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Set 1-

Economic Insects In Some Streams of Northern Utah

JAMES G. NEEDHAM and REED O. CHRISTENSON

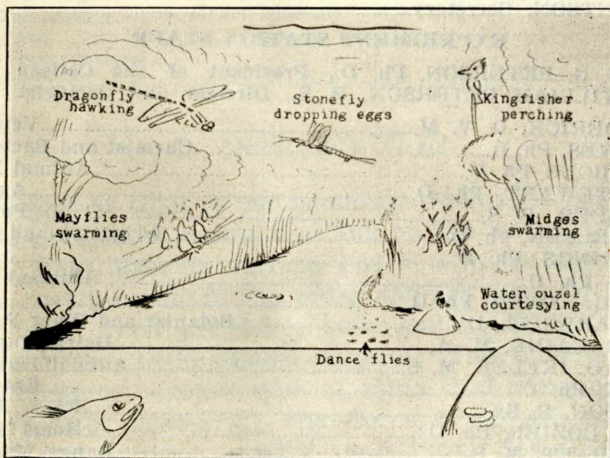


FIG. 1.—Diagram illustrating some of the commoner animals seen over Logan River

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LOGAN, UTAH

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ECONOMIC INSECTS IN SOME STREAMS OF NORTHERN UTAH

JAMES G. NEEDHAM and REED O. CHRISTENSON*

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INTRODUCTION

The food of trout in our mountain streams is mainly insects. It is, in part, land insects that fall on the water and are taken as they float upon its surface, but in a much larger part it is insects that grow up in the water and are taken in their immature stages. These are the constant and dependable food-supply. They have been little studied hitherto. This bulletin is a report of a preliminary examination of some Utah streams, made for the purpose of discovering what forms of life are present in the streams and in what relative abundance. Some are beneficial and some injurious to trout, being competitors with them for food.

Getting a living is the first business of life, and food is the basis of a living. Keeping alive is equally necessary, and this means escaping enemies. Perhaps a little more knowledge of the conditions that favor the trout in getting a living and in keeping alive may lead to more satisfactory practices in stream management.

The opportunity for studying a mountain stream in Utah came in the summer of 1926. From the middle of June to the

*Dr. James G. Needham is head of the Department of Animal Biology and Professor of Entomology and Limnology at Cornell University, Ithaca, New York. He was a special member of the Faculty of the National Summer School, U. A. C., 1926. Dr. Needham accumulated data for the writing of this bulletin during his summer stay in the state. He was assisted in this work by Mr. Reed O. Christenson, a graduate assistant in the Department of Zoology and Entomology, in the Utah Experiment Station, during the summer of 1926. Much credit is due Miss Elsie Broughton for assistance in the preparation of manuscript and drawings.

last of July residence was maintained beside Logan River at Birch Glen in the heart of the cañon where a large part of the time was spent studying the life of that beautiful stream. Mornings and evenings, the chief times of activity of aquatic insects, were especially fruitful. Most of the local species were reared, and it was thus possible to connect up the adults with their immature stages. Afterwards, the senior author made a short collecting trip with Dr. H. J. Pack⁽¹⁾ to Ogden, Weber, and Provo Rivers, and lesser streams, and obtained much additional material for comparison. The account of stream conditions in the following pages will, therefore, be largely drawn from Logan River since it is best known.

PLANT LIFE OF THE STREAMS

In the water, just as on land, plants provide the food for animals. Herbivorous animals eat the plants directly, and then the carnivores eat the herbivores; while parasites infest both while they live, and scavengers clean up their remains when they are dead.

The plant-food of these streams comes from two very different principal sources:

(a) Green plants that grow in the water

(b) Dead plant fragments drifted into the stream from the land. The growing herbage of the stream consists of both algae (plants of simple structure) and vascular plants (mostly seed plants and mosses).

The algae are of three principal types:

1. "Brook lettuce" whose flattened, bright, green leaf-like sprays adorn the rocks and tree roots in the rapid waters in Logan Cañon everywhere between altitudes of 5000 and 6000 feet. The broad, half-crumpled, thin, translucent sprays that sway gracefully in the passing current are very pretty; but they do not appear to be eaten extensively, at least not while green.

2. The fringing algae (*Cladophora*, etc.) that hang downstream from every solid support in masses of slender threads either green or brown. They sometimes grow like a woolly coat upon the surfaces of rocks in the current. When of more scattered growth they hang downstream like miniature pennants from many a rootlet and twig and pebble upon the bottom, and often from the exposed tips of the shells of the little white clams that are not wholly buried in the sandbars.

3. The slimecoat algae, the least conspicuous and yet probably the most important of all, that form coatings over the sur-

(1) Entomologist, Utah Agricultural Experiment Station

faces of stones making them green (or brown) and slippery. They also grow on the bottom gravel and over the stems of the larger plants. These are among the simplest of all plants, microscopic in size; and so they are not noticed at all except when they occur in masses. But they make up in reproductive capacity what they lack in size; and collectively they furnish the chief forage supply for some of the lesser herbivorous animals of the stream.

The vascular plants are of three principal sorts:

1. The water cresses that fill up every spring brook, providing abundantly both forage and shelter for scuds, mayflies, and caddis worms. About the edges of these water-cress beds small trout find a good living.

2. "Brook grass" that trails among the stones, broom-like, in the current of such streams as that in Boxelder Cañon (commonly called Brigham Cañon) and the middle fork of Ogden River.

3. Water mosses of various sorts that often densely cover the stones in spring brooks.

The vascular plants are absent from the open places of the larger streams, being unable to withstand the heavy impact of flood waters there. Only the simply organized algae, that have no complicated parts to be destroyed, can live there. And these, if ground out by the barrage of stone-carrying storm waters, quickly come again.

These minute and simple plants are also the ones that are eaten most extensively while green and growing. Many little herbivorous insects, like mayflies and midges, have developed in their mouthparts admirable little rakes and scrapers by means of which they take up the algae from the stones and stems. The larger plants must first die and disintegrate; then, their softened and broken remains are eaten by many herbivores.

The remains of land plants, bark, twigs, stems, leaves, etc. accumulate under the upstream side of every boulder on the stream-bed, and these furnish both food and shelter for a considerable population. They gather in leaf drifts upon projecting logs and brush at the banks of the stream where they harbor large numbers of stoneflies, mayflies, and caddis worms.

ANIMALS

This bulletin is about the lesser animals that fishes eat, but a word may be said in passing about a few of the larger animals that were observed. Besides the trout, which are of first inter-

est and importance, there is another food fish, the mountain herring (*Coreogonus williamsoni*), found sparingly in Logan River, and the worthless but interesting little sculpin called locally "bullhead" (*Cottus beldingi* Eigenmann & Eigenmann) is abundant there. During July the sandbars in shallow water were dotted over with little new-crop sculpins, their bodies about the size of grains of wheat, their backs speckled so like the sand that they were quite undiscoverable until lifted in a net.

Two birds that eat small trout were often seen. Water ouzels standing on partly submerged boulders, courtesying, or occasionally dashing underneath the water in a pool at the foot of a ripple; and kingfishers perching high or speeding clamorously away after a splash in the stream. An occasional water snake or frog would take leave of the bank. All these larger animals are competitors with trout for food (See Figure 1, Cover).

AQUATIC INSECTS

After the trout, the most important element in the animal life of Logan River is the aquatic insects. These bulk largest in quantity, are by far most numerous in kinds, and play an almost infinite variety of roles in the life of the stream. Some large groups of them, such as mayflies, are all herbivores, and because they feed the trout are to be considered as wholly beneficial. Others, such as the dragonflies, are carnivorous and are competitors with the trout for food. Other groups, such as the stoneflies, are of mixed habits—some herbivorous and some carnivorous. Some of the more important species will be considered first individually, grouped by orders, and to facilitate their recognition will be illustrated with simple outline drawings.

The food of trout being chiefly herbivorous aquatic insects, mayflies (the most important group of insects in Logan River) will be treated first.

MAYFLIES—ORDER EPHEMERIDA

Mayflies are all herbivorous in their immature aquatic stages. As adults they eat nothing and live only long enough to lay their eggs. The young (called nymphs in this publication) may be recognized by the possession of gills upon the back, in pairs upon some or all of the first seven segments of the abdomen. No other insects have gills so situated. Generally, there are three long hair-fringed tails, tho occasionally there are but two, the antennae are slender, and the long legs bear single stout claws at their tips. When the nymphs are

ready to transform, they come to the surface of the water; the nymphal skin splits down the back, and out of it comes the winged insect which at once flies away to some resting place in the trees. It rests for about a day, then casts another skin and becomes fully adult. Then follows mating and egg-laying.

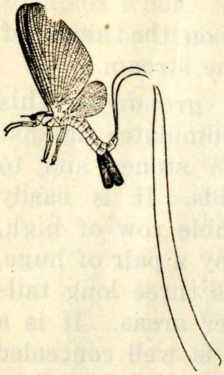


FIG. 2. The "Trailer" mayfly (*Ephoron*) preparing to liberate her eggs. Drawing by C. H. Kennedy

color, with eyes and wing pads blackish when fully grown. Its antennae are set in deep notches at the front of the head. The underside of the rear half of its body is developed into a broad sucking disc, by means of which it holds securely to the smoothest surfaces.

