than deep. The soil removed should be plowed up and shoveled to the lower or pond side. When the question of getting rid of the floods is disposed of, the dam may be built.

WASTEWAYS.—Many persons will not attempt to turn the floods around the dams by making canals, and therefore I would recommend that the wasteways to their dams should be cut around the end through the natural soil of the hill-side. This form of wasteway is merely a wide ditch, cut without fall, and extending far enough below the lower side of the dam to prevent the waste water from cutting that side of the dam away. Two or more rows of piling to arrest the cutting out may be required to be driven across this outlet, the upper ends being even with the bottom of the ditch. A row of narrow strips of boards may be driven in the mud close together in the pond above the mouth of this ditch to serve as a screen. If this screen or fence is located in 4 or 5 feet of water, and the two ends drawn in to the shore, it will be twice as valuable as if built immediately at the ditch mouth, for more surface would be exposed. The strips or stakes should be driven a foot into the soil below, and their upper ends on a level with the top of the dam. No dam, however small, should be built without a box in the bottom, provided with a gate, for drawing the water. Such a box should be made 6 or 10 inches square, of 2-inch plank, and reach entirely through the dam, and much pains must be observed to make it long enough. It should be well nailed together and be placed into the bottom of the dam at the lowest point. It should be placed upon one or more pieces of scantling laid in the soil at the base of the dam, and be nailed to these to prevent the water flowing under. The earth can be packed above and on the sides, the timbers being necessary only underneath. A gate should be put into the upper or pond end.

No dam should be made until a ditch has been cut along the line which it will occupy, and the light soil thrown out. Fresh earth put back into the ditch, well rammed, will prevent blowing out if the ditch is dug 2 or more feet. Ponds for raising the carp should be shallow, not more than from 2 to 4 feet deep, except at the dam, where there may be a depth of 5 or 6 feet.

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## 12.—ON A SKIN PARASITE OF THE CUNNER (CTENOLABRUS ADSPERSUS).

By JOHN A. RYDER.

Shortly after my return from Wood's Holl, Mass., an interesting specimen of the common Cunner, Chogset, or Blue Perch, was sent on from that place by Vinal N. Edwards, to Washington, on account of the peculiar spotted and rough appearance presented by the skin. At first one might have supposed that the peculiar whitish spots, with a dark halo of pigment around each of them, were points where some minute fungus

was vegetating and infesting the skin of the fish. Microscopic examination, however, soon showed that what was at first sight suspected to be a fungus was really an animal parasite which had bored its way from without into the skin of its host.

Upon consulting Dr. T. H. Bean, the obliging Curator of the Department of Fishes in the National Museum, he informed me that he thought there were in the collection a lot of specimens from farther north, of the same species, infested in a similar way. Dr. Bean kindly obtained two jars of these specimens for me, and also supplied a copy of the Museum record pretaining to them as follows:

N. M. No. 32354. Arichat, Cape Breton, 1882. W. A. Stearns.
N. M. No. 32355. Arichat, Cape Breton, 1882. W. A. Stearns.

Examination revealed the fact that these specimens were infested in precisely the same way as the one from Wood's Holl. Every part of the surface of the skin was found to be raised into small rounded papules or prominences of a blackish blue color, which it was found were caused by thick-walled cysts embedded in the skin, into the vicinity of which pigment cells had migrated or developed *de novo*. In all of the specimens the cornea was more or less infested by these cysts, which were imbedded in its substance, and, as in other parts of the skin, surrounded by opaque pigment cells, which in this situation would, of course, seriously impair vision, the cysts encircled with pigment cells, to the number of four or five, often having lodged immediately over the pupil or line of sight.

Upon removing the thin corneal membrane from the eye, and placing it in glycerine for a while, in order to render it transparent, the relations of the cysts were easily made out under the microscope. They were found to have very thick walls, which were also laminated. The thickness of the walls of the cysts varied considerably; and, as observed in some, was nearly twice as thick as in others. This difference in the thickness of the walls of the cysts is doubtless related to the length of time since the parasite bored its way into the skin. The oldest cysts doubtless having the thickest, the youngest ones having the thinnest walls.

The entire cyst proper measured about one one hundredth of an inch in diameter, while the halo of surrounding pigment according to its amount would increase this dimension to from one seventy-fifth to one-fiftieth of an inch, which was the size of the papules or swellings caused by the presence of the cysts when the skin was viewed superficially.

In the most badly infested specimens as many as 480 cysts were counted within an area of a single square inch of skin on the sides of the body. Here they seemed to be usually associated in groups numbering from one to fifteen to a single scale, and imbedded in the thin skin covering the scales. They were least numerous on the chin and under side of the jaws, but very numerously embedded in the skin which covered the fins. From this cause the pectorals, ventrals, anal, dorsal,

and caudal fins presented a peculiar densely mottled appearance, due to the aggregation of pigment cells in the vicinity of the cysts. The velar flaps within the anterior portion of the mouth were also infested, as well as the floor and roof of the mouth below the tongue, the inner surface of the opercles, and the anterior faces of the gill arches. The cysts were, on the whole, most numerous on the fins, embedded in the interradial membranes.

