

Food and parasitic nematodes of saithe, *Pollachius virens* (L.), from the Faroe Islands

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Food items and metazoan parasites were identified from the stomachs of 80 yearlings and 150 two-year-old saithe (*Pollachius virens* (L.)), sampled from the coastal waters of the Faroe Islands. Of a total of 65 food items found, 47 were identified to species or genus. Yearlings fed mainly on *Parathemisto* spp., euphausiids, *Pandalus* sp. and *Aphrodita aculeata*, while the two-year-old saithe exploited mainly euphausiids (especially *Meganyctiphanes norvegica*), sandeels (*Ammodytes* spp.) and gastropods (especially *Littorina* spp.). Parasites found included the nematodes *Anisakis simplex*, *Contracaecum* sp., *Hysterothylacium aduncum* and *Cucullanus cirratus*; the copepod crustaceans *Caligus* sp. and *Clavella* sp.; the acanthocephalan *Echinorhynchus gadi*; a single digenean trematode; and a single cestode plerocercoid. Adult saithe from the Faroe Shelf preyed mainly on fish (*Trisopterus esmarki*, *Micromesistius poutassou* and *Melanogrammus aeglefinus*), and saithe from Faroe Bank on *M. norvegica*. A discussion on a possible transmission route of *A. simplex* larvae is given.

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INTRODUCTION

The food of saithe (coalfish, *Pollachius virens* (L.)) in Faroese waters was investigated by Paulsen (1918), Berthelsen (1942) and Nicolajsen (1993). Food investigations of saithe have also been conducted in Icelandic waters by Pálsson (1983), in Norwegian waters by Lie (1961) and Nedreaas (1987), and in Russian waters (Barents Sea) by Mironova (1961). Although analyses of stomach contents usually are carried out as a part of general ecological or behavioural studies, they may also reveal important aspects of the life cycles of fish parasites. Most endoparasitic helminths are transmitted to the fish host by its prey, and stomach contents may include (1) recently ingested larvae or parasites which ultimately migrate to the body cavity or fillets (e.g. the nematode *Anisakis simplex*), (2) larval parasites that subsequently mature in the alimentary canal (e.g. the nematodes *Cucullanus cirratus* and, to some extent, *Hysterothylacium aduncum*) and (3) known or suspected intermediate hosts. In this study we examined relationships between larval parasitic nematodes (e.g. *A. simplex*) found in stomachs of saithe and their potential intermediate hosts (e.g. euphausiids) in the diet of saithe.

MATERIAL AND METHODS

YOUNG SAITHE FROM THE COASTAL WATERS OF THE FAROE ISLANDS

Stomachs were dissected from 80 yearlings and 150 two-year-old saithe, collected at Leirvík, Faroe Islands, from January through December 1996 (Højgaard 1997). The stomachs were frozen within hours of capture and stored at -18°C . Subsequently thawed and dissected, the contents were examined under a stereo-microscope at 6 to 50 \times , in physiological saline (0.9 % NaCl solution) where necessary. The stomachs were weighed with and without food content to determine the degree of fullness on a scale from 1 to 6 (1: empty; 2: small amounts; 3: half-filled; 4: full; 5: distension; 6: inverted) (see e.g. Lie 1961). Individual food items were weighed to 0.001 g and rounded up to 0.01 g. The degree of digestion was determined on a scale from 1 to 5 (1: not digested at all; 2: very little digestion, still possible to identify to species; 3: approximately 50 % digested, but possible to identify to taxonomic group; 4: highly digested, only parts of the animal can be seen; 5: fully digested, not possible to identify any group). The nomenclature and taxonomy of prey were according to



Hayward & Ryland (1996), and the names of algae, in some cases, were according to Jóhansen (1979).

ADULT SAITHE FROM THE FAROE SHELF

The stomachs of 24 three- to seven-year-old saithe from the Faroe Shelf (See Højgaard 1995a) were dissected, and the contents identified to species from remains or otoliths. Nematodes in visceral organs, with the excep-

tion of the stomach, were recovered by pepsin digestion (see Højgaard 1997) and counted.

