NOTES ON THE

AQUATIC INSECTS

OF

WALNUT LAKE

BY

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REPRINT OF PART OF THE REPORT OF THE BOARD OF GEOLOGICAL SURVEY OF MICHIGAN FOR 1907 ON THE BIOLOGY OF WALNUT LAKE BY T. L. HANKINSON AND OTHERS

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APPENDIX III.

NOTES ON THE AQUATIC INSECTS OF WALNUT LAKE.

WITH ESPECIAL REFERENCE TO A FEW SPECIES OF CONSIDERABLE IMPORTANCE AS FISH FOOD.

By JAMES G. NEEDHAM.

In June Prof. Reighard wrote me that the Survey at Walnut Lake was finding insects an important element in the food of fishes there, and asked whether I could not come myself or send some one to study them. Having no one to send at the time, and being greatly interested in the matter because of former similar findings of my own, I determined to go myself, if only for a little while. I was then on the point of departure for the meeting of the American Association for the Advancement of Science at Ithaca, and I stopped off *en route* to spend part of three days at Walnut Lake going, and a week, returning from the meeting. On these ten days—June 26–8, and July 8–14, I was favored by accessibility of quarters to collecting grounds, by good weather and good equipment, and especially by the intelligent aid of the two men in charge of the station work, Mr. T. L. Hankinson and Mr. Elmer McDonald. But even with these advantages, and with the aid of additional collections made before my arrival and after my departure, it was manifestly impossible to do more than scratch the surface of the insect problem in a few spots. Aquatic insects are a great host, and there is none of them whose life history is not beset with many unsolved problems.

Both Director Lane and Professor Reighard recognized the limitations and merely asked that I should proceed with such collecting and observations as would be possible during my stay. The results are embodied in the following pages.

In company with Mr. C. C. Adams and the station staff I first visited all the collecting stations on the lake looking out for the most favorable places for finding insects. Then I made a hasty examination of insects collected by Mr. Hankinson from fish stomachs, to see which appeared to be the important species. These proved to be, as usual, midges and May-flies, whose larvæ live in water of some depth.

The activities of the adults begin after sundown, so at the lake, until dark or later, I spent every evening at the exceedingly difficult task of observing the swarming and mating habits and succeeded in filling a few gaps in our knowledge of the more important species. I collected by day with a dredge in deep water, or with nets along shore. A single trap lantern, run every night, supplemented the collections with tens of thousands of specimens and a goodly number of additional species, mostly aquatic insects. I made a single trip down the outlet of the lake and found in the rapid part of the stream a fine station for collecting Parnid beetles.

A few species of great importance as fish food, however, received the greater share of my attention, and my observations thereon comprise the first part of the following paper, the second part being an annotated list of the aquatic insects observed, and the third part some observations made in cooperation with Mr. McDonald on a dipterous gall upon the submerged petioles of the yellow water lily.

I. THE IMPORTANT FOOD SPECIES.

Professor Hankinson's detailed report on the food of the fishes of Walnut Lake, given elsewhere in these pages, demonstrates again the great importance of the larvæ of midges of the genus Chironomus and of May-flies of the genus Hexagenia, and shows that fishes which forage on rocky shores, feed to some extent also upon the larvæ of May-flies of the genus Heptagenia. These insects have several common characteristics. They all have a very short period of adult life, during which no food is eaten; the mouth part in all are rudimentary. The adult life of all is concerned solely with reproduction, and they all leave the water with the sexual products practically mature. They all transform in open water, leaving their cast off skins floating upon the surface, and fly to some shelter on shore. They are all nocturnal or crepuscular in their adult habits, and in consequence, are very difficult of observation.

Chironomus.

This great genus of midges is represented by a considerable number of species at Walnut Lake. A few of the larger species that live in the deeper water are doubtless of most importance as fish food: for it is the larger larvæ that are found in their stomachs. The largest species of the genus, *Chironomus plumosus*, was common, and finding there my first opportunity for making observations on the habits of this species, I gave to it the greater share of my attention and time. I give a special account of it below, following this with some general observation on the structure and habits of a number of others of the larger members of the genus.

It may be said of the larvæ of the larger species of Chironomus that they are the well known "blood worms" one lifts with a dip net out of the black bottom mud of any deep pool, an inch or less in length, cylindric, of a bright transparent red color, legless, save for a pair of short prolegs at each end of the body, the anterior ones ending in a disheveled brush of soft hairs, the posterior ones bearing slender double-arched claws, hairless save for two conspicuous tufts of bristles on the end of the last segment of the body above and a few microscopic hairs about the head living in thin-walled tubes of homespun silk covered with adherent silt, and when torn from their tube swimming with figure-of-eight-shaped loopings of the body, they are easily recognizable by any one.

Chironomus plumosus, Linn. *The Plumed Midge.*—This species is easily recognized by its great size (11 to 12 mm. in length of body); it is the largest of the genus. It is common at Walnut Lake, but would not be likely to be found so except by a collector specially looking for it. An occasional specimen may be seen flying across the water from its place of transformation to find shelter among the trees on shore. Near the water's edge one will occasionally be flushed from a tree trunk or from an overhanging bough, and on sweeping the shore vegetation in sedgy areas with an insect net, one will often be taken from the dry summit of a typha stem. But few of the adults are discoverable except by watching for their evening flights.

Swarming and mating habits.—Chironomus plumosus appears on the wing for its mating flight at a time about midway between sundown and dark. Unfortunately, before its appearance nightfall has covered the surrounding woods and meadows with blackness against which the midges cannot be seen at all; they are only visible against the background of the lighted sky above. Hence one cannot see them coming from their resting places to join the company in flight. How eagerly I watched for this, only to have

the curtain of darkness fall to the edge of the horizon before any of the plumed midges had been sighted. Then a few would appear overhead, three or four or five of them, eight or ten meters high, and would quickly fall to flying horizontally back and forth upon a regular beat. Gradually they would be joined by others, but they never form thick clouds, as do many of the smaller species. The individuals stand well apart in their flight, with usually several decimeters space between them. After a little while one could determine by changing his base of observation that a considerable area was overhung by the hovering midges.

Their habit is to fly swiftly forward head to wind for a distance of about 10 meters, and then holding the body to the same position still, to drift rather more slowly backward to the starting point. This is repeated continuously by all the individuals in the flight, though not quite synchronously. When a good breeze is blowing they move quite horizontally, and in straight lines; when it is calm their movements are a little less regular. There seems always to be enough movement of the air to determine their position in flight, which is always head to windward. Even at the height of 10 meters one could see by looking carefully that nearly all the individuals were males. An occasional female could be recognized by her distinctly larger size. With a little practice the females could be followed through the entire course of their brief mating flight; for while the males appear to hover with the swarm through the whole period of observation, each female flies but a few minutes. She could be seen entering the swarm, rising in flight as if coming from some resting place in the marshes. She would take her place in the company, falling into step, so to speak, and moving back and forth at a proper interval, in straight, horizontal lines. Then, while in her windward course, a male would be seen to approach, to grasp her from above with his feet, and the two would appear as one for an instant. Then, having seized her abdomen with his claspers he would turn about face just at the time when she reached the windward end of the beat, and, heading the opposite way, after the manner of midges in copulation, in apparently active flight, lead the return course to the leeward end of the beat. There they would separate, the male returning to the swarm, the female leaving for parts unknown. She was always lost from view almost immediately. I could only see that in departing her flight had no relation to the wind; she flew obliquely downward, usually in the direction of the lake, but once or twice apparently in the opposite direction toward the trees. The whole mating act occupied hardly more than one or two seconds of time.

