Whaleworm, Anisakis simplex, *in the fillets of saithe,* Pollachius virens, *from Faroese waters*

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Úrtak

Hesi síðstu árini hava trupulleikar verið við rundorminum *Anisakis simplex* í upsaflaki. Stig vórðu tí tikin til at eftirkanna títtleikan av *Anisakis*-ormverum í upsavøddum av Føroya-leiðini í 1991-94. Miðaltíttleikin sýnist minkandi frá 97 % í 1991, til 67 % í 1994. Miðaltættleikin fyri hvønn aldursbólkin hjá upsanum var 0-27 av 3. stig ormveru fyri hvønn fisk. Vinstra síða hjá upsanum hýsir samanlagt fleiri ormverur (62 %) enn høgra síða (38 %), og er hesin munur hagfrøðiliga dyggur fyri búkpartarnar (uggarnar). Upsi tykist ikki funnin í hvalamagum í føroyskum havøki; men sannlíkt er, at sildreki er ein endavertur fyri *Anisakis* úr upsa.

Abstract

Some years ago the Faroese fish industry became avare of the problems with larvae of the nematode *Anisakis simplex* in fillets from saithe, *Pollachius virens*. In 1991-1994 samples were taken to examine the fillets of saithe from Faroese waters. The mean prevalence of infection decreased from 97 % in 1991 to 67 % in 1994. The abundance for the different year-classes was 0-27 third stage larvae. Left fillets of the saithe contained more larvae (62 %) than right fillets (38 %). The difference is statistically significant for the ventral parts of the fillets. Adult saithe has apparently not been found in the stomach of marine mammals in Faroese waters, but it seems likely that the minke whale is one final host to *Anisakis simplex* from saithe in this area.

Introduction

Saithe (coalfish, pollock), *Pollachius virens*, is of great importance in the Faroese fishery for human consumption. However, so far this species seems to have been neglected in terms of parasitological investigations. Apart from the extensive qualitative work on the nematodes of different fish species in Faroese waters by Køie (1993), apparently very few investigations have dealt with the parasites of the saithe. This study deals with the infection of the third stage larvae of the nematode *Anisakis simplex* in the fillets of the saithe. In Faroese waters the adult stages of *Anisakis simplex* are common in the long-finned pilot whale, *Globicepaha melas* (Trail, 1809), see e.g. Raga and Balbuena (1993). Intermediate stages have been found by Smith (1971) in the eupahusiaceans *Thysanosessa inermis* and *T. longicaudata.*

Materials and Methods

Between 2 March 1991 and 16 March 1994, a total of 313 saithe were examined at the filleting plant "Bacalao" (Table 1). Samples were collected from the fishery re-

search vessel "Magnus Heinason". The fish was caught by trawl in the standard estimation of different Faroese fish stocks. The saithe were filleted by hand on board and deep frozen. The age was determined by otoliths, but because of technical problems this was not possible for the samples from 1992 and for one sample from 1993. On shore, the right and the left fillets of each fish were kept separated. The right and left fillets of 305 fishes were divided into a dorsal and a ventral part. Further, each part were divided into an anterior and a posterior section (Fig. 2). Each of these sections were digested seperately in pepsin-HCl (21.7 g 1:2500 Sigma Pepsin, 21.7 ml 25 % HCl to 5 liter destilled water, pH 1.6) for 4-6 h at 30-37 °C. Remaining fish muscles received an additional digestion. The free nematodes were sieved, carefully picked out, counted and stored in 70 % ethanol for further control. Sources of error are partially digested bones who resemble nematodes. Microscopical examination showed typically 1-2 lower counts of nematodes per fish, but the macroscopic counts are used in this report. Statistical analysis included a paired two sample t-test when comparing the right and left parts of the muscles.

