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Anisakid larvae in cod from the southern Baltic Sea*

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Abstract

Between 1987 and 1993 3036 cod were caught in the southern Baltic Sea (ICES-subdivision 25 and 26). These were examined for extra-intestinal nematode larvae. Parasite larvae were found mainly in the liver, but also in the body cavities of the fish. *Contracaecum osculatum* was more common than *Hysterothylacium auctum* and *Anisakis simplex*. This was the first time that the latter species has been found in cod caught in the Polish Exclusive Economic Zone of ICES-subdivision 26. Only one cod was infected with *Pseudoterranova decipiens*. The smallest cod infected was 33 cm long, and prevalence and other infection parameters increased with fish length. While cod infection with anisakid larvae in the Polish fishing grounds was low (3.7 %), it was higher in the Danish and Swedish regions studied. Prevalence of fish infection varied between 0 and 7 % in monthly samples. It was found that female fish were more commonly infected than males. Infection with nematode larvae does not influence the body condition factor of cod, which is similar in both infected and non-infected fish.

Kurzfassung

Anisakidenlarven in Dorschen aus der südlichen Ostsee

In den Jahren 1987–1993 wurden 3036 Dorsche aus der südlichen Ostsee (ICES-Untergebiete 25 und 26) auf extraintestinale Infektion mit Nematodenlarven untersucht. In der Leibeshöhle der untersuchten Fische, vor allem in der Leber, wurden überwiegend *Contracaecum*-Larven, identifiziert als *C. osculatum*, und seltene Larven von *Hysterothylacium auctum* und *Anisakis simplex* gefunden. *A. simplex* wurde zum erstenmal in der polnischen Wirtschaftszone des ICES-Untergebiets 26 festgestellt. Nur in einem Dorsch wurden *Pseudoterranova-decipiens*-Larven gefunden. Der kleinste infizierte Dorsch war 33 cm lang, und mit steigender Körpergröße stiegen auch Befallsrate und andere

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Indikatoren der Infestation. Die Infestation der Dorsche mit Anisakidenlarven war in der polnischen Fischereiregion niedrig (3,7 %), in der dänischen und schwedischen Fischereiregion dagegen höher. Der Parasitenbefall der monatlichen Proben lag zwischen 0 und 7 %. Weibchen waren häufiger als Männchen infiziert. Die Infektion der Dorsche mit Nematodenlarven hatte keinen Einfluß auf den Konditionsfaktor (body condition factor) der Fische und ist bei den infizierten und nicht infizierten Fischen ähnlich.

Introduction

Fish infected with anisakid larvae (seafood-borne disease) may be a source of parasitic infection to man. Worldwide, twelve thousand documented cases of anisakiasis in man have so far been reported, mainly with larvae of *Anisakis simplex* and *Pseudoterranova decipiens* (Thiel *et al.* 1960; Jackson 1975; Petithory and Marty 1988; Ishikura and Namiki 1989). There have also been a few reports of humans being infected by *Contracaecum osculatum* larvae (Schaum and Müller 1967). Larvae of the above nematode species occur in sea fish (paratenic hosts), whereas adult forms live in sea mammals (Myers 1975; Berland 1989). Cases of eosinophilic granuloma in man have been described to be caused by *Hysterothylacium* sp. larvae (Petter 1969), which normally, like the adults, are found exclusively in fish.

The largest number of nematode infections in man have been recorded in Japan (11623 cases up to 1988) due to the consumption of raw or inadequately processed fish (Ishikura and Namiki 1989). There have also been reports of similar cases from the American continent (Jackson 1975) and Europe (Thiel *et al.* 1960; Anonymus 1988; Petithory and Marty 1988; Verhamme and Ramboer 1988) and Baltic Sea countries, including the former GDR (Lorenz and Warzok 1988). Therefore it is important, from a medical point of view, to analyse the current occurrence of these larvae in marine fish, including fish from the Baltic Sea.

The aim of this work was to analyse the present occurrence of anisakid larvae in cod caught in the southern Baltic region. Special attention was given to *Contracaecum osculatum* larvae, which have not been studied in this region recently. The results stem from studies carried out between 1987 and 1990. These were presented at the 15th Scandinavian Symposium of Parasitology in Uppsala, 4 – 5 Oct. 1991 (Myjak *et al.* 1991).

Material and Methods

The fish studied

The study included cod (*Gadus morhua* L.) which originated from fishing grounds of the Polish Exclusive Economic Zone, particularly ICES-subdivision 26, and from some Danish and Swedish fishing grounds (Figure 1). The fish samples were obtained from known fishing areas, from commercial (≥33 cm) and scientific (≥16 cm) catches. Fish caught during the R/V "Profesor Siedlecki" cruises in August 1987, October 1989, and October 1990 were included. From commercial catches random samples of fish (1 – 2 boxes of cod, 30 to 60 kg) were used for investigation, while in other cases all the fish caught were studied.