The laying of the eggs I did not succeed in observing. The triangle dredge brought up from the bottom a single clump of Chironomus eggs in 30 feet of water, forming so large a mass it could hardly have been laid by any other of our species. It was taken July 9th at station 5, placed in bottle of water in the laboratory, and there the eggs hatched on the 11th and 12th. The young larvæ swam freely upward and outward to become aggregated upon the lighted side of the bottle. Each still carried a little mass of unabsorbed yolk. Doubtless this is the time of their distribution over the bottom. Doubtless this is the time they get into the plankton in greatest numbers; the plankton chironomids are usually minute ones. By the 13th of July about half of those larvæ that had hatched were constructing such sort of cases on the bottom of the bottle and on the paper label it contained as the scanty sediment in the bottle allowed.

The further life history of this species has not been traced. Dr. Johannsen has described larvæ and pupæ from the Renwick marshes at Ithaca, N. Y.,

which he has referred to this species with a high degree of probability. The larvæ I found by dredging in 100 ft. of water in Walnut Lake were not the same species described by Dr. Johannsen; neither were those obtained earlier in the season from whitefish stomachs; neither were these last the same as those I dredged. It is highly probable, however, that this is one of several deep-water species of Walnut Lake, for in addition to the occasional very large pupa skins found floating on the surface, Mr. Hankinson has taken the newly emerged imagos on the surface over deep water.

I was able to determine approximately the number of eggs produced by this species by capturing a newly emerged female, keeping her until mature, dissecting out the ovaries and counting the eggs. The newly emerged adult is still reddish in color, especially at the sutures between body segments, the red color of the blood still showing through the slowly darkening cuticle. The ovaries contained in this case about 3000 eggs.

Chironomus meridionalis Joh.—I observed the swarming and mating habits of this species also on several evenings. At station 1 small swarms could be observed almost anywhere along shore as darkness was falling. The swarms maintained an elevation of but one to two meters above the ground. The flight of individuals was head to wind always, through a distance of hardly more than a meter, then a drifting backward to the rear of the swarm, forward and backward, in endless repetition, not, however, in straight lines, as in *Chironomus plumosus*, but with much irregular weaving up and down, and with a constant shifting of relative positions in the swarm. The females stay longer in the swarm in this species. I watched one female twenty minutes from her entering and then lost her without seeing the conclusion of her flight. I observed copulation in a number of other instances; it occurs quite as in *Ch. plumosus*, and has the same sequel—the female departs immediately thereafter, and the male returns to the swarm and resumes flying.

Chironomus albistria Walker.—Mr. McDonald found this species living in green petioles of *Nymphæa advena*, and showed them to me on my first visit to Walnut Lake. I was greatly interested to know a species with such a habit, and suggested that he rear some of the larvæ. This he did, obtaining his first imagos on July 10th. The adults were not observed at large, and nothing is known of their habits. Larvæ and pupæ are described below.

Formerly I found at my campus pond in Lake Forest, Ill., the dead leaves of typha teeming with larvæ of the chironomid *Tanypur carneus*, and I innocently supposed they were eating the leaves, until I made an examination of their stomach contents. This revealed to me the fact that their diet within the leaves was practically the same as that of other chironomid larvæ living upon the pond bottom—diatoms and the minuter algæ—while the tissue of the typha were not eaten at all; this was shredded and used to cover the silken tubes within which the larvæ dwelt in the excavations in the leaves, much as others live upon the pond bottom.

The larvæ of *Chironomus albistria* live in elongated excavations in the green nymphæa petioles, having one or more blackish minute openings to the outside. These openings, being slightly discolored, were an easy means of recognizing infested stems. The earliest of the leaves that reach the surface of the water were the ones most infested, and the longest internal chambers, with the largest external openings leading into them, were found near the base of these. However, many of the tunnels were cut high up on young vigorous petioles, and looked as if made by the chironomus larvæ themselves from the beginning; so I was curious to see whether these larvæ were eating

green plant tissue. I examined the stomach contents of half a dozen larvæ of different sizes, freshly brought in from the field. In the smaller ones I found only algæ and silt. In all of the larger ones I found a little, and one of the largest, much, nymphæa tissue. Certain parts of this tissue are exceptionally easy to recognize—the internal hairs, for instance, which spring from junction cells in walls separating the normal air spaces of the tissue of the petiole, and project into those spaces; these hairs are covered with microscopic prickles, and are easily recognizable even in fragments, while whole hairs were frequently found, and in the case of the one larvæ that had eaten most freely of the tissue, whole junction cells fairly well isolated from their surroundings, and burr-like with groups of these hairs projecting in all directions from them, were present.

The larvæ entering the nymphæa tissue needs but remove a few thin partition walls in order to have space enough to live in. It spins about itself the usual thin tissue of silk, and for a covering uses the materials of the demolished air-space partitions. Over the outside of the older parts of its case, and in the vestibule of its chambers diatoms and other very minute algæ flourish abundantly, as they do all over the outside of the stems. And the manner of life of these larvæ is not greatly different from that of their congeners on the pond bottom. Doubtless they are more protected during larval life; they show also some modifications of the minuter structures of the feeding organs to be mentioned in the following descriptions.

The larva when fully grown measures 16 mm. in length and 1 mm. in diameter. It is of the usual cylindric form, of a bright transparent red color, with a reddish brown head. The two caudal tufts contain each six very close set yellowish hairs, and there are two isolated hairs below the tufts above the anal gills. The latter are four as usual, thick, obtuse and hardly longer than the anal prolegs; there are no other abdominal gills. The claws of the prolegs are obliquely U-shaped. The labial border (Fig. 19) is of a very unusual form, being elongate and deeply bilobed, with no very distinct teeth save the two very large ones that terminate its lobes, and that are separated by a triangular space of their own width. There are faint indications of two low teeth nearer the median line, and of five outside on each lateral margin. The epipharyngeal comb is poorly developed, consisting of a row of three obtuse, triangular tubercles (Fig. 19 m).

Fig. 19.—*Chironomus albistria* Walker. m—The epipharyngeal comb of the larva; n—the labial border; both x 55.

The pupa measures 12 mm. in length. It is red in color, darkening with age with the appearance of the adult pigmentation. It possesses the usual thoracic tufts of respiratory filaments, sessile, short, spreading and very finely divided by successive branchings. Across the apex of the 2nd abdominal segment on the dorsal side there is a fine line of minute chitinous black

teeth, which scarcely extends down upon the sides. The postero-lateral expansion of the 8th abdominal segment ends in a digitate comb of about five posteriorly directed teeth, of which the middle one is longest and strongest, the second and fourth shorter and sub-equal, and the first and fifth minute or rudimentary, and before these on the lateral margin of the segment is a row of four slender distant spinules. The bifid ventral appendage of the end of the abdomen is slightly longer than the body of the caudal fin; the fringe of the fin is semi-circular in outline and contiunous over the two lobes; it is composed of very fine silky yellowish hairs, and is one-half longer than the 9th segment.

REMARKS ON TWO OTHER CHIRONOMUS LARVÆ FOUND IN DEEP WATER IN WALNUT LAKE, AND ON THE MEANS OF DISTINGUISHING THE SPECIES.

