15.—SOME OBSERVATIONS CONCERNING FISH-PARASITES.

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The purpose of this paper is twofold—first, to present, in the form of general considerations, some of the results of my own work; and, second, to suggest certain lines of research along which future investigations on fish entozoa should be made. In pursuance of this plan, bare anatomical details and wearying recapitulation of the names of helminthological writers and their works will be kept in the background.

I.

It is probably now pretty well known by most persons of average intelligence and information that cases of parasitism are not exceptional facts in nature, but that there is a fauna of considerable extent whose natural habitat is within other animals. Much work remains to be done before an approximately correct estimate can be made of the number of species which pass their lives within other animals. Von Linstow's *Compendium der Helminthologie*, 1878, enumerates 1,917 species of animals from which entozoa to the number of 2,755 distinct species have been reported. There are probably several duplicates in this list, but they are offset many times over by the new species which have been added to helminthological science in the fifteen years that have passed since the publication of Von Linstow's work.

There are few general statements in natural history that do not require qualification; and the one which would say when one animal eats another the life of the latter is by that act terminated affords no exception to the general rule. For, without doubt, there are thousands of species of animals which live to be eaten, and if eaten, live; and, conversely, if not eaten, perish. Those forms which take up their abode within other animals are, for convenience, called guests, and the animal which affords such entertainment to others is called the host.

Of all animals which nature thus requires to keep open house, the class of fishes takes the lead, not only for the variety of the forms and the number of the individuals harbored, but also for the frequency of individual cases of parasitism.

The cases of parasitism had in mind in the preparation of this paper all belong to those kinds which pass the entire cycle of their lives within other animals, that is, to the entozoa, properly so called.

II.

Each distinct species of fish is not unusually the host of one or more distinct species of parasite, or, at least, the usual host of one or more species. This is true especially of those species which belong to rather small natural orders, and which stand stiffly apart from other species. It will not, I think, be found so true of species, so-called, which are based on trivial differences. Therefore, when one is examining an animal for parasites from which no parasites have ever been reported, the probability is that if he finds any they will be new to science, especially if no parasites have been reported from any closely related species.

I will cite but one example, out of many that have come to my notice, in illustration of this conclusion. Some years ago I collected some entozoa from a specimen of *Polyodon spathula* from the Ohio River, a species from which, so far as I know, no entozoa had been reported, and which, moreover, is so different from any other existing species as to lead one to expect to find some entozoa or entozoon new to science. I found it harboring a considerable number of young cestodes belonging to the genus *Dibothrium*, which I shall describe and figure in a forthcoming report. Although the anatomy of the proglottides can be made out but imperfectly from my specimens, the external characters present such striking peculiarities that, even in the absence of many details of structure that are desirable to know in describing a new species, I feel justified in regarding it as a new species. I have found the same species in a lot of entozoa sent to me for identification by the U. S. National Museum. They are also immature, but there is not the slightest difficulty in establishing the identity of species in the two lots.

The above general statement is not to be understood to refer to larval forms, nor to mean that each species of entozoon is confined to a single host. Many of the nematodes, for example, and many of the cestodes, while in the encysted state, and a few in the adult, have a range of several hosts. I think it may be safely stated, however, that where two hosts are not nearly related the entozoa which infest one will, in general, be different from the entozoa which infest the other. On the other hand, hosts which are closely related are likely to be infested with similar entozoa.

For example, I have found repeatedly, in a number of species of flounders, viz, *Pseudopleuronectes americanus*, *Paralichthys dentatus*, and *Limanda ferruginea*, an echinorhynchus, often very abundant, which I have referred, somewhat questioningly, to the species *Echinorhynchus acus* Rud. Its favorite host is *P. americanus*, but it is far from uncommon in other flounders. Its range, however, does not appear to be limited to the *Pleuronectidæ*, for I have found specimens indistinguishable, except by a too refining process of species-making, from *E. acus* of the flounder, in the cod, haddock, sea-robin, sculpin and goosefish (*Gadus morrhua*, *Melanogrammus æglifinus*, *Prionotus evolans*, *Cottus æneus*, and *Lophius piscatorius*).

