

NOTES ON THE OCCURRENCE AND CONTROL OF THE TREMATODE.

Gyrodactylus, ECTOPARASITIC ON *Fundulus*.—BY JAMES NELSON GOWANLOCH, B. A., B. Sc., Head of the Department of Zoology, Dalhousie University, Halifax, N. S.

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It is the purpose of the present paper to record certain observations on the occurrence and control of the aberrant trematode *Gyrodactylus*.

Gyrodactylus is an eyeless, monogenetic trematode belonging to the family Gyrodactylidae (of which family it is the type genus) occurring as an ectoparasite on the gills, fins and body integument of fish. The animal is extraordinary in that the uterus usually contains sexually mature young which in turn contain another generation and this yet another generation so that as many as four successive generations may be distinguished at one time, one inside another, a situation that might well have been eagerly cited, had it been known at that time, by Charles Bonnet in support of the theory of "emboîtement."

During the progress of other work at the Atlantic Biological Station, St. Andrews, N. B., the writer noted the presence of *Gyrodactylus* as a parasite on *Fundulus heteroclitus* L, and subsequently certain studies of the form were carried out with especial reference to the effect it produced on the host fish, the susceptibilities of the parasite to control measures available in the treatment of the host and choice of host exhibited when various species of fish were made available. It should, perhaps, be pointed out that *Gyrodactylus* constitutes at times a very serious hatchery problem and measures for its control are therefore of considerable practical interest.

When first noted *Gyrodactylus* was observed to occur frequently on the fins of *Fundulus heteroclitus*. It was found that when these fish were held in aquaria supplied with abundant running sea-water and well fed with *Venus mercenaria* the trematodes multiplied with such rapidity that they most seriously affected the hosts and indeed frequently caused death. When

an example of these heavily infected hosts is studied it is found to exhibit whitish areas on the fins, around the mouth and around the eyes which areas, on microscopical examination, resolve themselves into masses of closely adjacent, extremely active *Gyrodactylus*. From two hundred and fifty to six hundred of the parasites may be present on a single host. Fish suffering from infection to this extent can be recognized easily even on a hasty macroscopic examination since they present a characteristic picture of anaemia.

The *Gyrodactylus* studied does not accord with any of the available specific descriptions and the determination or morphological description of the species will therefore be left to form the subject of a subsequent account. On the writer's return to Halifax *Fundulus* collected from various marshes within thirty miles of Halifax were searched and were found to be frequently and sometimes heavily infected with a *Gyrodactylus* evidently identical with the species noted in the Bay of Fundy.

Although not noted on any specimens of Sticklebacks (*Gasterosteus*) collected, *Gyrodactylus* was found to thrive on this host whenever *Gasterosteus* was placed in aquaria with infected *Fundulus*. Such parasitized *Gasterosteus* showed even more markedly than *Fundulus* the severe effects produced by the trematodes and almost without exception died. The flounder *Pseudopleuronectes americanus* proved to be immune to infection even when optimal conditions for the migration of the parasites to this host were provided. Careful examination of *Pseudopleuronectes* that had been confined with *Fundulus* carrying thousands of the parasites failed to show any infection and, furthermore, isolation of the flounders with numerous detached and hungry *Gyrodactylus* did not bring about parasitization of this fish.

An attempt was made to apply standard blood-counting methods to the more severely affected *Fundulus* in order to gain some exact measure of their abnormality but this was without success since the blood invariably coagulated before it could be diluted for spreading in the cell. The changes in blood were so

evident and so profound that some measurement of the effects was desirable and a haemoglobin estimation of a series of heavily infected fish together with normal controls was made by means of a Dare haemoglobinometer. For the use of this instrument the writer is gratefully indebted to Professor J. J. R. Macleod. The results appear in the following table.

RESULTS OF HAEMOGLOBIN ESTIMATION OF BLOOD OF FUNDULUS
HETEROCLITUS HEAVILY INFECTED WITH GYRODACTYLUS
WITH A COMPARISON SERIES OF NORMAL FISH.

Serial Number	Sex	Length in cms. to base caudal fin	Condition	Haemoglobin Reading
No. 1	Female	4.7	Heavily infected	20%
No. 2	Male	4.2	Unusually heavy infection	15%
No. 3	Female	4.8	Very heavy infection. Fish seemed almost bloodless	5%
No. 4	Male	4.9	Unusually heavy infection	18%
No. 5	Female	4.5	Heavy infection	38%
No. 6	Male	4.2	Heavy infection	39%
No. 7	Male	4.1	Heavy infection	21%
No. 8	Male	Less than 4.	Heavy infection	51%
No. 9	Female	3.7	Heavy infection	32%
No. 10	Male	4.7	Normal	71%
No. 11	Male	5.1	Normal	62%
No. 12	Male	5.0	Normal	60%
No. 13	Female	5.2	Normal	71%
No. 14	Female	6.1	Normal	68%
No. 15	Female	6.5	Normal	54%
No. 16	Female	6.1	Normal	56%
No. 17	Female	3.2	Normal	82%
No. 18	Male	6.2	Normal	51%
No. 19	Male	4.7	Heavily infected	20%
No. 20	Female	4.8	Heavily infected	15%
No. 21	Male	4.8	Heavily infected	35%

