15.7
Total or Average	*158*	*18.9*	*17.1*	*1.1*	*12.0*	*15.4*
1941						
Northern	15	19.0	17.0	1.1	12.8	
Central	33	25.9	22.1	1.2	15.8	
Southern	30	23.3	24.2	1.0	16.1	
Total or Average	*78*	*23.6*	*21.9*	*1.1*	*14.4*	

*Crippling loss in 1941 not tabulated by species on hunters' return forms.

practice. He found that the majority of leaf nests shot into did not harbor squirrels, and in instances where animals were present they usually did not jump from the nests if hit; if they were killed, he believed they usually were not recovered.

The types of guns used by Illinois squirrel hunters are indicated in table 24, which is based on 158 returned questionnaires.

A carving, fig. 38, by an unknown individual is indicative of public interest in squirrels.

Kill

Through the cooperation of the Illinois Department of Conservation, a good estimate of the 1942 squirrel kill in Illinois, based on hunters' kill return cards, is available. The total was 1,463,305 squirrels. A breakdown of the 1942 kill, as disclosed by the present investigation, is presented in table 25. We have no comparable data for 1940 and 1941, the hunting seasons principally represented in this study.

Table 24.—Types of firearms used by 158 Illinois squirrel hunters reporting in 1940.

Type of Firearm	Number	Per Cent
12-gauge shotgun	68	43
.22-caliber rifle	55	35
16-gauge shotgun	16	10
.410 bore shotgun	13	8
20-gauge shotgun	6	4
Total	*158*	*100*

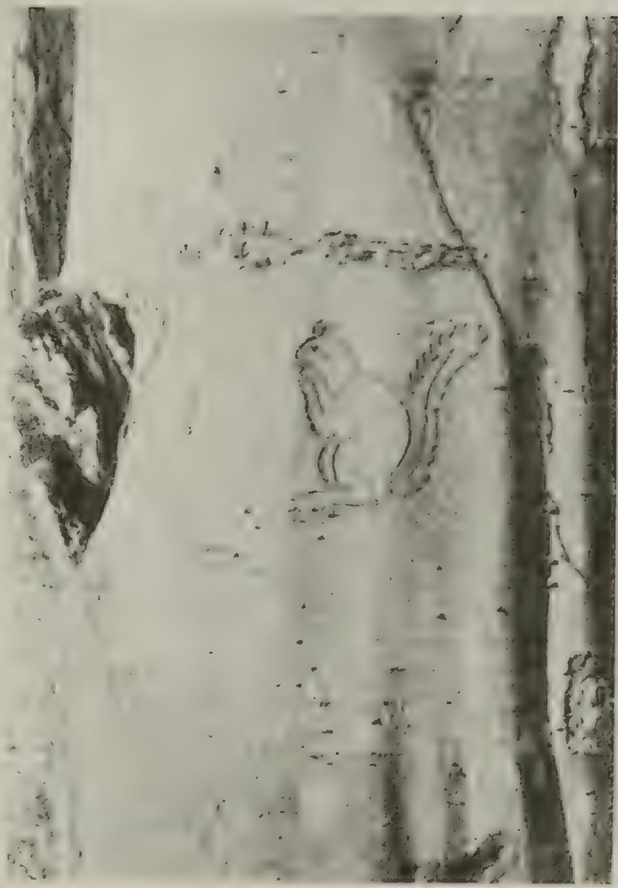

Fig. 38.—Carving found on a beech tree, Alexander County, 1941.

The dressed weights of squirrels, heads off, based on a small series handled by the writers, averaged about 0.98 pound for fox squirrels and about 0.60 pound for gray squirrels. These weights applied to the figure of 1,463,305 animals, approximately 65 per cent of them fox squirrels, indicate that the 1942 squirrel kill in Illinois represented about 1,240,000 pounds of high-quality meat, practically all of which was used for human food. The annual squirrel kill in Illinois is thus believed to repre-

Table 25.—Calculated squirrel kill in Illinois in 1942 based on hunters' kill return cards of the Illinois Department of Conservation.

Zone	Per Cent of Hunters	Fox Squirrel		Gray Squirrel		Total	
		Number	Per Cent	Number	Per Cent	Number	Per Cent
Northern	14.0	144,046	86.1	23,255	13.9	167,301	11.4
Central	26.7	372,399	87.4	53,687	12.6	426,086	29.1
Southern	59.3	430,609	49.5	439,309	50.5	869,918	59.5
Illinois	*100.0*	*947,054*	*64.7*	*576,251*	*35.3*	*1,463,305*	*100.0*

sent between 1 million and 1¼ million pounds of edible game.

MANAGEMENT

Management of wildlife resources is basically the maintenance of various species at any desired population level. To accomplish this objective, use is made of what is known of the life requirements of each species in question. Thus, in the field, pheasants may be provided with more adequate winter cover, or quails with brush-bramble thickets adjacent to food areas. If such changes plug the most serious environmental gaps confronting the species, the habitat is improved; and, in the broad sense, further improvement is attained only when the next most serious gap has been mended. It can be said that game habitats are no better than their weakest environmental factor, and that they usually may be improved up to the point where all conditions are optimum, after which intraspecific tolerance, or lack of it, becomes the important factor in population density.

Our present knowledge of squirrel ecology, admittedly inadequate, permits some general suggestions for managing fox and gray squirrels in Illinois.

Habitat Improvement

Among the more effective means of improving squirrel habitats are maintaining favorable food and den tree combinations through selective cutting and planting, maintaining hedgerows, providing den boxes, protecting against fire and grazing, and supplying feed in winter.

Forestry Practices.—In that fox and gray squirrels are dependent on woodland, no factor can be more important in their husbandry than the woodland management policy. Fortunately, good forest practices generally lend themselves to good squirrel management, especially in the case of fox squirrels. In fact, a small amount of cutting improves large, unbroken stands as squirrel range, because the openings so made promote the growth of food-producing brambles and shrubs, and hence greater variety in both cover and food resources. Fox squirrels may respond to improvements effected by selective cutting within a year or two; gray squirrels only after appreciable shrub growth has appeared. Shrub-bordered woodlots or stands provide variety in food resources, and the shrubs are of value in site protection. Logs and down treetops, or piled brush, have a certain, but unmeasured, attractiveness for squirrels, and their presence in the habitat adds to its quality.

Slashing, wherein all commercial timber is ruthlessly cut and logged, may—and indeed often does—destroy completely a woodland as a squirrel range. Such cutting, followed by fire, may eliminate occupancy even by fox squirrels for 10 to 25 years. Likewise, the cutting of all defective trees, to which cavity dens are largely confined, greatly reduces habitat quality, not only for squirrels but for other cavity-denning wildlife. Many defective trees are good mast producers. Release and improvement cuttings that result in taking out all or most individuals of such species as mulberry, black cherry, wild plum, hawthorn and wild grape make for food shortage during the spring and summer. It has been observed that one elm and one mulberry per acre in oak-hickory or beech-maple types may represent the difference between good, permanent habitat and that which is deficient for squirrels during the spring and early summer months. The usefulness of mulberry is noted by Goodrum (1938).

Naturalness in forest stands, involving a reasonable variety of species, the presence of all age classes, including some defective, cavity-containing trees, and an understory of shrubs and young trees, insures a satisfactory squirrel habitat in almost any part of Illinois, fig. 39.