This parasite is easily recognized by its color. In a large lot of them, and they frequently occur to the number of a hundred or more in the same host, particularly in *Pseudopleuronectes americanus*, the colors will be found to graduate from deep orange through pale lemon-yellow to cream-white. When placed in the ordinary preserving or hardening fluids they are apt to contract strongly, but if placed in fresh water while still alive they become turgid and straight.

A dibothrium (*D. manubriforme* Lt.) which I found in the billfish (*Tetrapterus albidus*) was, in the subsequent summer, found to infest also the closely related species, the sailfish (*Histiophorus gladius*). This dibothrium, while it bears some resemblance to *D. plicatum* of the swordfish (*Xiphias gladius*), is specifically different from it.

A singular cestode (*Thysanocephalum crispum* Lt.), found in 1883 and again in 1889 in the tiger shark (*Galeocerdo maculatus*), is apparently peculiar to that species. Likewise another cestode, which I have found repeatedly from 1882 to 1889 in the land shark (*Carcharias littoralis*), and which I have described under the name *Crossobothrium laciniatum*, appears to be peculiar to that host.

In general I may say that in a majority of the species which I have examined from which no entozoa had been already reported, I have found one or more entozoa that proved to be new to science.

While it would, of course, be entirely improper to set up peculiarities of this kind as criteria for the determination of species, I venture to say that the helminthologist who finds two species of fish, which ichthyologists have made generically different, habitually harboring identical kinds of entozoa, under similar circumstances, would not be surprised to see these genera united by the next disturber of ichthyological nomenclature; and, conversely, if two species which systematists have regarded as being closely related should be found to harbor a completely diverse set of entozoa under similar conditions of migration, food supply, etc., sufficient reason would thereby be afforded for asking that the morphology of the two species in question be reviewed.

Certain natural groups of animals, as orders for example, are infested by certain genera or even families of entozoa which are peculiar to them.

A notable example of this is furnished by those remarkable cestodes which have four eversible spinose proboscides, belonging for the most part to the two genera *Rhynchobothrium* and *Tetrarhynchus* and forming the family *Tetrarhynchidæ*. The *Tetrarhynchidæ*, in their adult form, are confined to the *Elasmobranchii*, sharks and skates. For this limitation of their habitat other vertebrates can not be too thankful. The proboscides are often relatively long, abundantly long enough in most cases to penetrate the mucous and submucous coats of the alimentary canal of their host. They are armed with multitudes, often a thousand or more, of sharp, recurved hooks, so that when they penetrate the stomach or intestinal walls of their host they can be dislodged only with great difficulty. They often burrow a little pit in the intestinal wall, where sometimes a cluster of scolices will be lodged together. I have occasionally seen the stomach and intestine of a large shark with several ulcerated pits due to the presence of such parasites. As a rule, however, the presence of a moderate number of intestinal parasites in the adult stage does not apparently cause much discomfort to the host. The sharks, for example, which I have examined, and I have examined a goodly number, all appeared to enjoy excellent digestion; their accessory digestive organs being in nearly every case clean and bright. Indeed, if a parasite were to cause much mortality by its presence in its final host it would not be long, as things go in the economy of nature, until it would either cause the destruction of the species to which its host belongs, or at least makes it exceedingly rare, and thus imperil its own existence as a species. Hence, among the entozoa of fishes, as among those of man and the domestic animals, it is the immature stage of the parasite that causes most mischief, and it works that mischief not on the final but on the intermediate host.

III.

It will be worth our while now to consider some of the injurious effects of the presence of entozoa among fishes.

I have found the larvæ of many of the *Tetrarhynchidæ* encysted in a number of food-fishes of our coast, such as *Pomatomus*, *Cynoscion*, *Scomberomorus*, *Lobotes*, *Caranx*, *Gadus*, etc. These were invariably blastocysts, inclosed in cysts of connective tissue and each containing an embryo tetrarhynch more or less developed. They occur in the body cavity, where they are either attached to the serous covering of the viscera, peritoneum or mesentery, or they may be buried in the liver or spleen or lying between some of the coats of the stomach or intestine.