ADULT SAITHE FROM THE FAROE BANK

Nematodes were found in the stomachs of 33 four- to six-year-old saithe from the Faroe Bank taken on 5-6 May 1993. The nematodes were stored in 70 % ethanol, cleared in glycerol, and selected specimens mounted in glycerol jelly.

Table 1. Stomach content and metazoan parasites of young saithe, caught in January to December at Leirvík, Faroe Islands in 1996. A total of 80 one-year old saithe and 150 two-year old saithe was examined; F= frequency in percentage (of fish numbers); W = weight in percentage of total food weighed; yr = year; unid. = unidentified; * = identification by otoliths. The table does not include the combined weight of crustacean and fish remains, constituting 1.1 % for one-year-old saithe and 9.2 % for two-year-old saithe. The weight of totally digested material was 44 % for one-year-old saithe and 13 % for two-year-old saithe.

Group (phylum or class)	Subgroup (class, order or family)	Genus or species	Age of saithe			
			1 yr F %	2 yr F %	1 yr W %	2 yr W %
Cnidaria	Hydroida	unid.	5.0	15.3	0.1	0.5
Platyhelminthes	Trematoda, Digenea	unid.		1.3		0.0
	Cestoda	unid. plerocercoid	1.3		0.0	
Nematoda	Anisakidae	<i>Anisakis simplex</i> (Rudolphi, 1809)	1.3	3.3	0.0	0.0
	Anisakidae	<i>Contracaecum</i> sp.		2.0		0.0
	Anisakidae	<i>Hysterothylacium aduncum</i> (Rudolphi, 1802)	27.5	33.3	1.5	0.6
	Cucculanidae	<i>Cucculanus cirratus</i> Müller, 1777	7.5	8.0	0.0	0.0
Acanthocephala	Palaeacanthocephala	<i>Echinorhynchus gadi</i> Muller		0.7		0.0
Annelida	Polychaeta, Sedentaria	<i>Pectinaria</i> sp.		1.3		0.0
	Polychaeta, Errantia	<i>Nereis pelagica</i> L.		0.7		0.0
	Polychaeta, Errantia	<i>Nereis</i> sp.		0.7		0.0
	Polychaeta, Errantia	<i>Aphrodita aculeata</i> (L.)	5.0	7.3	10.5	4.1
	Polychaeta	unid.		1.3		0.0
Crustacea	Copepoda	<i>Calanus finmarchicus</i> (Gunnerus, 1765)		3.0		0.0
	Copepoda	<i>Caligus</i> sp.	1.3		0.0	
	Copepoda	unid.		0.7		0.0
	Lerneopodida	<i>Clavella</i> sp.		0.7		0.0
	Cirripedia	<i>Lepas</i> sp.		0.7		0.1
	Mysidacea	<i>Mysis</i> sp.	3.8	3.3	0.1	0.0
	Isopoda	<i>Idothea baltica</i> (Pallas)		4.0		0.4
	Isopoda	<i>Idothea</i> sp.		0.7		0.0
	Amphipoda	<i>Parathemisto gaudichaudi</i> Guérin	10.0	1.3	0.3	0.4
	Amphipoda	<i>Parathemisto</i> sp.	46.3	20.7	18.3	0.6
	Amphipoda	<i>Caprella equilibra</i> Say	1.3		0.1	
	Amphipoda	<i>Caprella</i> sp.		0.7		0.0
	Amphipoda	<i>Gammarus</i> sp.	2.5	1.3	0.3	0.0
	Euphausiacea	<i>Meganyctiphanes norvegica</i> (M. Sars)		4.0		3.2
	Euphausiacea	<i>Thysanoessa</i> sp.		0.7		0.0
	Euphausiacea	unidentified	17.5	27.3	0.3	15.8
	Euphausiacea	furcilia	1.3	4.7	0.0	0.0
	Decapoda, Natantia	<i>Pandalus</i> sp.	10.0	18.7	6.9	1.9
	Decapoda, Natantia	<i>Pandalus</i> sp. (zoea-stage)		0.7		0.0
	Decapoda, Natantia	<i>Pandalus</i> sp. (larva)		0.7		0.0
	Decapoda, Reptantia	<i>Pagurus</i> sp.	8.8	8.0	0.9	0.3
	Decapoda, Reptantia	<i>Galathea</i> sp.	2.5	1.3	0.1	0.1



