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Title

The feeding of Nematode-infested Mysids to cod

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By W. F. Black

Abstract

In an attempt to elucidate the early stages in the life cycle of the codworm, Porrocaecum decipiens (Krabbe), cod having very low nematode infestations were fed mysids. In the first phase of experimental feeding, mysids were indicated as Porrocaecum carriers on theoretical grounds. In the second phase of experimental feeding, mysids were known to be infested with nematodes. Control cod were fed herring. The experimental feeding did not produce an increase in the worm infestation in cod. Some of the nematodes from mysids have recently been identified as Contracaecum.

Introduction

The nematode Porrocaecum decipiens (Krabbe) occurs as a larval form in a number of groundfish off the Canadian Atlantic coast (Scott, 1950) and occurs as an adult in seals (Scott, 1953). The Bras d'Or Lake of Cape Breton Island was used as an area for investigation since the cod from most parts of the lake were heavily infested with the nematode but from one area were almost worm free. The theory concerning the suitability of mysids as first intermediate hosts of the codworm is considered elsewhere (Black, 1957a, 1957b). Cod were kept in tanks in Baddeck Harbour in 1951 and 1952.

The controls were fed herring only, while the experimental animals were fed mysids. The capture and holding of these cod is described elsewhere (Black, 1957c). Experimental feeding in 1951 was undertaken on the purely hypothetical basis that mysids were the most likely carriers of the codworm, while the feeding in 1952 was based upon the knowledge that mysids are infested with nematodes (Black, 1957b).

Procedure

Two holding tanks were available for cod in 1951. One tank held control fish which were fed on frozen herring, the other, experimental cod which were fed pieces of herring and also herring stuffed with mysids. The mysids were of course broken up when they were forced into the herring tissue. Since all work was done in the field, often in freezing temperatures, it was impossible to identify the mysids which were presented to the cod in this manner. Subsequent identification of mysids indicate that all small mysids were probably Neomysis americana (S. I. Smith), while the large forms were of the genus Mysis and probably included both M. mixta Lilljeborg and M. stenolepis S. I. Smith. Mysids were designated only as either small or large, as indicated in Table I, which gives the dates of feeding with mysids, the number and size of mysids and the number of cod present in the tank on that date. While the number of cod never exceeded 45 on any feeding date, a total of 92 cod were present in the experimental tank for varying periods from the time of commence-

ment of experimental feeding until the conclusion of the experiment. Due to an unfortunate accident, the gear necessary for the collection of mysids (Black, 1957a) was lost on December 4, 1951, and was not replaced until late December when it was too late to continue the experiment. The cod from both tanks were removed on December 29 and examined according to the usual procedure (Scott, 1949).

Table I. Experimental feeding 1951.

Date	No. cod	No. mysids	
		Small	Large
7-XI-51	25		450
17-XI-51 *	45	380	75
20-XI-51	41		400
23-XI-51 *	42		245
30-XI-51 *	44		170
4-XII-51	43		200

*cod added to tank since previous feeding

In 1952, three holding tanks were utilized, two of which held controls. The fish from one of the control tanks were later used as experimental animals after the original experimental animals had been killed for nematode examination. During May and June the controls were fed pieces of frozen herring as in 1951, but a new means of introducing mysids to experimental fish was employed. Mysids were placed in pieces of cow intestine which had already been tied at one end and which were tied at the other end after the addition of mysids. Mysids were placed in these so-called sausages as soon as possible after being brought to the surface. In July, W. L. Klawe, using a few fish from one of the former control

tanks, presented the cod with mysids inserted into hake air bladders. Unfortunately, this experiment was very short lived as the fish soon ceased to feed and died, supposedly due to above optimum temperatures (Black, 1957c).

