



Baltic Marine Environment Protection Commission

HELCOM Workshop on Seal-Fisheries Interactions

SFI WS 1-2019

Copenhagen, Denmark, 27 June 2019

Document 2	English translation of a Soviet study "Infection of the liver of Baltic cod with roundworms"
Submission date	18.06.2019
Submitted by	CCB

The Meeting is invited to take note of the attached document containing an English translation of a Soviet study "Infection of the liver of Baltic cod with roundworms".

FISHERIES RESEARCH BOARD OF CANADA

Translation Series No. 1318

INFECTION OF THE LIVER OF BALTIC COD WITH ROUNDWORMS

by G. K. Petrushevsky and S. S. Shulman

Original title: Zarazhennost' Pecheni Baltiiskoi
Treski Kruglymi Chervyami

From: Trudy Akademii Nauk Litovskoi SSR, Ser. B,
2: 119-125. 1955.

Translated by L. Margolis

Distributed by the Fisheries Research Board of Canada
Biological Station, Nanaimo, B. C.

This translation was prepared primarily for the use of the Fisheries Research Board of Canada. It has Not been checked or approved by the authors.

Abstract: Having studied 742 specimens of cod, length 30 to 100 cm, in June-July 1949, the authors established that the intensity of infection of the liver of cod with roundworms increases with age of the fish. It was also established that the parasites negatively influence the fatness of the liver and the condition of the fish.

In Baltic Sea cod a disease of the liver, "nematodosis", caused by larvae of the roundworm Contracaecum aduncum (= C. clavatum) is widespread. It was established (1) that the liver of infected fish has a comparatively smaller size, a reddish-brown colour, and a hyperaemic character. It was also established that with heavy infections with this parasite the weight of the liver, the weight of the fish, and the ratio of these two values decreases. Thus, with increasing numbers of parasites (1, 10, 45, 62 specimens) the weight of fish of the same size (67 cm) drops from 2 to 1.5 kg, the weight of the liver drops from 175 to 5 g, and the percent ratio of weight of liver to weight of fish drops accordingly from 8.75 to 0.3%.

Considering the great importance to the national economy of cod liver and the oils extracted from it, we carried out a more thorough study of this disease. In June-July 1949 investigations were carried out on 542 cod of various sizes (from 30 to 100 cm) caught in the region of the Gotland trench and 100 specimens from the vicinity of Shventoi. In addition we used the results of examination of 100 cod from the Liepaya district, obtained jointly with E. L. Larionova of the Latvian Branch of VNIRO, and also data from complete parasitological examinations of cod carried out by us in the vicinity of Tallin, the coast of Riga, Klaipeda, and Kaliningrad.

The questions investigated were the relationship of degree of infection to age and size of the fish, and also the effect of infection on the fatness of the liver and the condition of the fish itself.

We obtained 100 cod in each of several different size groups, grouping them in the following way: from 30 to 40 cm, from 35 to 40 cm, from 50 to 65 cm, from 70 to 80 cm, from 80 to 100 cm. Of the latter group we obtained for examination only 39 specimens. (Table 1).

[p. 121] The results of the study show that 53-97.5% of the livers of cod are infected with roundworms; the lowest infection was in fish having a size of 30-40 cm, the infection rate increasing with age and reaching 97.5% in very large fish (80 to 100 cm). The maximum and mean number of parasites per fish also increased with age, reaching up to 300 parasites in a single fish. Thus, in cod the intensity of infection also increases with age. This fact is explained by the accumulation of parasites, which enter with the food, and the increase in the amount of the latter which in turn increases the possibility of infection.

The percent ratio of liver weight to total weight of fish varies from 1.2 to 3%, which is evidence of the extremely low fatness of the liver of cod during the summer period.

Comparison of the effect of infection on the fatness of liver of cod of different size groups is of some interest. For this purpose we divided each group of fish into (a) uninfected or lightly infected and (b) heavily infected, and calculated the percent relationship of liver weight to total weight for

each group. For small fish we consider the infection as heavy when more than 5-10 worms are present and for larger fish when more than 20 worms are present. The results of such a comparison show that the percent relationship of liver weight to total weight in lightly infected fish is higher than in heavily infected fish.