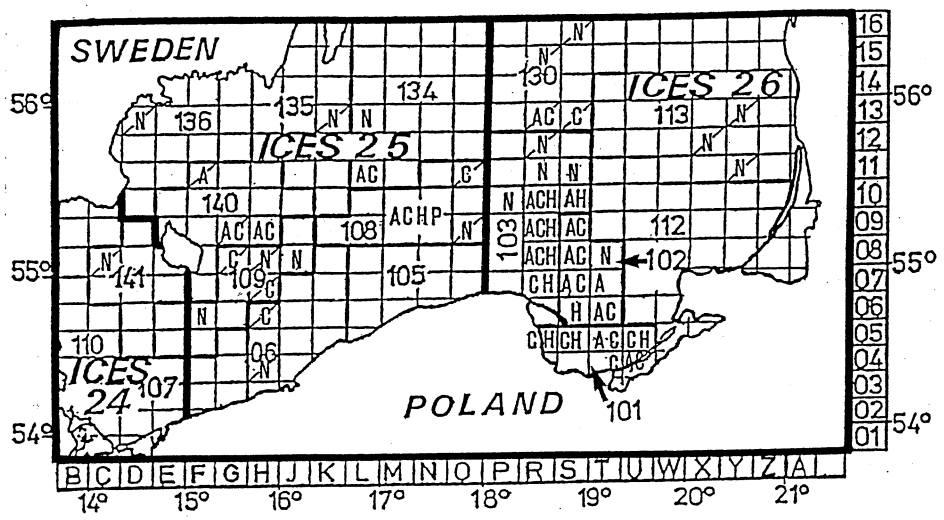

Figure 1: Cod fishing sites and infection by anisakid larvae. **A** = Anisakis simplex, **C** = Contracaecum osculatum C, **H** = Hysterothylacium auctum **P** = Pseudoterranova decipiens, **N** = negative samples, = ☐ number of fish examined <10, **101** = number of fishing ground, **R/10** = fishing area.

Investigation of parasites

The fish were examined for parasites immediately on board the ship, or within 24 hours after catching. The sex, total length, and weight of each fish was determined. After cutting the abdomen of the fish the occurrence and location of parasitic larvae in muscles and viscera were assessed by eye, or using a magnifying glass. The whole body cavity and the viscera were thoroughly examined. The liver was cut into fine pieces and examined for the presence of parasites. The edible fish parts were not digested during this study, and therefore the numbers of larvae recorded in these parts are a minimum estimate. The alimentary tract of the fish was not examined for parasites.

The following parasite infection parameters were calculated: Prevalence (percentage of fish infected), intensity (number of larvae /range, mean/ in fish infected), abundance (mean number of larvae per fish), density (mean number of larvae per kg of fish) (Smith, 1984) and a body condition factor ($K = g \cdot 100 \cdot L^{-3}$) according to Fulton (Petrushevski and Kogtara 1954; Kinne 1984).

Parasite identification

Nematode larvae were identified on the basis of morphology as *Hysterothylacium auctum* (Rud. 1802) is often synonymised with *H. aduncum* (Rud. 1802) (see Berland 1961, 1989; Fagerholm 1987, 1989a, 1989b), *Pseudoterranova decipiens* (Krabbe 1878) (Smith and Wootten 1984a, 1984b; Berland 1989), and *Anisakis sp.* and *Contracaecum sp.* (Berland 1961, 1989; Smith and Wootten 1984a, b).

The study of Grabda (1976b) revealed that the *Anisakis* larvae present in Baltic herring are *A. simplex* and isoenzymatic studies (gene electrophoresia) of Mattiucci *et al.* (1989) proved that these larvae belong to sibling species *A. simplex* B (Nascetti *et al.* 1986), with which cod become infected by eating infected herring. In addition, the *Contracaecum* larvae isolated from cod were subjected by us (Myjak and Szostakowska, ~~in press~~ 1994) to similar examinations according to Orecchia *et al.* (1986) and Nascetti *et al.* (1993) which revealed that they belong to sibling species *C. osculatum* C (Nascetti *et al.* 1993), which has been confirmed by Fagerholm (1978, 1982, 1988) and Nascetti *et al.* (1993) in cod from Northern Baltic.

Table 1: Occurrence of anisakid larvae in Baltic cod. * = 9 fish with mixed infection with *C. osculatum*. ** = fish with mixed infection with *C. osculatum*

Parasites	Prevalance (n = 3036)		Larvae (n = 1232)	
	%	number	%	number
Contracaecum osculatum	2,57	78	92.0	1134
Hysterothylacium auctum	0,49	15	1,46	18
Anisakis simplex	0,92	28*	3,73	46
Pseudoterranova decipiens	0,03	1**	0,16	2
Contracaecum/Hystero-thylacium (unidentified)	0,16	5	1,95	24
Anisakidae (unidentified)	0,13	4	0,65	8
Anisakidae (total)	4,0	121	100	1232

Results

105 fish samples comprising a total of 3036 cod were examined. 2653 (87 %) were of a body length permitted in commercial catches (≥33 cm), and only in these were anisakid larvae found. The nematode larvae were mainly just beneath the liver serosa or within the parenchyma of the liver (98 %). They were very seldom (1.9 %) found on the pyloric processes or on other internal organs.