Results

The nematodes collected from the digestion procedure all turned out to be *Anisakis simplex* third-stage larvae. The terms used in the following refer to Margolis *et al.* (1982). Prevalence, expressed as propor-

Date	Position	n	Mean age (years)	Prevalance (%)
02.03.91	62°42' N, 06° 07' W	25	5,4	96,0
07.03.91	62° 19' N, 08° 34' W	22	5,3	90,9
10.03.91	60° 46' N, 08° 29' W	23	6,4	100,0
11.03.91	61° 27' N, 07° 48' W	26	4,8	100,0
25.03.91	62° 44' N, 07° 00' W	25	5,8	96,0
d.u.1991	n.k.	8	n.k.	100,0
tot. 1991:		**129**	**mean:**	**96,9**
d.u.1992	n.k.	40	n.k.	95,0
tot. 1992:		**40**	**mean:**	**95,0**
29.08.93	62° 29' N, 06° 38' W	4	2,3	50,0
30.08.93	62° 29' N, 05° 18' W	10	4,2	70,0
31.08.93	62° 10'N, 05° 37' W	18	4,0	38,9
01.09.93	62° 36' N, 07° 01' W	9	3,2	77,8
02.09.93	62° 20' N, 07° 50' W	6	1,8	0,0
05.09.93	61° 05' N, 06° 55' W	2	2,0	0,0
d.u. 1993	n.k.	49	n.k.	93,9
tot. 1993:		**98**	**mean:**	**70,4**
13.03.94	61° 40' N, 05° 20' W	11	4,0	63,6
15.03.94	61° 55' N, 04° 52' W	9	5,4	77,8
16.03.94	62° 25' N, 05° 01' W	26	4,2	65,4
tot. 1994:		**46**	**mean:**	**67,4**
tot. n.		**313**		

Table 1. Date, position, number of fishes (n), mean age of fishes and prevalence of Anisakis simplex of saithe, Pollachius virens, from Faroese waters.
d.u.: date unknown; n.k.: not known; tot: total.

Talva 1. Yvirlit yvir tiknu sýnislutirnar av upsa av Føroya-leiðini; n: tal av fiskum; Mean age: miðalaldur (ár) fyri sýnið; prevalence: prosent-infektión við Anisakis simplex; d.u. veiðitíð ókend; n.k.: stað/aldur ókent/ókendur; tot: tilsamans.