It clings to stones when these are lifted by hand out of the current, and may be pushed about over their polished surface without releasing its disc. So closely does it cling that a knife blade may hardly be pushed beneath it. Its legs are laid down flat against the stone, and it moves habitually sidewise. It may be rotated by a pull on legs or tails without letting go. Indeed, a quick pull on one of the legs will often break that mem-

1. "Ginger Quill" (*Ephemerella doddsi*). When young⁽²⁾, this mayfly is found on the larger, smoother boulders in swift water of the open stream where it clings tightly to the bare rock surface. It is stout-bodied, hump-backed, and smooth-skinned, yellowish in

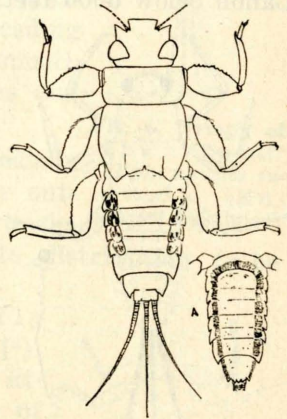


FIG. 3. Nymph of the "Ginger Quill" (*Ephemerella doddsi*). (Enlarged 4 times). a. Ventral view of sucking disc beneath abdomen

(2) As is well-known, the young of animals when they differ markedly in form from the adult are known as larvae, but there are two principal kinds of larvae among insects: (1) Long-legged ones that have wings developing externally on the back, called nymphs; and (2) larvae proper, that are more worm-like and have no wings visible externally. Accordingly, in the following pages, the young of the mayfly, stonefly, or dragonfly will be called a nymph; that of a midge or crane fly or caddis fly a larva.

ber off without releasing the disc. This holdfast is altogether unique in structure, tho superficially similar to that of the "redgill" to be mentioned later.

The place to look for the "ginger quill" is on the sides of the smoothest stones in the swifter parts of the stream.

2. "Prickleback" (*Ephemerella (Drunella) grandis*).—This mayfly nymph abounds in the trash that accumulates against obstructions in the stream. It clings to rough stones and to brush in the slower flowing parts of the rapids. It is easily recognized by its stout body that bears a double row of high, sharp spines the whole length of its back, and by a pair of huge, backward sloping tubercles upon its head. Its three long tails are alternately banded with lighter and darker areas. It is a stiff-legged, blackish, sprawling creature that is well concealed by its protective form and color while it lies still amid the sticks and bark fragments of the leaf drifts. It is common in Logan Cañon below 6000 feet.

It was already transforming when observations were begun the middle of June, and was still coming forth sparingly at the end of July. The adult is very similar to the adult "ginger quill" but has longer tails.

In Utah there is a second species of "prickleback" (*Ephemerella spinifera*) found but once. The dorsal spines of this species are of different proportions, as shown in Figure 4.

3. Colorado mayfly (*Ephemerella coloradensis*).—This is a very important species especially at the higher altitudes. It was found to constitute about 50 per cent of the food of the trout examined from Upper Logan River (near 7000 feet). It is similar to the preceding but smaller, has the double row of spines upon the back reduced to low prickles, and lacks altogether the big tubercles upon the head. Its fore femora are toothed upon the front margin, and its tails are banded alter-

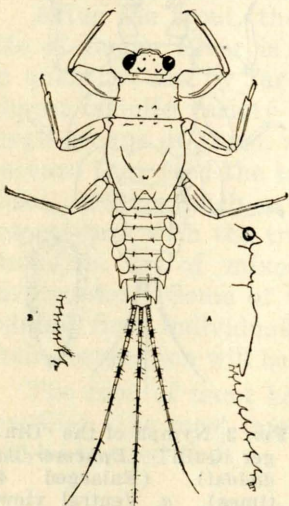


FIG. 4. Nymph of the "Prickleback" (*Ephemerella grandis*), dorsal view. (Enlarged 3 times) a. Side view showing spines on back. b. Spines on abdomen of smaller "Prickleback" (*E. spinifera*)

nately in lighter and darker areas. The coloration of its body is exceedingly variable, but usually shows on the back broad, whitish areas upon a darker ground.

This species lives among the stones and gravel rather than in the trash. It was not found in the swiftest water, but only in rapids where the flow was moderate. It is of general occurrence in the higher mountains of the Western States.

4. "Tip-tail" mayfly (*Ephemerella inermis*).

—This is a little brownish mayfly nymph that clings to roots and trash in the edges of the stream. Dislodged from its support, it feigns death for a time. Folding its legs close to its body and tipping its tails over its head, it becomes a most inanimate looking thing. But when it gets on its feet again and stretches its long, graceful, black-banded tails out behind, it is a much more graceful creature than any of the preceding species. It is quite smooth above, lacking both spines and tubercles.

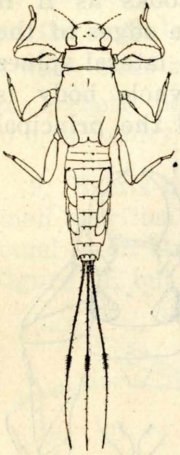


FIG. 5. Nymph of *Ephemerella coloradensis*. (Enlarged 2 times)

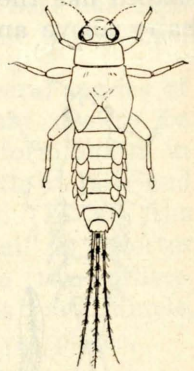


FIG. 6. Nymph of the "Tip-tail" (*Ephemerella inermis*). (Enlarged 3½ times)

This species was especially common in the cold water outflowing from the water-works into Logan River, tho the list will show its distribution to be rather general.

5. Margaret's mayfly (*Ephemerella margarita*)⁽³⁾.

—This is another dainty little species, the prettiest of the group in both form and coloration. Like the "tip-tail", it has no spines on either femora or back. It differs from that species in having no gills upon the third abdominal segment and in having a single wide blackish band across the middle of the tails. It is less common than the preceding species.

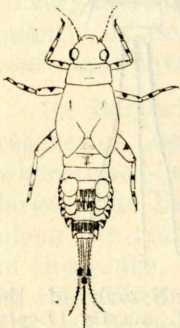


FIG. 7. Nymph of Margaret's mayfly (*Ephemerella margarita*). (Enlarged 3½ times)

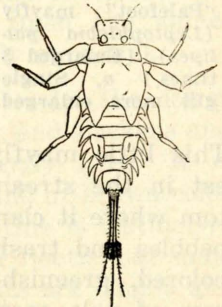


FIG. 8. Nymph of the "Sawtooth" mayfly (*Ephemerella hecuba*). Enlarged 3½ times)

6. "Sawtooth" mayfly (*Ephemerella hecuba*).—This species is probably of less eco-

(3) Named in honor of little Miss Margaret Hawley of Salt Lake City.

onomic importance than any of the preceding, but its form is very interesting. It was found only in Provo River all about the southern base of Mt. Timpanogos. It was found sparingly in the stomachs of rainbow trout taken from that stream.

It is the flattest mayfly nymph known. It looks as if it might have been run over by a steam-roller. The edges of the abdominal segments are spread out in great, flat, lateral spines shaped like the teeth of a circular saw. The whole body is hairy above and covered with adherent silt, and the principal

color pattern shown is a band of black across the middle of its long, fuzzy tails.

It lives on the silt-covered boulders in slack water at the edges of the stream. It clings closely, and when dislodged falls helplessly; and, bending its tail a little upward, discloses wide bars of brownish color across the abdominal segments on the smooth ventral side.

The adult is still unknown.

7. "Palefoot" (*Leptophlebia pallipes*).—

This little mayfly—one of the slenderest in the stream—lives upon the bottom where it clambers about among the pebbles and trash. It is rather plainly colored, greenish-brown, with a single row of pale spots down the middle of the abdomen. It has seven pairs of double gills that are more or less tuning-fork-shaped, with a black air tube extending down the middle of each division. The tips of the fork are pointed. The legs are not banded with color, and the three long tails are pale.

8. Pack's "Tusker" (*Leptophlebia packii*).—This species was found only in the north or left-hand fork of Ogden River. It is

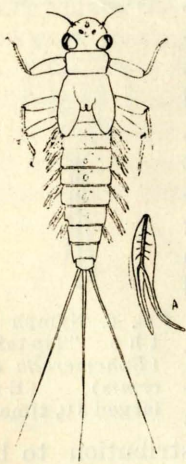


FIG. 9. Nymph of the "Palefoot" mayfly (*Leptophlebia pallipes*). (Enlarged 3 times.) a. Single gill more enlarged

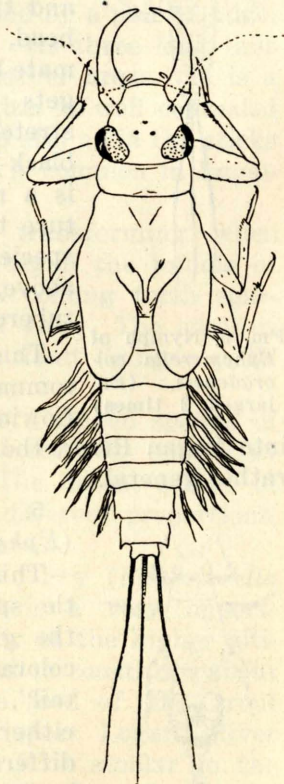


FIG. 10. Nymph of the "Tusker" mayfly (*Leptophlebia packii*). (Enlarged 5 times)

instantly recognizable and distinguishable from all other mayfly nymphs by the huge, ivory-yellow, pincher-like tusks that project forward from the mandibles more than the length of the head. It occurs on the beds of mixed sand or silt at the side of the stream in the shallows where the water flows quietly. It lies flat with legs outspread and tusks extended before its face. It was reared in October, 1926, by the Station Entomologist and was recently described by the senior author⁽⁴⁾. There has been no opportunity to learn anything about its economic importance.