Occurrence of parasitic larvae in cod

The mean prevalence of infection by anisakid larvae was 4.0 % (0 to 25 % in single samples). The mean intensity was 10.2 larvae per infected fish. The abundance and density were 0.41 and 0.36 respectively (Table 2, 4). The prevalence of cod infection with particular nematode species and the larvae number found in these fish are given in Table 1. *C. osculatum* was the most frequently found nematode species (2.57 % of fish examined, and 64.5 % of fish infected), comprising 92 % of all anisakid larvae found. *A. simplex* occurrance was threefold less (0.92 %), and *H. auctum* fivefold less (0.45 %). *P. decipiens* larvae were only found in one cod (0.03 %).

The majority of *C. osculatum* larvae (1127/1134) were located in the liver, and seven individuals on pyloric processes and mesentery. *H. auctum* were found on pyloric processes, peritoneum and

Table 2: Infection of Baltic cod with anisakid larvae in different fishing grounds; total data for the period 1987 - 1993 (Upper row: all anisakid larvae. Lower row: *Contracaecum osculatum* (L-3) larvae) In brackets: data without the fish with 500 larvae). * = including 3 fish from fishing ground 113.

Fishing grounds No	Number of fish examined	Length of fish in cm			% fish >55 cm	Weight of fish in g			Infection						
		range	mean	+/– SD		range	mean	+/– SD	number of fish infected	number of larvae	prevalence %	intensity range	intensity mean	abundance	density
101	841	16 – 88	39.0	11.1	7.6	40 – 7750	871	980	25	200	3.0	1 – 107	8.0	0.24	0.28
									15	185	1.8	1 – 106	12.3	0.22	0.26
102	778	25 – 97	45.6	10.1	15.2	160 – 11850	1247	1058	36	153	4.6	1 – 18	4.2	0.20	0.16
									25	124	3.2	1 – 18	5.0	0.16	0.13
103	1158	21 – 103	45.0	11.5	16.7	100 – 11250	1230	1008	42	316	3.6	1 – 53	7.5	0.27	0.22
									27	276	2.3	1 – 53	10.2	0.24	0.19
106 – 109	202	22 – 90	44.2	10.1	10.9	100 – 10850	1064	1078	7 (6)	531 (31)	3.5	1 – 500	75.9	2.63	2.46
												(1 – 11)	(5.2)	(0.15)	(0.15)
									6 (5)	528 (30)	3.0	1 – 498	88.0	2.61	2.46
												(1 – 11)	(6.0)	(0.15)	(0.15)
Total 101 – 109	2979	16 – 103	43.4	11.3	13.4	40 – 11850	1124	1070	110 (109)	1200 (700)	3.7	1 – 500	10.9	0.40	0.36
												(1 – 101)	(6.4)	(0.23)	(0.21)
									73 (72)	1113 (615)	2.4	1 – 498	15.2	0.37	0.33
												(1 – 106)	(8.5)	(0.21)	(0.19)
130, 134 135, 136	28	24 – 63	48.4	9.6	21.4	160 – 2740	1261	617	7	17	25.0	1 – 6	2.4	0.61	0.48
									3	11	10.7	1 – 6	3.7	0.39	0.31
140, 141	26	21 – 77	48.8	14.5	26.9	110 – 3900	1234	1079	4	15	15.4	1 – 9	3.7	0.58	0.47
									2	10	7.7	1 – 9	5.0	0.38	0.31
TOTAL	3036*	16 – 103	43.5	11.3	13.5	40 – 11850	1127	1067	121 (120)	1232 (732)	4.0	1 – 500	10.2	0.41	0.36
												(1 – 107)	(6.1)	(0.24)	(0.22)
									78 (71)	1134 (636)	2.6	1 – 498	14.5	0.37	0.33
												(1 – 106)	(8.3)	(0.35)	(0.19)

in the liver (5 larvae). Forty-three (out of 46) *A. simplex* larvae were found in the liver, two on pyloric processes and one on the peritoneum. The two *P. decipiens* larvae were in the liver.

Relationship between different fishing grounds, time of catch, and cod infection

Prevalence of infection by the four nematode species in cod caught in waters of the Polish Exclusive Economic Zone was low (Table 2 and Figure 1), being on average 3.7 % (range 3.0 to 4.6 %). Infection of cod from Danish and Swedish fishing grounds was higher, 15.4 and 25 %, respectively. These findings are further broken down:

Table 3: Prevalences of infection with anisakid larvae (upper row), including *Contracaecum osculatum* (L-3) larvae (lower row), of cod caught in particular months (total data for the period 1987–1993).