RESULTS

YOUNG SAITHE

Seventy-five different food items were recovered from 230 saithe, 36 from yearlings and 65 from two-year-olds (Table 1). Stomach contents included 47 food items, which were identified to species or genus, 9 parasite taxa, and two kinds of artefacts (nylon line, plastic). Of

the stomach content, totally digested material (stage 5) comprised 44 % by weight for the yearlings (one-year-old saithe), and 13 % of the stomach content for the two-year-olds, and was excluded from the calculations. Euphausiids were digested to the extent (mostly stage 4) that identification to species was seldom possible, although *Thysanoessa* sp. were identified in 0.7 %, and *Meganycitophanes norvegica* in 4.0 % of the cases. In the one-year-old saithe the main food items were (by %

Table 1. (Continued)

Group (phylum or class)	Subgroup (class, order or family)	Genus or species	Age of saithe			
			1 yr F %	2 yr F %	1 yr W %	2 yr W %
Mollusca	Crustacea	unid. mysis-larva		0.7		0.0
	Crustacea	unid. remains	13.8	10.7	6.1	0.9
	Polyplacophora	<i>Helcion</i> sp.	1.3	1.3	0.1	0.3
	Gastropoda	<i>Littorina littorea</i> (L.)	1.3	9.3	0.0	1.3
	Gastropoda	<i>Littorina obtusata</i> (L.)	2.5	2.7	0.2	0.0
	Gastropoda	<i>Littorina</i> sp.		4.7		0.3
	Gastropoda	<i>Gibbula</i> sp.		0.7		0.0
	Gastropoda	unid.		1.3		0.0
	Bivalvia	unid.	1.3		0.1	
	Cephalopoda	unid. larva	1.3		0.0	
Vertebrata	Pisces, Ammodytidae	<i>Ammodytes tobianus</i> L.		2.7		0*
	Pisces, Ammodytidae	<i>Ammodytes marinus</i> Raitt, 1934	1.3		0*	
	Pisces, Ammodytidae	<i>Ammodytes</i> sp.	6.3	36.0	6.8	37.1
	Pisces, Gadidae	<i>Trisopterus esmarki</i> (Nilsson, 1855)	1.3	0.7	0.0	0.0
	Pisces, Liparidae	<i>Liparis</i> sp.	1.3	0.7	0.3	0.6
	Pisces, Pholidae	<i>Pholis gunellus</i> (L.)		0.7		0.3
	Pisces, Cottidae	unid.		0.7		0.0
	Pisces, Scorpidae	unid.		0.7		0.0
	Pisces, Heterostomata	unid.	1.3		0.2	
	Pisces	unid.	1.3		0.1	
	Pisces	unid. larva		4.0		0.1
	Pisces	unid. juvenile	1.3		0.3	
	Pisces	unid. remains		8.7		3.5
	Aves	bird feather	1.3		0.0	
Plantae	Chlorophycophytta	<i>Ulva lactuca</i> L.		0.7		0.0
	Chlorophycophytta	unid.		0.7		0.0
	Phaeophycophytta	<i>Laminaria</i> sp.		0.7		0.0
	Phaeophycophytta	<i>Alaria esculenta</i> (L.) Grev.		0.7		0.0
	Phaeophycophytta	<i>Ascophyllum nodosum</i> (L.) Le Jol.		0.7		1.4
	Phaeophycophytta	unid.	3.8	4.0	0.1	0.6
	Rhodophycophytta	<i>Rhodomenia palmata</i> (L.) Grev.	1.3	2.0	0.2	1.8
	Rhodophycophytta	<i>Rhodomenia</i> sp.		0.7		0.0
	Rhodophycophytta	<i>Odonthalia dentata</i> (L.) Lyngb.	1.3	0.7	0.0	0.0
	Rhodophycophytta	<i>Plocamium cartilagineum</i> (L.) Dixon.	5.0	2.0	0.1	0.0
	Rhodophycophytta	<i>Plocamium</i> sp.		0.7		0.0
	Rhodophycophytta	<i>Ptilota plumosa</i> (L.) C. Ag.		0.7		0.0
	Rhodophycophytta	unid.	6.3	4.7	0.0	0.0
	Algae	unid.		0.7		0.3
Artefacts		nylon line		1.3		0.0
		plastic		1.3		0.0