Forest practices that result in leaving at least a few oaks, hickories and walnuts in the stand are of the greatest importance in maintaining the squirrel range. Of these three tree groups, the hickories, including the pecan, are, tree for tree, of the greatest value to squirrels. Hickories are generally considered of secondary commercial value for lumber, and a policy of favoring them in forest practices creates a conflict of interests. However, where hickory constitutes an appreciable part of the stand, as it does throughout much of the oak-hickory type, it is not necessary to save every hickory in maintaining good squirrel range. Under such circumstances, release and improvement cuttings may well favor the commercially more valuable oaks, walnuts and yellow poplar, reserving only a few hickories per acre.

Stand composition in high quality squirrel range must, however, consist of more than acorn and nut species, notwithstanding the essential function of these groups in producing food staples. Spring and summer food species are needed, since mast is not available until midsummer or later. Highly important are buds and seeds of elms and maples, the first green food of the year; mulberries, which tend to replace buds and seeds in the diet in May and which supply a staple food throughout July; and black cherries, wild plums, serviceberries and similar fruits, all of which become available in summer.

The mulberry is especially useful because it not only offers an attractive food during a food-deficient period, but is shade tolerant and grows and produces well under a variety of site conditions. It appears to do best on moist, fertile, riverbottom soils.

Osage orange trees in woodlots or other forested areas provide a good food resource. Cattle may eat Osage orange fruits during the winter and thus scatter viable seeds in droppings over woodlots and timbered areas. Many of the scattered Osage orange trees occurring in Illinois pastures and woodlots are believed to have originated in this manner. Squirrels are probably responsible for others.

Fig. 39.—Mixed hardwood stand, Piatt County. This forest type, common in Illinois, offers one of the best year around habitats for squirrels.

Brambles, particularly blackberries and raspberries, improve the food resources of any squirrel habitat, as does adjacent corn.

Hedgerows and Fencerows.—In farm localities, or in any region where woodland occupies only a small acreage, hedgerows and fencerows may constitute a very appreciable part of the squirrel habitat (Whitaker 1939). Even in more heavily wooded localities, hedgerows connecting two woodlots or stands, or offering shelter along cornfields or bramble patches, represent a valuable feature of the range. The most common black prairie squirrel habitat is the Osage orange-corn-soybean combination, supplemented in some cases by food- and cavity-bearing walnuts, oaks and maples, usually near a farmstead.

Although of very low carrying capacity for the total acreage involved, this type of habitat is in some respects satisfactory for fox squirrels, as is attested by the generally excellent condition of animals collected in it. Removal of hedgerows, which has been extensive during recent years, has measurably reduced the acreage of habitable fox squirrel range in the state.

Undoubtedly the best hedgerow cover for squirrels is offered by very large, untrimmed Osage orange trees, but a hedge of this size lowers the crop yield for a distance of 20 or 30 feet on each side and therefore is resented, with some justification, by many landowners. Smaller hedgerows are of material value to fox squirrels, and trimming, although it impairs, does not destroy their usefulness to squirrels. Fencerows of oaks, elms, maples, hickories or red cedars are commonly used by fox squirrels to the limit of food and cover offered.

The value, to fox squirrels particularly, of one or a few good food trees in hedgerows, corners or in open stands is appreciable. The most desirable species for such situations are hickories, including pecans, walnuts and most oaks. They are well adapted to hedgerow planting, as they produce well when isolated and thus favored by full light.

Den Boxes.—Den boxes, fig. 40, suitable for squirrels and other cavity nesting species have been tested extensively in Illinois (Hawkins & Bellrose 1941, Hesselschwerdt 1942, Yeager 1942, Brown & Bellrose 1943) and in Michigan (Allen 1942, 1943). The outcome of these studies leaves little doubt of the possibility of substituting artificial for natural cavities in regions where the latter are scarce or lacking. Den boxes appear to be especially useful on the black prairie, where the shortage of natural cavities is acute, and in food-producing forest stands too immature for cavity formation.

Almost any covered box or keg having an entrance hole and room for a nest will be used by squirrels if placed in a tree on their range. The box recommended here is 2 feet deep, 8 by 8 inches inside cross section, and with an entrance hole 3 inches in diameter. It should have a removable top to facilitate cleaning, which is occasionally necessary because squirrels fill boxes with leaves and other materials. Small cracks in the boxes do not seem to interfere with use of the box by squirrels, and a perch will be used if present but is not necessary. Boxes constructed from nail kegs or sound old lumber will last for 2 or 3 years or longer. Such boxes can be built and erected for a small sum each; if made of cypress or cedar lumber that must be purchased as new, the cost will be higher. However, nests made of the better material will give, with some repair, at least 10 years of service. Two or three boxes per acre are ample, and they should be placed in the larger trees, 20 feet or more above ground. In order to insure the most effective utilization, they should not be placed in den trees, but instead in sound trees some distance away from den trees. On large tracts, boxes placed on or near the timber edge are more attractive, at least to fox squirrels, than those 100 yards or more inside the stand. Where ample tree cavities already exist, it is a waste of time and materials to install artificial dens, and for this reason their use in most all-age stands is unnecessary.

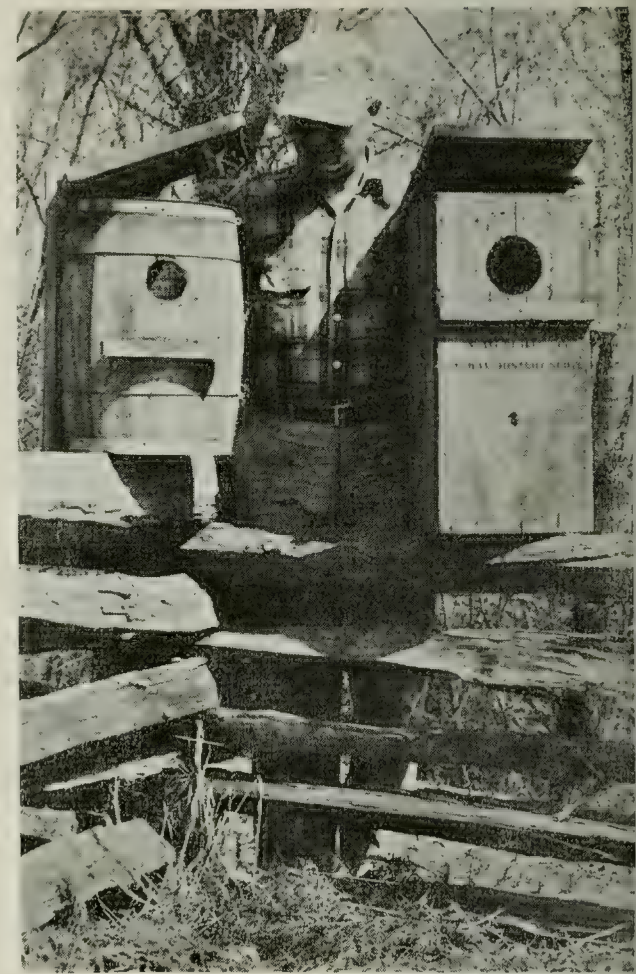

Fig. 40.—Two types of artificial den boxes suitable for squirrels. A box having a minimum cross section of 8×8 inches, at least 2 feet deep and with an entrance 3 inches in diameter, is recommended.