The scolex of a tetrarhynchus of the dusky shark (*Carcharinus obscurus*) is quite common in the squeteague or weakfish (*Cynoscion regalis*), where it may be found under the submucous coat of the stomach and intestine, often dotting the whole length of the alimentary tract with small specks. If one of these specks be punctured in July and August (the only months in which I have collected them) a small squarish or roundish scolex of a tetrarhynch is liberated. The abundance of these scolices in a single host explains the occasionally great abundance of the adult stage in the pyloric division of the stomach and the spiral valve of the dusky shark. That is, in such cases the shark has made a meal off of one or more fishes which were infested with the larval tetrarhynch in the encysted stage.

The cycle of life of these forms has not been proved in all cases, but from what is known of other members of the order it may be thus summarized: The larval tetrarynchs having been liberated by the action of the digestive fluids of the shark attach themselves to the walls of the stomach and intestine of this their final host, where they develop into the mature form, and whence chains of proglottides, containing numerous ova, escape. Some of these in due time may be themselves eaten by a squeteague or other fish, in which the ingested ova, instead of yielding to the action of the digestive fluids along with other food, undergo normal development, are hatched into minute six-spined embryos, which, boring through the tissues and finding lodgment somewhere in the body cavity of the intermediate host, there develop into a blastocyst in which a larval tetrarynch by and by makes its appearance. The larva, apparently, does not usually have the power of escaping from the blastocyst unless it is swallowed by the proper final host. These encysted forms in the squeteague, bluefish, etc., where only a few individuals are present, probably do little harm. It must be remembered, however, that the nourishing of every cyst is at the expense of a certain amount of vitality of the host; as the vitality of the host is diminished, the chances of its being caught by an active enemy are increased. Parasitism thus tends to perpetuate itself. The life-history of all these forms that require the intermediation of two hosts which stand toward each other in the relation of eater and eaten, has become adapted to the various vicissitudes and interrelations of the hosts.

Sometimes the presence of the parasite must work positive injury to its host. A case in point is that of a parasite which infests the liver of the large sunfish (*Mola rotunda*). I have been able to verify the statements of Cobbold concerning this parasite (*Tetrarhynchus repens*) and have seen the liver of a large mola tunneled in various directions by this parasite until the whole organ was little more than a sac of worms. Such a state of affairs must occasion a decided loss of vitality to the sunfish, and doubtless often causes it to fall a prey to some enemy from which it might otherwise easily escape, if the parasite does not at times itself bring about the death of its host.

One of the most interesting cases of parasitism in which direct injury results to the host, which has come to my attention, is that afforded by the trout of Yellowstone Lake (*Salmo mykiss*). It was noticed by successive parties who visited the lake in connection with government surveys that the trout with which the lake abounded were, to a large extent, infested with a parasitic worm, which is most commonly in the abdominal cavity, in cysts, but which in time escapes from the cyst and tunnels into the flesh of its host. Fish, when thus much afflicted, are found to be lacking in vitality, weak, and often positively emaciated.

It was my good fortune, in the summer of 1890, to visit this interesting region for the purpose of investigating the parasitism of the trout of Yellowstone Lake. The results of this special investigation were published in the Bulletin of the U. S. Fish Commission for 1889, vol. IX, pp. 337–358, under the title: "A contribution to the life-history of *Dibothrium cordiceps*, a parasite infesting the trout of Yellowstone Lake."

I found the same parasite in the trout of Heart Lake just across the great continental divide from Yellowstone Lake, but did not find any that had tunneled into the flesh of its host, while a considerable proportion of the trout taken in Yellowstone Lake had these worms in the flesh. Some of these worms were as much as 30 centimeters in length when first removed; others, which had lain in water a few hours after removal before they were measured, were much longer, as much as 54 centimeters. They are rather slender and of nearly uniform size throughout, 2.5 to 3 millimeters being an average breadth of the largest. I found the adult stage in the intestine of the large white pelican (*Pelecanus erythrorhynchus*), which is abundant on the lake and was found breeding on some small islands near the southern end of the lake.

