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On infestation of cod (Gadus morhua morhua L.)
with nematodes of Anisakidae Skrjabin et Karokhin, 1945

in the Barents Sea

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Abstract

Of five nematode species, found in cod, Contracaecum aduncum and Anisakis sp. turned out to be the most numerous and widely circulated. A level of infection with larvae of the above parasites increases with body length and age of cod. Forrocaecum decipiens larvae appeared to be the most abundant in cod of 40-45 cm long. Cod are infected with nematodes during their first summer. Pelagic fry are infested in mass by larval C. aduncum - they feed on Calanus. Young "bottom" cod are infested with Anisakis sp. as they transfer to preferable feeding on euphausiids. A change of source of infection of cod adult age groups, which receive greater number of C. aduncum and Anisakis sp. from fish - their food objects, - is considered.

Résumé

Le *Contracaecum aduncum* et l'*Anisakis* sp. sont les plus nombreux et les plus répandus parmi les cinq espèces de nématodes trouvées chez la morue. Le niveau de l'invasion par les larves des nématodes susmentionnées devient plus élevé avec l'âge et l'agrandissement de la taille des poissons. Les larves du *Forrcaecum decipiens* sont plus nombreuses chez la morue de 40-45cm. La contamination de la morue par les nématodes commence dès le premier été de sa vie. Les alevins pélagiques qui se nourrissent du calanus deviennent en masse l'objet de l'invasion des larves du *C. aduncum*. Quand les Euphausidae deviennent la nourriture essentielle des jeunes "bentiques" les derniers sont contaminés des *Anisakis* sp. La source de l'invasion est différente chez la morue plus âgée qui est contaminée par le *C. aduncum* et l'*Anisakis* sp. par l'intermédiaire des poissons dont elle se nourrit.

Introduction

Larval anisakid nematodes of the sea fishes are of particular importance today. We know cases of their pathogenicity for a man

(Myers, 1976). When heavily infected the fish noticeably lose their market qualities. In addition, larval anisakid nematodes are known to be used as biological indicators of local cod stocks in the North-East Atlantic (Platt 1975, 1976). However, despite a great deal of publications on anisakids, little is known about infection of fish with them in the Arctic waters. Some data on cod in this area are available from publications of Polyansky Yu.I. (1955) and N.E. Platt (1975). Information on infestation of cod of different length with anisakid nematodes in the Barents Sea is presented in this paper.

Material and Methods

The material for this study was collected in 1974 - 1979. Works were carried out during the sea cruises where live or just died fish were examined. An insignificant proportion of examined fish - fry mainly - were fixed in the 4 % formalin. In all 533 cod were dissected, 283 of which - for studying the age-length dynamics of fish infection with nematodes, 170 - to study the infestation of fish musculature and 100 cod fry (caught in February-March) - to study the stages of development of nematodes in a fish alimentary canal of the given age-group of fish. Species diagnostics of parasites was made on alive or fixed in Barbagallo's liquid material with its further clearing in lectic acid. The developmental stages of worms were determined according to B. Berland (1961). Infection of fish is characterized by extensity in % ^{and} intensity (minimal, maximum and medium) presented

by a number of parasites in a fish.

R e s u l t s

Five nematode species relating to two families, Rhabdochoniidae Skrjabin, 1946 and Anisakidae Skrjabin et Karokhin, 1946 were discovered in the Barents Sea cod. Representatives of the former family, Ascarophis morhuae and A. filiformis are encountered only in a fish stomach and are very rare. On the contrary, infestations of cod with C. aduncum, Anisakis sp. and to a lesser degree with P. decipiens proved to be high.

Larval and adult C. aduncum nematodes were found in 92 % of examined fish with intensity of worms I-376 (32,0 on the average) per fish. The main larval localization is in the fish body cavity and mesenteries of the internal organs.

A degree of infestation of cod with larval Anisakis sp. is somewhat lower than with C. aduncum and makes 66,6 % of a number of examined fish with the intensity of infection I-108 (4,4 on the average) parasite per fish. They were most common in a liver and mesenteries. Larval Anisakis sp. were found in bowels and muscles too.

Infestation of cod with P. decipiens appeared to be less significant. Their larvae were discovered on a liver (rarely in bowels) of 12,4 % examined fish with intensity 0-II (0,3 on the average) parasite.

Age variations in infestations of cod with the above nematodes are expressed as follows. In comparison to infestation of cod of

5-20 cm long, infestation with C. aduncum is observed to increase extensively and intensively with age of fish. With further increase in host length infestation remains at the level of 100 % and a worm burden invariably increases.