I have had for study two species of Chironomus larvæ from Walnut Lake obtained from deep water, one taken by myself with a triangle dredge in 100 feet of water, and examined both fresh and preserved; the other taken from the stomach of a whitefish by Mr. Hankinson. The former is apparently identical with the species I found making up the greater part of the food of the brook trout in Bone Pond near Saranac Inn in the Adirondacks in 1900 (figured in detail by Dr. Johannsen on pl. 49 of Bull. 68, N. Y. State Museum). What the species is, is not yet known. Likewise, it is not yet known to what species of adult the other larvæ which the whitefish were eating so extensively in April belongs. It is doubtless a smaller species; the larva lacks blood gills on the penultimate abdominal segment. It is quite like the larva of *Ch. fulviventris* as described in Bull. 86, N. Y. State Museum and figured in plate 22, Figs 19 and 24–26; but it differs from that species in at least two characters of the sort that usually distinguish species in this genus. (1) The teeth of the labial border are similar as far out from the middle as the third in these two species, but of the remainder each side, it is the seventh (Fig. 20*q*), and not the fourth that is prolonged beyond the level of the tips of the others. (2) The three pieces of the epipharyngeal comb are three-toothed in fulviventris; they are five-rayed in the Walnut Lake species (Fig. 20*p*).

Fig. 20—Unknown Chironomus larvæ from stomach of whitefish; p—epipharyngeal comb, x 310; q—labial border, x 55.

It should be obvious at once that the most immediate and insistent need of such studies as that in progress at Walnut Lake is further life history work upon these important species. In order to assist any one who may take up that work in the discrimination of species among the larvæ of the genus, I present herewith a semi-diagrammatized figure (Fig. 21) of the mouth parts of the larva of *Chironomus viridicollis*, a species which I have bred from a sluggish stream (the Skokie) near Lake Forest, and I designate in that figure the typical parts of the curious and complicated mouth apparatus in this genus. It will be observed in the living larva that the mandibles do not

oppose each other in the usual way, but instead swing obliquely downward against the toothed edge of the labial border; that the epipharynx and the whole ventral border of the labrum and roof of the mouth has developed an armature of combs and rakers directed backward toward the mouth opening; and that the front of the head is developed into a narrow, rounded prominence, beset with hairs, the lowermost of which are often decurved and pectinated. The homologies of all these parts are by no means clear as yet. The more important parts are designated by tentative and provisional names in the explanation to the figure. The shape, number and proportions of the teeth in the labial border and in the epipharyngeal comb have been found most useful hitherto in the discrimination of the species, and figure 4 and the excellent plates in the monograph by Johannsen will abundantly illustrate the sort of differences likely to be found between them.

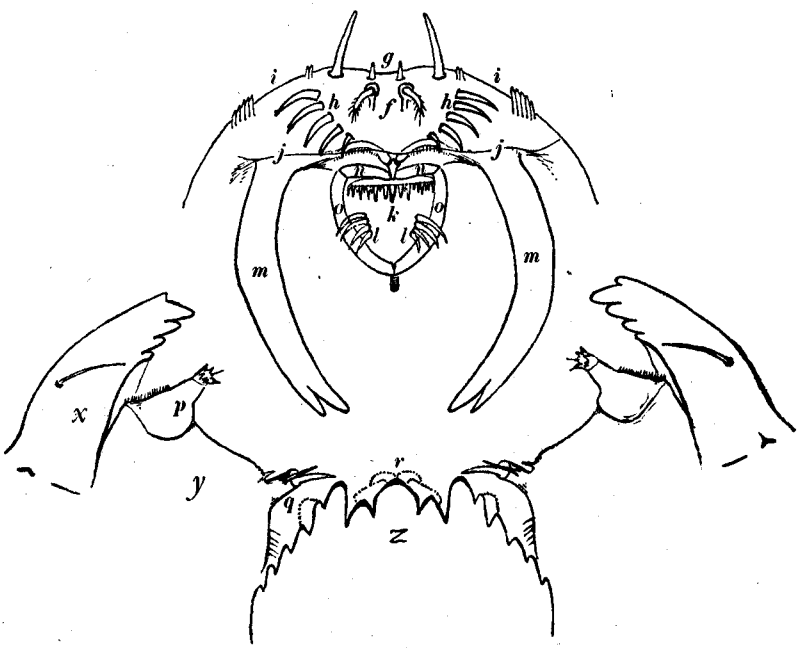


Fig. 21.—Semi-diagrammatic figure of the buccal apparatus of the larva of *Chironomus viridicollis* V. d. W., viewed from below, the mandibles, *x* and maxillæ, *y* spread out laterally, and the top of the mouth moved a little anteriorly so as to show all of the epipharyngeal armature (based on drawings by Mr. H. R. Stewart). The line *j-j* represents the labral margin of the mouth; the parts above it are on the front of the head, outside the mouth; the parts below it are in the roof of the mouth. The ill defined fringe of fine bristles along this margin has sometimes been designated as the anterior comb. *f*, the pedunculated palps (only their peduncles are shown in Miall and Hammond's *The Harlequin Fly*, Fig. 16), *g*, frontal sensory hairs; *h*, *h*, labral or external rakers; *i*, *i*, lateral papillæ; *k*, epipharyngeal (or posterior) comb; *l*, *l*, epipharyngeal or internal rakers; *m*, *m*, lateral arms; *n*, *n*, anterior cross bar; *o*, *o*, U-bar; *p*, maxillary palpus; *q*, lacinia of the maxilla; *r*, hypopharynx?; *z*, the labial border, heavily chitinized (in situ, the mandibles swing obliquely downward against this border).

A simple mode of manipulation enables one to mount preparations of the heads of chironomus larvæ for the microscope to show the above designated parts. The heads are cut off and boiled for a few minutes in a weak solution of caustic potash, then mounted ventral side up in balsam after the usual methods. A slight pressure upon the cover will usually cause the mandibles to swing outward, exposing fully the more important structures. The

parts may, of course be dissociated with needles and placed in any desired position.

The larval cases of Chironomus.—As already stated for *Ch. plumosus*, the larva begins a day or two after hatching to construct a case to dwell in. The basis of construction is the more or less silk-like secretion of the remarkable salivary glands, which hardens on contact with the water. It is spun out not in threads, but in tenuous sheets of more or less flocculence, to which silt adheres readily, protectively coloring the whole exterior. Since the larva crawls into the bottom silt and fashions its case there, it is probable that there is no voluntary adding of pieces to the outside as with caddis fly larvæ, but that the secretion holds fast automatically to whatever touches it. That it holds silt securely is evidenced by the figure in plate 75, which was made from cases taken up in a dredge in 100 feet of water, sifted roughly, carried to the laboratory, and lifted out with a forceps on to a white plate before being photographed. These are not portable cases, they are mere run ways or silk-lined tunnels through the silt. They are usually open at both ends, and may readily be torn open anywhere. They are usually many times as long as the larvæ that live in them. The same diatoms and other algæ are found adhering to them and to the bottom silt generally as are found in the larval stomachs. The cases are very fragile, many will not stand to be lifted out of the water by one end. They are not eaten with the larva but are winnowed out. Such sweeping or fanning action of the fins as many fishes use in making their nests would be more than sufficient to tear up the cases and dislodge the larvæ.

Fishes eat, and doubtless by preference, the larger larvæ. Some indirect evidence on this point was obtained by comparing the sizes of a lot that had been eaten with a sample catch taken from the lake bottom with the dredge. A short haul was made in 100 feet of water and about half a bushel of black bottom mud was brought up and sifted for Chironomus larvæ. These were separated by Mr. McDonald according to sizes into four groups and counted with the following results:

Length of larvæ.	Number.	%
12–18 mm.	6	1.25
9–10 mm.	75	15.
8–9 mm.	225	46.
7–8 mm.	185	37.75
	491	100.

Then a well preserved lot of larvæ from the stomach of a whitefish (No. 680*) were likewise similarly separated into groups and counted, with the following results:

Length of larvæ.	Number.	%
12–18 mm.	99	57
8–12 mm.	70	40
7–8 mm.	5	3
	174	100

Clearly the fishes eat the larger larvæ.