Control of Fire and Grazing.—The burning and grazing of woodlands in Illinois is a common practice. About 10 years ago, approximately 75 per cent of all timbered area in the state was grazed (U. S. Department of Commerce 1935), and an unknown, but appreciable, percentage is burned annually, especially in the south-central and southern counties. Both burning and grazing are injurious to timber growth as well as to the site, as has been pointed out many times.

Due to the arboreal nature of squirrels, fire and grazing are not so injurious to them as to ground-frequenting birds and certain other wildlife. In woodlots having very heavy ground cover, light grazing may be of some benefit both to fox squirrels (Allen 1941, 1943) and gray squirrels (Goodrum 1940). However, grazing of wooded land gives neither a good pasture nor a good woodlot, and sound land use decrees that stock be kept off forested range. Very heavy grazing undoubtedly depletes the quality of squirrel habitats wherever it occurs, since it results in decreased food supply through the destruction of shrubs and brambles. This practice, therefore, may easily result in food shortage, or at least a shortage of certain attractive foods, during the months prior to the ripening of mast.

Fire is actually and potentially so destructive to Illinois woodlands that its suppression in these areas is considered desirable at all times. There is no evidence pertaining to this state that fire is ever of benefit in squirrel management.

Winter Feeding.—It is only during periods of heavy ice or actual food shortage that winter feeding of squirrels in Illinois is recommended. Snow is of little hindrance to successful foraging, since both fox and gray squirrels dig readily through a foot or more of snow to reach food, fig. 41. On the better oak-hickory range in the state it is rare indeed that feeding is necessary; and, due to availability of waste corn left by mechanical pickers, it is needed on the extensive black prairie type only during periods of heavy ice.

If conditions warrant feeding, it is recommended that ear corn, hickory nuts, walnuts or unroasted peanuts be used. Corn, because of its abundance, availability and attractiveness to squirrels, is by far the most practical emergency food. Ears may be impaled on spikes driven upright through small poles or boards; nuts may be placed in trays or hoppers in such a manner as to prevent excessive scattering. A corn shock near the woods border makes a simple and effective feeder. Feeding operations should be centered on the best squirrel range, to take advantage of maximum cavity and natural food availability. Chapman & Baumgartner (1939) recommended one feeding station per 25

Fig. 41.—Squirrels are capable of digging through a foot or more of snow in finding Osage orange fruits or stored nuts or acorns.

acres of woodland. Hawkins (1937) estimated that individual squirrels consumed about 2 pounds of shelled corn per week. A practical feeding station is shown in fig. 42.

Winter feeding projects are relatively easy to organize among sportsmen and conservationists, but such activities are also easy to neglect during severe weather. A feeding program, if it is neglected during a critical period, especially after squirrels or other game have been concentrated by feeding during mild weather, may do more harm than good to the animals.

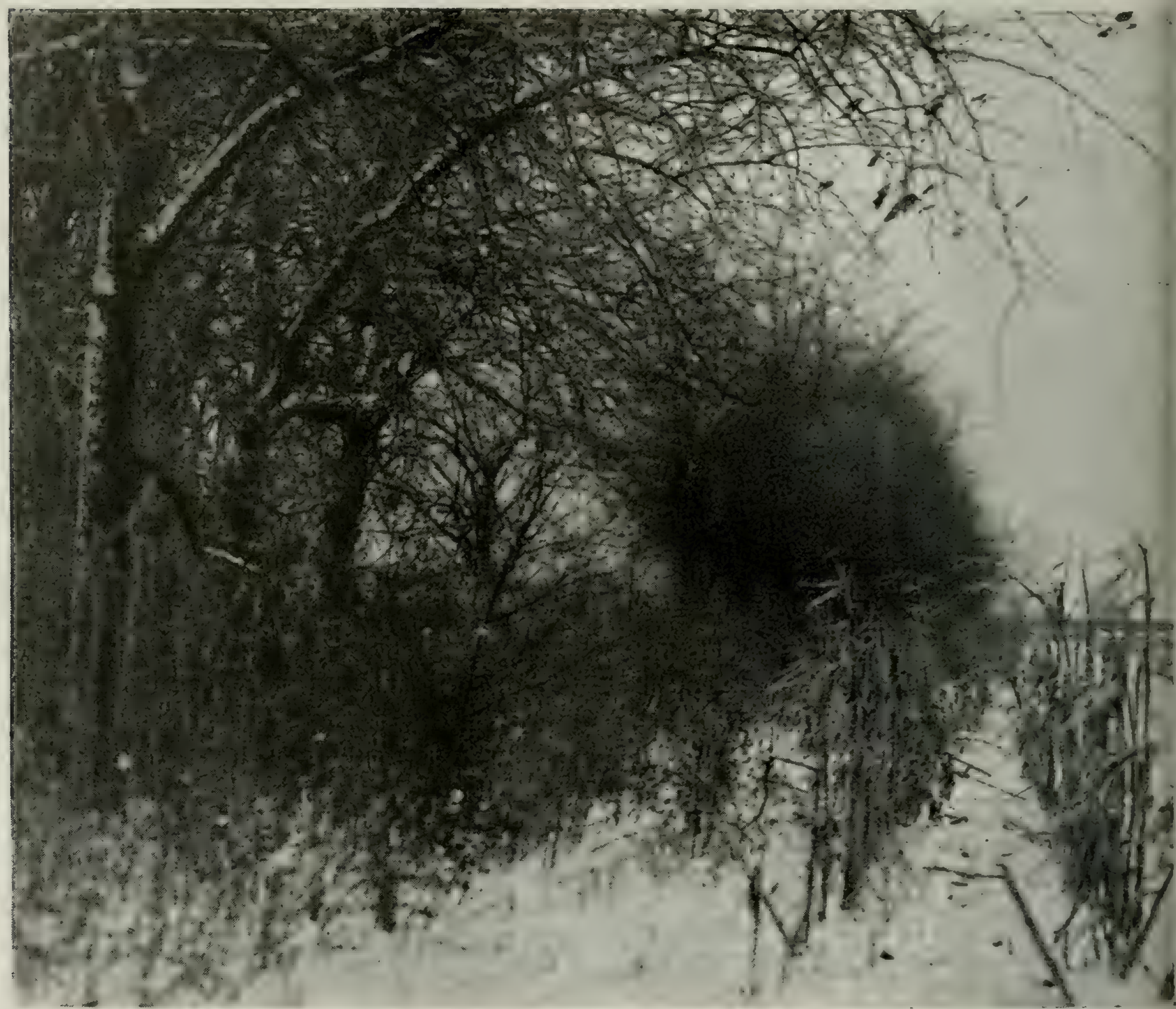

Fig. 42.—A practical winter feeding station—standing corn adjacent to a woodlot and hedgerow, Champaign County.

Hunting Seasons

The regulations under which squirrels are hunted are among the most important factors in their management. One of the ultimate objectives of this study was the determination of dates for biologically sound open seasons on fox and gray squirrels in Illinois.

The Illinois squirrel season has always begun early and lasted long, and the bag limit has been liberal. Despite heavy hunting and extensive habitat depletion in the state, squirrels, particularly fox squirrels, have maintained appreciable populations. This circumstance attests eloquently to high quality in much of the Illinois squirrel range. A comparison of the 1944 season in Illinois with seasons in other central states is given in table 26.