The typical feature of cod parasitized with Anisakis sp. is the constant increase of a number of infested fish with age as well as of worm burden per one host. (Table I). However, despite the general trend of nematodes to increase level of infestation throughout the whole fish body, we can make out some peculiarities as to infestation of some organs. Thus, for cod under 20-30 cm with C. aduncum on a liver an increase in both extensity and intensity of infestations is typical. A liver of larger fish is less infested with this type of nematodes and the fish over 50 cm had a liver free from larval C. aduncum.

A number of Anisakis sp. on a liver and a number of fish infested with them increases (Table 2).

Larval P. decipiens were found on a liver of cod of different length groups but were the most common in fish of 40-50 cm long (extensity of infestation - 18,2 %, a mean intensity - 0,3 parasite per fish).

When larvae of different types of nematodes are present in fish body cavity and on mesenteries a pattern of infestation corresponds to general character of age-length dynamics of fish infestation (Table 3).

In respect to nematode infestation of the fish alimentary canal we can say that no changes are observed with increase in

host age (Table 4). In the matter of developmental stages of C. aduncum in the young cod bowels, ^{Cf} 45 parasites discovered only 5 (females), taken from two fry, were on the 5th stage of development. One half of the rest were larvae on the IVth developmental stage and the second half - on the 3d one.

Larval Anisakis sp. were found in muscular tissue of 25.2 % of fish. Intensity of infestation was 0-10 (0.75 on the average) parasite per fish, they occurred mainly in musculature of larger cod.

Discussion

There is much information in scientific literature on intermediate hosts of Contracaecum aduncum, Anisakis sp., Porrocaecum decipiens (Review of Cheng, 1976; Smith, & Cotten, 1978). In the Barents Sea the Calanus finmarchicus copepods and decapods Pandalus borealis are known to be primary intermediate hosts of C. aduncum; euphausiids Thysanoessa raschii, amphipods Caprella septentrionalis and decapods Hyas araneus - of Anisakis sp.; decapods Scleroplax borealis - of P. decipiens (Uspenskaya, 1963). Decapods and amphipods are of secondary importance as food items for cod and their occurrence in fish stomachs is comparably low (Novikova, 1965). Calanus finmarchicus, the most numerous plankton of the Barents Sea constitute the feeding base of cod pelagic larvae and fry. Other representatives of copepods are rare and sporadic during the first three months of life (Sysoeva, 1975). Apparently,

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this is the period that young cod are massely infested with C. aduncum parasites. Examined sank fry of 5.1-10.0 cm were found to be infested with the worm by 55 % and the intensity of infestation reached up to 10 parasite per fish. In relation to the bottom young cod a proportion of copepods in their food is very small and, according to long-term data, is 0.4 % (in weight). It is during this bottom way of life that the young cod begin to feed on fish (Ponomarenko, 1965). However, despite the significance of copepods in feeding of this age group of cod, degree of infestation of cod with nematodes of C. aduncum increases. It can be suggested that for older age-groups of cod the plankton-eaters are the main source of infestation with larval C. aduncum. This results in 100% - infection with this type of nematodes. At the same time the fish worm burden constantly increases.

It was noted that infestation of cod with larval Anisakis sp. begins somewhat later than that with C. aduncum and evidently coincides with the beginning of large pelagic fry feeding on euphausiids. The fish between 5.1 - 10.0 cm turned out to be infested with Anisakis sp. by 10.0 %. Mean infestation intensity made up 0.1 parasite per fish. Euphausiids Thysanoessa inermis and Thysanoessa raschii, being in the second place after Calanus in the biomass of the Barents Sea plankton, constitute the feeding base of the sank young cod (Ponomarenko, 1968). 22.2 % of cod of the above length were infested with mean intensity 0.2 parasite per fish.

Level of infestation of adult cod increases although the euphausiids, as distinct from copepods, are constantly present in food of cod of different age-length groups (Novikov, 1965). The main food objects of cod are made up by the fish. This results in accumulation of nematodes in a fish body alongside with the increase in extensity of infestation.

Thus, along with age variation of feeding spectrum of cod an increase in their infection with C. aduncum and Anisakis sp. is observed. Pelagic fry, feeding on Calanus, are infected in mass by the larval C. aduncum. With transfer to preferable feeding on euphausiids the bottom young cod are infected by the larval Anisakis sp. The main food objects of older cod are constituted by the fish. The significance of other objects in their feeding is markedly reduced. For reasons given it can be deemed that a change of the source of infection is underway and the major body of nematodes C. aduncum and Anisakis sp. is received by the cod from their food objects - fish.