Table II gives the type and approximate number of mysids introduced at each feeding and the number of cod present at each feeding. The maximum number of cod present on any occasion was 44, and a total of 50 fish were present in the tank from the commencement of experimental feeding. In 1952 (excluding the July experiment) the numbers of fish in both experimental and control tanks were steadily reduced, not by natural deaths as in 1951, but by removal for examination for worms. The second experiment in which the fish were fed hake bladders filled with mysids, involved only 9 cod. The large mysids fed to cod in 1952 were again a mixture of Mysis mixta and M. stenolepis. The small mysids were mainly Neomysis americana but also included numbers of the young of the year of M. stenolepis and probably also M. mixta.

Table II. Experimental feeding 1952.

Date	No. cod	No. mysids	
		Small	Large
16-V-52	38	500	
17-V-52 *	44	310	
27-V-52	44		750
29-V-52	44		411
2-VI-52	24		2000
4-VI-52	23		2900
6-VI-52	23		2791
10-VI-52	23		2192
13-VI-52	15		287
16-VI-52	15		408
20-VI-52	15	"thousands"	
21-VI-52	15	1200	

(cont'd)

Table II (cont'd)

Date	No. cod	No. mysids	
		Small	Large
24-VI-52	10	2500	
26-VI-52	10	1158	
27-VI-52	9	2080	
2-VII-52	9	557	
3-VII-52	9	6000	
4-VII-52	9	527	
7-VII-52	9	369	
9-VII-52 **	9	432	
10-VII-52 **	9	246	

*cod added since previous feeding

**second technique involving different fish

Discussion

1951 Results

The results of worming of experimental and control fishes from the feeding program of 1951 are given in Table III. There is no marked difference in worm numbers for experimental and control fish so that tests of significance have not been applied. The negative results obtained from this feeding program were not considered conclusive, since relatively few mysids were presented to the experimental fish. In addition, the mutilated condition of these mysids was thought to be conducive to the escape of any nematodes which might be present.

Table III. Worm incidence 1951.

	Experimentals		Controls	
	Length	Incidence	Length	Incidence
5-year-old cod	40.7(3)	0.67	41.5(2)	3.0
6-year-old cod	42.0(13)	1.54	41.7(6)	0.67
7-year-old cod	44.0(4)	0.75	41.3(3)	0
Total	42.2(20)	1.25	41.5(11)	0.91

1952 Results

1) Mysids in cow intestine. The results of worming experimental and control fishes of the 1952 experiment are presented in Table IV. These results are quite negative and in view of the numbers of mysids presented to the cod, it would seem likely that the nematodes in mysids did not include Porrocaecum decipiens. Although the same fish were used for the entire period in 1952, there is no increase, even slight, in the worm incidence over the period of experimental feeding (Table V). Empty pieces of cow intestine were found floating in the tanks some days after feeding and while at first it was feared that the entire mass might have been rejected, examination of experimental fish stomachs revealed that mysids within the sausages were apparently digested and absorbed by the cod, after which the rather indigestible cow intestine was rejected, presumably by regurgitation. The fact that this regurgitation of the pieces of intestine occurred at a relatively short time after ingestion prompted a further evaluation of the feeding technique and worming results. It is not known how long it takes for the nematode to penetrate digestive tract, or in fact whether Porrocaecum would penetrate cow intestine, how long the pieces of intestine remained in the cod stomach, or whether the nematode was capable of penetrating both the cow intestine and cod stomach in quick succession.

Table IV. Worm incidence 1952.

	<u>Experiment 1</u>	<u>Experiment 2</u>	<u>Control</u>
No. cod	39	7	26
Mean length	46.6	47.1	46.1
Nematodes, mean	1.9	3.4	1.6
Nematodes, range	0-11	0-7	0-8

Table V. Worm incidence, cod experiment 1.

<u>Date</u>	<u>No. cod</u>	<u>Mean length</u>	<u>Nematodes, Mean</u>	<u>Nematodes, Range</u>
31-V-52	19	47.7	2.0	0-11
11-VI-52	8	43.9	1.5	0-6
23-VI-52	5	44.8	3.2	1-5
9-VII-52	7	47.7	1.4	0-3

ii) Mysids in hake air bladders. The second experiment of 1952, designed and executed by W. Klawe, was an attempt to eliminate some of the unknown factors posed by the feeding of mysids in cow intestine. Unfortunately, when this work was begun few fish were available and the rapidly increasing water temperature soon brought an end to this experiment. The results of this brief period of experimental feeding are certainly more suggestive of a difference in the worm incidence in experimental and control fish than either of the other experiments. The numbers involved, however, were too low and the feeding period too short to warrant any conclusion, but these results certainly indicated the desirability for further experimental feeding of mysids.