Of the midwest states, only Missouri and Kentucky, with 153-day and 84-day seasons, respectively, had longer open seasons than the central and northern zones in Illinois. Only Missouri had an earlier season than the southern zone. The daily bag limit in the midwest states was rather uniform, table 26, and apparently satisfactory. Only Michigan had a season limit on the kill, the total being 25.

It is interesting to note that long seasons are, for the most part, in those states where the oak-hickory forest type is most extensive. These forests, in the central states, probably reach their best development in Missouri and Illinois. That this correlation of season with habitat should occur is perhaps significant; it appears to be an instance in which the law of supply and demand exerts a dominating influence on legislation governing the utilization of a wildlife resource.

Effect of Early Seasons.—The basic effects of early-season hunting may be summarized as follows: (1) Approximately 50 per cent of the kill is of first-litter young; (2) the kill includes a considerable portion of the pregnant and lactating females; and (3) many young squirrels too immature to be self-sustaining die of starvation.

From a biological standpoint, there is no real objection to a high percentage of young squirrels in early-season bags. Mature animals appear to be the more certain winter-season breeders. From the standpoint of the hunter, young squirrels rank higher than old, as they are of maximum tenderness and palatability, whereas breeding squirrels, particularly spent males and lactating females, are relatively low in these qualities.

The chief objection to early-season hunting is that it results in the destruction of pregnant and lactating females; the pregnant animals involve unborn young, and many of the lactating females involve

Table 26.—Squirrel hunting seasons in midwest states, 1944.

State	Season Dates	Days in Season	Bag Limits			Resident License Cost
			Daily	Possession	Season	
Illinois	September 1–November 16—Northern Zone August 15–October 30—Central Zone July 15–October 15—Southern Zone	76 77 93	5	10	None	$1.50
Indiana	August 10–October 8	60	5	5	None	$1.50
Iowa	September 15–November 15	62	6	12	None	$1.00
Kentucky	August 1–September 15 November 24–December 31	84	6	12	None	$1.00 (county) $3.00 (state)
Michigan	October 15–November 5—Lower Peninsula	22	5	10	25	$1.00
Minnesota	October 15–December 31	77	7	14	None	$1.00
Missouri	June 1–October 31	153	6	9	None	$1.00 (county) $2.50 (state)
Ohio	September 15–September 30	16	4	8	None	$1.25
Wisconsin	October 16–November 12	28	5	10	None	$1.00

young too immature to be self-providing. Cross (1942) found 100 per cent pregnancy during the period September 1–15 in a sample of 39 adult squirrel females in Virginia.

The calculated degree of loss in unborn and immature squirrels resulting from an early hunting season in Illinois is given in table 27. The calculations in this table are from data given in tables 2, 3, 15 and 20. The dates of the period included in table 27 (July 16–October 31) were chosen because they are a compromise between the 1944 hunting seasons in the central and southern zones, where most of the squirrel kill was made and where most of the data in tables 15 and 20 were gathered in the years of this study. Table 3 indicates that of each 100 squirrels bagged during the period July 16–October 31 (the kill during the period of November 1–15 in the northern zone is negligible, while the kill during the period July 15–31 in the southern zone is appreciable), approximately 70 per cent were fox squirrels and 30 per cent were gray squirrels. In each 100 animals, there was an average of 12.8 mature and therefore potentially breeding fox squirrel females and 7.7 potentially breeding gray squirrel females (figures derived from table 15). Pregnant among these mature females was an average of 3.7 fox squirrels and 2.9 gray squirrels, and lactating among them was an average of 3.7 fox squirrels and 2.4 gray squirrels.

The average number of young per litter during the second season, as determined in the Illinois study, was 2.57 in fox squirrels and 2.43 in gray squirrels, table 20. Calculations based on these data give, for each bag of 100 squirrels, a loss of 9.5 unborn young and 9.5 suckling young of the fox squirrel, and 7.0 unborn young and 5.8 suckling young of the gray squirrel. Only females showing unmistakable evidence of lactation were classified as lactating; additional losses in young may have resulted through killing of mothers in the last stages of lactation or those still exercising parental care over young. The losses in unborn and suckling young were in addition to squirrels bagged and fatally hit by hunters in the period beginning July 16 and ending October 31, table 23.

For each 100 squirrels bagged, 31.8 unborn and suckling animals, table 27, as well as the squirrels fatally wounded and not recovered, must be added to the kill in order to obtain the total theoretical loss. The net loss might be somewhat less due to the fact that squirrels suffer some mortality during the post-natal and juvenile periods. This loss, although not known, is probably low, since the young are relatively free from predation and usually are well protected against the elements.

A calculation of the total loss of unborn and suckling young may be made by applying the findings in table 27 to the total kill, which, as discussed under the heading "Kill," was calculated for 1942 at 1,463,305 animals. The ratio of 31.8 young lost for every 100 squirrels bagged applied to this kill figure gives 465,331 as the calculated number of young lost in an Illinois season that begins early, July 16, and continues through October.

Recommended Seasons.—The one change needed in current Illinois laws to provide a biologically sound squirrel hunting season is a later opening date in each zone. In recommending this change, however, the writers have not forgotten that early seasons are traditional in the state, and that there are thousands of hunters who sincerely believe in summer squirrel hunting. That these hunters argue with some logic is indicated by the fact that, despite early hunting seasons in the past, in many parts of the state there is still good squirrel hunting. However, abundance of squirrels in certain areas may be the result of one or more of a number of conditions, some of them local, that favor squirrel survival. In some parts of the state hunting is comparatively rare early in the season and is intensive only through the peak of the mast season, roughly August 15 to September 15. In many places, late in the season, when squirrels are scarcer and the population becomes scattered, interest in squirrel hunting decreases. In some agricultural communities the fall farm harvest requires the attention of a large number of potential hunters. In many counties, the advent of the dove, waterfowl and upland game seasons further reduces the number of squirrel hunters. It is probable that the 76- to 93-day season in Illinois results in only a slightly larger kill than would a 45-day season coming during the main mast season. However, a season be-

Table 27.—Calculated loss in unborn and suckling young per 100 squirrels bagged in Illinois, July 16–October 31, inclusive, 1940–1943. A kill ratio of approximately 70 fox squirrels to 30 gray squirrels was obtained from Illinois kill figures, table 3.

Types of Loss by Species	Number Per 100 Squirrels (70 Fox Squirrels, 30 Gray Squirrels)
Mature, potentially breeding, females (table 15)	
Fox squirrels, 21 of 115 animals (tables 14 and 15; 18.3% of 70 animals)	12.8
Gray squirrels, 16 of 62 animals (25.8% of 30 animals)	7.7
Pregnant (table 15)	
Fox squirrels, 6 of 21 mature females (28.6% of 12.8 mature females)	3.7
Gray squirrels, 6 of 16 mature females (37.5% of 7.7 mature females)	2.9
Lactating (table 15)	
Fox squirrels, 6 of 21 mature females (28.6% of 12.8 mature females)	3.7
Gray squirrels, 5 of 16 mature females (31.3% of 7.7 mature females)	2.4
Unborn young*	
Fox squirrels (3.7 x 2.57) 9.5	
Gray squirrels (2.9 x 2.43) 7.0	
Total unborn young	16.5
Suckling young*	
Fox squirrels (3.7 x 2.57) 9.5	
Gray squirrels (2.4 x 2.43) 5.8	
Total suckling young	15.3
Total loss	*31.8*

*Average size of second-season litters: fox squirrels, 2.57; gray squirrels, 2.43; table 20.

ginning later than the present one would result in the survival of a much greater number of unborn and suckling squirrels that now are lost through destruction of pregnant and lactating females.