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Table I

Infestation of cod of different length groups with nematodes

Length group, cm	No. of dissected fish	<u>Contracaecum aduncum</u>			<u>Anisakis sp.</u>		
		% of infestation	Intensity of infe. min.-max. mean		% of infestation	Intensity of infe. min.-max. mean	
5,1-10,0	20	55,0	1-10 2,0	10,0	1-1	0,1	
10,1-15,0	45	79,9	1-13 3,2	22,2	1-1	0,2	
15,1-20,0	6	100,0	1-9 6,3	33,3	1-1	0,3	
20,1-25,0	18	100,0	3-47 19,5	50,0	1-5	0,8	
25,1-30,0	37	97,3	2-97 32,2	75,7	1-11	2,0	
30,1-35,0	49	93,8	1-153 28,4	79,6	1-10	2,4	
35,1-40,0	16	100,0	16-176 47,2	93,8	1-16	3,4	
40,1-45,0	25	100,0	6-110 44,5	84,0	1-21	6,0	
45,1-50,0	22	100,0	4-103 46,5	90,9	2-35	5,0	
50,1-55,0	29	100,0	2-173 56,5	93,1	1-108	15,6	
55,0-60,0	16	100,0	2-376 87,6	93,8	3-70	14,9	

Table 2

Infestation of cod liver of different length groups with nematodes

Length group,	<u>Contracaecum aduncum</u>			<u>Anisakis sp.</u>		
	% of infestation	Intensity of infe. min.-max. mean		% of infestation	Intensity of infe. min.-max. mean	
5,1-10,0	5,0	1-1 0,1	-	-	-	-
10,1-15,0	11,1	1-4 0,2	11,1	1-1	0,1	
15,1-20,0	-	-	16,6	1-1	0,2	
20,1-25,0	33,3	1-12 2,5	11,1	1-5	0,3	
25,1-30,0	40,5	1-6 0,9	45,9	1-6	1,0	
30,1-35,0	30,6	1-7 0,7	48,9	1-9	1,2	
35,1-40,0	12,4	2-6 0,5	68,8	1-4	1,3	
40,1-45,0	12,0	1-2 0,2	64,0	1-11	2,9	
45,1-50,0	4,5	3-3 0,1	63,6	1-10	2,6	
50,1-55,0	-	-	82,8	1-22	5,4	
55,1-60,0	-	-	75,0	2-18	5,7	

Table 3

Infestation of body cavity and mesenteries of cod of different length groups with nematodes

Length group, cm	<u>Contracaecum aduncum</u>			<u>Anisakis sp.</u>		
	% of infestation	Intensity		% of infestation	Intensity	
		min.-max.	mean		min.-max.	mean
5, I-10,0	55,0	I-10	1,9	10,0	I-I	0,1
10, I-15,0	53,3	I-12	2,0	6,7	I-I	0,1
15, I-20,0	83,3	3-9	5,5	16,6	I-I	0,2
20, I-25,0	88,9	4-47	14,3	33,3	I-2	0,4
25, I-30,0	97,3	2-78	26,2	24,3	I-8	0,6
30, I-35,0	89,8	I-II0	24,2	36,7	I-6	1,0
35, I-40,0	100,0	15-170	41,0	62,5	I-12	2,0
40, I-45,0	96,0	8-100	39,1	52,0	I-17	2,8
45, I-50,0	90,9	4-103	42,9	59,0	I-9	2,4
50, I-55,0	93,1	I-133	43,2	55,2	2-77	8,3
55, I-60,0	100,0	2-376	75,8	75,0	I-52	8,6

Table 4

Infestation of cod alimentary tract of different length groups with nematodes

Length group, cm	<u>Contracaecum aduncum</u>			<u>Anisakis sp.</u>		
	% of infestation	Intensity		% of infestation	Intensity	
		min.-max.	mean		min.-max.	mean
5, I-10,0	10,0	I-2	0,1	-	-	-
10, I-15,0	51,1	I-3	0,9	4,4	I-I	0,1
15, I-20,0	66,0	I-2	0,8	-	-	-
20, I-25,0	44,4	2-12	2,7	5,6	I-I	0,1
25, I-30,0	48,6	2-27	5,1	27,0	I-3	0,4
30, I-35,0	30,6	I-13	3,5	10,2	I-3	0,2
35, I-40,0	37,5	2-40	5,7	6,2	I-I	0,1
40, I-45,0	56,0	3-32	5,2	16,0	I-3	0,3
45, I-50,0	22,6	I-30	3,5	-	-	-
50, I-55,0	48,3	I-96	13,3	27,6	I-23	1,9
55, I-60,0	43,8	I-77	11,8	6,3	5-5	0,3