In the paper alluded to above, I attempted to account for two things concerning this parasitism among the trout of Yellowstone Lake: First, the abundance of parasitized trout in the lake; second, the migration of the parasite into the muscular tissue of its host. The argument can not be well summarized in as short space as the requirements of this paper demand. It is sufficient to say that what appear to me to be satisfactory explanations are supplied by the peculiar conditions of distribution of fish in the lakes of this national park. Until three or four years ago, when the U. S. Fish Commission stocked some of the lakes and streams of the Park, the conditions with relation to fish life in the three principal lakes were as follows: Shoshone Lake, no fish of any kind; Heart Lake, at least three species, *Salmo mykiss*, *Leuciscus atrarius*, and *Catostomus ardens*; Yellowstone Lake, one species, *Salmo mykiss*. Shoshone and Yellowstone lakes are separated from the river systems which drain them by falls too high for fish to scale. Heart Lake has no such barrier. The trout of Yellowstone Lake are confined to the lake and to 18 miles of river above the falls. Whatever source of parasitism exists in the lake, therefore, must continue to affect the fish all their lives. They can not be going and coming from the lake, as the trout of Heart Lake may freely do. If their food should contain eggs of parasites, or if the waters in which they swim should contain eggs or embryos of parasites, they would be continually exposed to infection, with no chance for a vacation trip for recuperation. To quote from my report:

It follows, therefore, from the peculiar conditions surrounding the trout of Yellowstone Lake, that if there is a cause of parasitism present in successive years the trout are more liable to become infested than they would be in waters where they had a more varied range. Trout would become infested earlier and in greater relative numbers, and the life of the parasites themselves—that is, their residence as encysted worms—must be of longer duration than would be the rule where the natural conditions are less exceptional. * * * There are probably not less than one thousand pelicans on the lake the greater part of the time throughout the summer, of which at any time not less than 50 per cent are infested with the adult form of the parasite, and, since they spend the greater part of their time on or over the water, disseminate millions of tapeworm eggs each in the waters of the lake. It is known that eggs of other dibothria hatch out in the water, where they swim about for some time, looking much like ciliated infusoria. Donnadieu found in his experiments on the adult dibothria of ducks that the eggs hatched out readily in warm water and very slowly in cold. If warm water, at least water that is warmer than the prevailing temperature of the lake, is needed for the proper development of these ova, the conditions are supplied in such places as the shore system of geysers and hot springs on the west arm of the lake, where for a distance of nearly three miles the shore is skirted by a hot spring and geyser formation with numerous streams of hot water emptying into the lake, and large springs of hot water opening in the floor of the lake near shore.

Trout abound in the vicinity of these warm springs, presumably on account of the abundance of food there. They do not love the warm water, but usually avoid it. Several persons with whom I talked on the subject while in the park assert that diseased fish—that is to say, those which are thin and affected with flesh-worms—are more commonly found near the warm water; that they take the bait readily, but are logy. I frequently saw pelicans swimming near the shore in the vicinity of the warm springs on the west arm of the lake. It would appear that the badly infested or diseased fish, being less active and gamy than the healthy fish, would be more easily taken by their natural enemies, who would learn to look for them in places where they most abound. But any circumstances which cause the pelican and the trout to occupy the same neighborhood will multiply the chances of the parasites developing in both the intermediate and final host. The causes that make for the abundance of the trout parasite conspire to increase the number of adults. The two hosts react on each other and the parasite profits by the reaction. About the only enemies the trout had before tourists, ambitious to catch big strings of trout and photograph them with a kodak, began to frequent this region, were the fish-eating birds, and chief among these in numbers and voracity was the pelican. It is no wonder, therefore, that the trout should have become seriously parasitized. It may be inferred from the foregoing statements that the reason why the parasite of the trout of Yellowstone Lake migrates into the muscular tissue of its host must be found in the fact that the life of the parasite within the fish is much more prolonged than is the case where the conditions of life are less exceptional.

The case just cited is probably the most signal one of direct injury to the host from the presence of parasites that I have seen. I shall enumerate more briefly a few additional cases out of a great number that I have encountered in my special investigations on the entozoa of fishes for the United States Fish Commission.