Thus, on a large amount of material (about 400 fish) the same regularity is obtained. Heavy infection with roundworms causes a reduction in the weight of the liver. It is necessary to bear in mind that it is precisely on the percent relationship of liver weight to weight of fish that the fishing industry plans the yield of oil. The indicated values show that for the summer time this relationship has a mean of 2.2% and does not exceed 3%.

The weight of the liver can be shown to be influenced not only by the number of parasites, but also by the duration of the infection, the age of the parasites, the resistance and different physiological conditions of individual fish, the season, and other factors.

For examination of the influence of the duration of the infection and the age of the parasite we separated the worms into large (i.e., older) and small (i.e., younger) ones. Generally, the liver weighed less in those cases in which the infection was caused by large worms (Table 2).

If one takes cod in the size range of 50 to 60 cm from the vicinity of Shventofi, it is found that the mean ratio of liver weight to body weight in the group of fish infected with more than 20 roundworms is 2.2%. If one separates from this group fish in which the liver was infected with more than 10 large parasites, then the mean percent ratio in them is found to be 1.8%, i.e., almost one-half percent lower. Cod of size 70 to 80 cm, caught in the Gotland trench, gives the same picture. The mean ratio of liver weight to body weight in fish infected with more than 20 parasites amounts to 2%; in this same lot of fish, in which livers contain [p. 122] more than 10 large worms, the mean ratio of liver weight to body weight is 1.5%.

It is also evident that livers in which the parasites are located only at the surface usually have a healthier appearance and a greater weight than livers perforated with worms. In a number of cases the fish itself actively combats the parasites: encapsulation and calcification of them takes place. Frequently the liver with such encapsulated and dead worms has a normal weight.

G. K. Petrushevsky and E. P. Kogteva (1954) established that there is a decided influence of worms, not only on the weight of the liver of cod, but also on the general condition of the fish. The latter was computed according to Clark's method, i.e., for the weight of the fish without the internal organs. Of 600 fish examined for this purpose, 100 were free of parasites and their coefficient of condition was 0.941. The remaining fish were infected with parasites, the number of which reached up to 200 and more. The coefficient of condition of the group of fish in which the number of parasites was from 100 to 200 was 0.793-0.627.

Thus, we see that the coefficient of condition of cod with massive infection is reduced from 0.941 to 0.627.

It is necessary to note that the liver of cod is an organ that reacts sensitively to any change in the physiological condition of the fish. Thus, a cod affected with ovarian cystitis had a liver with a very negligible weight (25 gm, with percent ratio of 1.7), although the number of worms was not large (4 specimens). Cod [p. 123] heavily infected with other parasites - the acanthocephalan Echinorhynchus gadi - also weighed comparatively little. Finally, the weight of the liver decreases markedly at the time of spawning.

The reduction in the weight of the liver at the time of the spawning period and a seasonal variation in the liver weight associated with this is also noted by Kand (2). In addition, he notes that the highest indices of the fatness of the liver occur in February. Variation in the infection of the liver of cod in relation to the season has been well demonstrated by S. Getsevichyute^{1/}. However, it seems to us that the fluctuation in weight of the liver is not only of a seasonal nature. Thus, the overall percent ratio of the liver weight to total weight for fish examined by us in February 1946 was 3.5%. According to Kand's data, the mean percent ratio in February 1945 was 4.62%. Thus, one can assume that the weight of the liver of cod can be different in different years.

Further, we very frequently observed worms occurring in capsules in different stages of decomposition. It is evident that as a reaction to the presence of the worms in the liver the fish isolates them which leads to their death. The percent of encapsulated worms ranged from 50 to 80. Very frequently we observed mixed infections, in which we found mobile worms side by side with encapsulated ones in the liver. In the final stages of the influence of the host on the parasite one can observe complete destruction of the worms and transformation of them into a yellowish-brown amorphous concretion.

We examined the disease of the liver of cod in different localities of the Baltic basin. Naturally, there would be some differences if we were to take fish belonging to different stocks. Thus, fish of the size 50 to 60 cm taken from the catch in the Gotland trench and from the vicinity of Shventoi in July 1949 differ somewhat in the percent infection with larvae of C. aduncum, as well as in the ratio of liver weight to weight of fish (Table 3).