Hexagenia variabilis Eaton.—This species is common at Walnut Lake,

*This fish had eaten also 5 Sayomyia larvæ, 1 Hexagenia larva and a little mussel, Pisidium

though little in evidence by day. An occasional specimen can be seen flying upon the transformation from open water to the woods on shore. At rest on shore, particularly when at rest on boats or fences or other exposed objects, they are conspicuous enough because of their large size. They sit rigidly, and, if approached quietly, allow themselves to be picked up with the fingers. I could not discover any place or time of swarming, nor find any considerable number of individuals on the wing at any given place. Yet the abundance of the cast skins that float upon the surface shows that a considerable number of imagos are emerging all the while. In Bull. 47, N. Y. State Museum, I published an account of the life history of this species with figures of larval and adult stages.

The eggs are probably laid upon the surface of the water, the female falling flat upon the water with wings outspread and liberating them there. I frequently saw females floating thus at nightfall, but was not able to demonstrate that they were ovipositing. Many other May flies liberate their eggs in this manner. The eggs doubtless settle to the bottom, tending apart as they fall, and becoming scattered somewhat, according to the depth and currents of the water. The larvæ live as shallow burrowers in the bottom silt. The length of the larval life is unknown. When grown they swin to the surface and transform there. The subimago emerges suddenly from a rent in the back of the old larval skin, its wings expanding fully almost at once; it stands for an instant on the surface and then flies away toward the shore. This transformation occurs at any time of day or night. The final moult, the casting of the subimago skin occurs within 24 hours thereafter, the period intervening being spent in inactivity. The evening following is probably the period of adult activity—the time when the mating flight occurs, and when the eggs are laid, though observations are yet lacking upon these points.

I was able to determine at Walnut Lake the egg-laying capacity of this species. I captured sub-imagos when leaving the water or when resting on shore, kept them through their final moult until fully adult and obtained their eggs. I was preparing to get the eggs by dissection of my first specimen when I made a curious discovery. I placed the fully adult female upon water in a watch glass and with fine scissors, snipped off her head. Immediately she began depositing her eggs* in the water beneath her, pouring them out rapidly from both oviducts, and not ceasing until they were all deposited (this I determined by dissection later). This occupied not more than two minutes. A partial count and estimate of the number of eggs thus laid put it at about 9000. The method thus found being so easy of application, I repeated the performance with a number of other females, obtaining somewhat smaller numbers, though the lowest estimate was 7850 eggs. The average number was about 8000.

The eggs are translucent whitish, oblong, broadly rounded on the ends, and show no visible micropyle. They are already filled at laying with minute yolk balls. The chorion is very thin and transparent, and the gelatinous envelope is exceedingly scanty, and at first little adhesive, insomuch that the eggs roll freely about in the water. However, after they have lain in the water a few hours a gelatinous connection is easily seen between two eggs that lie in contact, and any silt in the water becomes attached to them. These eggs, being unfertilized, showed no signs of further development.

It was most interesting to see this automatic response on the part of the

*This reaction does not follow like treatment of any other Mayfly on which I have tried it—not even the closely allied *H. bilineata* Say.

female to an unusual stimulus, leading to the complete performance of the last important act of her life. I doubt not that it may be brought about in other ways. Mr. Viereck showed me a pair of this species that he had caught somewhere in Pennsylvania on his way to the Ithaca meeting. Having no cyanide bottle he killed them by pinching the thorax, whereupon the female extruded *into the air* in two oblong packets the entire contents of her ovaries.

Along the wave-washed, marl-floored shallows between stations 1 and 7, and between stations 7 and 15, I could find any evening a number of adult females flying. They were certainly "going through the motions" of laying eggs, falling flat upon the surface with wings outspread, rising, flying on, and falling again, or sweeping along for a time close to the jutting edge of the sedge zone at the shore. But I caught a dozen or more of them at different times and they were all spent females, with no eggs remaining. This, always just as darkness was closing in. They had laid their eggs probably earlier in the evening, and perhaps farther out from shore. The larvæ are found mainly in deeper water.

Heptagenia pulchella and the *twilight procession of swarming species.*—This is in every respect a very different May-fly, more nocturnal, more secretive, more fragile, with depressed larvæ that cling closely to stones, preferably on wave-washed shores. The larvæ are eaten by shore-feeding fishes, and are easily collected by picking them from stones quickly lifted out of the water, but the imagos are infrequently seen. Subimagos, at leaving the water fly to lights occasionally; they transform within twenty-four hours and probably mate and oviposit the night following their last moulting, though this has not yet been observed.

There is a regular procession of crepuscular insects appearing on the wing for their mating flight on the shore of Walnut Lake during July. Directly after sundown the little red-eyed fly, *Synechis simplex* Walker, appears in ill-defined companies darting about in irregular, though chiefly horizontal flight, usually near, but not over the water. Then the beautiful May-fly, *Ephemera simulans*, appears in companies of males over the edge of the water. The flight of one of these companies is a most delightful performance to witness, it is so light and graceful, and appears, withal, so exhilerating. Yet it is all up and down in vertical lines. With upturned head each individual flies rapidly upward, mounting quickly to a height of ten or fifteen meters, then spreading its wings out horizontally it falls upon them, with long fore legs extended forward and longer tails extended backward full length, rudderlike, keeping it always head to wind. Thus it descends, floating on the air, yet not drifting, until at the lower level of the swarm (four or five meters above the water), it lifts its head and rises rapidly again in flight And the whole company flying and falling thus, weaving up and down in vertical lines, and passing and repassing each other, create a scene of great animation.

About as soon as the flight of the *Ephemera* swarms is well established, *Chironomus plumosus* appears in the horizontal flight that I have described on preceding pages. *Chironomus meridionalis* also appears nearer the ground. Then, as the darkness deepens, the May-fly *Cœnis*, the smallest of all the *Ephemera*, comes out to perform in little swarms, which one may see if he chance to come close enough; they are hardly visible for a distance of more than a few feet. These are males also, which weave up and down in straight lines, hardly rising higher than one's head.

Last of all the visible performers, *Heptagenia*, appears when it is almost to

dark to see, in small companies of males, which weave up and down *obliquely*, flying forward and upward, head to wind, and drifting and settling downward and backward to the starting point. How high these go could hardly be told on the several occasions when I watched them, the white forms being little visible against the sky (one could see them but a few feet) but they descend to a level easily within reach of a net. Whether females come near these swarms when in search of mates I was wholly unable to observe. Detailed knowledge of the mating and ovipositing habits of this species will be gleaned with great difficulty. A search light which we brought into requisition at station 1 was of no practical assistance in observing any of the flights above described.

I reared this species at Saranac Inn, N. Y., in 1900, and published a description of the larvæ in Bull. 47, N. Y. State Museum, p. 421 (Pl. 15, Fig. 15). The importance of the larvæ as fish food may be gathered from the facts Mr. Hankinson has furnished elsewhere in this report. The food of the larvæ consists of such dead plant materials, and living algæ intermixed therewith as they may find about the under surfaces of the stones to which they cling It is intermixed with much silt and with some sand. I examined a number of specimens carefully and could find no animal remains whatever.

II.—ANNOTATED LIST OF THE SPECIES OBSERVED.

Plecoptera. Stoneflies.

1. *Chloroperla brunneipennis* Walsh. Two males of this species came to a trap lantern set by the aquaria on the outlet of Walnut Lake on the night of July 1st. They were the only stoneflies seen.

Ephemerida. Mayflies.

