
FISHES IN THEIR RELATION TO THE MOSQUITO PROBLEM

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Paper presented before the Fourth International Fishery Congress
held at Washington, U. S. A., September 22 to 26, 1908

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Some phases of the mosquito problem are extremely simple and easy of solution, but there are others that have not as yet attracted much attention and that, in the opinion of the writer, will not be so easily solved. The class of mosquitoes represented by the rain-barrel wigglers constitutes, with the salt-marsh species, the most of the mosquitoes, and the most pestiferous of them as mere annoyances. The problem of dealing with these is one of simple engineering, filling and draining, with the oil barrel as an auxiliary.

But the *Anopheles* mosquito is altogether in another class and will require a very different and more complex sort of treatment. It is, in fact, to a great extent a separate problem.

Though fewer in numbers than the other mosquitoes, the *Anopheles* is more to be dreaded because of its wary and insidious manner of attack and of its infectious character. It breeds in both quiet and running water, but always where there is ample protection for its eggs and larvæ, among and over masses of aquatic or semiaquatic plants, confervæ, duckweed, lily leaves, drift, floating dead leaves, and débris. And, lying and moving horizontally on the water, so completely does it assimilate with its surroundings in both color and shape that it is only discernible to the sharpest vision, generally only by its movements, which are sidewise or backward on the surface unless seriously disturbed, when it wriggles down into the water.

After a series of observations and experiments covering several years the writer is not convinced that *Anopheles* can be exterminated by any method so far advanced, or without very great difficulty and the use of every available agency. The character and magnitude of the problem are not yet understood. Several years ago, in an examination of Central Park, New York, *Anopheles* larvæ were found to be abundant, though up to that time the locality was supposed to be free from them. They were found in unsuspected places, and not where the other mosquito larvæ were found, and they were found abundantly in other unsuspected places in New York as well. Moreover, although thousands of

dollars have since been spent in the attempt to destroy the breeding places, they are no doubt still occupied, within gunshot of the stately Fifth avenue homes and nearer to the beautiful playgrounds of the park. The same conditions will be found to prevail in every city.

The most prolific source of *Anopheles* supply is the ornamental plant pond, which is becoming one of the most beautiful features of landscape gardening, public and private. These aquatic gardens provide *Anopheles* with habitats closely approximating the conditions it enjoys in nature, with, however, many protective advantages. Waters of this character can not be treated with oils or chemicals without destroying their beauty. Thus it becomes a serious problem how to destroy this pest and yet preserve the beauty of the ornamental plant pond.

Anopheles, as well as all other mosquitoes, have numerous enemies in addition to fishes. All the aquatic beetles and their larvæ (and they are numerous), the dragon flies and their larvæ, the boat flies, the crane flies and their larvæ (and where these latter are numerous few mosquito larvæ will be found), the water skaters, and many others.

The use of fishes for the purpose of destroying mosquito larvæ is looked upon generally as an easy solution of the problem, and numbers of species have been recommended for the purpose, but so far as *Anopheles* is concerned the fishes have been generally useless. It is true that by their presence in the more open spaces they limit the areas in which mosquitoes would otherwise propagate in great numbers, and no doubt they destroy some *Anopheles*, as well as some of all other species of mosquitoes.

All small fishes, whether of the smaller species or the young of the larger kinds, will be found to eat mosquito larvæ with avidity if supplied to them. This fact alone can not be taken as evidence of usefulness in this respect in a natural condition. Nevertheless, there is no doubt that the myriads of small fishes everywhere on the salt marshes and as well in all open waters, salt and fresh, prevent by their presence such a multiplication of mosquitoes as would make life unendurable. In this respect even the most insignificant of the fishes are useful and merit our gratitude.

In considering the usefulness of fishes in this relation the natural habits and characteristics of a species are the only safe guides. That they will eat mosquito larvæ if confined in an aquarium is to be expected. But will they do so in a natural condition? Will they seek for them as food? Stagnant water, where there is an abundance of plant life, affords such a great abundance and variety of larvæ and other low forms of animal life that fishes could hardly be expected to develop epicurean tastes for particular kinds of larvæ. They appear rather to gorge themselves with whatever comes in their way. The

great need is that there shall be enough mosquito eaters to consume all the other food that occurs and all the mosquitoes as well. And this means enormous numbers of fishes. What this involves is yet to be determined. We have no adequate conception of it.