9. *Baetis* mayfly (*Baetis* sp.).—There are several species of small mayflies belonging to the genus *Baetis* that are to be found in all stream-beds. They are all of the form shown in Figure 11, but differ in color pattern and in length of tails and antennae. In all, the middle tail is shorter than the two others. The gills are simple, single, oval plates.

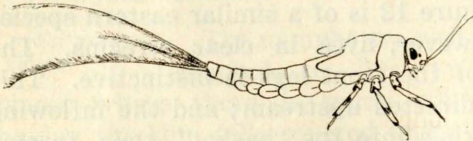


FIG. 11. Nymph of *Baetis tricaudata*. (Enlarged $3\frac{1}{2}$ times)

These dart about over the bottom like dwarf minnows. They always stand head upstream, poised on tiptoe, ready for a spring. On the bottom they are very hard to see because their coloring is highly protective, but when lifted on a net they flop about like minnows and show themselves. They are so very active, they are caught by young trout and are found frequently in stomach examinations. They feed upon the slime-coat algae covering the stones and are generally abundant.

10. Bandwing mayfly (*Callibaetis pallidus*).—In the lower reaches of Logan River where the water warms and slackens and where weed-beds come in, this very pretty mayfly lives. It is larger than *Baetis*. The adult female has a band of brown color along the front margin of the forewing, and this is distinctive of the genus. The nymph is similar to that of *Baetis*, but some of the gills on the anterior abdominal segments are double and the middle tail is as long as the others.

11. Ameletus mayfly (*Ameletus velox*).—This is similar in form to *Baetis* but larger in size and darker in color, and the middle tail is as long as the others. The gills are all single. The species named above was seen during the first few days of the

(4) Needham, J. G. "A Baetine Mayfly Nymph with Tusked Mandibles." In CANADIAN ENTOMOLOGIST, Vol. 59 (Feb. 1927), pp. 44-47.

study on Logan River, resting on the sloping banks of mixed sand and silt at the edge of the stream. Its dark mottling matched the bottom perfectly in color. It was hard to see until captured. It is an early-season species.

Within a week all had transformed and none could be found anywhere near the camp. However, in the

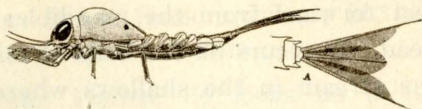


FIG. 12. Nymph of "Howdy" mayfly (*Chiotenetes albomaculatus*). (Enlarged 4 times). a. Tails of same above showing fringes. Drawing by C. H. Kennedy

colder water of the springs nearer the head of the river nymphs were still common on July 26.

12. Howdy mayfly (*Chiotenetes* sp.).—Nymphs belonging to this genus were found under loose bark on submerged logs in the quiet muddy waters of the lower reaches of Logan River. These were not raised. Figure 12 is of a similar eastern species of *Chiotenetes*, which, however, lives in clear streams. The long fringe on the inside of the front legs is distinctive. This fringe is set forward and directed upstream; and the inflowing current washes food materials into the "basket" thus formed beneath the mouth. Thus, they take what the river brings them.

13. "Western bunch-gill" (*Siphonurus occidentalis*).—In a bed of water weeds at the swimming hole near the sugar factory below Logan on the river, this fine species was common. It was actively transforming on July 16, and nymphs were still transforming on July 26. The slack water of the weedbeds was its home.

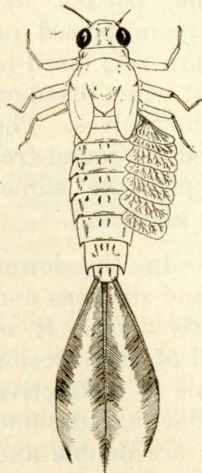


FIG. 13. Nymph of "Western bunch-gill" (*Siphonurus occidentalis*). (Enlarged 4 times)

Another smaller species with longer antennae and lighter coloration was found on July 26 at Peterson's Spring. It dwelt among the cresses in the spring pool and was common there. It was not reared.

14. Snowflake mayfly (*Tricorythus ex-plicatus*).—This was the smallest mayfly found. It was not very common on Logan River, but on Provo and Weber Rivers it was extraordinarily abundant. On July 28 vast swarms filled the air above these streams for many miles. They flew as thick as snowflakes in a storm, and were almost as white, and the individuals were not much larger. Millions and millions of

wings glancing in the light of the morning sun made scenes of great animation.

The adults have but two wings, the hind wings being altogether lacking. The wings are white with a purplish streak along the front margin. They fly by day, the swarms being thickest in the forenoon. The males fly highest, up to 50 feet or more, in vertical lines, up and down, incessantly. The females, after mating, fly low over the rippled surface of the stream, each carrying her little bunch of eggs extended at the tip of the abdomen and ready to let fall into the water. On sweeping the wet hand-screen thru the swarm, it was covered at one stroke with hundreds of females and their loosened egg masses.

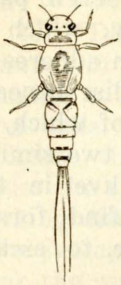


FIG. 14. Nymph of the "Snowflake" mayfly (*Tricorythus explicatus*).

(Enlarged 4 times)

The nymphs are well adapted to live in places where there is much silt, having the thin gills covered under a pair of triangular gill plates that grow on the second abdominal segment. By this plate they may be recognized. They were common in the muddy covering of submerged logs in Logan River near its mouth and on silt-covered stones in Weber and Provo Rivers. They make up in numbers for what they may lack in size. No one can witness their milelong swarms without being convinced that they play an important role in the economy of the river.

15. "Redgill" (*Rithrogena mimus*).—This remarkable mayfly nymph is common to Logan River on the larger stones in rather rapid water. It is a very beautiful creature, having the abdomen encircled with large gills of a bright rose red color by which it may be instantly recognized.

The gill plates are especially noteworthy. They are extended

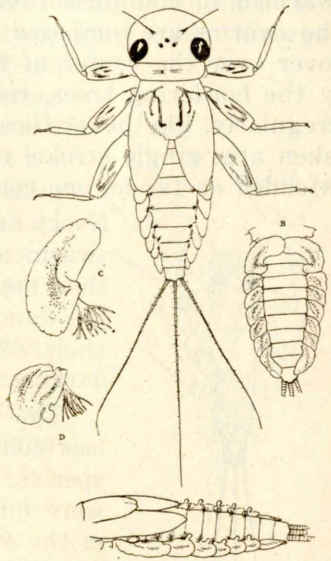


FIG. 15. Nymph of "Redgill" mayfly (*Rithrogena mimus*). (Enlarged 5 times). *a.* Oblique lateral view of abdomen showing gills, gill plates, and ear-like lobes upon same. *b.* Ventral view of abdomen showing sucking disc formed by gills. *c.* Gill of foremost pair more enlarged. *d.* Gill of second pair more enlarged.

laterally and laid down flat in an overlapping series to form a continuous margin about the body. The foremost pair is greatly enlarged and extended forward and inward to meet and overlap underneath the thorax. Thus, the seven pairs together form an oval inclosure beneath the body, which is in fact a sucking disc by means of which the nymph adheres to the stones. This is the functional parallel to the disc beneath the abdomen in *Ephemerella doddsi*, in the making of which, as shown in Figure 3, no gills are involved. Here are two similar devices that enable these two mayfly nymphs to live in the swifter waters. Thus, they are probably able to find forage that is not available to others and so, in a measure, to escape competition.

This was one of the few species of mayflies of which adults were seen in abundance. During the last week in June they swarmed in countless thousands over the river at nightfall. The swarms are composed of males that fly continuously. They hover over the center of the stream in the green lane formed by the bordering trees, rising and falling and swaying about irregularly, like hover-flies. A dozen or more could easily be taken at a single stroke of a long-handled net. The swarm extended as far as one could see both up and downstream.

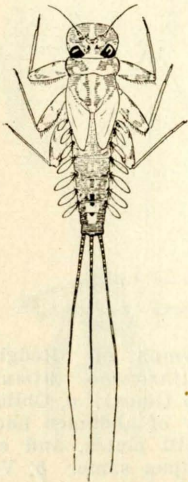


FIG. 16. Nymph of "Dandy" mayfly (*Rithrogena elegantula*). (Enlarged 5 times)

Every few minutes a female would join the swarm and find a mate, and the two would then depart together, with no disturbance to the dance of other revellers which continued their exhilarating aerial performance until darkness hid them from view.

The nymphs of this species seemed to be less common than were half a dozen other species, but the vast swarms of the adults were quite convincing as to their prevalence in the stream. When one considers that the females are probably as numerous as the males, and that each female may lay 1500 eggs, such nuptial flights as these clearly foretell Nature's provision for restocking the river.

16. A second species of *Rithrogena*, *R. brunnea*, was found associated with the "redgill" in Logan River, and as its gills often had a greenish cast, it was commonly spoken of as the "green gill". The nymph was very similar to the preceding, but the gills differed in three points: (1) They

lacked the red color; (2) those of the foremost pair were not so broad, not quite meeting on the middle line underneath the thorax; and (3) the little rounded, upcurving lobes on the hind edge of the gill plates were less developed.

17. "Dandy" (*Rithrogena elegantula*).—This mayfly was common in the streams of the plain where its nymph was found clinging to submerged logs and timbers. It has three very long tails. Its gills are outspread along the sides of the abdomen, the first pair being neither enlarged nor turned forward under the thorax. They hardly overlap, and they do not form a sucking disc. In the slack waters of the lower river no special adhesive appliance is necessary. Grown nymphs obtained from near the mouth of Logan River and from Bear River near Amalga were reared in cages in a biological laboratory tank at the college.