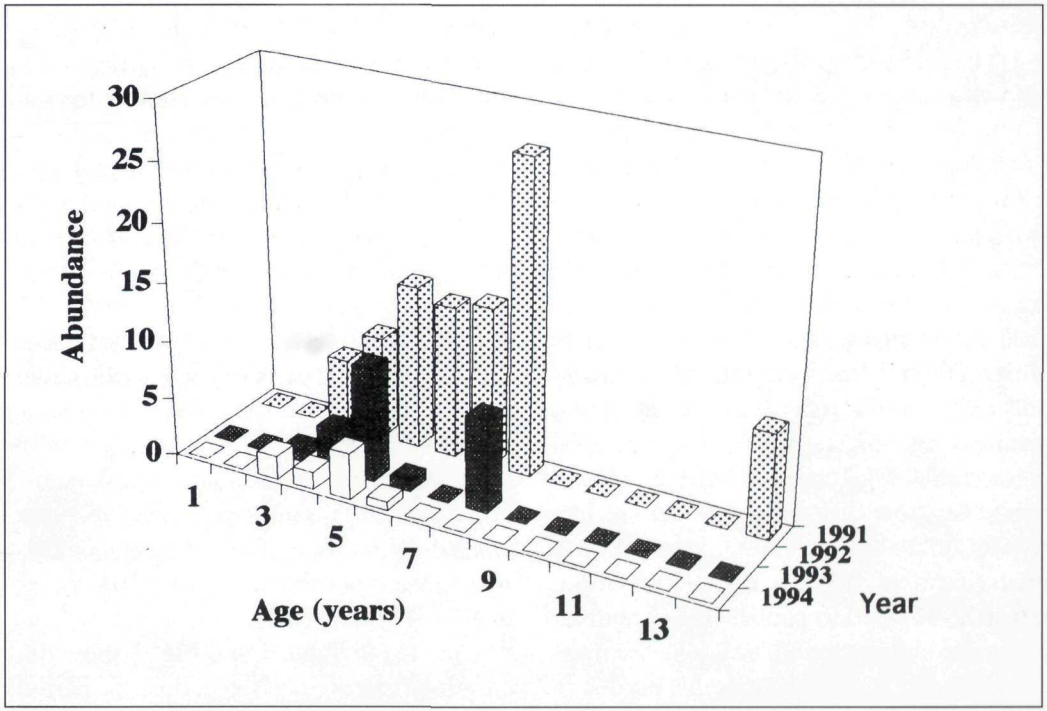

Fig 1. Abdundance (mean number per fish examined) of Anisakis simplex larvae in the fillets of saithe, Pollachius virens, from Faroese waters 1991-94.

Mynd 1. Tættleiki (miðaltal fyri hvønn kannaðan fisk) av Anisakis simplex ormverum í upsaflaki av Føroya-leiðini 1991-94.

tion of saithe infected, varied from zero to 100 %. The mean values for each year declined from 97 % in 1991, to 67 % in 1994 (Table 1). A tendency of decreasing infection in the same age-class could also be observed (Table 2). Abundance, expressed as the mean number of parasites per saithe, including uninfected fish, varied between zero and 27 larvae per fish (Fig.1). The right and left anterior sections of the ventral fillet (A and D) were statistically different ($p<0.001$ and $p<0.01$, two sample t-test, see Fig.2 and Table 3). The left fillet contained 62 % and the ventral sections had 95 % of the total number of larvae found (Fig. 2). The ventral anterior sections contained 75 % of the nematode larvae in the fillets.

Discussion

Hauksson (1992) investigated a large number of various fishes from Icelandic waters for nematodes in all organs and in the muscles. In saithe he found a range of 0-33 *A. simplex* larvae per fish, the prevalence was

Year	1991			1993			1994		
Age	M	SD	n	M	SD	n	M	SD	n
3	6,0	5,3	3	1,0	1,5	20	2,0	2,6	8
4	8,8	8,9	25	3,6	4,1	10	1,5	1,9	22
5	14,0	15,5	41	9,8	8,4	5	4,0	4,3	7
6	13,0	11,3	32	1,0		1	0,8	0,9	8
7	13,7	14,6	10	0,0		1	0,0		1

Table 2. Abdundance (M) and standard deviation (SD) of Anisakis simplex larvae in the fillets of age groups of aithe, Pollachius virens, from the Faroe-Area. n: number of fishes.

Talva 2. Miðaltøl (M) og standardfrávik (SD) fyri Anisakis simplex ormverum í upsaflaki hjá fylgjandi árgangum av upsa, Pollachius virens. n: tal av upsa.

72.2 % and abundance 3.89 larvae per fish. However, no larvae were found in the muscles. This could be due to the technique used, which was slicing and inspection on candle table. The relatively small and transparent larvae easily escape detection, like in McClelland *et al.* (1990) who report a loss of 68 % of *Anisakis simplex* in a visual search, compared to pepsin-HCl-digestion. The same authors found 5-10 % in the muscles of the total *Anisakis simplex* burden in Canadian saithe ("pollock"). Køie (1993) reported *Anisakis simplex* third stage larvae in the mesenteries and on the surface of the internal organs in 27 fish species from Faroese waters. Six out of ten small saithe (28-32 cm) were infected. Even if the larger gadoids and some other fishes were only examined in the viscera and head, the thorough work of Køie *op.cit.* seems to point out the difficulty in finding *Anisakis simplex* in the musculature by visual examination.