While, as has been stated, all fishes have some measure of usefulness, if only in the way of deterrent effect, there are only a few species likely to be found in waters in which mosquitoes breed, and especially where *Anopheles* breeds. The most important of these are: The goldfish, which are introduced; several species of *Fundulus* (the killifishes) and allied genera; three or four species of sunfish; the roach or shiner; and one or two other small species of cyprinoids. In addition, there are a few sluggish and solitary species like the mud-minnow (*Umbra*) and the pirate perch (*Aphredoderus*), which live among plants. The sticklebacks have been mentioned in this connection, but the Atlantic coast species are undoubtedly useless for the purpose, being bottom feeders, living in the shallow tide pools and gutters, hidden among plants, or under logs and sticks at the bottom, where they find an abundance of other food.

In the salt marshes there are myriads of killifishes running in and out and over them with each tide, while countless numbers of other and smaller genera, such as *Cyprinodon* and *Lucania*, remain there at all stages of the tide. So numerous and active are all these that there is no possibility of the development of a mosquito where they have access. Of the killifishes two species, *heteroclitus* and *diaphanus*, ascend to the farthest reaches of tide flow, but it is a question as to whether they would prove desirable for the purpose of stocking landlocked waters, since they are much like the English sparrow, aggressive toward the more peaceable and desirable kinds. Even *Cyprinodon*, which would seem to be a valuable small species for the purpose, is viciously aggressive toward goldfish and no doubt all other cyprinoids. It is characteristic of all killifishes that they must be kept by themselves in aquaria. They are the wolves and jackals of the smaller fishes.

As a destroyer of *Anopheles* the writer has for several years advocated the use of *Gambusia affinis*, a small viviparous species of fish to be found on the south Atlantic coast from Delaware to Florida. A still smaller species of another genus, *Heterandria formosa*, ranging from $\frac{1}{2}$ inch to $\frac{3}{8}$ inch in length for the males to 1 inch or $1\frac{1}{8}$ inches in length for the females, is generally to be found with *Gambusia* and is of the same general character. Both of these species are known as top minnows from their habit of being at the surface and feeding there; the conformation of the mouth, the lower jaw projecting, is evidence of such feeding habit. Both are to be found in great numbers in the South in the shallow margins of lakes, ponds, and streams in the tide-water regions wherever there is marginal grass or aquatic or semiaquatic vegetation to

afford them shelter from the predaceous fishes. They are also to be found in shallow ditches and surface drains where the water is not foul, even where it is but the fraction of an inch deep. In fact, if any fishes will find their way to the remotest possible breeding places of the mosquito it will be *Gambusia* and *Heterandria*. And they are the only ones, so far as the writer's observation goes, that can be considered at all useful as destroyers of *Anopheles* larvæ.

To what extent they could be acclimated in northern waters has yet to be determined. They are to be found in the Ohio Valley as far north as southern Illinois, hundreds of miles above tide water, where the climate must be quite severe. In 1905, at the earnest request of Prof. John B. Smith, state entomologist of New Jersey, the writer planted about 10,000 *Gambusia* and *Heterandria* in New Jersey waters. Some 8,000 were planted in one locality which was thought to afford very favorable conditions. In 1907 Mr. Henry W. Fowler, ichthyologist of the Academy of Sciences of Philadelphia, and author of "Fishes of New Jersey," found considerable numbers of *Gambusia* in the vicinity of Cape May, some 90 miles from where the plant was made. This opens up a very interesting question. Mr. Fowler contends that *Gambusia* should be considered as indigenous to New Jersey. Very strong arguments to the contrary can be advanced, but the question is not of importance in connection with this paper, except that it either gives a farther northern range to the species or that, on the other hand, it shows the possibility of introducing them.

The writer has come to the conclusion, after many experiments in small ponds, that a combination of the goldfish, which is ornamental and useful in the open water, the roach or shiner, which is a very active species, two small species of sunfish, which live among plants, and the top minnow would probably prove to be more effective in preventing mosquito breeding than any other fishes. The goldfish is somewhat lethargic in habit, and is also omnivorous, but there is no doubt that it will devour any mosquito larvæ that may come in its way or that may attract its attention. The one great objection is that it grows too large and that it is cannibalistic, so that when a pond is once stocked with large goldfish the number of young to survive will be small.

The roach is probably the most widely distributed and abundant of all the small fishes except the cyprinodonts. It is a very active fish, always ranging about in search of food.