18. "Coquette" (*Iron longimanus*).—This is another swift water species. The nymph has but two, very long, divergent

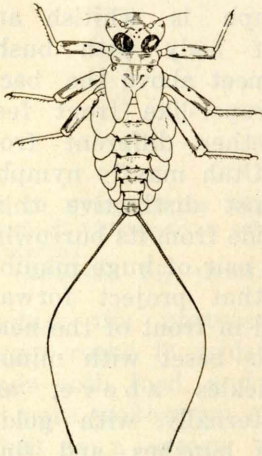


FIG. 17. Nymph of "Coquette" mayfly (*Iron longimanus*). (Enlarged 5 times)

tails. Its flat head is widest across the front and tapers to the rear. The gills form a close-laid overlapping series as in the "redgill", with those of the foremost pair enlarged in front and overlapping beneath the thorax. It was reared at Birch Glen, and was found generally

distributed in rapid mountain streams.

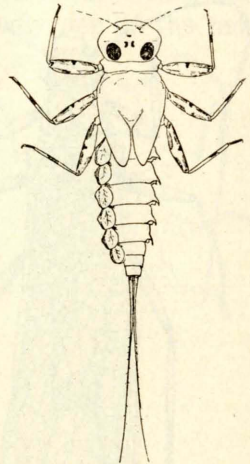


FIG. 18. Nymph of *Epeorus* sp. from Weber River. (Enlarged 5 times)

19. *Epeorus* sp.—Nymphs of this species were found at a number of places in Weber and Provo Rivers on July 28, too late for rearing as the work for this season closed at that time. Like those of the preceding species, they have but two tails. The head, however, is widest across the middle, and the gills of the foremost pair are not turned forward underneath the thorax.

All the gills have a curving ridge paralleling their outer margin, and underneath their bases, the lateral margins of the abdominal segments are produced into strong sharp thornlike lateral spines.

20. "Trailer" (*Ephoron album*).—This is a burrowing mayfly found in those portions of the Jordan, Bear and Logan Rivers, where these streams meander slowly across the plain. It was first collected from Bear River near Amalga west of Smithfield, later from near the mouth of Logan River; repeated efforts were made to rear it at the college, but without success. Apparently it would not stand the change of water. But when leaving Utah on July 29, the senior author and the Station Entomologist obtained life-history material on the Jordan River near River-ton. Cast nymphal skins and dead adults of both sexes were hanging by thousands on drooping branches of sweet clover that trailed in the edges of the current. These stranded individuals were adequate for determining that it was the same species collected earlier in Bear River.

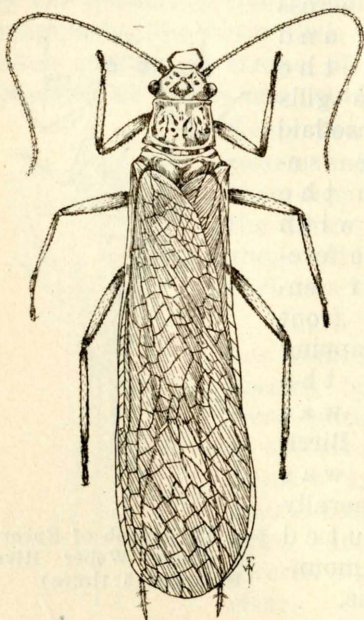


FIG. 19. Adult of the "Big Curler" (*Pteronarcys* sp.). (Enlarged 2 times)

The nymph is whitish and cylindric of body with bushy gills that meet above the back, and big scraper-like front feet. It is altogether different from any other Utah mayfly nymphs, and the most distinctive thing about it, aside from its burrowing legs, is the pair of huge manibular tusks that project forward and upward in front of the head. Each tusk is beset with minute brown prickles above, and fringed externally with golden hairs. Big bunches and lines of similar hairs decorate also the front legs and sides of the head.

The adult is a big mayfly of very pale coloration, with broad, white wings that have a line of purplish pigment paralleling their front border. The colorless tails are extremely long and flexuous (whence the common name). The eggs are extremely numerous (1000 or more) and are laid all at once in two large yellow packets, as indicated in Figure 2.

STONEFLIES—ORDER PLECOPTERA

The nymphs of stoneflies are of different food habits. The first two species treated below are chiefly herbivores that feed upon leafage and other disintegrating remains of land plants fallen into the streams; the others are carnivores, and are therefore directly or indirectly competitors with the trout for food. All stonefly nymphs climb out of the water and up some solid support to transform, and leave their cast skins gaping and empty upon the banks of the river, usually not far from the water's edge. The adults are longer-lived than are mayflies, and the herbivorous ones, at least, do some feeding after they take to the air.

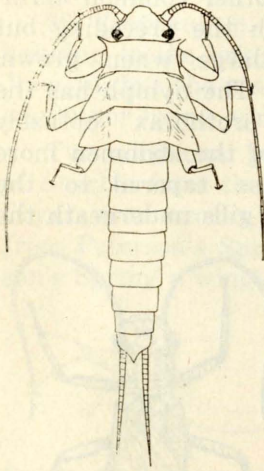


FIG. 20. Nymph of the "Big Curler" (*Pteronarcys californica*).
(Enlarged $1\frac{1}{2}$ times)

against the upstream side of the larger rocks in midstream where it finds both food and shelter. Fifty or more well-grown nymphs could be taken on a screen on dislodging a single large stone; and in Provo River south of Mt. Timpanogos it was even more abundant than at Birch Glen (on Logan River). Nymphs mainly of two sizes indicate that at least two years are required for development. Adults are most abundant in the latter part of June. They appear earlier in the lower, warmer portion of the stream near the plain, and in the early season practical anglers are said to gather them there and take them upstream to points at which no adults have as yet appeared where they are used successfully

21. "Big Curler" (*Pteronarcys californica*).—This is a big, black, broad-winged stonefly that abounds in the clear waters of Logan River below 6000 feet. It is undoubtedly one of the most important insects of the stream. Its greatest abundance seems to be in the trash piles that gather

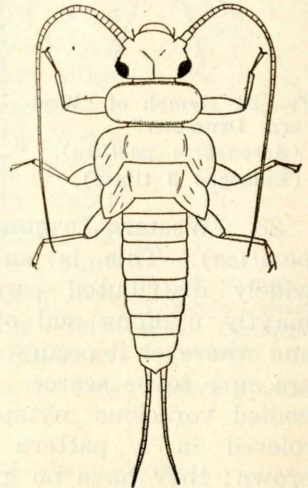


FIG. 21. Nymph of "Little Curler" (*Pteronarcella badia*). (Enlarged 3 times)

as live bait. Certainly, both adults and nymphs are eaten commonly by the trout.

The nymphs are locally called "stone-rollers" or "rock-rollers"—a name better reserved for certain fishes, for it is very inappropriate. These do not roll stone; they roll themselves, or rather, when disturbed, they curl up like kittens with their heads tucked under their bodies.

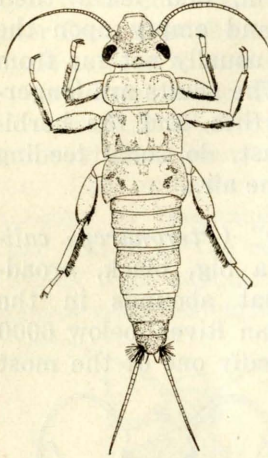


FIG. 22. Nymph of "Western Drummer" (*Acroneuria pacifica*). (Enlarged 3 times).

22. "Little Curler" (*Pteronarcella badia*).—This is another common herbivore associated with the preceding but less than half as large when grown. The adult is black. The nymph has the angles of the prothorax obtusely rounded, the sides of the abdomen more nearly parallel (less tapered to the rear), and there are gills underneath the first three basal segments of the abdomen. June is the month of its transformation. Nymphs were found in the north fork of Ogden River, but more abundantly in Logan River.

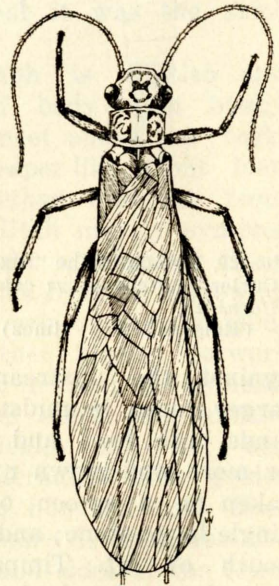


FIG. 23. Adult of *Isoperla* sp. (Enlarged 4 times)

23. "Western Drummer" (*Acroneuria pacifica*).—This is an important and widely distributed carnivore. It eats mayfly nymphs and other herbivores; and wherever it occurs abundantly these are sure to be scarce. The large flat-bodied voracious nymphs are prettily colored in a pattern of yellow and brown; they have no gills on the basal abdominal segments, but there are white tufts of gills between the tails at the end; there are also other tufts about the bases of the legs. The adult male has a round percussion disc or hammer underneath the next to the last (ninth) abdominal segment, with which he drums or taps on the leaf or other surface beneath his feet (whence the common name), supposedly to attract the attention of the female.

24. *Isoperla* sp.—This little carnivore was found not uncommonly in Logan River, where on June 25 was reared a single undeterminable female. Later some additional nymphs were obtained from the north fork of Ogden River.

25. *Alloperla pallidula*.—This is a tiny pale green stonefly often seen flying over the river in late afternoons and evenings in July. Its slender nymph lives among the pebbles in the rapids and shoals of Logan River.

26. *Isogenus* sp.—Cast skins of a member of this genus were hanging to the bridge timbers at Birch Glen (Logan River) on June 14, but the season of flight was apparently over. Neither adults nor living nymphs were seen.

Two additional genera of small stoneflies were seen—species of *Leuctra* from the spring brook across the canyon road from Logan water-works and a single nymph of a species of *Nemoura* from Peterson's Spring at the head of Logan River. In Peterson's Spring a wingless stonefly, new to science, was also found.