In the face of the considerations listed above, we feel that it would be unwise to enact a squirrel season beginning so late that it would prevent all losses attributable to the killing of pregnant and lactating females. Such a season could hardly begin earlier than October 1, and it would certainly be opposed by a large number of hunters. On the other hand, it is clear that the 1944 season, opening July 15 in the southern zone and August 15 in the central and northern zones, is too early, and that such a season results in the death of many thousands of squirrels that are not bagged. We suggest as a reasonable compromise the seasons given in table 28, which takes into consideration the precedent for early hunting in the state, the minimum requirements for adequate reproduction, and the high productive capacity of much of the Illinois squirrel range.

It goes without saying that, although the seasons proposed here will result in appreciable loss due to starvation of young, this loss will be materially less than at present. In time it may be practical to enact laws establishing seasons that give squirrels greater protection in order still further to reduce juvenile losses. It is not out of place to point out that seasons

Table 28.—Recommended squirrel hunting seasons in Illinois.

Zone	Dates	Limits		
		Daily	Possession	Season
Northern......	September 15–November 15............	5	10	None
Central........	September 15–November 15............	5	10	None
Southern......	September 1–October 31................	5	10	None

making for minimum losses due to starvation of immature squirrels are desirable from the humane standpoint.

The proposed seasons are further justified by the current reduction and depletion of Illinois squirrel habitats, especially in the southern zone, by very extensive lumbering. Military requirements for walnut, oak and other hardwood timber, in addition to domestic requirements, are unavoidably resulting in grave acreage and quality losses in the range. Intelligent laws require that these conditions be taken into consideration.

Our recommendations are based in part on Illinois hunters' opinions, table 29.

Opinions as indicated in table 29 reflect no marked preference for either of the two seasons, the second of which began 14 to 31 days later than the first. This is not surprising when it is known that both the 1940 and 1941 dates made possible hunting during the mast season. Most of the hunters desiring an earlier season, somewhat less than one-fourth of the total, like to hunt during the mulberry season, when squirrels are concentrated in the vicinity of mulberry trees. More than 75 per cent of the hunters were satisfied with the present season or desired a later one.

Illinois hunters were so obviously satisfied with kill limits, which were the same in all years of the present study, that this item was not included in the 1941 ques-

Table 29.—Opinions of 236 hunters on the 1940 and 1941 squirrel hunting seasons in Illinois.*

Zone	Number of Hunters Reporting†	1940						Number of Hunters Reporting	1941		
		Season Should Be			Bag Limit Should Be				Season Should Be		
		Earlier	Same	Later	More	Same	Less		Earlier	Same	Later
Northern..........	18	0	5	13	7	7	3	15	3	6	6
Central............	30	12	13	5	3	16	1	33	9	14	10
Southern..........	110	27	46	37	8	73	0	30	5	15	10
Total..............	*158*	*39*	*64*	*55*	*18*	*96*	*4*	*78*	*17*	*35*	*26*
Per cent...........	...	*24.7*	*40.5*	*34.8*	*15.2*	*81.4*	*3.4*	..	*21.8*	*44.9*	*33.3*

*Seasons: 1940—northern and central zones, August 1—October 15, southern zone, July 15—September 10; 1941—northern zone, September 1—November 15, central zone, August 15—October 30, southern zone, August 1—October 15; limits—both years, all zones, 5 daily, 10 in possession; no season limit.

†All hunters reporting did not express an opinion on all items of questionnaire.

tionnaire. The writers endorse the limit of five squirrels per hunter per day.

SUMMARY

1. This investigation (Illinois Federal Aid Project 14-R) was initiated in furtherance of biologically sound squirrel hunting seasons and progressive squirrel management in Illinois.

2. Field work covered a 4-year period; the first 2 years, beginning July 1, 1940, were given to a full-time study and the last 2 years to part-time study. During the first year, 10 days per month were spent by the senior author in each of the three zones into which the state is divided for administration of hunting laws; during the second year, intensive local study was pursued by the same author in Pike County, in the central zone, and in other representative areas inhabited by both fox and gray squirrels. Part-time field work, by the junior author, was carried on mainly in the central zone.

3. No completely satisfactory census technique was developed. The need for such is obvious. Time-area counts of animals and nest counts probably give a rough census. Exhaustive live trapping supplies reliable population numbers, but is too slow and time-consuming for wide-scale use.

4. The western fox squirrel (*Sciurus niger rufiventer*) inhabits most wooded areas, including small woodlots and hedgerows, in every Illinois county. The gray squirrel (*S. carolinensis leucotis* and/or *S. c. carolinensis*) occurs in all Illinois counties except some on the black prairie. It is confined to dense forest stands and is most numerous in those with brushy understory in the river bluffs and bottoms areas. The red squirrel (*Tamiasciurus hudsonicus loquax*) was not found in Illinois by the writers.

5. Fox squirrel density in the areas studied varied from 0.02 to 2.23 animals per acre. Gray squirrel density, on one representative area, was 1.49 per acre; the combined density of both species in this area was 2.34 per acre. An average of about one squirrel per acre on good Illinois habitat appears likely.

6. Species ratio (based on hunters' kill in the 1940 and 1941 seasons) was 69.7 fox squirrels and 30.3 gray squirrels. The ratio varied by zones; being 86.1 fox squirrels to 13.9 gray squirrels in the northern zone, 87.4 to 12.6 in the central zone and 49.5 to 50.5 in the southern zone. Species ratios based on other source data and for other years differ somewhat, and indicate that gray squirrels may constitute as much as 35 per cent of the squirrel population of this state.

7. Sex ratios (based mainly on hunters' kill in 1940 and 1941 and to a small extent on litters and live- and steel-trapped animals) showed a preponderance of males in both species. The ratio was 143 males to 100 females in fox squirrels and 144 males to 100 females in gray squirrels. The actual sex ratios are believed to be more nearly equal than these figures indicate.

8. The best criteria of maturity in males (November–July) are Cowper's glands of one-half inch or more in diameter and enlarged testes with scrotum devoid of hair (or nearly so) on entire ventral surface; for females, large, dark and protruding nipples. Immature males have undeveloped Cowper's glands even during the mating season and only the posterior end of the scrotum devoid of hair; immature females have mammae with small nipples nearly hidden by hair.

9. Age class figures for Illinois fox squirrels, as indicated by several hundred animals shot and trapped by the writers, were as follows: 57.8 per cent adults, 26.7 per cent spring juveniles and 15.5 per cent summer juveniles; for gray squirrels the figures were, respectively, 65.4, 22.4 and 12.2 per cent. The comparatively low kill of summer juveniles is undoubtedly an important factor in maintaining squirrel populations.