1. *Ephemera varians* Walsh.—Swarming flights (described above) of this species I observed off stations 1 and 15. The species was apparently common earlier in the season, for it would have been hard to get during my stay so many specimens as Professor Hankinson took on the 29th of May at station 46. The larvæ were taken at a number of stations on the softer marl bottoms. Their food consists of marl and the substances intermixed therewith. It is readily dissected out of the alimentary canal as a cylinder of apparently pure marl, which when crushed on a cover glass reveals scanty amounts of remains of filamentous algæ, and of the disintegrating fragments of the higher plants from shore. I could discover in it no animal remains whatever.

2. *Hexagenia variabiliis* Eaton.—I took adults of this species on every day of my stay at Walnut Lake. Mr. Hankinson took a subimago in transformation on the 25th of June. His fish food data will show the wide seasonal and dietary range of the species. I have already given an account of its habits so far as known.

3. *Heptagenia pulchella* Walsh.—Probably occurs at all the stations where there are stones or timbers to which the larvæ can cling. They are easily collected in abundance at station 23. While we were coursing round with a searchlight in the bow of the boat at station 54 a number of subimagos, apparently just risen from the water, came to the light. I have given above brief and fragmentary notes on the habits of the species.

4. *Callibætis ferruginea* Walsh.—Of this species I collected at station 7 a few males, swarming just before dark, weaving up and down in a small

company, and a single female, swept from a clump of Decodon near by—July 7th. Although I did some collecting hereabout, I did not find the larva.

5. *Blasturus cupidus* Say.—Two female subimagos of this species were found floating on the surface at station 225 on the 14th of May, probably having drifted out with the wind from shore; this is not characteristically a deep-water form.

6. *Ephemerella excrucians* Walsh.—A few larvæ of this species were collected at stations 6, 26 and 28 during the month of May.

7. *Ephemerella* sp.—A single curious larva *with prominent head tubercles*, was taken on the 26th of May (Coll. No. 927).

8. *Cœnis diminuta* Say.—Imagos and subimagos of this species came to our trap lantern at station 1 in some numbers on the nights of 7th, 9th and 13th of July. I observed the males swarming in their flights at stations 1 and 7. I took a few larvæ in a triangle dredge at station 4, and in a sieve net at station 7. The larvæ are so small and cling so closely to the stems, even when withdrawn from the water that they are not often seen.

Odonata. Dragonflies and Damselflies.

1. *Gomphus spicatus* Hagen.—This species was flying not uncommonly when I first arrived at the lake on June 26, and a few specimens were captured when they alighted on the boat that day and the day following. I found young larvæ abundant at station 1, and sifted out quite a number of them from the bottom marl with a sieve net. There were taken from most of the shore stations at different times during the season. The cast nymphal skins were found associated with those of the following species, which see.

2. *Dromogomphus spinosus* Selys.—This species was coursing the surface of the lake with the foregoing one late in June, and would alight once in a while on the boat, where two specimens were captured. I found the cast nymphs skins at station 27, where there is a narrow beach of sand, some three feet wide, with stunted sedge growth at its landward side. They lay at the rear of the sand, among the projecting sedge roots, and were hard to find, though not uncommon. The bottom slopes rapidly here, and is silted with marl and strewn with coarse gravel. Bottom collecting on such a shore should find the larvæ.

3. *Basiæschana janata* Say.—A single cast larval skin of this species was found clinging to a stem that overhung the outlet brook about 100 yards distant from the lake.

4. *Aeschna clepsydra* Say.—Occasional adults of this species were seen coursing the lake during July. One male captured served for identification. A few large nymphs of the genus that may as well as not be of this species were collected during May.

5. *Anax junius* Drury.—This ubiquitous species, so common to the southward, was at Walnut Lake rather rare. I saw but one or two specimens flying. I captured a single nymph at station 7.

6. *Macromia illinoiensis* Walsh.—This fine species is very common about the chara beds on the bottom of the lake, especially where the growth is sparse, exposing flat bottom areas on which the larvæ may lie hidden. There are few finer examples of protective coloration than these larvæ present, nevertheless, they are much eaten by fishes. If overturned by the fishes in fanning the bottom, they would be readily seen with the light yellow color of the under surface of the body exposed. I took larvæ with the triangle

dredge at station 4 and in the deeper water opposite; also with a sieve net at station 1, and they have been taken in many other places in the lake, always in connection with a scanty growth of chara. Mr. McDonald found larval skins of this and the next following species on the sedges at the bank at station 34. No adults were observed.

7. *Epicordulia princeps* Hagen.—This species was constantly seen in flight over the lake. None were captured, however. Being easily recognizable in flight, it was not deemed desirable to make the effort necessary to catch even a single specimen. The copious masses of gelatinous egg strings seen commonly about the borders of the lake hung upon projecting stems just below the surface of the water, doubtless belonged either to this or to the species next following. I took larvæ of this species at stations 1 and 7, and Mr. McDonald took cast skins from shore at station 34 as noted above.

8. *Tetragoneuria cynosura* Say.—This species was rather common, one or two specimens were taken on my first visit for the sake of certain determination. I found the larvæ abundant at station 7 and they were collected sparingly at other places. Doubtless some of the egg masses referred to above belonged to this species. I have figured these in Bull. 47, N. Y. State Museum, p. 491.

9. *Somatochlora* sp.—Several young larvæ that I took with sieve net at station 7 are nearest this genus, but are not like those of any of the known larvæ described therein.

10. *Perithemis domitia* Drury.—I saw a single male of this species sitting on a nymphæa leaf at station 54, and though I did not capture it, I was close enough for certain identification.

11. *Celithemis elisa* Hagen.—This beautiful insect was very common all about the lake. During sunshine the adults were flying in pairs all about the bulrush beds, while the solitary males exercised "squatter sovereignty" over little areas, perched on the top of some tall stem standing in the midst of his domain. During the first week of July the cast larval skins were hanging thickly to the bulrush stems. I collected the nymphs at station 7.

12. *Celithemis eponina* Drury.—I took a single larva of this species at station 7, and I think I saw one or more of the adults in flight.

13. *Leucorhinia intacta* Hagen.—Common, especially about the nymphæa beds. I collected the larvæ at station 7.

14. *Sympetrum rubicundulum* Say.—This species was just becoming common on the wing at the time of my departure. That was too early for many *Sympetra*. Doubtless other species would be found later in the season.

15. *Pachydiplax longipennis* Burmeister.—A few specimens of this species were seen in June, and one was captured. The larva apparently was not encountered.

16. *Mesothemis simplicicollis* Say.—I captured a single adult of this species July 14, by the outlet to Evans' pond, near Walnut Lake. Mr. Hankinson took two larvæ at Orchard Lake on the 18th of June.

17. *Ladona exusta* Say.—I captured a single adult of this species at station 20 on June 26.

18. *Libellula luctuosa* Burmeister (= *basalis* Say).—Not uncommon about the shallows bordering the lake; belongs to the fauna of pools and shallow ponds rather than to that of lakes.

19 *Libellula pulchella* Drury.—This is an abundant species of some importance to fishes that feed in shallow water. In all collecting with hand nets from the bottom it was encountered. It was abundant at stations 1 and 7. In such places the females could frequently be seen ovipositing

by dipping the tip of the abdomen repeatedly and rapidly into the surface of the water.

20. *Tramea lacerata* Hagen.—Two adults of this species, apparently, were seen but not taken. No larvæ of this genus were encountered.

21. *Calopteryx maculata* Beauvois.—This species swarmed about the outlet, more abundantly in the rapid places in the stream, where many females could be seen busily depositing their eggs in the trailing and hardly submerged stems of *Potamogeton nuttalli.*

22. *Lestes unguiculata* Hagen; 23. *Lestes rectangularis* Say.—These two species were both found among the vegetation on the west shore of the lake —single male specimens of each.