Months	I	II	II	IV	V	VI	VII	VIII	IX	X	XI	XII
No. of fish examined	654	186	884	266	203	225	98	142	0	206	36	136
Mean length of fish in cm ± SD	42.5 12.2	45.5 12.8	44.4 10.9	45.2 10.5	45.3 11.4	46.1 9.6	38.3 9.7	41.2 8.7	– –	41.7 14.0	42.7 7.0	38.5 7.7
Percentage of fish >55 cm	15.1	21.0	14.6	11.6	15.3	16.4	6.1	7.7	–	13.6	2.8	2.2
No. of fish infected	18 14	5 4	31 22	17 10	7 2	13 8	4 3	10 3	– –	15 11	0 0	1 1
Prevalence in %	2.7 2.1	2.7 2.5	3.5 2.5	6.4 3.8	3.4 1.0	5.8 3.5	4.1 3.1	7.0 2.1	–	7.3 5.3	0 0	0.7 0.7

a) *C. osculatum* larvae – Prevalence: between 1.8 and 3.2 % in different Polish fishing grounds (10.7 % in Swedish), and between 0 and 20 % in single samples. Intensity: between 1 and 498 larvae were found in cod from most of the fishing grounds,

b) *A. simplex* larvae – Prevalence: between 0 and 0.69 % (12.5 % in the fishing ground No. 140), 0 to 21 % (3 per 14 fish) in single samples. Intensity: 1 to 3 larvae were found in the Polish fishing grounds (Nos. 101 - 103, 108) and in the Swedish ones (Nos. 140, 134, 130),

c) *H. auctum* larvae – Prevalence: between 0 and 0.64 % (0 to 4.8 % in single samples). Intensity: 1 to 2 larvae were found mainly in the fishing grounds Nos. 101 – 103 (ICES – subdivision 26) and in the fishing ground No. 108 (ICES – subdivision 25),

d) *P. decipiens* larvae – Prevalence: between 0 and 0.69 %. Intensity: 2 were found only once in cod caught in the fishing ground No. 108.

Table 4: Infection of Baltic cod with anisakid larvae in relation to fish body length (In brackets: including *Contracaecum osculatum* (L-3) larvae).

Length class of fish in cm	Number of fish examined	Infection					
		number of fish infected	number of larvae	prevalence %	intensity	abundance	density
16 – 20	18	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21 – 25	61	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
26 – 30	141	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
31 – 35	558	3 (0)	4 (0)	0.5	1.3	0.01	0.02
				(0)	(0)	(0)	(0)
36 – 40	672	7 (0)	7 (0)	1.0	1.0	0.01	0.02
				(0)	(0)	(0)	(0)
41 – 45	454	6 (2)	17 (3)	1.3	4.5	0.06	0.07
				(0.4)	(1.5)	(0.01)	(0.01)
46 – 50	394	10 (6)	40	2.5	4.0	0.10	0.08
			(35)	(1.5)	(5.8)	(0.09)	(0.07)
51 – 55	326	15 (8)	26	4.6	1.7	0.08	0.04
			(16)	(2.4)	(2.0)	(0.05)	(0.03)
56 – 60	175	17 (13)	60	9.7	3.5	0.34	0.16
			(52)	(7.4)	(4.0)	(0.30)	(0.14)
61 – 65	99	16 (11)	68	16.2	4.2	0.69	0.24
			(60)	(11.1)	(5.4)	(0.61)	(0.21)
66 –70	64	15 (10)	103	23.4	6.9	1.61	0.46
			(93)	(15.6)	(9.3)	(1.45)	(0.41)
71 – 75	36	10 (9)	177	27.8	17.7	4.92	1.09
			(170)	(25.0)	(18.0)	(4.72)	(1.04)
≥ 76	38	22 (19)	720	57.9	32.7	18.95	2.93
			(705)	(50.0)	(37.1)	(18.55)	(2.87)
TOTAL	3036	121	1232	4.0	10.2	0.41	0.36
		(78)	(1134)	(2.6)	(14.5)	(0.37)	(0.33)

Comparison of nematode larvae in fish caught in particular months (Table 3) did not reveal any clear seasonality in parasite occurrence. However, the highest percentage of infected cod was recorded in October (5.3 % infected with *C. osculatum* and 7.3 % infected with four anisakid species). No parasites were found in November.

Relationship between infection and length or sex of fish

An analysis of infection rate in relation to fish body length (5 cm length classes) is presented in Table 4. The smallest infected cod was 33 cm long, and so fish below the minimum body length allowed for commercial catches were not infected. The infection rate increased with fish length

Table 5: Infection of Baltic cod with anisakid larvae in relation to the sex of the fish. (Upper row: all anisakid larvae. Lower row: including *Contracaecum osculatum* (L-3) larvae). In brackets: data without the fish with 500 larvae.

Sex	Number of fish examined	Length of fish in cm			% of fish > 55 cm	Weight of fish in g			Infection					
		range	mean	± SD		range	mean	± SD	number infected fish	number of larvae	prevalence %	intensity range	intensity mean	abundance	density
Male	1644	16 – 86	41.5	9.5	6.9	40 – 10850	904	725	44	722 (222)	2.7	1 – 500 (1 – 53)	16.4 (5.2)	0.44 (0.11)	0.49 (0.15)
									29	696 (198)	1.8	1 – 498 (1 – 53)	24.0 (7.1)	0.42 (0.12)	0.47 (0.14)
Female	1373	20 – 103	45.9	12.8	22.6	70 – 11850	1396	1318	76	509	5.5	1 – 107	6.7	0.37	0.27
									49	438	3.6	1 – 106	8.9	0.32	0.23

(y = 1.04x - 43.15, r = 0.871 for fish infected with anisakid larvae and y = 0.89x - 38.06, r = 0.849 for fish infected with *C. osculatum*). While only up to 4.5 % of the fish shorter than 56 cm were infected, over 23 % of those more than 65 cm were infected. The remaining infection parameters also changed with the increasing body length (*e.g.* intensity: y = 0.61x - 25.31, r = 0.800 for fish infected with *C. osculatum*).