The codfish very commonly harbors a dibothrium (*D. rugosum*), which fixes itself firmly in a branch of the pyloric cœca, the chain of proglottides extending into the intestine. In all cases that I have seen the head and anterior portion of the body of the worm have been firmly impacted in a yellowish, waxy secretion, which is, in part at least, derived from degenerated tissue of the cœcal appendage. These parasites must interfere seriously with the digestive processes of their host, and therefore by just so much impair its vitality. I have found the striped bass (*Roccus lineatus*) about Woods Holl, Mass., almost without exception, infested with a thorn-head worm (*Echinorhynchus proteus*). These parasites are always attached, often to the number of several hundred, firmly to the walls of the large intestine of their host. In most cases the thorny proboscis and inflated portion of the neck have penetrated the intestinal walls and protrude into the body cavity, where they are covered by a waxy secretion from the tissues of their host. This boring process gives rise to considerable inflammation, and the rectum of the fish is usually much inflamed. Evidently these parasites, in addition to the disadvantage to which they subject their host by their passive presence, not infrequently work them positive harm and lessen their chances, by some not inconsiderable increment, of long life with all that that means to the species in the life race. My check-list shows that I have examined this fish nine times in the course of several successive years, and have obtained this particular echinorhynchus in all but one lot.

Almost every specimen of such common food-fish as *Cynoscion*, *Pomatomus*, *Roccus*, etc., that I have examined, has been found to harbor a greater or less number of larval forms, of which the genera *Rhynchobothrium*, *Tetrarhynchus*, and *Syndesmobothrium* are most common. Frequently one will be found which is so badly parasitized that it is quite evident that the fish is obliged to expend a considerable stock of its own vitality to nourish its uninvited guests.

In the autumn of 1889 Dr. David Starr Jordan found an interesting case of parasitism in some young suckers (*Catostomus ardens*) which he had collected in Witch Creek, a small stream which flows into Heart Lake, in the Yellowstone National Park. Specimens of these parasites were sent to me for identification. They proved to be a species of ligula, probably identical with the European *Ligula simplicissima* Rud., which is found in the abdominal cavity of the tench. On account of its larval condition, in which it possesses few distinctive characters, I described it under the name *Ligula catostomi*. These parasites grow to a very large size when compared with the fish which harbors them, often filling the abdominal cavity to such a degree as to give to the fish a deceptively plump appearance. The largest specimen in Dr. Jordan's collection measured, in alcohol, 28.5 centimeters in length, 8 millimeters in breadth at the anterior end, 11 millimeters at a distance of 7 millimeters from the anterior end, and 1.5 millimeters near the posterior end. The thickness throughout was about 2 millimeters. The weight of one fish was 9.1 grams, that of its three parasites 2.5 grams, or 27½ per cent the weight of the host. If a man weighing 180 pounds were afflicted with tapeworms to a similar degree, he would be carrying about with him 50 pounds of parasitic impedimenta.

In the summer of 1890 I collected specimens from the same locality. A specimen obtained from a fish 19 centimeters in length, measured while living 39.5 centimeters in length and 15 millimeters in breadth at the anterior end. Another fish, 15 centimeters in length, harbored four parasites, 12, 13, 13, and 20 centimeters long, respectively, or 58 centimeters aggregate. Another fish, 10 centimeters long, was infested with a single parasite which was 39 centimeters in length.

These parasites were found invariably free in the body cavity. Dr. Jordan's collections were made in October and mine in July of the following year. Donnadieu has found that this parasite most frequently attains its maximum development at the end of two years. It is probable, therefore, that Dr. Jordan and I collected from the same generation. Since these parasites, in this stage of their existence, develop, not by levying a toll on the food of their host, after the manner of intestinal parasites, but directly by the absorption of the serous fluid of their host, it is quite evident that they work a positive and direct injury. Since, however, they lie quietly in the body cavity of the fish and possess no hard parts to cause irritation, they work their mischief simply by the passive abstraction of the nutritive juices of their host, and by crowding the viscera into confined spaces and unnatural positions. The worms, in almost every case, had attained such a size that they far exceeded in bulk the entire viscera of their host.

From the fact that the examples obtained were of comparatively the same age, it may be justly inferred that the period of infection to which the fish are subjected must be a short one. I did not discover the final host, but it is almost certain to be one or more of the fish-eating species of birds which visit that region and presumably one which, in its migrations, pays but a brief visit to this particular locality. This parasite was found only in the young suckers which inhabit a warm tributary of Witch Creek. They were not found in the large suckers of the lake. These young *Catostomi* were found in a single school, associated with the young of the chub (*Leuciscus atrarius*), in a stream whose temperature was 95° F. near where it joined a cold mountain brook, whose temperature was 46° F. We seined several hundred of these young suckers and chubs, ranging in length from 6 to 19 centimeters. The larger suckers were nearly all infested with these parasites, the smaller ones not so much, and the smallest scarcely at all. Or, to give concrete examples: of 30 fish ranging in length from 14 to 19 centimeters, only one or two were without parasites; of 45 specimens averaging about 10 centimeters in length, 15 were infested and 30 were not; of 65 specimens averaging about 9 centimeters in length, 10 were infested and 55 were not; of 62 specimens less than 9 centimeters in length, 2 were infested and 60 were not. None of the chubs were infested with this parasite.