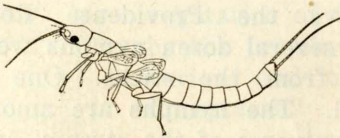


FIG. 24. Adult of *Isoperla petersoni*. (Enlarged $2\frac{1}{2}$ times)

All stages were found together, nymphs and adults looking very much alike.

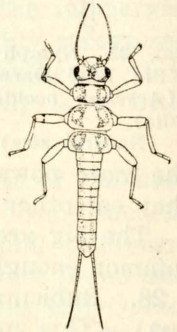


FIG. 25. Nymph of *Isoperla petersoni*. (Enlarged $2\frac{1}{2}$ times)

They were living among the mosses that covered all the stones in this spring, and some of them were among the water cresses just below it. Mating and egg-laying were in progress, and the eggs were found suspended in masses of loose gelatin from the stones in the water. Figure 24 shows the adult, which has been described by Dr. Claassen under the name *Isoperla petersoni*. It is the first known species of its genus with rudimentary wings.

DRAGONFLIES AND DAMSELFLIES—ORDER ODONATA

These are all carnivores. There are few of them in the river itself, and these are only in places of quiet water, but the adults of the larger, stronger flying dragonflies go hawking up and down the cañon over the river in numbers and are a conspicuous part of its insect life. They are great consumers of adult mayflies and midges.

27. Big Blue Darners (*Aeschna occidentalis*).—These are the largest dragonflies seen in the Logan Cañon. They like to

fly in the sunshine over the river. They fly unceasingly back and forth in sweeping curves, hawking as they go, and feeding almost unceasingly on the little insects that they capture in mid-air. The females are especially active at the close of the

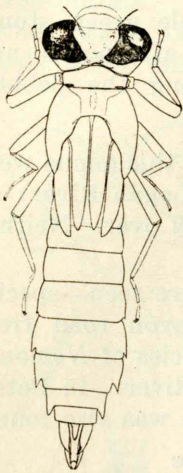


FIG. 26. Nymph of "Big Blue Darner" (*Aeschna occidentalis*).

(Natural size)

day, when in the twilight callow mayflies, craneflies, and midges are emerging from the river and taking their first flight. Several times they were observed picking these easy captures out of the air until the approach of darkness put an end to their feasting. They could be seen taking *Ephemera*, *Tanytarsus*, and *Antocha*. A few of the hawkers were taken with a net; the captives were still held in the jaws of these blue darners.

The nymphs of the blue darners cling to submerged sticks in the more quiet pools of the lower river, at the edge of the plain, where the water is still clear. From a single shady pool above the Providence Road bridge in Logan several dozen nymphs were taken by hand from the sticks. One of these was reared. The nymphs are among the more powerful of the lesser carnivores of the stream, and they eat other aquatic insects in great variety.

The big green darner (*Anax junius*), a pond species, was common enough on the plain but was not observed on the rivers.

28. Rubicund dragonfly or "Toper" (*Sympetrum rubicundulum*).—This small, red dragonfly fairly swarmed in July in the low-ground meadows along Logan River below the water-works. Doubtless, they breed in the slack water above the power-dams, for this is a pond species. The adults fly intermittently and rest on the vegetation between sallies. They feed upon the smaller insects of both meadow and stream. In an hour's collecting below the water-works scores of this species as well as the damselfly (*Lestes*), next mentioned below, were captured.

The "toper" nymph is a bottom sprawler or a clamberer over bottom trash.

29. *Lestes uncatatus*.—This long bronzy, green damselfly is an associate of *Sympetrum* in the meadows and swales of the lower river, but it flies only in

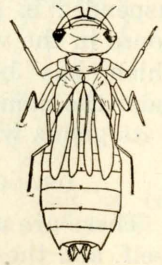


FIG. 27. Nymph of Rubicund Dragonfly (*Sympetrum rubicundulum*). (Enlarged 2 times)

short sallies and keeps to the cover of the grass or bushes. It feeds mainly on other smaller damselflies and midges. The nymph clammers among the stems of standing vegetation in still or very slowly flowing waters. It feeds on a great variety of small, soft-skinned water insects and crustaceans.

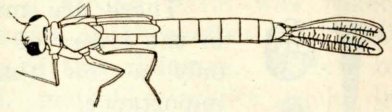


FIG. 28. Nymph of *Lestes uncatatus*. (Enlarged $1\frac{1}{2}$ times)

30. *Amphiagrion amphion*.—This is a damselfly of the swales. It is a little red fellow, half as big as a *Lestes*. A sooty, black color covers and obscures the red on the thorax and the tip of the abdomen. No other damselfly in the fauna studied is of its dark red color; hence, it is easily recognized. Specimens were obtained from two localities on Logan River—one from a swale in a dilatation of a spring brook between the water-works and the Logan Cañon Road, and the other from a swale beside an irrigation canal just outside the Fairgrounds east of Logan.

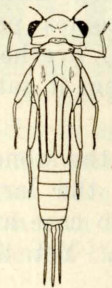


FIG. 29. Nymph of *Amphiagrion amphion*. (Enlarged 2 times)

The nymph is a climber among the submerged vegetation of the swale and is readily recognized by the prominent hind angles of the head. It is curious and interesting, but probably is of little importance.

There were several other genera of *Odonata* seen on the lower river, other pond forms such as *Libellula*, *Leucorhinia*, *Enallagma* and *Ischnura*. On the clayey bank of Bear River were found cast nymphal skins of species of *Gomphus* and *Ophiogomphus* which had transformed earlier in the season; in Weber River a single half-grown living nymph of *Ophiogomphus* was taken from the silted stream-bed.

CADDIS FLIES—ORDER TRICHOPTERA

The larvae of the caddis flies (also called caddis worms) are mainly herbivorous. They are largely eaten by trout, especially the first one named below. The adult caddis flies may be eaten when they return to the water to lay their eggs, but it is pupal caddis flies that are most commonly found in trout stomachs. The larvae are often well concealed and protected by a covering of stones, and the adults are mostly far away in the air; but the pupae must leave the shelter of the stones and swim to the surface of the water, naked and exposed. This is the weak point

of their life history; and many of them are snapped up by fishes while making this perilous passage to the surface to transform.

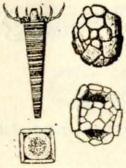


FIG. 30. Caddis fly cases. Case of *Brachycentrus* with larval head and legs extended at front. End of case when prepared for pupation showing perforated wall. Dorsal view of case of *Glossosoma* sp. Ventral view of same. (From Lloyd)

There are many kinds of caddis flies living in the rivers of Utah. Mention is made here of only a few that seem to be of considerable importance.

Square-cased caddis worm (*Brachycentrus* sp.).

—This is a common and important species. In many of the rivers of Utah it covers the upper surface rocks just where the water breaks over them. In the upper reaches of Weber River, for example, there are scores of the square cases attached to every large cobblestone in the stream. The cases are covered with bits of wood placed crosswise, consolidated, and lined with silk. They taper from front to rear and all point downstream. They are attached to the stone at the lower edge of the front margin. The larva, living inside, retreats within when disturbed, and comes part way out and lifts its legs (like arms) overhead when it wants to feed. With its spiny legs it gathers its food out of the passing current.

The cases, fully exposed as they are on the top of the stones, are where hungry trout can get them; but because the larva cannot be extracted from the case and must be eaten case and all or not at all, it is probably not very choice food. Yet the cases are commonly found in trout stomachs.

Glossosoma sp.—This small caddis worm makes a heavy nearly hemispherical case of bits of stones. It creeps around on and near the bottom. When grown and ready for pupation the larvae gather together on the downstream face of the larger stones in the river channel, and fasten their cases to the rock with silk, transforming inside them. Figure 39 shows an abundance of them.

Despite the fact that there is much more stone than caddis worm in one of these cases (and the two are to the trout inseparable), they are sometimes eaten; however, they were found but sparingly in trout stomachs. Oftener, pupae are taken when emerging.

Other caddis worms of many sorts were found in every stream. The net-making *Hydropsyche* spins its drift-catching

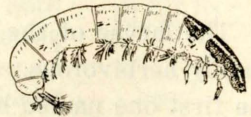


FIG. 31. Larva of Net-making Caddis Worm (*Hydropsyche*). (Enlarged 2 times)

silken "basket" in every riffle among the stones. The greenish larvae, dislodged from their shelters between the rocks, were taken on hand screens whenever a strong riffle was raked. They are known by the copious tufts of threadlike gills that hang in bunches on the underside of the abdomen. A few of the pretty, gray-brown, mottled, moth-like adults could be found at any time about the bridge at Birch Glen (Logan River).

The eggs were often observed on the side of stones under water. They are roundish, liver-colored eggs that are laid in a scanty coating of gelatin in flat one-layered patches the size of a dime. Larvae, pupae, and adults were found occasionally in trout stomachs.

Platyphylax sp.—This is a large caddis worm that makes a cylindrical case more than an inch long covering it over with coarse sand grains. When grown, the larva closes the rear end of its case with a perforated grating of silk, attaches the other end to a submerged log or other solid support, and enters the pupal stage. On July 26 in Temple Fork, Logan Cañon, on every stick that lay in the edge of that cold stream bearing these cases they were found attached by one end. All had spun up for pupation, altho about half still contained larvae not yet transformed.

In the right fork of Logan River on the water cress and on sticks in springy places, the long-pointed cases of an unknown caddis worm (of the family *Leptoceridae*) were abundant. These cases were very slender, and their smooth walls were covered with very fine grains of sand. They were eaten by small trout taken at the same place.