10. Little or no competition between fox and gray squirrels was observed.

11. Both species were most active early in the morning, the hour of greatest activity being from 6:00 to 7:00. The greatest activity hour for the afternoon was, in fox squirrels, between 4:00 and 5:00; in gray squirrels, between 5:00 and 6:00. The fox squirrel showed the greater tendency to be active during midday hours; the gray was active later in the evening. Individuals of both species were seen to be active during showers, or soon after, and in deep snow; in both species, high winds, heavy rains, snow-

storms, very high temperatures and also very low temperatures appeared to reduce activity.

12. The two types of movements noted in squirrel populations were daily activity, mainly associated with feeding, and seasonal dispersal, perhaps associated with the annual readjustment of populations, in the late summer and fall. The former usually involved only a few acres; the latter, probably up to several miles. Mass migration was not observed in either species although it has been reported often in the gray squirrel.

13. Neither weight nor length of squirrels proved to be a reliable indicator of age at all seasons of the year. Adult fox squirrels taken in a 2-year period averaged about 1.70 pounds; adult grays, 1.18 pounds. Spring-born juvenile fox squirrels weighed 1.61 pounds by November; spring-born juvenile gray squirrels, 1.27 pounds by October. Length was found to be probably an even less reliable age indicator than weight.

14. Stub tail was the only deformity observed; 13.5 per cent of all fox squirrels and 12.3 per cent of all gray squirrels examined were affected. This deformity, probably due to fighting and mating chases, in no way impeded travel or other activity.

15. Only six of the squirrels collected showed wounds of serious nature. Most badly wounded animals that escape hunters are believed to die in dens, nests or other retreats.

16. Fox and gray squirrels molt once annually, both species undergoing a body and then a tail phase. Males and spring juveniles molt before females, usually before midsummer. Females that produce second-season litters molt last, beginning after lactation is under way. Few color types were found in Illinois squirrels.

17. Neither parasites nor diseases appeared to be of importance in Illinois squirrel populations. Mange, the most prevalent disorder, was observed in only two localities (cities excepted), neither serious. Predators likewise appeared to cause little loss; adult squirrels are too active and alert, and the young are too well protected to be captured easily.

18. Breeding studies were based mainly on 722 fox squirrels and 353 gray squirrels handled in the laboratory. Specimens of both species were available each month from July, 1940, to October, 1942. Other biological and all ecological studies were based on these animals, an additional 2,594 fox squirrels and 1,121 gray squirrels taken mainly by hunters, and more than 2 years of field observations.

19. Both fox and gray squirrels have two breeding seasons per year, the first in winter and spring and the second in spring and summer. Second-season litters appear to be confined largely to vigorous females over 18 months old. Both spring-born and summer-born animals attain sexual maturity at the age of about 10 to 12 months, and the females produce their first young when approximately a year old.

20. In Illinois the breeding season of fox squirrels precedes that of gray squirrels by about 10 days or 2 weeks. Between the northern and southern limits of Illinois there is a difference of about 3 weeks in the average breeding dates for both species. In the central zone, the peak of winter breeding determined for fox squirrels was in late December; in gray squirrels in early January; summer breeding peaks, for fox squirrels, the first 2 or 3 weeks in June; for gray squirrels, the last half of June or a little later. Corresponding peaks may be expected approximately a week earlier and later, respectively, in the southern and northern zones.

21. Mating chases, often involving several squirrels, are characteristic of both species. In males, enlarged testes and Cowper's glands are obvious indications of breeding condition, and the scrotal sac becomes smooth and stained as the breeding season advances. In females, oestrus is indicated by the swollen and discolored vulva.

22. In both species gestation appears to require about 44 or 45 days. In the fox squirrel, pregnancy peaks occurred in early February and late July; lactation peaks in March and August. In the gray squirrel, corresponding peaks were about 10 days to 2 weeks later. Lactation in the gray squirrel extended into October.

23. Squirrels are born both in tree cavities and in leaf nests, more commonly in the former. The average number of young in the litters counted was, in fox squirrels, 2.49 in spring and 2.57 in summer; in gray squirrels, 2.74 in spring

and 2.43 in summer. The eyes of juvenile squirrels open at about 4 weeks; weaning occurs at about 8 to 10 weeks, at which time the hair is well developed. Young squirrels become fully self-sustaining when between 3 and 4 months old.

24. Illinois squirrel habitats are of two types, agricultural and woodland. The former consist mainly of farm woodlots, hedgerows and wooded stream valleys; the latter, the more extensive wooded areas, both upland and bottomland in character. The upland and bottomland types combined provide roughly 6,750,000 acres of squirrel range in the state; agricultural types provide a much smaller acreage of habitable range. Minor habitat types consist of reforested stripmines, estates, parks, college campuses, and many towns and cities.

25. During this investigation, a total of 76 kinds of food plants for Illinois squirrels were recorded; these included 56 trees and shrubs, 2 vines, 4 brambles, 6 wild herbs, 7 cultivated crops and various fungi. Six groups provided most of the staple foods—hickories (including pecan), oaks, walnuts, elms, mulberry and field corn. In Illinois almost any fruit may be important seasonally or locally. Mixed stands produce the greatest variety and abundance of food. Cultivated crops, mainly corn, are of far greater importance to fox squirrels than to gray squirrels. No study of the animal food of squirrels was made. Squirrel food shortage appeared to be rare on Illinois range.

26. Illinois squirrels follow a somewhat distinct order of succession in the utilization of foods. In late winter or spring they feed on the buds and then the flowers and seeds of elms, maples and other hardwoods. Later they make use of mulberries and bramble fruits. The mast season, from July or August through October, is the period of greatest food abundance.

27. Squirrels show definite preferences when several foods are abundant at one time. Hickory nuts seem to rank first with both fox and gray squirrels.

28. Storing or caching, which seems to be instinctive in squirrels, is apparently an extension of the morning and afternoon feeding periods during the mast season. The stored foods observed in the present study were mainly nuts and acorns.

29. The gnawing of bones, observed in both squirrel species, may be for the purpose of obtaining minerals.

30. Fox squirrels apparently are able to inhabit range lacking open water, provided succulent foods such as green corn, blackberries or Osage orange fruits are available. Gray squirrels were never found on areas entirely devoid of open water.

31. Both fox and gray squirrels use cavity and leaf nests, and in both species cavities are important as young-rearing sites. Either type of nest appears to meet the essential requirements of either species, but both types of nests are found in the habitats of highest quality. Squirrels utilize practically any kind of tree for nest location, but, because of abundance and statewide distribution, the oaks are by far the most important group. The oaks, maples, American elm, white ash, beech, sweet gum, and, in extreme southern counties, cypress and tupelo gum are the chief sources of nest cavities for Illinois squirrels.

32. Squirrel hunters are mainly farmers, laborers and small-town businessmen. Slightly more than one squirrel killed per hour was reported by a group of 236 Illinois hunters in 1940 and 1941. A bag figure believed to be more nearly representative for Illinois is between 0.5 and 1.0 squirrel per hour. Crippling loss, calculated from hunters' reports, was about 15 per cent of all squirrels known to have been hit; this figure does not take into account the loss in squirrels not known to have been hit. The 12-gauge shotgun was the most popular arm of Illinois hunters, followed by the .22-caliber rifle and the 16-gauge shotgun.