The two small species of sunfish, of the genus *Enneacanthus*, are very widely distributed. They live wholly among plants and feed upon larvæ of all kinds.

The top minnows are foragers always on the move in the search for food, skimming over the tops of plants with restless energy.

All of the above-mentioned species are among the most abundant wherever found. If the range of the top minnows can be extended north it will prove to

be a valuable aid. They are quite prolific, throwing off young to the number of perhaps 10 to 20 at intervals of about a week from April to October. The young of May will be breeding by July or August the same year, thus giving a second generation in one summer.

But notwithstanding all that has been said, it is a question in the mind of the writer whether any combination of fishes will prove effective as against the *Anopheles* genus of mosquitoes under present conditions of growing ornamental aquatic plants. There must be a change in the construction and management of the water garden. As these are under the charge of intelligent men, it is only necessary that the problem should be understood and that the laws should compel the eradication of *Anopheles* and provide for an espionage over the places where it breeds. But until some organized branch of the state governments takes up an investigation of this phase of the problem in a comprehensive manner nothing will be done. The magnitude of the task is not yet comprehended. It is quite possible that all of the beautiful masses of aquatics can be grown on mud alone without destroying their ornamental character, leaving the large open ones to the water in such a way that the fishes can do their work easily. In the great wild areas of swamp and stream aloof from human abodes the problem is more serious and will tax human ingenuity, but here only the hunter and fisherman are concerned.

At present the attitude of the public mind toward suggested means of exterminating mosquitoes is good-naturedly tolerant but incredulous. And while the children are being crammed with Greek, Latin, and geometry they do not learn how to prevent the breeding of mosquitoes about their own homes or how properly to screen the houses in which they live. It is a lamentable fact that even where mosquitoes are most numerous and virulent not one house in a hundred, it is safe to say, is mosquito-proof. There is an old saying that "What is everybody's business is nobody's business." Practical work to be effective must be somebody's particular business. Local boards of any kind can not easily run counter to individual sentiments and prejudices. It is the State alone that can overcome local stumbling blocks and inspire respect, and it is for this reason that attention is called to the seriousness of this problem and the suggestion offered that it is worthy of the serious consideration of those whose interest is in the waters where mosquitoes breed and abound—the fish culturists and fishermen, represented by the fish and game commissions.

In a paper prepared for the meeting of the American Mosquito Extermination Society in 1905 the writer advanced the opinion that experimentation with and the supplying of fishes for the purpose of mosquito extermination is at least as properly the function of fish and game commissions as that of supplying them in the interests of sport and recreation, which is as much as can justly be claimed for trout culture. The mosquito problem involves both the comfort

and health of all classes of citizens. The desirability of the participation of fish commissions in the work, however, appears to the writer to be a question that can only be settled by submitting it to those who would be most nearly concerned with its practical operation, those engaged in fish-cultural work and who have at their command the necessary equipment and knowledge.

It may be argued that the study of the mosquito problem should devolve exclusively upon the agricultural departments. In 1900 or 1901 this question was suggested by the writer, and the Commissioner of Fisheries then decided that the work properly belonged to the entomological division of the Agricultural Department. At first thought this seems a logical conclusion; but when we come to realize fully the magnitude of the task one is compelled to conclude that its accomplishment will require the combined efforts of all the available resources of the States and probably of the National Government.

The fish and game commissions have in their service a body of men whose duties include an espionage of both the land and waters of the States. By enlarging their powers and authority there is already available a capable organization which needs only efficient direction and support to accomplish great practical results in this direction.

There is another side to the question. The fish and game commissions do not have to the extent that they should the sympathy and support of the public in general, the prevailing idea being that they represent the interests of the sportsmen—gunners and anglers. And from this class alone there should be a vigorous support for such a development, not only because of the promise of greater comfort in their outings, but also because of the added popularity it would most surely give to the work of fish and game commissions and to legislation affecting the waters. If fish culture is to be progressive it must enlist the sympathy of all classes of citizens. It must justify itself by its usefulness. Those engaged in it and in fish and game protection should welcome every opportunity to broaden the scope of fish work. There should be a desire to extend its popularity by enthusiastic support of any line of investigation or work which will benefit the public at large. There is now a precedent in the action of the United States Bureau of Fisheries in collecting and sending fishes to Hawaii for the purpose of mosquito destruction, and there is no reason why the fish and game commissions with their trained experts should not cooperate in absolute harmony with the divisions of entomology, thus avoiding the creation of dual functions in state work.