24. *Lestes vigilax* Hagen; 25. *Lestes inequalis* Walsh.—These two species were found on the outlet a hundred yards distant from the lake—single male specimens of each.

26. *Argia violacea* Hagen.—Common all around the lake and down the outlet; more characteristic of flowing than of still water.

27. *Nehallennia irene* Hagen.—Abundant about the outlet. Could be swept in the sedge zone about the lake almost anywhere.

28. *Enallagma hageni* Selys; 29. *Enallagma ebrium* Hagen; 30. *Enallagma civile* Hagen.—All found about the lake border, the first most common, the last least common. Transforming in the bulrushes everywhere, but no attempt was made to identify the larvæ.

31.—*Enallagma antennatum* Say.—Very common about the outlet.

32. *Enallagma signatum* Hagen; 33. *Enallagma pollutum* Hagen.—Both very common, especially about stations 15 and 54. The latter is the latest flying of all Odonata, pairs being seen on the wing repeatedly when it was too dark to tell without capturing them in a net and looking more closely, whether they were big May-flies (*Hexagenia*) or not.

34. *Ischnura verticalis* Say.—Rather uncommon; taken only a few times.

Hemiptera.

The following species of this order were kindly determined by Mr. J. R. de la Torre Bueno of New York City:

Corisa sp.—Young individuals not uncommon about submerged vegetation.

Notonecta variabilis Fieb.—Common at station 7.

Ranatra quadridentata Stal.—Adults were rarely seen, but half grown larvæ were common at many places in shore vegetation. A few floating typha stems bristling with the curious appendages of the contained ranatra eggs were found at station 7.

Belostoma (formerly *Zaitha*) sp.—A few adults were taken with a sieve net from the ditch back of station 7.

Gelastocoris sp.—This undescribed species was common on the narrow strip of sandy beach at station 27.

Acanthia sp.—Not uncommon on mud at edge of water.

Gerris marginatus Say; *Gerris sp.* (undescribed).—Common everywhere on the water at the edge of the standing vegetation.

Neuroptera.

Sialis infumata Say.—This orl fly was very abundant at Walnut Lake early in the season. Larvæ were collected on the bottom in many places during April and May, and they were then being eaten commonly by fishe:.

About the latter end of May the adults were abundant; those in the collection bear the date of May 23rd. I took off station 3, in thirty feet of water, a half-grown larva of the next season's brood.

Chauliodes rastricornis Say.—A few young larvæ, probably of this species were found singly crawling on the under surfaces of nymphæa leaves.

TRICHOPTERA. Caddis flies.

Determined by Dr. C. Betten.

Phryganeidæ.

1. *Neuronia semifasciata* Say.—One female was collected on May 31st (No. 936) and another came to a lighted window of the laboratory on July 7th.

2. *Neuronia concatenata* Walker.—A number of specimens came to the window with the preceding species July 7th; two others, undated, bear the collection number 1383.

Limnophilidæ.

3. *Platycentropus hostis* Hagen.—One male (No. 1383).

4. Larvæ of an undetermined *Limnophiline*, in cases of vegetable matter covered with small bits of mussel shells and stones (the larger 33 mm. long) were taken, 4 on April 6th, and 4 on April 7th (Nos. 25 and 30).

5. Another *Limnophiline* larva, in a case ballasted after the manner of the case of Goera, was taken on the 10th of July.

Sericostomatidæ.

6. *Heliocpsyche* sp.—Several larvæ were taken from stones in a riffle in the outlet of Walnut Lake (the location for Parnid beetles mentioned elsewhere) on July 10th, and a single adult was swept from the sedges on the adjacent bank.

7. *Lepidostoma* sp.—One male, July 12th.

Hydroptilidæ.

8. *Agraylea* sp.—Trap lanterns drew a few female specimens during July.

9. *Oxyethira* sp.—A single female captured on the 25th of June bears the number 1313.

10. *Hydroptila* sp.—Four larvæ and one pupa in parchment cases 6 mm. long by 1½ mm. wide, were taken from Nymphæa petioles July 12th.

11. *Hydroptilid* larva of undetermined genus, in parchment cases 4 mm. long by 1 mm. wide at the one end tapering to ½ mm. wide at the other, taken with the preceding species, and attached like the cases of that one to the erect nymphæa petioles by two hold fasts at each end. These were obtained while collecting the stem-infesting *Chironomus* and *Hydromyza* larvæ, and were very common; they might have been obtained in great numbers.

A large number of additional adult *Hydroptilidæ* were obtained by the trap lantern on the nights of the 25th of June and the 7th, 12th and 13th of July, but being mostly females, preserved in alcohol, they are hardly identifiable.

Hydropsychidæ.

12–23. Four species of the genus *Hydropsyche* came to the trap lantern on the 25th and 26th of June, and 12th and 13th of July; nearly all females.

Likewise, 3 species of the genus *Plectrocnemia*, and two of *Holocentropus*, one of each of these latter being very common. A species of *Tinodes* is likewise represented in the lantern catch of the same date by a number of females. Several larvæ of *Chimarrha*, and of one other undetermined *Hydropsychid* were taken from the rocks in the outlet of the lake on July 10th.

Leptoceridæ.

24. *Molanna cinerea* Hagen.—This species swarmed around a search light that was carried in the prow of the boat at station 54 on the night of July 13th, and a few were taken. A few additional came to the trap lantern.

25. *Triænodes ignita* Walker.—This species came commonly to the trap lantern, a few on the 25th of June and on the 7th of July, and many on the 13th.

26–35. Four species each of *Oecetis* and *Leptocerus*, one *Leptocella* and one *Setodes*, came also to the trap lanterns with the foregoing on the 25th of June and the 7th to the 13th of July. A few of these represented in some numbers by both sexes, will doubtless later be more specifically determinable.

At least 35 species are represented in the collection, nearly all obtained in the trap lantern on four favorable evenings. The material was not adequately cared for, being merely dumped into alcohol; it is sufficient, however, to indicate that there is a good caddis fly fauna in Walnut Lake to reward the more careful labors of the future collector.

Coleoptera.

Haliplus ruficollis, DeG.—Three adult specimens I took with a sieve from the trash in the ditch back of station 7 on July 11th. Though especially sought for, not a single *Dytiscid* was seen.

Gyrinidæ were not very common, but could be found in the more sheltered places among shore vegetation.

Gyrinid larvæ were taken not infrequently. I took a small one at station 1, and a larger one in deeper water at station 7. A large one taken by Mr. McDonald at station 47, and put in a vial of water to be brought home alive with some larvæ of *Chironomus albistria*, was of a beautiful transparent red color when I received it half an hour later; but three of the midge larvæ had become white; the color was transferred with their blood.

A single adult *Tropisternus* was taken on June 26th.

A number of small larvæ of *Hydrophilidæ* were taken with a sieve net in the ditch back of station 7.

A few specimens of *Berosus* sp. came to a trap lantern set beside the aquaria on the outlet the night of July 12th.

Macronychus glabratus Say.—Abundant on stones in the rapids a mile from the lake—the station for the following Parnidæ also.

Stenelmis sp.—Likewise abundant.

Elmis bivittatus Lec.—One specimen taken.

Elmis quadrinotatus Say.—Common.

Ancyronyx variegatus Germar.—One specimen taken.

Galerucella nymphæa L.—Common about the nymphæa beds, the larvæ feeding in considerable numbers on the leaves.

Donacia palmata Olivier.—Common about nymphæa beds.

Donacia sp.—Less common, about the Scirpus covered areas.

DIPTERA.