The rate of cod infection with anisakid larvae was also analysed in relation to the sex of the fish (Table 5). The prevalence of infection among females was 5.5 %, and among males 2.7 %, and among fish infected with *C. osculatum* 3.6 and 1.8 %, respectively. The remaining infection parameters were greater in males compared with females.

Condition factor

The body condition factor, according to Fulton's method, for non-infected cod (K = 1.086 to 1.174) was similar in each length classes compared with that calculated for fish infected with *C. osculatum* (K = 1.022 to 1.242) or with all anisakid larvae (K = 1.054 to 1.175).

Discussion

In contrast to the results obtained earlier by Polish workers (Studnicka 1965; Ganowiak 1968; Rokicki 1975; Grabda 1976a) and others (Shulman 1948; Petrushevski and Kogtara 1954; Gecevicjute 1955), we have shown that larvae of the species *C. osculatum* occurs as well as *H. auctum* and *A. simplex* larvae. *C. osculatum* dominated the parasites (92 %). Only one cod was infected with *P. decipiens*.

Isoenzymatic examinations of *Contracaecum* larvae from cod caught in three different fishing grounds enabled us to determine it as *C. osculatum* C (Mattiucci and Myjak, pers. comm. 1993). Among three sibling species of

C. osculatum (A, B, and C) for C the name *C. osculatum* must be maintained (Nascetti *et al.* 1993). Recently, it has been stated that it is very difficult, or even impossible to distinguish between *Contracaecum* L-3 larvae and larvae of the genus *Phocascaris* found in fish (Myers 1975; Fagerholm 1982; Smith and Wootten 1984b). Although no isoenzymatic examinations with all *Contracaecum* larvae were performed it is very unlikely, however, that the larvae found by us belonged to *Phocascaris* since it has not been found in the Baltic Sea. Larvae reported in herring (Sjöblom and Kuittinen 1976) were apparently the L-3 stages of *C. osculatum* (Fagerholm, 1982), which occurs in different fish species in the northern Baltic. However, it cannot be ruled out that some of the *Contracaecum* larvae found in the southern Baltic belong to nematode species which have birds as a final host. Cormorants infected with *Contracaecum* live in a big colony (about 4500 nests) on Vistulasandbar. Therefore it is necessary to verify the identification on a larger number of *Contracaecum* larvae found in the southern Baltic (especially in the ICES-subdivision 26). We are now performing such isoenzymatic examinations.

Our studies support the findings of Fagerholm (1978, 1982, 1988) who demonstrated experimentally that the larvae found in the livers of cod caught in the northern Baltic Sea and Gulf of Bothnia belong to *Contracaecum*, and are identical with the larvae of *C. osculatum* occurring in the seals from that region. He also recorded, although only in isolated cases, the presence of *H. auctum* larvae in the body cavities of cod, *i.e.* on the pyloric processes, but never in the liver. For this reason, he thinks, and his opinion is supported by other authors (Kinne 1984; Smith and Wootten 1984b; Valtonen *et al.* 1989), that previous identifications of larvae isolated from the cod liver were erroneous since they were reported as *Hysterothylacium (Thynnascaris, Contracaecum) aduncum* = *auctum*. Our investigation have shown that *H. auctum* larvae occur sporadically in the body cavity of cod (prevalence only 0.49 %). In contrast to Fagerholm (1982), we also found them in the liver of cod, though only sporadically (5 larvae per 1209). This does, however, indicate, that they can occur in this organ. We found *H. auctum* larvae mainly in cod caught in ICES-subdivision 26. Their low prevalence infection in ICES-subdivision 25 need not be related to their absence from this region, but rather to the low number of fish examined. *A. simplex* larvae were found in Baltic cod for the first time by Grabda in 1974 (Grabda 1976a), and it was suggested that the source of infection was herring. While the prevalence of this parasite was rather high in Grabda's study, the prevalence was lower (2.9 %) in the present study (1987-1993 in western fishing grounds ICES-subdivision 25). This may have been connected with the period in which the fish were caught (mainly in August and October) in that region, *i.e.* during the months in which the lowest infection was recorded between 1974 and 1975 by Grabda (1976a, fig. 4). It is worthwhile mentioning that our finding of *A. simplex* larvae for the first time in cod caught in the eastern fishing grounds - fishing areas R to U (ICES-subdivision 26) - extends the hitherto known range of this parasite in the Polish Exclusive Economic Zone. It now corresponds to the range of *A. simplex* larvae in herring (Rokicki 1972; Lubieniecki 1972; Grabda 1974; Strzyzewska and Popiel 1974; *Myjak* and Szostakowska). Further to the East, in Gulf of Riga, only one infected cod has been reported so far (Vismanis 1987).