From the fact of our finding the parasite encysted it is evident that it is not an adult form, but that it is part of the life-cycle of some species which infests in great numbers one or two other hosts, in which it undergoes its complete development and metamorphosis. It is also in the highest degree probable that it is in fact a Platyelminth or Flat worm, belonging to the group *Trematoda*, which are almost all truly parasitic, presenting a remarkable life-history and exhibiting a true alternation of generations in the course of its migrations from host to host. The animal becomes sexually mature in the intestine of some vertebrate host, where it discharges its eggs into the fæcal matters of the intestine. These ova are then expelled with the fæcal matters, and, finding their way into the water, there hatch out as a ciliated larva, after which it loses its cilia; soon afterwards it enters the body of a snail or other mollusk, where it grows into a sexless individual, in the hollow sac-like interior of which a second generation of asexual individuals quite different from the first are developed from the walls of the sac, provided with tails for the purpose of propulsion. The sac or "nurse" in which these tailed forms develope then ruptures, and the tadpole-like forms escape which are known as *Cercaria*. These then swim about in the water until they find a proper host, into the skin of which they bore, at the same time losing their tails and becoming encysted, as we have observed to be the case with the creature infesting the skin of the Cunner. The next step in their development is the adult sexual state; this develops directly from the tailless larvæ inclosed in the cysts, such as are found in the specimens before us. If another fish should swallow the infested Cunners, the embryos of the parasites would leave their cysts in the skin of the latter and develop into fluke-like parasites, which would very probably find their way into the vessels of the digestive apparatus and liver of their new host, where they would finally become mature or capable of producing eggs. If infested Cunners were imperfectly cooked and eaten by man, he would become the final host in which the worm would reach maturity. After a more or less prolonged stay in the final host, the adult parasites are expelled, and are as a rule within the limits of this group of a flattened or depressed form with a naked soft skin and provided with a mouth, the intestine branched and ending in numerous cæcal diverticula, with ventral suckers, sometimes armed with rings of hook-like chitinous organs. In the mature condition they are hermaphroditic.

*Gyrodactylus* is a genus of Trematodes which often infests gold-fish

in aquaria, and I have met with it in great numbers on the skin of these fishes in the adult state over the whole body of the fish and looking like very minute leeches. They are said to especially attack the gills of Cyprinoids, such as *Cyprinus*, *Carassius*, *Phoxinus*, and *Acerina* in Europe. Here in the United States I have seen thousands on a single gold-fish creeping over every part of the body, and they cannot therefore fail to be very injurious. This type is said to be viviparous, and to reproduce itself by internal gemmation parthenogenetically; a second generation appears within the first and even a third within the second before the *Gyrodactylus* is born. It is very small; has a large terminal sucking disk bearing a circlet of powerful hooks, with two long curved median spines more developed than any of the other parts of the armature of the sucking disk. These parasites are doubtless often transported from one part of the country to another with gold-fish for ornamental purposes, and in this way uninfested fish probably often become infested by being brought into contact with others which harbor the parasite.

Another genus of these parasites, *Bucephalus*, is said to infest the European oyster, *Ostrea edulis*, and passes into the encysted state in a fish which serves as food for a larger fish, *Belone vulgaris*, in the intestine of which the adult of the same worm, a species of *Gastrostomum* occurs. The American oyster, *Ostrea virginica*, is said to be infested by *Bucephalus cuculus*, Macrady. This should deter epicures from indulging too freely in raw oysters, in the ovaries of which it is said to occur, though it is probably a rare parasite, since in examining the soft parts of great numbers of oysters, it has never been my good fortune to meet with it.

The foregoing data supply us with the means of accounting for the manner in which the cysts found their way into the skin of the Cunners. It is probable that some mollusks inhabiting the waters in great numbers where the fish were taken were badly infested with the agamic nurses from which the tadpole-like larvæ escaped in great numbers, which then bored into the skin of the Cunners. But in order that the latter could be as badly infested as are the Wood's Holl and Cape Breton specimens, the free-swimming, Cercaria-stage of the parasite must have literally swarmed in the surrounding waters, if each of the thousands of cysts found on a single Cunner represents a *Cercaria*, as must be the case. I have before me sixteen specimens of infested Cunners from Cape Breton, the smallest 3½ inches, the largest 7 inches long, while the single specimen from Wood's Holl measures nearly 11 inches in length. Even the smallest of these specimens harbor not far short of a thousand encysted parasites, and some of the largest would probably by actual count be found to have five times as many imbedded in the skin. From this circumstance it is fair to infer that the surrounding water at the time the fish became infested must have been swarming full or literally alive with free-swimming *Cercariæ*, which bored into every exposed part of the skin of the fish, as our examination of the specimens has shown.