in weight): *Parathemisto* spp. (18.3 %), *Aphrodita aculeata* (10.5 %) and *Ammodytes* sp. (6.8 %). In the two-year-old saithe the figures were: euphausiids (15.8 %) and *Ammodytes* sp. (37.1 %) *Anisakis simplex* larvae were recorded in both age groups, but were rare in stomach contents. No *Pseudoterranova decipiens* occurred in the stomachs, and *Contracaecum* sp. was found only in the two-year-old saithe, but *Cucullanus cirratus* was recorded in both age groups of saithe. *Hysterothylacium aduncum* (larvae or adult) was the most prevalent nematode, being found in 27.5 % of the yearling and 33.3 % of the two-year-old saithe.

ADULT SAITHE FROM THE SHELF FAROE

The food of 17 (71 %) of 24 adult saithe from the Faroe Shelf consisted of "fish". The fish species identified were *Trisopterus esmarki*, *Micromesistius poutassou* (Risso, 1810), and *Melanogrammus aeglefinus* (L.). Crustaceans found in seven (29 %) saithe could not be identified because of the high degree of digestion. Third-stage larvae of *A. simplex* were found only in the stomachs of 2 (8 %) of 24 saithe from the Faroe Shelf. *A. simplex* larvae infected the viscera of 20 (83 %) saithe, however, with the mean number being 14.6 (range 1 to 50). *Hysterothylacium aduncum* adults were found in 22 stomachs (92 %), with the mean number 13.1 (range 1 to 52). *H. aduncum* larvae were found in five (21.0 %), mean number 0.21, maximum number 1).

Larval *Pseudoterranova decipiens* (in 17 %, mean 0.29 %, range 1 to 3) and *Contracaecum* sp. larvae (in 8 %, mean 0.13 %, range 1 to 2) were also recovered by digestion of viscera. *H. aduncum* adults were found in 67 %, mean 2.0, range 1 to 11, and *H. aduncum* larvae in 8 %, mean 0.08, maximum number 1.

ADULT SAITHE FROM THE FAROE BANK

Meganactiphanes norvegica was found in the stomachs of 32 (97 %) of 33 adult saithe from Faroe Bank, while "fish" occurred in stomach contents of four (13 %). No data was available for the food of one saithe. Third-stage larvae of *A. simplex* was found in the stomachs of 15 (45 %) of 33 saithe (mean no. 6.6, range 1 to 38). The stomachs of 15 saithe (45 %) contained both *M. norvegica* and *A. simplex* larvae. *H. aduncum* adults were found in all stomachs (mean no. 18.1, range 1 to 52) and *H. aduncum* larvae were found in six (19.4 %) of the 33 stomachs (mean no. 0.26, range 1 to 2).

DISCUSSION

Saithe are migratory fish which spend their first two years in coastal waters before moving offshore (Joensen & Tåning 1970; Højgaard 1997). Each habitat offers quite different food availability. The over-all picture

from the present study is of an extremely varied diet for the two age groups from coastal waters taken together, and appears to indicate two different feeding niches, leading to a minimum of competition for the common food items.

Given the low frequency of larval *A. simplex* in the stomach of young coastal saithe and adult offshore saithe from Faroe Shelf, and given the fact that *M. norvegica* was seldom identified in the stomach content of these fish, the relationship between the parasite and intermediate host was not evident. The frequent co-occurrence of *M. norvegica* and *A. simplex* larvae together in the stomachs of adult saithe from the Faroe Bank suggests, however, that *A. simplex* third-stage larvae may have been transmitted by *M. norvegica*. This finding is supported by successful transmission of *A. simplex* to *M. norvegica* (see Højgaard 1995b) and from field data on other fish species. Sluiter (1974) reported a significant correlation between the number of *Anisakis* sp. larvae and the euphausiids *M. norvegica* and *Thysanoessa raschii* in the stomachs of herring, *Clupea harengus* L. *M. norvegica* is also found in about 25 % of the stomachs of Atlantic salmon, *Salmo salar* L., (J.A. Jacobsen, pers. commn), with high levels of larval *A. simplex* (Beverley-Burton & Pippy 1978; Bristow & Berland, 1991; Holst & al. 1993; Berland & Jacobsen 1997). It should be borne in mind, however, that the prevalence of infection in euphausiids may vary extensively (Smith 1983) and that host susceptibility to infection also exhibits variation (McClelland 1994).

