MAYFLIES—A STAPLE FOOD OF FISHES IN HILL STREAMS

JAMES G. NEEDHAM
Dept. of Entomology, Cornell University, Ithaca, N. Y.

In the hill streams of New York it is the brook trout that is the angler's chief interest. Brook trout have foods that are not of the kinds used in the hatcheries. Perhaps insects never will be used there, yet they are staple foods. I speak of the herbivorous insects that grow naturally in the brook, among which are mayflies, caddis flies, and midges. It is the mayflies to which I wish to direct attention.

Mayflies are found only at the waterside. They are delicate insects that one often sees fluttering singly from the water surface up to the tree tops, or that sometimes gather in great swarms. Every observant angler has seen them snapped up by fishes at the water when they settle down close to it to lay their eggs. As adult insects they are very short lived, at most only a few days being allowed them, but as larvae in the water they live long. Most of them require a year for development, and some of them several years. It is as larvae that most of them are eaten, and this of course is not observed by the angler: what goes on under the water is really far more important than what is seen at the surface. Mayfly larvae are available and are eaten by fishes all the year around. Stomach examinations of small stream fishes everywhere have shown a high percentage of mayfly larvae in the food. I have found in the Wasatch Mountains of northern Utah more than fifty per cent of the food of rainbow trout to be mayfly larvae of the genus Ephemerella.

These larvae live mainly under stones in the riffles. They become dislodged with the rolling of the stones, and they drift with the current into the pools where the trout lie in wait. When grown they crawl or swim to the surface to transform. Often they are not successful, but are caught in the current and swept down stream. Drift-net studies by Paul R. Needham have shown that a large proportion of the fish food carried by the current is mayflies.

Mayflies are very prolific. A single female of any of the larger species may lay several thousand eggs. If only a very few adults escape being eaten they may supply eggs enough to restock the stream.

The food of mayfly larvae is mainly plants of a lowly sort—the algae that grow upon the rocks in the riffles. These are very minute plants—most of them microscopic; but they make up in numbers and reproductive capacity what they lack in size. Some

of them are diatoms and live in the film of ooze that covers the submerged stones, making them brown and slippery. Others are green algae that form fringes trailing in the current from the downstream side of the stones. These thrive best in sunny riffles, which are the "meadows"—the chief food-producing area of fish forage. The pools below them where the trout lie are the "feed lots."

In most of our clean streams, where plant life has not been destroyed by pollution, there is much more forage grown than is utilized. That is to say, our streams are capable of producing more mayfly larvae and other herbivorous aquatic insects than they yield at present. More of fish-sustaining forage might be raised in them. Stocking is needed, not at first with more fishes but with more food animals to insure a living for the fishes that are there.

Our culture of fishes began with saving the eggs. I call your attention to the fact that the culture of mayflies has in England begun with saving the eggs. There, it has been found that the eggs laid on projecting stones are greedily devoured by many kinds of enemies. When a float is anchored above the surface and attached with wire to the bottom so that it does not get away, eggs are then deposited on the float and the enemies cannot crawl up the wire to get at them, with the result that vast numbers of them hatch which would otherwise be eaten. This is a very crude beginning to be sure, but one that has undoubtedly increased in certain streams the number of available mayfly larvae.

Fishes must eat; food is the first requisite of all living things, and the food that will be available in the streams that we love to visit will have to be produced in those places. There is excess of eggs naturally produced, and some of it can be saved by protective measures. We have not in this country as yet done anything in that line; we are lacking in the necessary information.

The way to find out is to live with these useful species, just as we have done with the species of economic importance in agriculture: cut the problems small enough so that they can be handled; put on each job someone with time and training and equipment, and let him alone; do not ask for results prematurely.

All economic procedure is based ultimately on the intimate and detailed knowledge of habits and natural history. We have never gotten down to careful and sustained observations in this field. We have not really made a start in the control of the life of this rapid, clear water of our hills.