TWO-WINGED FLIES AND MIDGES—ORDER DIPTERA

The aquatic larvae of this group are of very diverse habits. The midge larvae are among the most important herbivores of the streams, but most of the others are carnivores.

Logan midge (*Tanytarsus logani*).—This little midge, one of the smallest insects of the river, is probably one of considerable importance as a primary flesh producer. It is among the smallest and the palest of the things seen flying over the river, or resting on the over-hanging herbage, or filling the webs of spiders beside the stream. It would hardly be noticed by the ordinary observer, but it is present in vast numbers. Every bar of bare sand and silt along the banks at Birch Glen is fairly filled with the tubes in which its larvae live. On taking up the surface layer of sand to a depth of about an inch and sifting it (after the silt and sand have all run thru), there will remain a mass of the brownish

vermiculate tubes of these larvae equal in bulk to a third or a fourth of the sand sifted. As these tubes lie upon the sifter or in the dish, in a moment, one here and one there begins to wiggle with the undulations of the body of the contained larva, resuming its activity. Most of the tubes will at times be found to contain living larvae or pupae of this species. The larvae make the tubes by sticking together bits of sand and silt using as an adhesive the secretion of large modified salivary glands. This secretion is fluid when expressed but hardens on contact with the water.

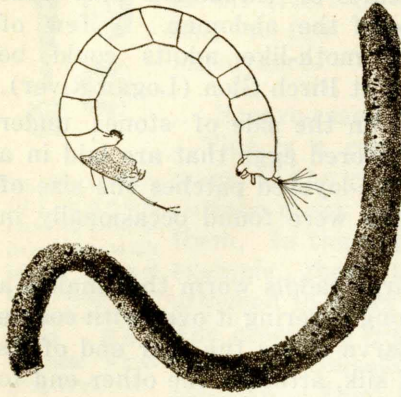


FIG. 32. Larva of Logan Midge (*Tanytarsus logani*) and its case. (Enlarged 8 times)

Bottom diatoms are the chief food of these larvae, if one may judge by diets that have been studied elsewhere; and the larvae and pupae themselves are eaten by every little carnivore of the stream.

Antocha monticola.—This faded-looking crane-fly, that one sees so commonly at Birch Glen rising from the surface of the river and fluttering away to a resting place in the bordering vegetation, lives as a larva and a pupa on the downstream face of the rocks in the open river, where there is considerable current. It constructs a very inconspicuous case or shelter on the face of the rock and lives concealed. One may look for it a long while without much success, but if the rocks be scraped and the scrapings examined in a dish of water the uncovered larva and pupa will be found. The larva is carnivorous. They have been observed holding midge larvae in their rapacious jaws. So far as is known, they have never been found in the food of fishes.

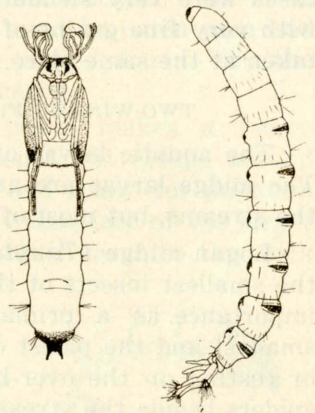


FIG. 33. Larva and Pupa of the lotic Crane-fly (*Antocha monticola*). (Enlarged 5 times)

Ptychoptera lenis.—This is a crane-fly of the river edges. The adults have polished bodies banded with black and brown color,

narrow clear wings, and long black legs. They sit or hang suspended among the leaves of the herbs that fringe low boggy shores, or they make short sallies out over the edges of the stream, returning at once to shelter. The larvae live in the sand and silt near the edge burrowing in it and reaching betimes (by means of their long, telescopic, respiratory tailtube, Fig. 43) up to the surface for air.

4. *Limonia venusta*.—This pretty crane-fly has brown dotted wings. It was found on the sides of the larger rocks in midstream. Its larvae lived in the shelter of mixed mosses and algae at the waterline. Pupae were found in spun shelters at the same place. They were found transforming on July 18.

Other crane-flies of Logan River were taken only as adults. Species of *Limnophila*, *Helobia* and *Tricyphocera* were found at the margin of the water. One little grayish crane-fly (*Psilococnopa mormon*⁽⁵⁾) is known only from the specimens that gathered in small companies on the outside of rearing cages as they hung half submerged in the river under the bridge at Birch Glen. For many days together in late June they were found perching in a row just above the waterline. Nothing further is known of their habits.

The push-ring crane-fly (*Eriocera* sp.) was found in Logan River, but was much more common in the upper reaches of Weber and Provo Rivers.

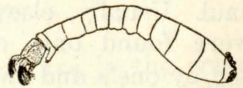


FIG. 34. Larva of Black Fly (*Simulium* sp.) (Enlarged 4 times)

Blackfly (*Simulium* sp.).—The larvae of this fly hang head downward in the stream, suspended by a single anal sucking disc from the upper surface of a rock or log. It is fully exposed to view. It is found in swift-flowing water where the current breaks over obstructions. It is so near the top and in a sheet of water so thin that it is generally out of reach of the fishes; but these larvae are eaten betimes—perhaps when dislodged from their support.

The color is black; the bag-shaped body tapers to the head. On the front of the head above the mouth are two plancton-gathering "fans" whose plumose rays strain out food from the passing current. It is mostly of a vegetable nature but very mixed.

The larva when grown spins a brown cornucopia-shaped

(5) Described as *new* under this name by Dr. C. P. Alexander.

"basket" about itself on the vertical face of the rock and transforms in it to a pupa, having branching antler-like horns.

Net-winged midges (*Bibiocephala* sp.).—The larvae of these are found attached to smoothest, current-swept stones in the swiftest waters. Each larva bears a row of powerful sucking discs on the underside of its body. On these it creeps like a caterpillar. By means of these it clings securely. Between these suckers the body is notched in a peculiar form by which it is instantly distinguishable from all other aquatic insects.

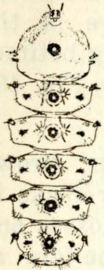


FIG. 35. Larva of Net-winged Midge (*Bibiocephala* sp.). (Enlarged 4 times)

The pupa is found on the vertical face of the same stones usually on the downstream side. It is very black in color, oval (or nearly hemispherical) in form, and has two short, thick, flat, respiratory horns rising from its upper (anterior) end.

Snipe fly (*Atherix* sp.).—The larvae of this fly are found creeping among the rocks in the stream-bed. They were encountered in extraordinary abundance in Weber River near Oakley. A score or more of them were taken on the hand screen at a single haul. Usually, elsewhere, they were found only occasionally and by one's and two's.



FIG. 36. Larva of Snipe Fly (*Atherix* sp.). (Enlarged 3 times). Proleg detached and more enlarged

The larva is carnivorous. It will be easily recognized by its lack of head, its stout, crotchet-bearing, bifurcated prolegs, its paired lateral filaments, and its two, tapering plumose tails.



FIG. 37. Larva of Deer Fly (*Chrysops* sp.). (Enlarged 3 times)

The larvae may be recognized by the spindle-shaped form of body, tapering to both ends (tho more to the front), and ringed with tubercles on each segment.

Soldier Fly (*Stratiomyia melanostoma*).—Larvae of this fly were found at several places along Logan River, usually where a thin layer of soft silt or muck covered the bottom in very shallow, slow-flowing water. The flat larva is stiff and stick-like when disturbed. It widens behind the narrow head and then

Deer fly (*Chrysops* sp.).—Sandy shores of Logan River were, in places, full of the carnivorous larvae of this species, associated with midge larvae and white clams, on one or both of which they probably were feeding.

tapers gradually to its long-pointed tail (Fig. 44). It is colored like the silt amid which it lies and is very inconspicuous.

Besides the midges and craneflies, one adult fly, a dance fly (*Hilara* sp.), was taken commonly by the trout as food in Logan River. It is a little black fly that skims ceaselessly over the surface of the water in horizontal curves, almost touching it. Its larva was not seen.

Other orders of insects than the five discussed above are of less importance. Hemiptera, or true bugs, are represented by a few shore bugs at the banks, and by a few water striders, (*Gerris remigis*), etc. on the surface. The Coleoptera and beetles have a larger representation of which the most important in Logan River are diving beetles of the genus *Hydroporus* (see p. 33 and riffle beetles (*Parnidae*). The latter are found sparingly both as larvae and as adults clinging to the under surfaces of stones. The big black *Amphizoa* was encountered once in the left fork of Provo River above Woodley, on submerged logs. Other animals are those mentioned in the introduction, a few oligochaete worms always taken on the screens when bottom gravel was stirred in the rapids, a few leeches, and the little white clams mentioned on page 34.

WHERE THE INSECTS OF THE RIVER LIVE AND HOW TO FIND THEM

As by going fishing one learns where fish live in the river, so we may learn of other things there by collecting them. The methods are simple. The apparatus is inexpensive. The results are much surer than from angling with hook and line; we do not wait for them to bite.

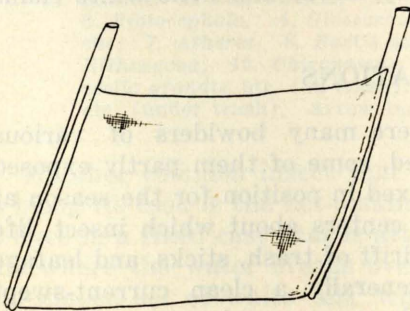


FIG. 38. Hand-screen for collecting insects in rapids

Hand-picking from sticks and stones lifted from the water will discover many of the insects that cling to their surfaces. Indeed, for those that cling most persistently, like the larvae of black flies, net-veined midges, riffle beetles, spun-down caddis worms, and the nymphs of

such mayflies as have disc-like holdfasts, there is no better way. Those that drop off into the water on disturbance will be missed by this method.