Tipulidæ. Craneflies.

Goniomyia subcinerea O. S.; *Goniomyia blanda*, O. S.—Came commonly to light, the former in greater numbers.

Limnobia cinctipes Say.—Under linden trees on shore; rarely attracted to light.

Amalopis inconstans O. S.—In deep shade on shore; rarely attracted to light.

Erioptera chlorophylla, O. S.—One of the commonest *Tipulidæ* at Walnut Lake, if not the commonest. It could be found by sweeping vegetation anywhere near shore. Taken in the trap lantern every night, and often in considerable numbers.

Antocha opalizans, O. S.; *Erioptera straminea*, O. S.; *Erioptera caloptera*, Say; *Erioptera parva*, O. S.; *Erioptera septentrionis*, O. S.; *Geranomyia canadensis*, Westw.; *Ulomorpha pilosella*, O. S.; *Limnophila quadrata*, O. S.; *Rhamaphidia flavipes*, Macq.—All came to light; all could be collected by sweeping under the edges of the tree growth on shore.

Bittacomorpha clavipes.—A ditch back of the Decadon beds at station 26. The north inlet to the lake sheltered this species in abundance.

Tipula sp.—Common throughout the sedge zone.

Toxorrhina magna O. S.—A single female specimen taken from a boat as it flew overhead at station 15 just before dark on July 8th.

CULICIDÆ. Mosquitos.

Psorophora ciliata Fabr.—A few specimens only of this species came to the trap lanterns.

Anopheles punctipennis Say.—Common; many taken in trap lantern.

Anopheles maculipennis Meigen.—Not common; but few seen.

Culex perturbans.—The predominant mosquito, whose biting was not uncommonly bad.

Sayomyia punctipennis Say.—Abundant; taken by thousands in the trap lantern when set with out-look over the lake. Larvæ perhaps of this species were eaten by whitefish.

CHIRONOMIDÆ. Midges.

The species named in this family and in the next one have been determined by Dr. O. A. Johannsen of Cornell University.

Chironomus plumosus, Linn.
Tanypus monilis (some in trap) numerous.
Tanypus sinuosa.
Protenthes culiciformis.
Procladius pusillus (trap).
Chironomus meridionalis (numerous).
Chironomus tentans.
Chironomus albistria (bred).
Chironomus similis (numerous).
Chironomus scalaenus var. (trap).
Chironomus pallidus (trap).
Chironomus devinctus (trap).
Chironomus brunneipennis (trap).

Chironomus halteralis (trap) numerous.
Chironomus decorus.
Chironomus plumosus.
Chironomus nigricans.
Chironomus viridicollis.
Cricotopus trifasciatus (some in trap) numerous.
Cricotopus sylvestris.
Metriocnemus exogitans (trap).
Tanytarsus flavellus (trap).

Rhyphidae.

Rhyphus punctatus (trap).

Tabanidæ.

These and the following families have been determined by Mr. D. W. Coquillett of Washington, D. C.:
Tabanus lineola Fabr.; *Chrysops striatus* O. S.; *Chrysops plangeus* Wied.; *Chrysops niger* Macq.—All common along shore.

Stratiomyiidæ.

Odontomyia vertebrata Say; *Odontomyia plebej* a Loew.—Occasionally seen flitting over vegetation about the shores. Egg masses were rather common on projecting bur-reed leaves.

Leptidæ.

Chrysopila proxima Walker.—Common at the outlet.

Scatophyagidæ.

Hydromyza confluens Loew.—This species, which makes galls in the petioles of nymphæa leaves is especially discussed further on.

Empididæ.

Syneches simplex Walker.—This is the species that leads the procession of swarming species after sundown, as detailed on preceding pages.

Cyrtidæ.

Ogcodes costatus Loew.—On willow tree overhanging water at outlet.

Syrphidæ.

Eristalis bastardi Macq.—Over shallow water about acquatic plants everywhere.
Eristalis flavipes Walker; *Eristalis transversus* Wied.—Common about the shores.
Helophilus conostonus Will.—Common on iris flowers in the edge of the outlet.

Ephydridæ.

Hydrillia hypoleuca Loew.—Swarming upon white water lilies, blackening the flowers within by their abundance.

III.—AN AQUATIC GALL ON THE YELLOW WATER LILY, *Nymphæa advena*.

While collecting the larvæ of the midge *Chironomus albistria* Walker, from their holes in the petioles of nymphæa Mr. McDonald and I frequently came upon galls associated with them in the stems. These galls appear to be the first made known upon a member of the water lily family (Nymphæaceæ); also the first known to be made by a member of the dipterous family. Scatophagidæ; also the first to be found deeply and constantly submerged. Therefore a brief account of them should not be without interest.

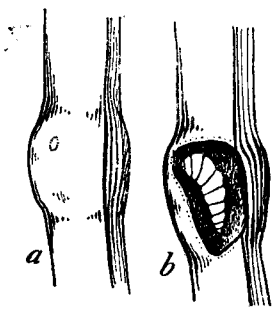


Fig 22.—Gall-bearing petioles of *Nymphæa advena*. *a*, external views of the gall; the dotted circle marks the epidermal window, through which the adult emerges. *b*, the gall cut open, showing the larva of *Hydromyza confluens* within.

The galls are rounded swellings upon the petiole, distending it and increasing it by a fifth to a third its normal diameter (Fig. 22). They may occur anywhere, except close to the surface or close to the bottom of the water. They are placed singly along the petiole, but occasionally are close enough together to appear superficially confluent. They occur most frequently upon the stalks of the earliest of the leaves that reach the surface (not at all upon the short stalked and wholly submerged leaves of earliest spring), and very sparingly upon the later leaves. On a vigorous plant with eleven floating leaves and two flower stalks, examined at station 26 on July 12th, nine pupæ and three larvæ were found in the petiole of the oldest leaf, while three were found in the two petioles next younger. Probably the attack of the gall maker begins when the first leaves reach the surface in late spring; then they have their first opportunity to reach the proper place of oviposition by crawling down the stalk.

The insect that causes the gall to grow is the larva of the fly *Hydromyza confluens* Loew (family *Scatpophagidæ*). No observations were possible upon any stages except the later larval, and pupal, and the transformation to the adult. The cavity within the gall is rather close fitting until the larva is well grown, but becomes larger and its walls become discolored later. Just before transformation to the pupal stage the larva eats a hole out to the epidermis, and returns to the center of the cavity; this hole is a passage of exit for the adult, which then has only to break through the transparent epidermal window to gain its liberty.

The grown larva measures 9 mm. in length and 2 mm in diameter; greatest it is shorter and thicker when contracted. The body is of a somewhat fusiform outline, rather obtuse at each end, gradually thickened to the fourth or fifth segment, and then slowly tapered posteriorly. The color is white.

No head is visible, but only a blackish mouth at the front end, below. A perforate cribriform plate of an inconspicuous brown color at each side of the prothoracic segment close behind the mouth terminates the longitudinal tracheal trunk of each side; this is shown at *d* in Fig. 6, dissected out entire. The air trunks end posteriorly in three pairs of radially placed slits, the lower one of which has its margin prolonged in a stout triangular sharply pointed spine. This spine is shown at the end of the body in Figure 6a; it is shown in side view enlarged more at Figure 6b; and the end view of spiracular aperatures of both air trunks are shown in their relative positions at Figure 6c. The form and position of this spine suggest that it may be used to break open the walls of air spaces in the nymphæa tissues, as a correspondingly placed spine connected with the spiracle in the larva of the beetle *Donacia* is used to puncture the tissues from the outside.