The conditions under which these fish were found are worthy of passing notice. The stream which they occupied flowed with rather sluggish current into a swift mountain stream, which it met at almost right angles. The school of young chubs and suckers showed no inclination to enter the cold water, even to escape the seine, but would dart around the edge of the seine, in the narrow space between it and the bank, in preference, apparently, to taking to the colder water. When not disturbed by the seine they would swim up near to the line which marked the division between the cold and the warm water, and seemed to be gazing with open mouth and eyes at the trout which occasionally darted past in the cold stream. The trout appeared to avoid the warm water, while the chubs and suckers appeared to avoid the cold water. It may be that what the latter really avoided was the special preserve of the trout, since large chubs and suckers are found in abundance in the lake, which is quite cold, a temperature of 40° F. having been taken by us at a depth of 124 feet.

Since the eggs of this parasite, after the analogy of closely related forms, in all probability are discharged into the water from the final host and hatch out readily in warm water, where they may live for a longer or shorter time as free-swimming, planula-like forms, it will be observed that the sluggish current and high temperature of the water in which these parasitized fish occur give rise to conditions which are highly favorable to infection.

It may be of passing interest to state here what I have recorded elsewhere, that ligulæ, probably specifically identical with *L. catostomi*, form an article of food in Italy, where they are sold in the markets under the name *maccaroni piatti;* also in southern France, where they are less euphemistically but more truthfully called the *ver blanc*. So far as my information goes, this diet of worms, like the historical episode of that name, is strictly European.

It is not necessary to prove cases of direct injury resulting from the presence of parasites in order to make out a case against them. In the sharp competition which nature forces on fishes in the ordinary struggle for existence, any factor which imparts an increment either of strength or of weakness may be a very potent one, and in a long term of years may determine the relative abundance or rarity of the individuals of a species. In most cases the interrelations between parasite and host have become so adjusted that the evil wrought by the parasite on its host is small. Parasitic forms, like free forms, are simply developing along the lines of their being, but unlike most free forms they do not contribute a fair share to the food of other creatures. I have been too busy with the practical work of describing actual species to speculate on the question of their utility, and, moreover, have had no experience in teleological reasoning. It does appear to me, however, that if the question could be referred to all the rest of animated creation, there would be practical unanimity in the declaration that those animals which pass all or the greater part of their existence as parasites are supremely unnecessary.

IV.

I am sometimes asked substantially this question: Of what use is the study of these comparatively obscure forms? In answer I must admit that a large majority of the species belonging to the orders *Trematoda*, *Cestoda*, and *Nematoda*, which furnish about all the entozoa, have little other than a zoölogical interest. But as I understand scientific investigation it very often does not concern itself about questions of practical utility.

Again, I am asked: What remedy is proposed for those cases of parasitism which are plainly injurious? A few remarks on the subjects suggested by these two questions may not be inappropriate. As to the utility of helminthological investigations, it may be said that they stand in the same category as any other scientific investigation. Where there is exhaustive knowledge of the thing itself the application of that knowledge towards getting good out of it or averting evil that may come from it first becomes possible. For example, a knowledge of the life-history of *Trichina spiralis* and its pathological effects on its host has taught people a simple way of securing immunity from its often deadly effects. A knowledge of the life-histories of the various species of tæniæ which infest man and the domestic animals, frequently to their serious hurt, has made it possible to diminish their numbers, and may in time lead to their practical extinction.