AVERAGE OF HAEMOGLOBIN ESTIMATION FOR NINE NORMAL

FISH	63.89%
AVERAGE FOR TWELVE HEAVILY INFECTED FISH	25.75%

The effect of lowered salinities in causing the migration or death of the parasites was observed by exposing heavily infected, adult *Fundulus* to a series of different media constituted as follows: (1) Normal sea water with a salinity of approximately 30 parts per mille; (2) Sea-water diluted to a salinity of 20; (3) Sea-water diluted to a salinity of 15; (4) Sea-water diluted to a salinity of 10; (5) Fresh water; (6) Distilled water. In each case the water was thoroughly aerated before use and *Fundulus* each bearing from 250 to 500 parasites were subjected to these conditions. It was found that within a half an hour all of the trematodes in distilled water and the majority in fresh water had either left their hosts or were dead but in the salinity of as low as ten parts per mille the *Gyrodactylus* remained attached to the host after seventy-two hours exposure. In higher salinities they appeared to carry on their normal activities. The host fish, usually hardy and unaffected by wide variations in salinity, appeared to suffer from diffuse haemorrhages over the surface of the fins when exposed to distilled or to tap water. However the trematodes were affected long before such results appeared in the hosts and as indicated an exposure of less than an hour in distilled water or of less than two hours in fresh water served to completely clear the host fish of trematodes.

Further observations of the effect of lowered salinities upon the activities and viability of *Gyrodactylus* were then carried out by the isolation of quantities of the trematodes in watch glasses containing either fresh water or distilled water, the accompanying controls of corresponding numbers being placed in normal sea-water. Without exception these control animals exhibited a normal behaviour throughout the entire course of the experiment. The results may be stated briefly. The trematodes subjected to the action of fresh water showed immediate and extreme distress. Within seven minutes many of the parasites had ceased movement and within fifteen minutes many were dead. In two and a quarter hours two-thirds were dead while at five hours all except two individuals had succumbed. These two exhibited feeble movements and survived

only a short time. A repetition of the experiment afforded closely similar results. Distilled water killed many of the animals in six minutes and all were dead in twenty three minutes. Here also repetitions gave little deviation from these results. The control animals in normal sea-water were held for twenty-four hours and showed no effects of their detachment from the host other than an increase in motor activity undoubtedly due to hunger. The introduction of a little *Fundulus* blood into the watch-glasses after this period of starvation invariably caused them to become tremendously active in the most agitated and entertaining manner, as they would fling themselves end over end along the surfaces of the glass as if in deliberate search of a new host.

For the purpose of ascertaining the exact cause of death, whether due to the loss of blood or to introduced secondary infections of other organisms, a close examination was made of hosts which had succumbed to the effects of the parasites. The histological picture clearly showed that other organisms were not involved but that death was undoubtedly due to the direct loss of blood caused by the collective feeding activities of the great numbers of these minute trematodes, each of which, individually, could alone cause but trifling damage. The fins, lips and borders of the eye orbits were the regions on which the parasites were most numerous but when infection became heavy the *Gyrodactylus* occurred over the whole external surface of the host including the scales and even the cornea of the eye. Their activity is most remarkable. The animals constantly shift from place to place and attach themselves by means of their two retractile cephalic lobes and their caudal disk which is powerfully armed with hooks. The host suffers the loss not merely of the blood upon which they feed but also the diffuse haemorrhages which drain from the innumerable, minute perforations that the parasites inflict. This is the direct cause of death.

SUMMARY

1. Observations on the occurrence and activity of *Gyrodactylus*, a monogenetic trematode occurring as an ectoparasite on *Fundulus heteroclitus* in the Bay of Fundy and in the neighborhood of Halifax, N. S., are here reported.

2. *Gasterosteus* also serves as host but *Pseudopleuronectes americanus* proved not to be susceptible.

3. The trematodes remained apparently unaffected by a series of lowered salinities ranging down to ten parts in a thousand but exposure to the action of either fresh water or distilled water causes the rapid migration of the parasites from the hosts and their death.

4. The toxic action of tap water was found to be lethal in about five hours, that of distilled water lethal in about twenty minutes.

5. The haemoglobin of the parasitized fish was found to be reduced in some instances to less than one twelfth of the normal value, the average for the series examined giving a reading of only forty per cent of the value shown by normal fish.

6. The direct cause of death was found to be the loss of blood from the innumerable minute perforations which the parasites make during their feeding activities.

7. Treatment of affected fish with fresh-water is an evidently available means of destroying the parasites.