A **hand-screen** of wire cloth is the best of tools for general stream collecting. One is easily made from a strip of wire cloth, 1x2 feet, and two round willow sticks. The folded-over ends of the wire cloth should be inserted into slits made with a rip-saw in the handles and nailed fast there. The screen is best held in the current by one person facing upstream, while another person vigorously stirs the stones or brush above it to dislodge the insects. These are washed by the current onto the screen, which is then lifted to find them. The larger forms may be picked off directly; but when there is much trash present, the smaller life may be hard to see. A good way to find them is to dump all that is on the screen into a white-lined dish of clean water, in which the least insects (by reason of their active swimming) may readily be seen.

Willow is recommended for handles because of its lightness. A light screen may be unloaded easily (even in a small dish of water) by bringing the two handles together, holding them both in one hand, and dashing them down against the other hand held stiffly above the dish. The jolt will discharge all the contents into the dish. Most of the material for this bulletin was obtained by this simple method.

A **sieve net** is very useful for exploring bars of sand or of mud and getting the forms that live in the bottom. It is merely a sieve fixed rigidly on a long handle. It first scoops up the bottom material, and then sifts it. Less conveniently, this material may be shoveled onto a hand-screen or into a hand-sifter and then sifted; but the sifting should be done under water. The midge larvae that live in tubes in the sand and the burrowing crane-fly and caddis fly larvae and little white clams are best obtained in this way.

ASSOCIATIONS

In the open stream there were many boulders of various sizes scattered over the river-bed, some of them partly exposed but most of them submerged, fixed in position for the season at least, and relatively dependable centers about which insect life gathered. There was always a drift of trash, sticks, and leafage under the upstream side, and generally a clean current-swept depression just below. Often there was a drapery of "brook lettuce" suspended from the sides, and always there was a film of slime-coat algae over the whole surface.

On the upper surface of those rocks fully exposed to view, there were commonly found groups of two very different insects:

(1) naked black-fly larvae, hanging and swaying downward in the current, attached by a sucker at the rear end of the body, and (2) caddis worms of the genus *Brachycentrus* in square cases, the rim of which at the larger upstream end is attached to the top of the rock by means of silk. These cases are rather firmly fixed in position. The caddis worm retreats inside to avoid danger, or comes partly out at the front end to feed. It lifts its spinous legs in the water overhead, and strains its living out of the passing current. Either of these two current-fed insects might sometimes be found attached to the sprays of "brook lettuce" or to elevated points on driftwood and twigs.

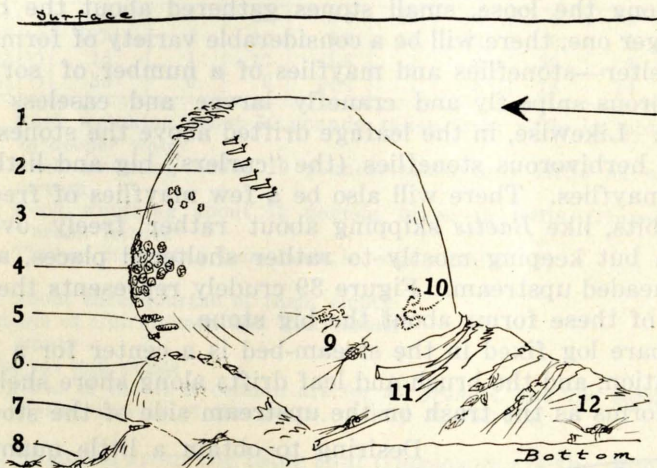


Fig. 39. Diagram of localization of insects about a large boulder in the stream. 1. *Simulium*. 2. *Brachycentrus*. 3. *Bibiocephala*. 4. *Glossosoma*. 5. *Antocha*. 6. *Hydropsyche*. 7. *Atherix*. 8. *Baetis* and *Leptophlebia*. 9. *Iron* and *Rithrogena*. 10. *Chironomus* and *Tanytarsus*. 11. *Ephemera grandis*, etc. (on trash). 12. *Acroneuria*, *Pteronarcys*, etc. (under trash). Arrow indicates direction of current.

Another common insect that depends on the flowing water to bring its food is the net-making caddis worm (*Hydropsyche*). It lives in a fixed case that is attached to the rock beyond the line where the water breaks over a current. It spins a little cup-shaped net of white silk where the water will fall thru the meshes, keeping it distended. The door of the case opens into the bottom of this catching net. In the bottom of the net is a fine-meshed catching surface, that is, a sort of dinner plate, from which the net-maker eats whatever suitable food the current brings him. His is a mixed diet of diatoms, algae, vege-

table fragments, and minute insects, according to the bestowal of Providence.

Sticking to the smooth sides of the rock are a number of slimecoat algae-feeders that have special means of holding on net-veined midges, larvae, and such mayfly nymphs as are equipped with a single large sucking disc.

On the downstream face of the stone there may be considerable numbers of the cases of the caddis worm, *Glossosoma*, assembled for pupation and sealed down to the surface. Commingled with these will be some inconspicuous cases of the little carnivorous crane fly, *Antocha*. There may be small midge tubes in less sheltered places on the sides of the stone.

Among the loose, small stones gathered about the base of the larger one, there will be a considerable variety of forms seeking shelter—stoneflies and mayflies of a number of sorts and carnivorous snipe fly and crane fly larvae and caseless caddis worms. Likewise, in the leafage drifted above the stones there will be herbivorous stoneflies (the "curlers" big and little) and other mayflies. There will also be a few mayflies of free-ranging habits, like *Baetis* skipping about rather freely over the bottom but keeping mostly to rather sheltered places, and always headed upstream. Figure 39 crudely represents the localization of these forms about the big stone.

A bare log fixed in the stream-bed is a center for a similar association, and the brush and leaf drifts along shore shelter the same forms as the trash on the upstream side of the stone.

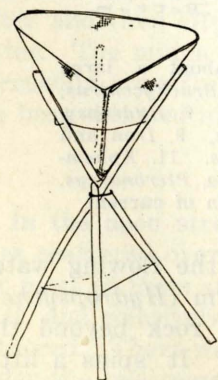


FIG. 40. Tripod and screen for quantitative study of inhabitants of rocks.

Desiring to obtain a little quantitative data concerning the insect life of these open rivers, the simple expedient of a screen funnel upon a tripod set in the bed of the river was hit upon. A stone could be lifted directly into the funnel (a hand-screen held below it to catch what jarred loose). It could be scraped and washed clean in the funnel, which would then hold everything that came from it.

The tripod was made of green birch sticks wired together at three levels, as shown in Figure 40. The funnel was made from a square yard of wire cloth, folded as filter paper is folded, for a laboratory funnel. When the catch was all washed down in the bottom of the funnel, this was opened and the catch dumped in a dish of water for examination.

Several rocks were examined quantitatively. These rocks were chosen from situations which were as different as could be found, and yet were all in more or less rapidly flowing water. Also, a piece of timber was taken from the edge of the river, and by scraping in the funnel the larger part of the life on it was collected. This also was counted. The life in these four samples is recorded in the accompanying table.

TABLE 1.—Insects from rocks and timber in Logan River taken below bridge at Birch Glen, July 11, 1926

Samples	Glossosoma	Brachycentrus	Petro-narcys	Bae-tis	Ephem-er-ella ⁽⁵⁾	Anto-cha	Midg-es ⁽²⁾	Simu-lium ⁽⁴⁾	Misc.	Total
1	551 ⁽¹⁾	3	5	28	8.2	43	10	0	8	658
2	330 ⁽¹⁾	107 ⁽³⁾	2	10	3.6	19	12	0	3	492
3	222 ⁽¹⁾	16	1	17	1.5	1	4	27	8	300
4	38 ⁽¹⁾	33	0	6	14.7	1	5	18	14	127

Sample 1. Rock weighing about 50 pounds, taken from riffle in midstream in deeper water

Sample 2. Rock weighing about 10 pounds, taken near riffle on edge of stream

Sample 3. Rock weighing about 12 pounds, taken in riffle, fringed with "brook lettuce"

Sample 4. Timber projecting from bank in edge of riffle

(1) Cases, about three-fourths of them empty

(2) Specimens of *Chironomus* and *Tanytarsus*

(3) A few empty

(4) Both larvae and pupae

(5) The figures of the first column are for *E. grandis*, and the second for the smaller species of the genus, mainly *E. inermis*.

It will be noted from the table that *Glossosoma* is the dominant form on two of the rocks. After allowing for empty cases, living individuals outnumbered all other kinds. These cases were amassed not on the surface facing the running water, but on the downstream side of the stone, or in irregularities where eddies are formed. It seems that while the cases are more abundant in swift water, they are more often found so situated on the rock that the full force of the river does not strike them.

Brachycentrus cases were found on the ridges of rocks, all with openings upstream. In some instances, there were rows along the top of the rocks, and in others they were along the side. Very few, however, were found in the deeper parts of the riffle.

The forms appearing to prefer the timber were *Simulium* larvae, and nymphs of *Ephemerella grandis*. *Simulium* larvae and pupae were also fairly abundant on the rock which was fringed with "brook lettuce". They pupate among the leaves.

The life among the small stones was in general similar to that on the larger ones. The only common additional inhabitant was an undetermined oligochaete worm.

On similar bare rocks in swifter waters some distance above the Birch Glen bridge, forms with better devices for sticking fast to the rocks were found—the net-veined midge, *Bibiocephala*, and the mayflies *Ephemerella doddsi*, *Rithrogena mimus*, and *Ircn longimanus*.