Although we found in one case two *P. decipiens* larvae in a cod liver, it seems doubtful that this species is permanently present in the Baltic (Smith and Wootten 1984c). However, it has been found in herring in the northeastern Baltic (Turovsky 1992), and in cod caught close to Baltic Sea, in the Kattegat (Thulin et al. 1989). The prevalence of infection of cod by *C. osculatum* (2.57 %) and *H. auctum* larvae (0.49 %) in the southern Baltic fishing grounds is relatively low,

and is much lower than found in the 1970's (Grabda 1976a). In that period cod were infected with larvae referred to as *C. aduncum (= H. aduncum = H. auctum)*. Through the southern Baltic region, the infection frequency tends to increase eastwards (from 4 % to 55 % in particular fish samples), reaching a maximum in ICES-subdivision 26.

High rates of cod infestation with nematode larvae were observed also by Studnicka (1965) and Ganowiak (1968). The latter found that in the 1960's 24 – 50 % of the cod were infected with these larvae identified as *C. aduncum*. In the southern Baltic some authors (*e.g.* Petrushevski and Kogtara 1954), have reported that in 1954 as much as 97.7 % of the cod were infected with *C. aduncum*, while according to Shulman (1948), in 1946 88 % of the cod caught in the Liepaja region were infected. The larvae were found in the liver and were then identified as *C. clavarum*.

The low present prevalence of infection of cod from the southern Baltic confirms the findings of Lang (1988) who found only one *Contracaecum* larva and three *A. simplex* larvae in the livers of 449 cod from this region in December 1987. It is worth mentioning that although Lang (1987) found larvae and adult forms of *H. auctum* in the alimentary tracts of 14 % of the fish, he did not find any larvae of this species in the body cavities. In recent years, between 14 and 30 % of the cod caught in the northern Baltic (Gulf of Bothnia, Åland Islands) were infected with *C. osculatum* larvae located in the liver (Fagerholm 1982; Valtonen *et al.* 1988; Thulin *et al.* 1989). The cod were, however, much longer (on average 60 cm, Fagerholm 1982), than those examined by us and had been caught near seal habitats, – the definitive hosts of this parasite.

Our investigations have proved, that the infection rate increases as the fish grow in length, confirming previous observations on other fish species (Valtonen *et al.* 1988). This is particularly the case in cod longer than 55 cm. Consequently comparison of data is only possible if authors specify fish body lengths. Our results can be compared with those obtained by Grabda (1976a, fig. 4) for fish of the same body length classes, caught in the same region of the Baltic (Table 4). The comparison shows that in this region, in all body length classes, the infection by *C. osculatum / H. auctum* larvae is at present much lower than at the beginning of the 1960's.

In line with the results of Grabda (1976a), no seasonality was found in the occurrence of *C. osculatum* larvae. Studnicka (1965) and Ganowiak (1968) found these larvae more frequently in cod caught in spring, while Gecevičjute (1955) recorded the highest prevalence in June, and the lowest during winter.

It is likely, that the higher prevalence of infection found in female compared with male fish is not sex related, but is due to the larger length of female fish (Table 5). Other parameters of infection were indeed higher in males, but the cause was one individual specimen infected with 500 larvae. If this was excluded, the parameters would be higher in females than in males. Our own investigations show, that cod infection with nematode larvae do not influence the body condition factor of the fish and is similar in infected and non-infected fish. Even in cod with the highest number of anisakid larvae (500) the body condition factor is high (1.45). According to Petrushevski and Kogtara (1954) increasing infection is accompanied by decrease in the fish body condition factor value. Fagerholm (1989a) reports, that in earlier investigations nematode larvae (then erroneously identified as *H. aduncum = H. auctum*) were considered the cause of considerable injuries to the liver and decrease of the body condition factor value. He wrote "Current results, however, imply that this 'cod-syndrome' is not primarily caused by the nematodes but by external factors, probably by physiological changes of cod in a suboptimal low-salinity envi-

ronment". However, a critical analysis of the effect of these larvae upon the condition of cod still remains to be made. It can be stated that earlier identifications of the larvae isolated from cod livers in the area studied were erroneous, since most of them were *C. osculatum*. Thus their lower present prevalence in cod can now be attributed to the lower numbers of the Baltic seals (including *Halichoerus grypus*), the main final hosts of this parasite in this area. The possibility of disturbances to the development or transmission of the parasite as a result of increasing pollution in the Baltic Sea cannot, however, be excluded.

Being a parasite of sea mammals, *C. osculatum* may be dangerous to human health (Schaum and Müller 1967). Since the larvae occur primarily in fish liver, which is seldom eaten raw, the likelihood of humans becoming infected with this parasite is small. However, infected livers represent a hygienic problem and should be removed from further food processing. As shown by Grabda (1976a), *A. simplex* larvae are also present in the muscles of the Baltic cod. When fish is not correctly processed, these larvae can remain alive and then be a threat to human health.

References

Anonymus, 1988: Parasitic diseases. Anisakiasis. Wkly. Epidem. Rec. 41: 311 – 314.

Berland, B., 1961: Nematodes from some Norwegian marine fishes. Sarsia. 2: 1 – 50.