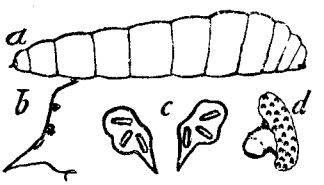
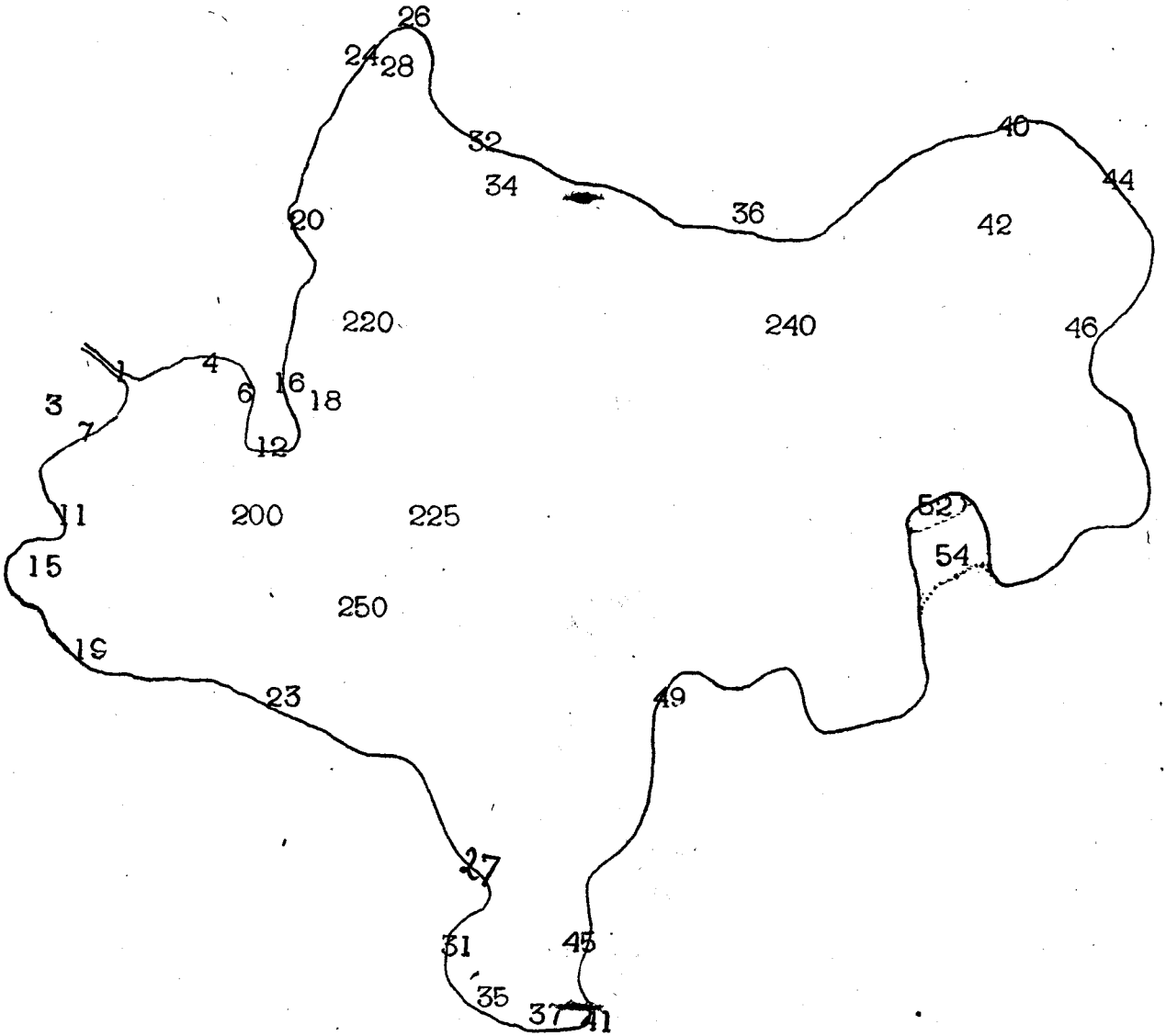


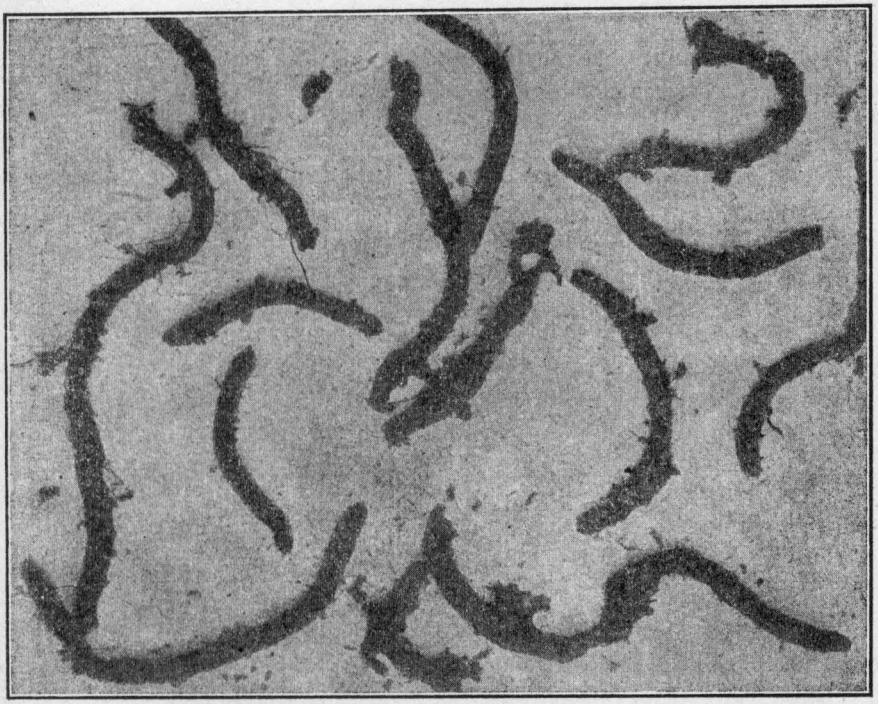
Fig. 23.—The larva of *Hydromyza confluens*. *a*, side view of the whole larva; *b*, the caudal peritreme spine, greatly enlarged; *c*, posterior view of of the respiratory aperatures; *d*, the prothoracic spiracular apparatus, removed and enlarged (the mark close behind the mouth in the upper figure shows the location of this.)

At transformation, the larval skin contracts into a puparium, the anterior spiracular apparatus becomes pushed out upon each side to form a prominence as high as wide, and the perforations appear as minute roughness upon its surface; the posterior spines remain projecting; the contracted body within shapes itself into the pupa, and between this and the anterior end of the puparium is clearly seen through the transparent wall the furcated buccal armature that lined the larval mouth.

The decaying of the tissues about the walls of the gall when the leaf gets old, together with the perforation of the wall by a passage for exit, weaken the stalks, and they break readily across the top of the gall during the pupal stage of the contained insect. Thus the pupæ are readily obtained. Some of those obtained on the 12th of July were placed alive in a dry bottle, and several of these transformed the next day. About the same time adults were noticed commonly about the lily beds, sitting upon the leaves, and taking flight readily upon approach. On the night of July 13th, while we were boating with a search light about station 54, they flew in some numbers to the light. This species will doubtless be found commonly about Nymphæa beds in the United States, notwithstanding that it appears to have been reported hitherto only from Canada.



OUTLINE MAP OF WALNUT LAKE, OAKLAND COUNTY, MICHIGAN, SHOWING LOCATION OF STATIONS.



CHIRONOMUS CASES, 3.