The data in Table 1 and Fig. 1 show decreasing figures of larvae in the time period 1991-1994, both in prevalence (percentage infected) and abundance (mean number of larvae per fish examined). The high values

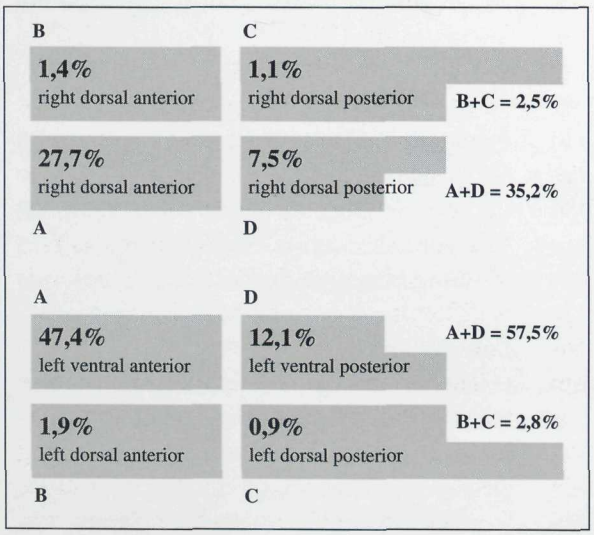

Fig. 2. The distribution of Anisakis simplex larvae in the fillets of saithe, based on 305 fishes. The figure shows a filleted saithe, cut into the eight parts, mentioned in the text (imagine you are looking down onto the two halves of the fish muscles). A-D: letter designation of the different parts of the lateral muscles (bold numbers are percentages of total larval counts).

Mynd 2. Býtið av Anisakis simplex ormverum í upsaflaki, grundað á 305 fiskar; dorsal: ryggpartur; ventral: búkpartur; anterior: fremri; posterior: aftari; left: vinstraflak; right: høgraflak. Myndin sýnir teir átta partarnar, ið hvør upsin var lutaður sundur í, aftaná at verða skorin til flak (á myndini sæst niður á ávikavist høgra og vinstra flakið). A-D: bókstavanøvn fyri teir ymsu partarnar av fiskavøddunum (tøl við tjúkkum stavum eru prosent-virðir av samlaðum ormveru-tali).

Year	1991	1992	1993	1994	Totals:
infected fishes	125	38	68	31	262
not inf. fishes	4	2	22	15	43
total right	4,96	4,71	4,40	0,97	4,31
total left	8,70	8,87	5,63	1,71	7,10
stat. diff.	***	*	n.s.	n.s.	***
right A	4,09	3,05	1,92	0,15	2,72
left A	7,31	5,95	2,29	0,61	4,64
stat. diff.	**	n.s.	n.s.	*	***
right D	0,52	1,23	1,00	0,41	0,74
left D	0,91	1,98	1,61	0,50	1,18
stat. diff.	*	n.s.	n.s.	n.s.	**
right B	0,13	0,15	0,19	0,02	0,13
left B	0,19	0,23	0,24	0,02	0,19
stat. diff.	n.s.	n.s.	n.s.	n.s.	n.s.
right C	0,07	0,05	0,21	0,07	0,11
left C	0,02	0,28	0,11	0,02	0,09
stat. diff.	n.s.	n.s.	n.s.	n.s.	n.s.

Table 3. Values of the mean for paired two sample t-tests for the difference in the number of Anisakis simplex larvae in the right and left sections of saithe fillets, A, D, B, C, as in Fig. 2; *: $p<0.05$; **: $p<0.01$; ***: $p<0.001$; n.s.: not significant; stat. diff.: statistical difference (the table is comparing infected fishes only).