Berland, B., 1989: Identification of larval nematodes from fish. In: Möller, H.(ed.): Nematode problems in North Atlantic fish. Report from a workshop in Kiel, 3 – 4 April 1989. Int. Counc. Explor. Sea, C.M./ F 6: 16 – 22.

Fagerholm, H.-P., 1978: New implications of the nematode infection of Baltic cod liver. ICOPA IV Warszawa, sect. C., 192 pp.

Fagerholm, H.-P., 1982: Parasites of fish in Finland. VI. Nematodes. Acta Acad. Abo. Ser.B. 40 (6): 1 – 128.

Fagerholm, H.-P., 1987: *Gammarus oceanicus* (Crustacea: Amphipoda) as an intermediate host of *Hysterothylacium auctum* (Nematoda: Ascaridoidea); Life cycle and taxonomy of the parasite. Information Inst. Parasitol. Abo Akademi. 19: p. 30.

Fagerholm, H.-P., 1988: Incubation in rats of a nematodal larva from cod to establish its specific identity: *Contraceacum osculatum* (Rudolphi). Parasit. Res. 75: 63 – 67.

Fagerholm, H.-P., 1989a: Nematode parasites of fish in Northwestern Europe. Materials of the International Symposium within the Program of the Soviet-Finnish Cooperation, Petrozavodsk, 10-14 January 1988., p. 37 – 41.

Fagerholm, H.-P., 1989 b: Biology of *Contracaecum* species occurring in fish. In: Möller, H. (ed.): Nematode problems in North Atlantic fish. Report from a workshop in Kiel, 3 – 4 April 1989. Int. Counc. Explor. Sea, C. M./ F 6: 15 pp.

Ganowiak, Z., 1968: Inwazja nicieni w wątrobie dorszy bałtyckich jako problem oceny sanitarnej (The nematodes invasion in liver of Baltic cods as a sanitary evaluation problem). Med. Wet. 24: 564 – 565.

Gecevičjute, S., 1955: Sezonnaja zaražennost pečeni baltijskoj treski *Contracaecum aduncum*. Trudy A.N. Litovskoj SSR, Serija B.2': 127 – 129.

Grabda, J., 1974: The dynamics of the nematode larvae, *Anisakis simplex* (Rud.) invasion inthe southwestern Baltic herring (*Clupea harengus* L.). Acta Ichthyol. Piscat. 4: 3 – 21.

Grabda, J., 1976a: The occurrence of anisakid nematode larvae in Baltic cod (*Gadus morhua*

callarias L.) and the dynamics of their invasion. Acta Ichthyol. Piscat. 6: 3 – 21.

Grabda, J., 1976b: Studies on the life cycle and morphogenesis of *Anisakis simplex* (Rudolphi, 1809) (Nematoda: Anisakidae) cultured in vitro. Acta Ichthyol. Piscat. 6: 119 – 141.

Ischikura, H.; Namiki, M., 1989: Gastric anisakiasis in Japan. Epidemiology, diagnosis, treatment. Tokyo: Springer-Verlag.

Jackson, G.J., 1975: The "New Disease" status of human anisakiasis and North American cases: A reviev. J. Milk. Food Technol. 38: 769 – 773.

Kinne, O. (ed.), 1984: Diseases of marine animals. Vol. IV. Part 1. Introduction, Pisces. Hamburg: Biologische Anstalt Helgoland. 541 pp.

Lang, T., 1988: *Hysterothylacium aduncum* (Nematodâ) in Baltic cod (*Gadus morhua* L.). Int. Counc. Explor. Sea. C.M./ J 20: 8 pp.

Lorenz, G.; Warzok, R., 1988: Intestinale anisakiasis (Heringswurmkrankheit). Pathologe. 9: 199 – 203.

Lubieniecki, 1972: The occurrence of *Anisakis sp.* larvae (Nematoda) in herring from the Southern Baltic. Int. Counc. Explor. Sea C.M. / H 21: 5 pp.

Mattiucci, S.; d'Amelio, S.; Rokicki, J., 1989: Electrophoretic identification of *Anisakis* sp. larvae (Ascaridida: Anisakidae) from *Clupea harengus* L. in Baltic Sea. Parassitologia. 31: 45 – 49.

Myers, B. J., 1975: The Nematodes that cause anisakiasis. J. Milk. Food. Technol. 38: 774 –782.

Myjak, P.; Szostakowska, B., 1994: Genetic identification of *Contracaecum* larvae occurring in cods from southern Baltic. Biul. Metod.-Org. Inst. Med. Morsk. Trop 27 (1/2) (Abstracts of communications of the 17th Congress of the Polish Parasitological Society, Gdynia, 15 – 17 Sep. 1994): p.43.

Myjak, P.; Wyszynski, M.; Rokicki, J.; Wojciechowski, J., 1991: Occurrence in Southern Baltic fish of Anisakidae larvae dangerous to man. Bull. Scandin. Soc. Parasitol. Vol. 1, p. 66 (Proceedings of the XVth Symposium of the Scandinavian Society for Parasitology, Uppsala, Sweden, 4 – 5 Oct. 1991).