33. The calculated squirrel kill in Illinois in 1942 was 1,463,305 animals, of which 64.7 per cent were fox squirrels and 35.3 per cent were gray squirrels. The northern zone produced 11.4 per cent, the central zone 29.1 per cent and the southern zone 50.5 per cent of this kill. A total of about 1,240,000 pounds of high quality meat was produced, practically all of which was used for human food.

34. In general, good forest practices, especially the maintenance of mixed, all-age stands and protection from fire and grazing, lend themselves to good squirrel management. Selective cutting, except

when a large percentage of the food trees are removed, may improve the range as squirrel habitat by breaking up solid stands and promoting shrub, vine and bramble growth in the openings. Only a few hickories, elms or mulberries, in addition to oaks, beech or maples, are needed in a stand to provide all necessary squirrel food. Development of fencerows and hedgerows greatly improves fox squirrel range on the prairie. Den boxes are needed only where cavity shortage actually exists. Winter feeding is unnecessary except during periods of crusted snow, heavy ice or actual food shortage.

35. The Illinois squirrel hunting season is traditionally long and is early in starting; in the past it has usually opened in midsummer and continued 75 days or more. Such a season may result in a calculated loss of 31.8 unborn and suckling squirrels for each 100 squirrels bagged, or a total yearly loss of approximately 465,000 unborn and suckling squirrels (hunters' kill, 1942, used as a basis).

36. The squirrel hunting season recommended for Illinois is September 15 to November 15 in the northern and central zones, and September 1 to October 31 in the southern zone. This season will not prevent all loss in unborn and nursing squirrels, but will materially reduce the losses now occurring. Recent severe depletion of the habitat, due to heavy cutting to meet war needs, is an added reason for a hunting season based upon serious consideration of the life history of the animals.

LITERATURE CITED

Allen, Durward L.

1940. A point on fox squirrel management: Shooting into nests is wasteful hunting. Mich. Cons. **9**(12): 11. 1 fig.

1941. Rose Lake Wildlife Experiment Station; Second annual report. Mich. Dept. Cons. Game Div. 365 pp. (Mimeographed.)

1942. Populations and habits of the fox squirrel in Allegan County, Michigan. Am. Midland Nat. **27**(2): 338–79. 19 figs.

1943. Michigan fox squirrel management. Mich. Dept. Cons. Game Div. Pub. **100**. 404 pp., 152 figs., index.

Anderson, R. M.

1932. Methods of collecting and preserving vertebrate animals. Can. Natl. Mus. Bul. 69. 141 pp., 46 figs.

Baker, Rollin H.

1944. An ecological study of tree squirrels in eastern Texas. Jour. Mammal. **25**(1): 8–24. 5 figs.

Baumgartner, Luther L.

1938. Population studies of the fox squirrel in Ohio. N. Am. Wildlife Conf. Trans. 3, **1937**: 685–9.

1939*a*. Foods of the fox squirrel in Ohio. N. Am. Wildlife Conf. Trans. 4, **1938**: 579–84.

1939*b*. Fox squirrel dens. Jour. Mammal. **20**(4): 456–65. 3 pls.

1940. Trapping, handling, and marking fox squirrels. Jour. Wildlife Mgt. 4(4): 444–50. 1 pl., 16 figs.

1943*a*. Fox squirrels in Ohio. Jour. Wildlife Mgt. 7(2): 193–202. 1 pl.

1943*b*. Pelage studies of fox squirrel (*Sciurus niger rufiventer*). Am. Midland Nat. **29**(3): 588–90.

Boulware, Jean T.

1941. Eucalyptus tree utilized by fox squirrel in California. Am. Midland Nat. **26**(3): 696–7. 1 fig.

Brooks, Fred E.

1922. Note on a feeding habit of the gray squirrel. Jour. Mammal. 4(4): 257–8.

Brown, Louis G., and Frank C. Bellrose, Jr.

1943. Use of nesting boxes for wood ducks by other wildlife. Jour. Wildlife Mgt. 7(3): 298–306. 1 pl.

Cahalane, Victor H.

1942. Caching and recovery of food by the western fox squirrel. Jour. Wildlife Mgt. 6(4): 338–52.

Carlson, A. J.

1940. Eating of bone by the pregnant and lactating gray squirrel. Sci. n. s. 91(2372): 573.

Case, H. C. M., and K. H. Myers

1934. Types of farming in Illinois. Ill. Ag. Exp. Sta. Bul. 403. 226 pp., 40 figs.

Chandler, Asa C.

1942. Helminths of tree squirrels in southeast Texas. Jour. Parasitol. **28**(2): 135–40. 3 figs.

Chapman, Floyd B.

1936. Fox squirrels and gray squirrels. Ohio Div. Cons. Bul. 127. 4 pp. (Mimeographed.)

1937. Controlled squirrel and rabbit hunting on state hunting preserves, 1936. Ohio Wildlife Res. Sta. Release 37. 11 pp. (Mimeographed.)

1938*a*. Controlled squirrel hunting on Ohio hunting preserves, 1937. Ohio Wildlife. Res. Sta. Release 68. 8 pp. (Mimeographed.)

1938*b*. Summary of the Ohio gray squirrel investigation. N. Am. Wildlife Conf. Trans. 3, **1937**: 677–84.

1939. A summary of the gray squirrel investigation in southeastern Ohio. U. S. Dept. Ag. Wildlife Res. and Mgt. Leaf. BS-134. 9 pp. (Mimeographed.)

Chapman, Floyd B., and Luther L. Baumgartner
[1939.] Winter feeding of squirrels. Ohio Div. Cons. Bul. **150.** 7 pp., 1 pl.

Cottam, Clarence
1941. How fast can a fox squirrel run? Jour. Mammal. **22**(3) : 323.

Coventry, A. F.
1940. The eating of bone by squirrels. Sci. n. s. **92**(2380) : 128.

Cross, R. H., Jr.
[1942.] Breeding habits and management of the gray squirrel in Virginia. Va. Comm. Game and Inland Fish. 5 pp. (Mimeographed.)

Dambach, Charles A.
1942. Gray squirrel feeding on *Crataegus*. Jour. Mammal. **23**(3) : 337.

Davis, Wm. T.
1907. Insects as the food of squirrels. Can. Ent. **39**(1) : 16.
1924. Oak apple galls destroyed by gray squirrels. Brooklyn Ent. Soc. Bul. **19**(3) : 91–3. 1 fig.

Deuber, Carl G.
1934. Defoliation activities of gray squirrels in American elm trees. Sci. Monthly **38**: 60–3. Illus.

Dice, Lee R.
1931. Methods of indicating abundance of mammals. Jour. Mammal. **12**(4) : 376–81.
1941. Methods for estimating populations of animals. Jour. Wildlife Mgt. **5**(4) : 398–407.

Dozier, Herbert L., and Harrold E. Hall
1944. Observations on the Bryant fox squirrel. Md. Cons. **21**(1) : 2–6. Illus.

Edminster, Frank C.
1937. An analysis of the value of refuges for cyclic game species. Jour. Wildlife Mgt. **1**(1–2) : 37–41.

Goodrum, Phil D.
1938. Squirrel management in east Texas. N. Am. Wildlife Conf. Trans. 3, **1937**: 670–6.
1940. A population study of the gray squirrel in eastern Texas. Tex. Ag. Exp. Sta. Bul. **591.** 34 pp., 5 figs.