Talva 3. Tøl fyri miðalvirðir frá paraðari t-test fyri munin í tali av Anisakis simplex ormverum í vinstru (left) og høgru (right) pørtunum av upsaflaki A, D, B, C, eins í Mynd 2. *: $p<0.05$; **: $p<0.01$; ***: $p<0.001$; n.s.: ikki signifikantur munur; stat. diff.: hagfrøðiligur munur (talvan samanber bert fiskar, ið eru infiseraðir).

of the standard deviation compared to the mean values (Table 2) reflect a general pattern in parasitologic examination, the tendency of high levels of variation. A slight decrease in infection levels with the time for the same age-group can nevertheless be seen in Table 2. This may be explained by an increase in the immune response effect from the infected fishes, as is suggested by Priebe *et al.* (1991). Decreasing infection levels in saithe from length group 40-49 cm are also reported by Scott (1985).

The pooling of all fishes examined in Fig. 2, showing the distribution of the *Anisakis simplex* larvae in the fillets could be critisized. However, in an extensive statistical analysis Novotny and Uzmann (1960) found no dependence between age of fish or geographical place, and the distribution of *Anisakis* sp. larvae in chum salmon, *Oncorhynchus keta*.

The higher abundance found in the left side of the fish is striking (Fig. 2 and Table 3). The ventral parts A, D were statistically different when comparing the right and the left side, but not the dorsal parts B and C. Brattey and Bishop (1992) report the same difference for *Anisakis simplex* in the fillets of cod from Canadian waters. They also found significant difference between the bellyflaps (referred to as "the napes"). A similar distribution for *Pseudoterranva decipiens* in Canadian cod is reported by Brattey *et al.* 1990.

Why the two different fish species saithe and cod do have uneven distributions of the nematodes in the musculature remains to be explained. One possible reason for the difference between the left and the right side could be the assymetry of the organs inside the body cavity. But this hypothesis is difficult to prove by experimental infection.

The comparison of saithe from Faroese waters with other areas in the North Atlantic is justified in Joensen and Tåning (1970), who report considerable migrations to and from the Faroe area to Icelandic wa-

ters, Norwegian waters and the North Sea. The present study showed prevalences from 67.4 % to 96.9 % in the muscles, the abundance ranging from 0 to 27 per fish. The reason for these high values most likely are explained by the main diet of the adult saithe, which according to Joensen and Tåning *op.cit.* are: herring, scopelids, euphausiaceans and cephalopods, who generally are infected with *Anisakis simplex* (see e.g.; Davey 1972; Smith 1983, 1984).

Taking into account the high abundances of *Anisakis simplex* found in the fillets of saithe, and keeping in mind that the stock of saithe is among the largest fish stocks in the area, the question arises whether the saithe contributes to the maintenance of *Anisakis simplex* in population or not. If the saithe can pass these nematode larvae to its final host, then it may be considered to have importance. If not, then it is a blind alley or "wrong address" for the *Anisakis simplex* larvae. Desportes and Mouritsen (1993) found no saithe in the stomach of the pilot whale, a common whale in Faroese waters. In Canadian Pacific waters Margolis and Pike (1955) found adult *Anisakis simplex* in the stomach of the killer whale, *Orcinus orca*. However, neither Bloch and Lockyer (1988) nor Sigurjónsson (1993) report saithe as a food item for killer whales in European waters. Haug *et al.* (1995), however, found adult saithe in the mink whale, *Balaenoptera acutorostrata*, from Lofoten-Vesterålen. Mink whale from this area and from around Faroes is considered to belong to the same, relatively large North-East stock (Sigurjónsson 1993). This whale contains high infections of mature *Anisakis simplex* (Aspholm 1995). Even if no records seem to exist of adult saithe in mink whale in the Faroe-area, the situation must presumed to be the same as in other parts of the North-East Atlantic. Then the infection of saithe with *Anisakis simplex* third stage larvae most likely will contribute to the completion of the *Anisakis simplex* life cycle. Whether this contribution is high or low the work of Aspholm *et al.* (1995) should be kept in mind. They showed that a low infection of the final host of sealworm *Pseudoterranova decipiens* appear to sustain a stable infection in the surrounding fishes. A similar mechanicm, too, may be working in the *Anisakis simplex*-life cycle.

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