It is, of course, not possible with the material at present in my hands to identify the species, nor can we do more than indulge in surmises as to what must be the hosts in which the *Redia* or nurse stage of the parasite resides. That probably is some mollusk abounding near where the infested Cunners were taken. To make out the complete life-history of the parasite which we are now dealing with would probably take several years, and would involve the necessity of a prolonged residence in the localities where the infested fish were taken in order to be able to trace the parasite from one host to another. All that we can now be assured of is that the cysts contain a *Cercaria* in the encysted or pupal stage, and that the parasite is one of many similar forms known to infest fishes of the family of *Cyprinidæ*, especially where the encysted state also occasionally produces papules on the skin.

The accompanying pathological effects produced by means of physiological processes are of the greatest interest to the writer, and are significant in connection with known facts relating to the movements of pigment or color-bearing cells. These, as is well known, are specialized differentiations of ordinary cells charged with black, brown, red, or yellow granules. Why the presence of the cysts should attract pigment cells or cause them to be developed in places normally devoid of them is the question raised by what we have learned from a study of the tissue adjacent to the cysts. Normally, and for a very obvious reason, the cornea of fishes is quite transparent, but the infested corneas of the Cunners before us have pigment cells developed around the cysts, and they thus partially intercept the light passing into the eye, as already noticed. Where the cysts are numerous and adjacent, or nearly in contact in the corneal tissue, the crowded masses of pigment cells produce an opaque reticulum, in the meshes of which the cysts are lodged. But aside from these the less densely aggregated pigment cells in the vicinity are of the greatest interest, especially when studied in relation to the structure of the cornea, the principal tissue of which is known to be laminated and to contain cellular nucleated bodies, known as corneal corpuscles of a flattened or depressed form, with long protoplasmic processes extending out into capilliary spaces between the laminæ, and thus in stained preparations producing the appearance of a close network of fine fibers when a prepared cornea is viewed flatwise by transmitted light. The protoplasmic processes of the superimposed corpuscles existing between layers of a slightly different depth have a tendency to run at right angles to each other, and the stained filaments of corpuscles of different laminæ therefore tend to divide the transparent interspaces of the corneal substance into quadrangles. This is precisely what happens in some cases with the pigment cells, which have accumulated in the infested cornea of the Cunner. The color-bearing plasma of the pigment cells seems, therefore, either to have wandered into the corneal lacunæ previously occupied by the corneal corpuscles, and to have displaced them, or the corneal corpuscles them-

selves, owing to the irritation produced by the intruding parasite, have developed pigment granules in their interiors, and become like pigment cells in optical character. Specimens of the cornea cleared in glycerine show this criss-cross arrangement of pigmented plasma, embedded somewhat like the warp and woof of a loosely woven kind of cloth in the clear corneal substance. More usually, however, the pigment cells are unmodified chromatophores, especially where they lie superficially and do not fall under the influence of the corneal lacunæ normally inhabited by the corneal corpuscles, where they of course would have their shapes modified to correspond with the form of the bodies which they have replaced.

I have for a long time known that the chromatophores or pigment cells of fishes have a certain power of movement among the cells of the skin, especially of embryos, and that they not only slowly change their form but also their positions by means of what cannot be regarded as other than a special kind of independent amœboid migratory movement. In this way their modes of aggregation are slowly altered, while an actual growth and extreme flattening occurs in the course of development, during which they seem to cover more space than at first, and I am very doubtful as to whether they have multiplied, especially in certain cases, so as to cover a greater area, as might at first be supposed. This power of movement of the pigment cells, I believe, explains quite readily the aggregation of these bodies in the vicinity of the parasitic cysts found in the skin of the Cunner. That the distribution of the coloring tissue has been modified in the specimens before us no one can deny, and I am loth to believe that the color-bearing cells have been multiplied in consequence of the irritation caused by the parasites. On the fins, for example, wherever there is a cyst present, there the pigment is sure to have accumulated, and in the light of our present knowledge I see no more satisfactory explanation of the fact than that here given.

What stimulus other than irritation would be adequate to produce the physiological impulse leading to the migration of the color-bearing cells, I am quite unable to conceive. Can it be that the physiological function of pigment cells is in this case defensive or reparative? It is possible, in consequence of their nearness to the irritating cause, that they are among the first amoeboid bodies on hand to attempt to assume some protective function. That such is their function here I have also no doubt whatever. If they are generated in consequence of the irritation produced by the parasite, which is very doubtful, then is there all the more reason to suppose that they have a reparative or protective function. Of one thing we may be sure, that they have some share either directly or indirectly in carrying on some salutary metabolic process, else we should not find them in the vicinity of the cysts, no matter whether they are developed there *de novo* or have migrated into their new positions from adjacent groups of pigment cells which are, as is well known already, very abundant in the skin of the Cunner.

WASHINGTON, *November* 7, 1883.