Goodwin, George G.
1934. The gray squirrel migration. Nat. Mag. **23**(5) : 221–2, 255–6. 2 photos.

Graham, Edward, and Jacob Uhrich
1943. Animal parasites of the fox squirrel, *Sciurus niger rufiventer,* in southeastern Kansas. Jour. Parasitol. **29**(2) : 159–60.

Hahn, W. L.
1909. The mammals of Indiana. Ind. Dept. Geol. and Nat. Res. Ann. Rep. **33**: 417–654.

Hamilton, W. J., Jr.
1943. Caterpillars as food of the gray squirrel. Jour. Mammal. **24**(1) : 104.

Harkema, Reinard
1936. The parasites of some North Carolina rodents. Ecol. Mono. **6**(2) : 153–232.

Hawkins, Arthur S.
1937. Winter feeding at Faville Grove, 1935–36. Am. Midland Nat. **18**(3) : 417–25.

Hawkins, Arthur S., and Frank C. Bellrose, Jr.
1941. Wood duck habitat management in Illinois. N. Am. Wildlife Conf. Trans. 5, **1940**: 392–95.

Haymond, Rufus
1869. Mammals found in Franklin County, Indiana. Ind. Ag. and Geol. Rep. **1869**: 203–8.

Hesselschwerdt, Robert E.
1942. Use of den boxes in wildlife restoration in intensively farmed areas. Jour. Wildlife Mgt. **6**(1): 31–7. 4 pls.

Hibbard, Claude W.
1935. Breeding seasons of gray squirrel and flying squirrel. Jour. Mammal. **16**(4): 325–6.

Hicks, Ellis A.
1942. Some major factors affecting the use of two inventory methods applicable to the western fox squirrel, *Sciurus niger rufiventer* (Geoffroy). Iowa State Col. Jour. Sci. **16**(2): 299–305.

Hungerford, K. E., and N. G. Wilder
1941. Observations on the homing behavior of the gray squirrel (*Sciurus carolinensis*). Jour. Wildlife Mgt. **5**(4): 558–60.

Jackson, H. H. T.
1910. The distribution of certain Wisconsin mammals. Wis. Nat. Hist. Soc. Bul. **8**(2): 86–90.
1921. A recent migration of the gray squirrel in Wisconsin. Jour. Mammal. **2**(2): 113–4.

Katz, Julius S.
1939. An annotated bibliography of references concerning parasites of squirrels (family Sciuridae). Ohio Wildlife Res. Sta. Release 131. 21 pp. (Mimeographed.)

Kennicott, John
1857. The quadrupeds of Illinois, injurious and beneficial to the farmer. U. S. Pat. Off. Rep. Ag. for 1856, pp. 54–67.

Leopold, Aldo
1933. Game management. Charles Scribner's Sons, New York. xxi+481 pp., 35 figs.

Lyon, M. W., Jr.
1936. Mammals of Indiana. Am. Midland Nat. **17**(1): 1–384. 112 figs.

Middleton, A. D.
1930. The ecology of the American gray squirrel (*Sciurus carolinensis* Gmelin) in the British Isles. London Zool. Soc. Proc., pt. 3, **1930**: 809–43. 4 figs., 6 pls.

Mossman, H. W., John W. Lawlah and J. A. Bradley
1932. The male reproductive tract of the Sciuridae. Am. Jour. Anat. **51**(1): 89–155. 7 pls., 16 figs.

Necker, Walter L., and Donald M. Hatfield
1941. Mammals of Illinois. Chicago Acad. Sci. Bul. **6**(3): 17–60. 15 figs.

Nichols, John T.
1927. Notes on the food of the gray squirrel. Jour. Mammal. **8**(1): 55–7.

Osgood, Frederick L., Jr.
1938. The mammals of Vermont. Jour. Mammal. **19**(4): 435–41.

Pearce, John
1938. Identifying tooth marks of some northeastern animals on forest vegetation. N. Am Wildlife Conf. Trans. 3, **1937**: 690–4.

Seton, Ernest T.
1928. Lives of game animals. Literary Guild of Am., Inc., New York. **4**: 9–58; 82–106. Illus.

Stoddard, H. L.
1920. Nests of the western fox squirrel. Jour. Mammal. **1**(3): 122–3. 1 pl.

U. S. Department of Commerce
1936. United States Census of Agriculture: 1935. Vol. 1. xxxix+950 pp.

Terres, J. Kenneth
1939. Gray squirrel utilization of elm. Jour. Wildlife Mgt. 3(4):358–9.

Terrill, H. V.
1941. A preliminary study of the western fox squirrel, *Sciurus niger rufiventer* (Geoffroy), in Missouri. Graduate thesis, University of Missouri. 164 pp.

Whitaker, H. L.
1939. Fox squirrel utilization of Osage orange in Kansas. Jour. Wildlife Mgt. 3(2):117. 1 pl.

Woods, Gordon T.
1941. Mid-summer food of gray squirrels. Jour. Mammal. 22(3):321.

Yeager, Lee E.
1936. Fox squirrel seriously damages elm tree. Jour. Mammal. 17(4):417–8.
1942. Coal-stripped land as a mammal habitat, with special reference to fur animals. Am. Midland Nat. 27(3):613–35. 8 figs.

Yeatter, Ralph E., and David H. Thompson
1943. Cottontails, tularemia and weather. Ill. Cons. 8(4):6–7, 36. Illus.

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Recent Publications

A.—ILLINOIS NATURAL HISTORY SURVEY BULLETIN.

Volume 21, Article 6.—Preliminary Investigation of Oak Diseases in Illinois. By J. Cedric Carter. June, 1941. 36 pp., frontis. + 51 figs., bibliog. (Bound with Article 7.)

Volume 21, Article 7.—A Needle Blight of Austrian Pine. By Robert L. Hulbary. June, 1941. 6 pp., frontis. + 3 figs., bibliog. (Bound with Article 6.)

Volume 21, Article 8.—Duck Food Plants of the Illinois River Valley. By Frank C. Bellrose, Jr. August, 1941. 44 pp., frontis. + 35 figs., bibliog., appendix.

Volume 22, Article 1.—The Plant Bugs, or Miridae, of Illinois. By Harry H. Knight. September, 1941. 234 pp., frontis. + 181 figs., bibliog., index. $1.25.

Volume 22, Article 2.—Studies of North American Plecoptera, with special reference to the fauna of Illinois. By T. H. Frison. September, 1942. 122 pp., frontis. + 126 figs., bibliog., index. $1.00.

Volume 22, Article 3.—Management of Small Artificial Lakes: a summary of fisheries investigations, 1938-1942. By George W. Bennett. February, 1943. 20 pp., frontis. + 7 figs., bibliog.

Volume 22, Article 4.—The Prairie Chicken in Illinois. By Ralph E. Yeatter. May, 1943. 40 pp., frontis. + 18 figs., bibliog. (Bound with Article 5.)

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Volume 23, Article 4.—Wetwood of Elms. By J. Cedric Carter. August, 1945. 42 pp., frontis. + 30 figs., bibliog.

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3.—Fieldbook of Native Illinois Shrubs. By Leo R. Tehon. December, 1942. 307 pp., 4 color pls. + 72 figs., glossary, index. $1.25.

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