The bridge itself seemed to be a favorite resort for stoneflies. This was evidenced by the number of cast skins left by them upon the bridge timbers at transformation. From a single square yard of the log abutments were gathered cast skins of stoneflies in numbers, as follows:

<i>Pteronarcys californica</i>	82
<i>Pteronarcys badia</i>	10
<i>Isogenus</i> sp. ?	9
<i>Acroneuria pacifica</i>	6
<i>Isoperla</i> sp. ?	3
Undeterminable small specimens.....	3

Another count was made of the insects on moss-covered bowlders in Logan River where it leaves the mountains at the Crockett Avenue bridge in the city of Logan. The inch-deep layer of moss was fairly filled with the silt-covered tubes of midge larvae. Cobblestones, here fairly uniform in size and averaging perhaps 25 pounds in weight, covered the bed of the shallow stream. There was an abundance of small forms. A sample count (°) of the insects on a single cobblestone was as follows:

Midge larvae (<i>Chironomus</i> and <i>Tanytarsus</i>).....	400
Blackfly larvae (<i>Simulium</i>)	60
Undetermined water mites.....	50
Square-case caddis worms (<i>Brachycentrus</i>).....	40
Mayfly nymphs (<i>Ephemerella</i>).....	11
Miscellaneous small insects	13

The bare banks.—The banks of Logan River were also explored where there were stretches of smooth sand and shoals of sand and silt. Here the midge larvae outnumbered all others put together, and probably provided nearly all the food for the others; for with the exception of the clams, the others are all carnivores. Two sorts of midge larvae were present, both of them living in slender tubes of silt buried in the sand, where they were unnoticed by the casual observer. The commonest proved to be a species new to science, recently described

(°)Count made by S. S. Christenson

by Dr. O. A. Johannsen as "*Tanytarsus logani*." This is called the "Logan midge" in the preceding list. Its larva is pale straw color. The other is a bit larger and reddish in color and belongs to the genus *Chironomus*. Both were obtained by sifting.

Far more in evidence on the bars were the little diving beetles (*Hydroporus corvinus*) that continually dodged in and out of the sand. They would dart into view, and swim rapidly tho irregularly for a little way, and then dart under cover of silt and trash, and disappear as if by magic. Occasionally, while swimming, one would rise and tip the water surface for a breath of fresh air, and then scurry away below again. They were easily collected on a little screen lifter. As fast as those first seen were caught, others would appear—from nowhere—in apparently unending supply. They like cover, and are most abundant where a little loose trash is drifted over the sand.



FIG. 41. Adult Diving Beetle (*Hydroporus corvinus*). (Enlarged 10 times). (Drawn by Minnie B. Scotland)

The larvae of these beetles were obtained only by sifting. They run rapidly, with their pig-like noses held down in a pig-like attitude, and they hide quickly amid the trash. Close searching revealed a few of them wherever sifting at the banks was done, silt mixed with a little trash yielding more of them than sand when bare. They were mainly among the midge tubes which largely fill the surface layer. They probably feed on the midge larvae.

There are several kinds of burrowing carnivorous fly larvae associated with the midges in the sand: horsefly larvae (*Chrysops*) and crane-fly larvae of several genera.

One of these (*Eriocera*), a large smooth pale one, has a pushing ring near the rear end of the body which is useful for progression, being extensible at will.

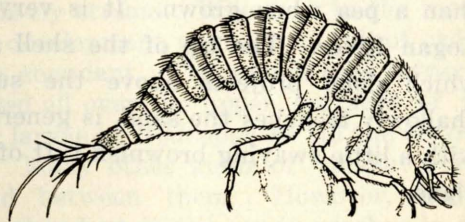


FIG. 42. Larva of *Hydroporus corvinus*. (Enlarged 10 times)

Another crane-fly of most interesting habits is *Ptychoptera lenis* whose larvae burrow in the sand at the river margin, and later move shoreward into the muck layer just above the water-

line to transform. The larva has a long respiratory tube on its tail end, and the pupa has an equally long one at its front. On

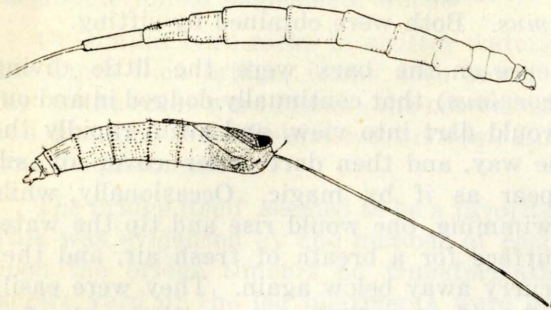


FIG. 43. Larva and pupa of Cranefly (*Ptychoptera lenis*). (Enlarged 3 times)

June 20 this species was seen in transformation upon a bank. The pupae are buried full length vertically in the bank where the sand merges into muck. When ready to transform they use the spines, with

which the body to rearward is ringed, to push upward; first the long respiratory horn rises out of the muck, then the body follows it, the horn held out like a fishing pole ahead. Then, when nearly out, the skin splits on the back of the thorax and the adult fly steps out, at first pale, but soon becoming black and brown. Mature males that had emerged earlier were on hand, ready to seize and claim each new female as soon as she was freed from her old pupal skin.

Another interesting burrower in the sand is the little white clam, *Pisidium huachucanum*. It is one of the smallest of bivalves, hardly larger than a pea when grown. It is very common in Logan River. The tip of the shell at the rear which alone projects above the surface, as it shallowly trenches the sand, is generally crowned with a little swaying brownish tuft of filamentous algae.

Besides these burrowers and tube dwellers, equally characteristic of the sandy edges of the river are a few forms that habitually lie flat upon the surface of the sand. Such are the soldier fly larvae (*Stratiomyia*) and the new crop of little sculpins.

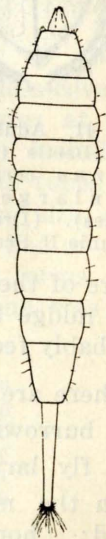


FIG. 44. Larva of Soldier Fly (*Stratiomyia*). (Enlarged 2 times)

SOME GENERAL OBSERVATIONS ON THE LIFE OF NORTHERN UTAH STREAMS AS OBSERVED IN 1926

Logan River is a mayfly stream. In all its better portions mayfly nymphs form the bulk of its animal population. From an altitude of 6000 feet down to the plain, the big stonefly *Pteronarcys* is abundant and very important, but mayflies abound all the way up to the river's source.

It is not equally productive of fish forage everywhere in the mountains, the carnivorous stoneflies (*Acroneuria*, etc.) being in the ascendancy in several places, and the best forage organisms consequently less plentiful. Such was the case in the right-hand fork near the Boy Scout Camp, in the left-hand fork above Ricks Spring, and in Beaver Creek near its mouth.

Boxelder Creek in Boxelder Cañon (known locally as Brigham Cañon) is another mayfly stream. Portions of this stream are filled with brook grass and in the shelter of the broom-like masses of this plant scuds abound also; but the mayfly nymphs are everywhere.

Ogden River appears to be much richer in trout food in its upper reaches than below the forks, where it is too much altered by power and irrigation developments. The north fork yielded especially interesting mayfly nymphs. The boulder-filled channel of the lower river at "Idlewild" is choked with fleshy algae, among which snails abound. Shore bugs stand on the gas-filled mats of the algae, or leap from one flat to another, and good forage organisms are well-nigh absent.

Weber River is a caddis-fly stream. Wherever in the mountains it is undisturbed by development works, it is full of caddis flies and mayflies are less abundant. The square case larvae of *Brachycentrus* are sprinkled all over the upper surfaces of the rocks, and the net-making larvae of *Hydropsyche* fill the crevices on the downstream side. Many other kinds of caddis worms are disposed around and between them. However, mayfly nymphs seem to be more abundant in the upper reaches in and above Kamas Valley.

Provo River in a stretch below Vivian Park showed most extraordinary abundance of nymphs of the big stonefly *Pteronarcys*. Dozens of these large nymphs would roll upon the collecting screen from under every large overturned stone. It was along this river, also, for a long way both above and below the mouth of Deer Creek that the vast swarms of adults of the

snowflake mayfly (*Tricorythus*) filled the air. The nymphs were, of course, abundant in the water.

Spanish Fork was also visited, but since it was in flood from recent heavy rains it was impossible to gather enough material from it to justify an opinion as to its character.

The spring brooks, tributary to all these rivers, were choked with water cress, and in the beds of water cress, scuds and *Baetis* mayflies were abundant. Young trout thrive in the open water adjacent to these cress beds.

CONCLUSION

The work done in Logan River has a direct bearing upon at least two of the projects that are before the Utah Fish and Game Protective Association.

1. To find out and designate the places best adapted for planting of young fish.
streams.

2. To determine the adequacy of fish-food in the several streams.

The carrying out of these two projects by the methods described would not be very expensive, for the apparatus needed is exceedingly simple; and all that is required is labor and a little knowledge of aquatic life in general. It has been the object in the writing of this bulletin and in the preparation of the figures and descriptive notes of the preceding pages to make it possible for any careful person who has even a little biological training to identify the food organisms. Those taken from the stomachs of the fishes and those from the rivers should be studied together.

This study is only a beginning—a scouting of the field, suggestive, not conclusive—looking toward the real survey work that must be done before intelligent stream management is possible. When the well-tried methods of the Experiment Station—plodding, fact-finding methods that have made our agriculture what it is today—are applied to the problems of aquatic life, then there will be a fish culture worthy of the name. At present fry are raised, distributed, and the making of them into fishes is left to chance.