So with the parasites of fishes. Whenever for any reason or reasons parasitism of any sort becomes so prevalent with any species as to amount to a disease, the remedy will be suggested, and in some cases may be practically applied. If, for example, it were thought desirable to counteract the influences which are at work to cause the parasitism of the trout of Yellowstone Lake, it could be very largely accomplished by breaking up the breeding-places of the pelican on the islands of the lake. With regard to parasitism among the marine food-fishes, the remedy, while plainly suggested by the circumstances, might be difficult of application. Yet something could be done even there, if it were thought necessary to lessen the amount of parasitism. If such precautions as the destruction of the parasites which abound in the viscera of fish before throwing them back into the water, and if no opportunity be lost of killing those sharks which feed on the food-fishes, two sources of the prevalence of parasites would be affected and the sum total of parasitism diminished. These remarks are made not so much because such precautions are needed, as to suggest possible applications of knowledge which is already available.

Some parasitic forms, however, are and must remain ineradicable, for the reason that food-fish are their final hosts, and the intermediate hosts are a necessary food of the fish. For example, the intermediate hosts of certain echinorhynchi which infest some species of fish have been found to be certain small crustacea, as *Echinorhynchus proteus*, which has *Gammarus pulex* for an intermediate host; while the gasteropoda are almost universally infested with cercariæ, the larval stage of the trematoda.

V.

Some lines of investigation which suggest themselves as of importance to the science of helminthology will now be briefly treated. By way of introduction to this part of the subject in hand I wish to be indulged in a short digression. It often happens that the working helminthologist wishes to identify the host of some form which he has found. In order to do this in a great many orders of animals he is obliged to waste a great deal of time in rummaging through the ordinary books with which every good general library is supplied, and even then too often with the result that the species, not necessarily an uncommon one, can not be identified. There is certainly need among working naturalists for compilations which will enable one to do in zoölogy what he can do in botany with the aid of such works as Gray's Manual.

It is surely contrary to the spirit of true science that the acquisition of correct systematic knowledge in zoölogy should be limited to the vicinity of large libraries, or that there should be an hierarchy of specialists to whom we must go in order to learn the systematic position of every form that is at all unusual. Morphological and embryological investigations are of the greatest importance, and in the end must be depended on in testing and revising the work of the systematist; but is there not danger that in all this anxiety about cell division, panmyxia, the transmissibility of acquired characters, the meaning of sex, etc., to which our most prominent biologists are giving time and talents, a generation of students is being produced who are attempting to work out problems in this country for which we are not ready? At least, while there are so many groups of animals practically untouched and so much to be done in the way of studying animals in their bionomic relations, it is certainly not unfitting to speak a word occasionally to incite to the study of nature as she is in nature and not wholly as she is in the laboratory. I am ready to confess for myself in this regard that I sin daily, for I preside as best I can over a laboratory where, to borrow an idea from my highly esteemed and most excellent friend Prof. S. A. Forbes, nature is boiled in corrosive sublimate and fried in paraffin before she is given serious study.

For the orders which are comprised in the study ordinarily designated by the term helminthology—viz, *Cestoda*, *Trematoda*, *Acanthocephala* and *Nematoda*—there is call for much preliminary work before such a compilation as I have been pleading for in other orders can be made anything like exhaustive; and this because of the little pioneer work that has been done.

In my own work I have been compelled, by stress of circumstances, to confine my collections almost entirely to the vacation months of July and August and to rather limited localities; but even here I have found material so abundant and so much of it new that I have kept thus far, for the most part, along the somewhat antiquated but still necessary path of systematic work.

Among the subjects which should engage the attention of the helminthologist who takes up the study of fish-parasites I should place first what I will call pioneer work; not because I think it to be of most absolute importance, but because it should precede other kinds of investigation. It is of supreme importance, it seems to me, to have full descriptions, accompanied with sketches, of the adult forms of entozoa which infest the fish of our waters. As much work as possible should, at the same time, be done on larval forms. Whenever larval forms can be certainly identified as the immature form of some adult, or where, as in the case of larval tetrarhynchs, there are constant adult characters present in the larva, there should be full descriptions given, always accompanied with sketches. Date of capture and name of host should, of course, be given in all cases. Incidentally these descriptions should include just as much anatomical and histological detail as the material at the disposal of the investigator and his time will permit. For most of the entozoa, which are often very variable in shape, the more detailed the description is the better. Furthermore, investigations should be carried on in every month of the year in which the fish under examination can be obtained. Notes should be made, at the time of collecting, of the food of the fish; this may lead to the discovery of the intermediate host.