No larval *Pseudoterranova decipiens* was found in the stomach, despite the rather high levels of infection in the viscera and muscles (23 to 38 % prevalence of infection with larval *P. decipiens* in one-year-old saithe, and 18 to 60 % prevalence of infection in two-year-old saithe (Højgaard 1997)). This finding may indicate a rapid migration of larval *P. decipiens* out of the stomach. The very low numbers of *A. simplex* larvae found in the stomach of young saithe, compared with (1) high levels of infection in the viscera and fillets of young saithe (20 to 80 %) and (2) a substantially higher number in the stomach of adult saithe also suggests a relatively rapid escape out of the stomach in young saithe, while a longer migration time appears to occur in large fish when their stomachs are filled with euphausiids.

According to Paulsen (1918) macroplankton in the stomachs of one-year-old saithe from the Faroes consisted of copepods and ostracods, while euphausiids were lacking. In a more extensive study of 0-group and one-year-old saithe from the Faroes, Berthelsen (1942) stated that "euphausiids have been observed in only few cases". Both Paulsen (op.cit.) and Berthelsen (op.cit.) investigated saithe in the late spring or early summer (May/June) in sheltered fjords. The present study and



the cited studies are therefore not directly comparable. However, littoral species such as amphipods, isopods, mysids and polychaetes, seem to occur in similar frequencies in the yearlings in both studies (see Table 1). Invertebrate and fish food items in Nedreaas (1987) and the present study seem to correspond closely in annual and species variation. The same picture is appearing when comparing results from Barents Sea saithe (See Mironova 1961).

The food of adult saithe in the Faroe area was investigated by Andreassen & Guðjónsson (1984); they reported Norway pout as the main food item. Both Nicolajsen (1993) and P. Steingrund (pers. commn) found Norway pout, euphausiids and blue whiting to be the most important food for adult saithe in Faroese waters. Wootten (1978) reported high levels of infections with *A. simplex* larvae (and *H. aduncum* and *Contracaecum* sp.) in small (0- to two-year-old) gadoids such as Norway pout and haddock in the northern North Sea. Data on the infection of small (0- to one-year-old) specimens of blue whiting (*Micromesistius poutassou* (Risso, 1810)), seems not to be available, but examinations of adult (2 to 12 years) *M. poutassou* showed high levels of infection with larval *A. simplex* (see e.g. MacKenzie 1979; Karasev 1989; Køie 1993a; Højgaard 1998). Norway pout, haddock and blue whiting were found in the stomach of adult saithe from Faroe Shelf and these fish species feed on euphausiids (see e.g. Raitt 1968; Joensen & Tåning 1970; Andreassen & Guðjónsson 1984). It seems likely, there-

fore, that the adult saithe acquire a substantial proportion of their infection with larval *A. simplex* by feeding on fish transport hosts that have fed on infected euphausiids. These findings may help to explain the high levels of larval *A. simplex* infection that Højgaard (1995a) reports in adult saithe.

In samples from both the Faroe Bank and from the Faroe Shelf, prevalence and intensity of infection with *H. aduncum* was very high. Smith (1983) recorded *H. aduncum* in euphausiids, but Køie (1993b) elucidated the life cycle of *H. aduncum* and reported copepods, mysids, amphipods and isopods, among others, as intermediate hosts, but not euphausiids. *H. aduncum* has been recorded in poor cod, *Trisopterus minutus* (see Wootten 1978; Køie 1993a), in haddock (see Wootten 1978; Køie 1993a) and in blue whiting (see Køie 1993a; Karasev 1989). Apparently saithe is infected with *H. aduncum* by feeding on these fish species, as well as by preying on the invertebrate intermediate hosts mentioned above.

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