If we could do for the extraordinarily fecund mayflies anything comparable to what we have done for the fishes by means of hatcheries, you can readily see what an increase of fish food would result. Here is where our aquiculture lags. The game fishes themselves, have not received too much attention, but their for-

age has received far too little. We are only beginning to study the smaller "bait" fishes, with a view to controlling the supply. We have done almost nothing to increase production of the staples of food for small fishes. It is here that aquiculture has fallen farthest behind agriculture. The insects that affect land crops in North America are looked after by several hundred well trained and well paid entomologists. Those that affect our fish crop—even those that most sustain it in inland waters—are neglected altogether. There is not a single person paid to devote his time to their study. A few persons give to it such time as they can steal from other occupations. I believe that increase in fish forage in our hill streams will come when properly equipped persons have been assigned to definite and specific tasks and kept at them long enough to find out something. As in agriculture so here the old complemental methods of observation and experiment will bring the increase.

Discussion

MR. ADAMS: I would like to ask Dr. Needham whether the success of that Mayfly culture would be dependent on stream management that would guarantee more or less a constant volume of water in the stream? Would there not be a great mortality through the rise and fall of the level of the streams that is characteristic of most streams in this country?

DR. NEEDHAM: Undoubtedly there are casualties in the streams that we shall never be able to control, but under natural conditions there are enough in there to keep things going, and there is no reason why we cannot increase the amount by the same methods as those employed with fishes, if we could only find out how to carry these animals past the point where the greatest losses occur.

MR. ADAMS: In some of our streams the natural reproduction of trout is more or less a thing of the past. Where fish large enough to be caught are put into those streams, how would you go about making an intensive production of Mayflies or any other food that would to some extent match this intensive stocking?

DR. NEEDHAM: I confess I do not know; I am only standing up here and telling you I believe I know the way to find out. But it has not been tried.

MR. WICKLIFF: How long do the legal trout put in these streams stay there? What percentage do the fishermen catch before they have had a chance to eat very much?

DR. NEEDHAM: Do not ask me such difficult questions—I do not know.

MR. WICKLIFF: Mr. Adams raised a point, and I would like to know what percentage of legal trout they put in these streams that the fishermen catch are caught out before the food supply is exhausted. Perhaps somebody from New Jersey could give us some information on that.

DR. NEEDHAM: I cannot even attempt to answer the question.

MR. ADAMS: I think we all recognize in Dr. Needham a pioneer in the work in this particular field. In the early days of the development of the arti-

ficial propagation of game birds we felt that the maggot was a very necessary element in the feeding of game birds, and we still think so—if it were possible to produce maggots on an enormous scale, at a price. Dr. Needham, through his pioneer work in that field, evolved a plan for producing maggots without animal food but on vegetable products, and he is running true to form in bringing forward now the same line of thought in regard to the animal life required in our streams for the feeding of our fish. I only hope that in the several states as time goes on, the men who have charge of this work will emphasize the fact that Dr. Needham and his group are certainly working in the right direction. It is a good deal like what Charlie Hayford said to me yesterday—as a matter of fact we are producing today in the several states the volume of fish that we actually need for restocking purposes, were it a fact that we could mesh our fish production with the scientific research that Dr. Needham suggests and get into those streams a proper food supply and bring about a condition under which all the favorable biological factors are present to match the artificially produced plantings that we made in those streams. I hope that we will give increasing attention to this matter of scientific research rather than proceeding alone on the practical side of the work of striving to produce more and more fish and shoving them into our waters with very little thought as to what they will find in the way of food and cover and living conditions after they are chucked in there.

DR. NEEDHAM: Just one word more. I work in the agricultural experiment station. The insects affecting agriculture are attended to by at least five hundred men paid for the job, while in aquiculture, in our fish raising, we have not one man paid anything to deal with the important question of insects as fish forage.

THE PRESIDENT: Can you answer the question Mr. Wickliff put, Mr. Hayford?

MR. HAYFORD: Would you repeat the question, Mr. Wickliff?

MR. WICKLIFF: I understand you introduce legal trout into your streams and allow the fishermen to go out and catch them soon after they are introduced. The question is, how long do these legal trout remain in the streams before the fishermen are allowed to go out and catch them?

MR. HAYFORD: That is rather a hard question to answer, because the conditions in the stream might be good and they might catch a great many more than they would under other conditions which would not be so good. I think there ought to be further study on that question. It is a matter of intelligent planting with reference to food conditions in all the streams.

THE PRESIDENT: Is there any further discussion on this important presentation made by Dr. Needham? The importance of increasing fish food production in our streams can hardly be overemphasized; it is one of the great problems that is facing us at the present time. It is unquestionably true that in many cases several times the number of fish are being planted in our waters that these waters under present conditions can support. The problem is one which I think will be a major question we shall have to meet in the near future.