Next, the life-histories of those forms which are already known, or thus become known in carrying on the pioneer work, should be made out. Enough is already known on this subject to furnish, in most cases, a working clue. In this, as in the pioneer work, attention should be given to anatomical and histological details, to which may be added, as occasion offers, embryological details. I think this order is preferable, for the reason that where the investigator is engrossed with the study of the early stages of little-known forms, there is danger of confusion resulting from the mixing of descriptions of young forms which are specifically different. This source of error is probably not so likely to arise in the case of the cestodes and nematodes as of the trematodes.

In this connection I may mention two or three cases which occur to me as worthy of further investigation. In almost every specimen of squeteague (*Cynoscion regalis*) which I have examined, I have found the cystic duct infested with young tetrabothria. They are usually attached in clusters to the wall of the duct, and apparently get their nutriment mainly by absorption from the walls of the cystic duct, through the scolex, which is provided with a special sucker. When disturbed they easily become detached and float about in the amber-yellow contents of the duct. Forms closely resembling these, though usually smaller, are also frequently met with in the intestine of the same fish. I have also found them in the intestine of the goose-fish (*Lophius piscatorius*) and in the cystic duct of a flounder. Some of them appear to be the young of an echeneibothrium. If collections were made at other times of the year than the summer, which is the only time I have had an opportunity to collect them, it should not be a difficult matter to identify them and to make out some or all of their life-history.

Another case of parasitism, or rather condition of parasitism, which calls for special investigation, is that furnished by many of the encapsuled nematodes. In the majority of fish which I have examined, I have found a greater or less number of nematodes, coiled up and enveloped in a thin cyst, and usually attached to or enveloped in the serous investment of the viscera. In many species they are few, but in some, of which *Lophius* is a notable example, they are very abundant and almost invariably present in every specimen. These encapsuled nematodes are always immature. I have been able to refer some of them to species described by Leidy and others; some agree superficially with *Agamonema communis* for example, but upon closer examination will be found to be covered by a thin investment which itself bears the distinguishing characters of *Agamonema*, while within this investment is a nematode which is plainly a rudimentary *Ascaris*.

Again, I have found specifically identical forms encysted in the body-cavity and free in the intestine of the same fish. For example I found *Dacnitis globosa* Duj. frequent in the alimentary canal, in the vicinity of the pyloric cœca, and the same species in pediculated cysts in the body-cavity of the same fish, *Salmo mykiss*. Special attention should be given to these encapsuled, encysted, and immature nematodes. The investigations should be made to cover as many months of the year as possible, and attention should be given to details of structure, since the immature stages of this order have few distinguishing features that can be made use of in classification.

Another nematode, which I have collected a few times, shows such a remarkable difference between the young and the adult as to call for special study. This is a filaria of considerable length which I have found on the ovaries of *Pomatomus saltatrix* and of *Lobotes surinamensis*, a description of which will be given in a forthcoming paper. I have received the same worm in a collection of entoza from the United States National Museum. The host in this case was *Megalops thrissoides*. This worm grows to great length. One specimen from *Lobotes* measured 580 millimeters. The aggregate length of the fragments from *Megalops* was over 3 meters, the diameter about 1 millimeter throughout. The adult worm is bluntly rounded anteriorly and tapers to a blunt point posteriorly. It is viviparous and contains, on account of its great length and the small size of the young, from 0.2 to 0.36 millimeter in length, an enormous number of young. The latter are somewhat long-clavate in shape, thickest posteriorly, bluntly rounded at posterior end, while anteriorly for about one-third of the entire length they taper to an exceedingly minute, attenuate point. The young thus resemble the genus *Trichosoma* in outline. Whether these young filariæ make their escape from the parent and penetrate the tissues of the host, or whether they must await the ingestion of their host by some other animal before they are liberated to begin a new life, I do not know. It is certain, whatever their ultimate fate may be, that no one would suspect them of being the young of the filaria which gave them birth if they had not been seen in the uterus of the parent.

Lastly a very careful examination of the invertebrate food of fishes for larval parasitic forms should be made, so as to be able at last to determine the intermediate host or hosts of all the known adult forms.

It is not at all unlikely that some practical results would follow such investigations.

WASHINGTON AND JEFFERSON COLLEGE,

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