Nascetti, G.; Cianchi, R.; Mattiucci, S.; d'Amelio, S.; Orecchia, P.; Paggi, L.; Brattey, J.; Berland, B.; Smith, W.; Bullini, L., 1993: Three sibling species within *Contracaecum osculatum* (Nematoda, Ascaridida, Ascaroidea) from the Atlantic Arctic-Boreal region: Reproductive isolation and host preferences. Int. J. Parasitol. 23: 105 – 120.

Orecchia, P.; Paggi, L.; Mattiucci, S.; Smith, J. W.; Nascetti, G.; Bullini, L., 1986: Electrophoretic identification of larvae and adults of *Anisakis* (Ascaridida: Anisakidae). J. Helmintol. 60: 335 – 338.

Petithory, J. C.; Marty, B., 1988: L'Anisakiase en France. La lettre de l'Infectiologue. 3: 96 – 99.

Petrushevski, G. K.; Kogtara, E. P., 1954: [Effect of parasitic diseases ôn the condition of fish] (in Russian). Zool. Zh. 33: 395 – 405.

Petter, A. J., 1969: Enquête sur les Nematodes des poissons de la région nantaise. Identification des larves d'Ascarides parasitant les sardines (en rapport avec les granulomes éosinophiles observés chez l'homme dans la région). Ann. Parasitol. 44: 559 – 579.

Rokicki, J., 1973: Helminths of certain clupeidae, mainly of the herring *Clupea harengus* L., in South Baltic. Acta Parasitol. Pol. 21, 443 – 464.

Rokicki, J., 1975: Helminth fauna of fishes of Gdańsk Bay (Baltic Sea). Acta Parasitol. Pol. 23: 37– 84.

Schaum, E.; Müller, W., 1967: Die Heterocheilidiasis. Eine Infektion des Menschen mit Larven von Fisch-Ascariden. Dtsch. med. Wschr. 92: 2230 – 2233.

Shulman, S.S., 1948: [A helminth disease of the liver of cod]. (in Russian). Rybn. Khoz. Kiev 4: 38 – 40.

Sjöblom, V.; Kuittinen, E., 1976: *Phocascaris sp.* (Nematoda) larvae in Baltic herring, a new parasite for the Baltic Sea. Fin. Fish Res. 2: 1 – 3.

Smith, J. W., 1984: Larval ascaridoid nematodes in myopsid and oegopsid cephalopods from around Scotland and in the Northern North Sea. J. mar. biol. Ass. U.K. 64: 563 – 572.

Smith, J. W.; Wootten, R., 1984a: *Anisakis* larvae ('Herringworm') (Nematoda) in fish. In: Sindermann, C. J. (ed.): Fiches d'identification des maladies et parasites des poissons, crustacés et mollusques, No.8. Copenhague: Conseil International pour l'exploration de la Mer.

Smith, J. W.; Wootten, R., 1984b: *Phocascaris* (*Contracaecum* larvae) (Nematoda) in fish. In: Sindermann, C. J. (ed.): Fiches d'identification des maladies et parasites des poissons, crustacés et mollusques, No.9. Copenhague: Conseil International pour l'exploration de la Mer.

Smith, J. W.; Wootten, R., 1984c: *Pseudoterranova* larvae ('codworm') (Nematode) in fish. In: Sindermann, C. J. (ed.): Fiches d'identification des maladies et parasites des poissons, crustacés et mollusques, No.7. Copenhague: Conseil International pour l'exploration de la Mer.

Strzyżewska, K.; Popiel, J., 1974: Characteristic of herring infested by *Anisakis* larvae caught in the Gulf of Gdansk. Int. Counc. Explor. Sea, C. M. / H 15: 4 pp.

Studnicka, M., 1965: Internal parasites of the cod, *Gadus callarias* L., from the Gdansk Bay of the Baltic Sea. Acta Parasitol. Pol. 13: 283 – 290.

Thiel, P. H.; van Kuipers, F. C.; Roskam, R. T., 1960: A nematode parasitic of herring, causing acute abdominal syndromes in man. Trop. Geogr. Med. 2: 97 – 113.

Thulin, J.; Höglund, J.; Lindesjöö, E., 1989: Fisksjukdomar i Kustvatten. (Fish diseases in coastal waters of Sweden). Stockholm: Naturvardeverket Forlag, 126 pp.

Turowsky, A.; Aps, R.; Raid, T., 1992: The parasitic infestation and growth of clupeides in the north-eastern Baltic. Int. Counc. Explor. Sea, C. M. / J 43: 10 pp.

Valtonen, E.T.; Fagerholm, H.-P.; Helle, E., 1988: *Contracaecum osculatum* (Nematoda:Anisakidae) in fish and seals in Bothian Bay (northeastern Baltic Sea). Int. J. Parasitol. 18: 365 – 370.

Verhamme, M. A. M.; Ramboer, C. H. R., 1988: Anisakiasis caused by herring in vinegar: a little known medical problem. Gut 29: 843 – 847.

Vismanis, K. O., 1987: Parazitologicheskie issledowaniya ryb Rizhskogo zaliva. Izv. AN Latv. S. S. R. (Biol. Nauki.) 9: 99 – 105.

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