Cod investigated in other regions of the Baltic Sea are also heavily infected with roundworms. The exception consists only of cod from the Gulf of Riga which, on the basis of the weight of the liver and the general condition of the fish as well as on the degree of infection with parasites, differ sharply from cod from other regions of the Baltic Sea.

Cod from the Gulf of Riga are much less infected than cod from the vicinity of Liepaya (see Table 4).

[p. 124] Interesting work on the question of the vitamin A content of the liver of cod was carried out by co-workers of the Latvian and Estonian branches of VNIRO (2-5).

The fat content of the liver of healthy fish was 57% and in infected livers it was reduced to 14.5%. The quantity of vitamin A in infected livers was not reduced but was higher than in healthy ones: from 270 I.U. per g it rose to 1200. Thus, parasites do not cause a reduction in the vitamin A content of the liver, and because heavy infections with roundworms are associated with a

^{1/} See p. 127 of the present volume.

significant decrease in the weight of the liver itself as well as in the quantity of fat it contains, then consequently the amount of vitamin A in 1 g of fat in infected livers is considerably higher.

Taking into account the potential for variation in degree of infection, weight of liver and condition of fish in relation to season, condition of sex products, place of feeding and a number of other factors, we consider that it is necessary to approach very cautiously the problem of standardization of the yield of oil from the liver. Different norms have to be established with respect to the year, season, and place of capture of the cod.

Conclusions

1. The degree of infection of the liver of Baltic cod with the roundworm Contracaecum aduncum in June-July varies from 53 to 97.5%. The lowest of all was infection of fish having a length of 30 to 40 cm (53%); the highest of all was in large fish from 80 to 100 cm (97.5%). Thus, infection rate increases with age.

2. The intensity of infection also increases with age of cod: from 1.82 to 66 parasites (mean) per infected fish.

3. The percent ratio of liver weight to weight of fish varied from 1.2 to 3%. In heavily infected fish it was significantly lower than in lightly infected fish. Large worms cause a greater reduction in the weight of the liver than small ones.

4. The coefficient of condition of cod with massive infections is reduced from 0.941 to 0.627.

5. Further studies are required on the influence of various factors (season, place of feeding, physiological condition, and others) on the degree of infection and to understand the relationship of them to the fatness and condition of the fish.

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Received 10-XI-1954

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Table 1. Infection of the liver of cod

Size of fish (in cm)	Place caught	Date	% infected	No. worms in each fish		Ratio of liver weight to total weight (in %)	Lightly infected		Heavily infected	
				maximum	mean		No. of parasites	Ratio of liver weight to total weight (in %)	No. of parasites	Ratio of liver weight to total weight (in %)
30-40	Gotland trench	14.VII.1949	53	21	1.82	1.77	0-5	1.85	more than 5	1.09
35-40	"	30.VI.1949	60	43	2.88	1.2	0-5	1.4	"	1.0
50-60	"	4.VII.1949	77	80	9.99	3.0	0-5	3.86	more than 10	2.8
50-65	"	2.VII.1949	85	130	14.85	2.9	0-5	4	more than 20	2.2
70-80	"	6-13.VII.1949	97	200	42.96	2.0	0-10	3.51	"	2.0
80-100	"	11-13.VII.1949	97.5	300	66.0	2.5	0-10	3.47	"	2.09
50-60	Shventofi	19.VII.1949	87	114	22.2	2.5	0-5	2.8	"	2.2

Table 2. Relation of weight of liver to size of parasite

Size of fish (in cm)	Number of parasites of large size	Number of parasites of small size	Ratio of liver weight to body weight (in %)
59	6	40	6.66
59	36	20	1.0
70	3	37	4.1
70	22	0	1.6
75	0	63	3.4
75	17	4	1.2
84	11	25	4.9
85.5	31	0	1.5
89	54	19	3.3
89	97	4	1.3

Table 3

Locality	% infection	Ratio of liver weight to fish weight in %
Shventoīi	87	3
Gotland trench	77	2.5

Table 4

Locality	Number of fish examined	% fish infected	Mean ratio of liver weight to fish weight in %
Liepaya	100	88	2.03
Gulf of Riga (Mangale)	90	7.7	9.11