Identification of nematodes

Until 1956, the nematodes found in mysids had not

been identified, so that the experimental work was carried out at first on the theory that Porrocaecum might be found in mysids and later on the knowledge that mysids harboured nematodes (Black, 1957b). The stomachs of many of the experimental fish were examined for nematode presence. No nematodes were found penetrating the stomach wall. Nematodes were found free in the stomachs and some inside still intact sausages. Some of these nematodes have recently been identified as Contracaecum by B. J. Myers. Some nematodes were found partly penetrating the cow intestine as shown in Figures 1 and 2, and others were actually within a piece of cow intestine as shown in Figure 3. These nematodes which were actively penetrating the cow digestive tract have likewise been identified as Contracaecum. There is thus no evidence for the presence of Porrocaecum in either the cow intestine or the cod stomach wall as a result of the experimental feeding program.

In 1956, D. M. Scott examined nematodes from a few mysids taken in the Great Bras d'Or. Of those which he has been able to identify, all are Contracaecum (Black, 1957b).

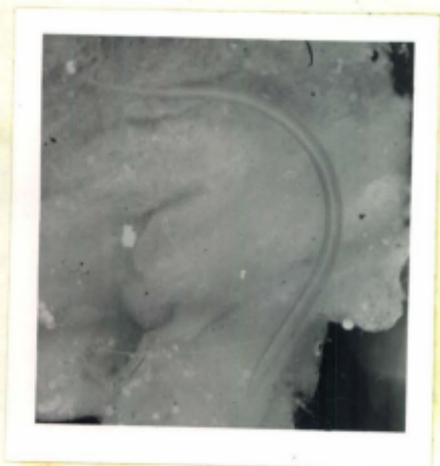


Figure 1. Nematode partially penetrating mucosa of cow intestine used in experimental feeding.



Figure 2. Nematode partially penetrating mucosa of cow intestine used in experimental feeding.



Figure 3. Nematodes within wall of cow intestine as seen through serosal layer.

Conclusions

The experimental feeding of mysids containing nematodes has not resulted in increased incidence of Porrocaecum in cod. The various limitations to the techniques utilized which have been noted indicate that further experimental feeding of mysids would be in order. However, nematodes taken from cow intestine utilized in feeding mysids to cod have recently been identified as Contracecum, and the only nematodes identified from mysids have likewise proven to be Contracecum, so that further experimental work on the life cycle of Porrocaecum decipiens, with mysids as a suspected intermediate host, seems rather unwarranted.

Acknowledgements

I would like to express my appreciation to W. L. Klawe who continued the experimental work in 1952 after my departure and who designed the second experiment in that year; to D. M. Scott who has identified some of the nematodes from Great Bras d'Or mysids as Contracecum; to Miss B. J. Myers for identifying nematodes from cod stomachs as Contracecum.

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Errata

Fisheries Research Board of Canada

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From the Formula 5 on, page 7, it should read:

$$(5) \quad \frac{dY}{dt} = \left| \left(\frac{\partial n_i}{\partial t_F} w_i \right)_t \right|$$

The right hand size refers to the norm of the diagonal matrix of the elements

$$\left(\frac{\partial n_i}{\partial t_F} w_i \right)_t$$

We may note that

$$\frac{\partial n_i}{\partial t_F} = -n_i \frac{dF(t)_i}{dt}$$

where the derivative $\frac{\partial n_i}{\partial t_F} \dots$ etc.

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$$\frac{1}{x^2} = x^{-2}$$

$$\frac{d}{dx} x^{-2} = -2x^{-3}$$

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