A note on the variation in sealworm (*Pseudoterranova decipiens*) infection in short-horn sculpin (*Myoxocephalus scorpius*) with host age and size at two locations in Norwegian inshore waters

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ABSTRACT

A total of 540 shorthorn sculpins were collected between 1991 and 1996 from Hvaler and Vega in Norway. The sculpins were caught in traps or by gillnets near seal haul-out sites in both areas. Size, age and intensity of *P. decipiens* infection were recorded for most fish sampled. Stomach contents of a subsample from each area were examined and the frequencies of occurrence of prey items were determined. Sealworm abundance (mean number of worms in all fish examined) increased significantly with host age and length within given age groups of sculpins from both areas. Sealworm abundance and mean intensity (mean number of worms per infected fish) in sculpins from Vega were lower than those found in the more rapidly growing fish from Hvaler. Abundance of sealworm peaked in 6 year old fish from Vega and in 4 year old fish from Hvaler. Fish and amphipods were the prey items found most frequently in the stomach of fish from Hvaler, while fish and decapods were found most frequently at Vega.

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INTRODUCTION

The ascaridoid nematode *Pseudoterranova decipiens* (Krabbe, 1878), also known as cod- or sealworm, matures in the stomach of seals, while benthic invertebrates and demersal fish host the larval stage(s) (McClelland 1990, 1995). There is some disagreement as to whether sealworm develop to the L2 (Measures and Hong 1995) or the L3 (Køie *et al.* 1995) larva within the egg. The eggs then sink to the seabed. The L2 (or L3) larva which emerges from the egg attaches there until it is eaten by an invertebrate host, usually a small crustacean. The larvae are then transmitted either directly, or via larger crustaceans to a fish host. The shorthorn or common sculpin (*Myoxocephalus scorpius* L.) (Fig. 1) is one of the most heavily infected fish species found near seal colonies in North Atlantic waters (Haukson 1992, Jensen and Andersen 1992, Jensen *et al.* 1994). This fish species is a long

Fig. 1. *The shorthorn sculpin (Myoxocephalus scorpius) may be a major intermediate host of sealworms in Norwegian waters. Photo: T. Jensen*

living sedentary species that is widely distributed in temperate and cold coastal waters (Scott and Scott 1988, Pethon 1989).

The main objective of this study was to describe and compare *P. decipiens* infections in sculpins from two locations; Hvaler and Vega (Fig. 2). These two areas differ in topography and are located at different latitudes. Further, only common seals (*Phoca vitulina*) are present at Hvaler, while both common and grey seal (*Halichoerus grypus*) haulout sites are found at Vega (Jensen *et al.* 1994). Since sealworm larvae are transmitted to a given host in its prey and may be long lived in their fish intermediate hosts (Hemmingsen *et al.* 1993), the following hypothesis will be tested: Sealworm abundance increases with host age, and with host length within given host age groups.

MATERIALS AND METHODS

The Torbjørnskjær archipelago at Hvaler in the outer Oslofjord consists of about ten small islands and skerries. It is a usual haul-out site for a colony of common seals (N. Markussen, University of Oslo, personal communication). Sculpins were caught here in the near vicinity of the skerries and small islands, at depths less than 20-25 meters. In contrast, the rocky habitat at Vega in Nordland county covers an area of 1500–2000 km^2, with about 6500 islands and skerries. Most of the area is of less than 40 m in depth (Fig. 2.). Both grey and common seals are found at Vega. Grey seals, however, are more abundant and range over a larger area than common seals (K.A. Hovland, personal communication, 1980, Vega, Norway).

At both places, sculpins were caught using traps and gill nets(see Jensen *et al.* 1994 for details). The fish were deep frozen within a few hours of being caught and then transported to the laboratory. Prior to the parasitological examination, the fish were thawed overnight. Length and weight were recorded and otholiths were removed to be used for age determination. The fish were then cut open and worms in the body cavity were removed and counted. The fillets and napes were examined by systematic destruction of the flesh over a light table and worms were removed and counted. Only very seldom were necrotic worms found and they were not counted. Worms were stored in 80% ethanol. The stomach content of 40 sculpins from Hvaler and 35 from Vega were examined and the frequency of occurrence of prey items was determined.

Table 1 shows the number of sculpins sampled by year in the two areas. Age could not be determined for all fish and these were not included in analyses which required ages. Most of the samples were taken during the spring months. Prevalence (the percentage of fish infected) varied between 90% and 100% in all samples. A Fisher exact test was applied to test for differences in sealworm abundance between age and size groups.

RESULTS

Total abundance of *P. decipiens* differed between years at both Vega and Hvaler (Table 1), but

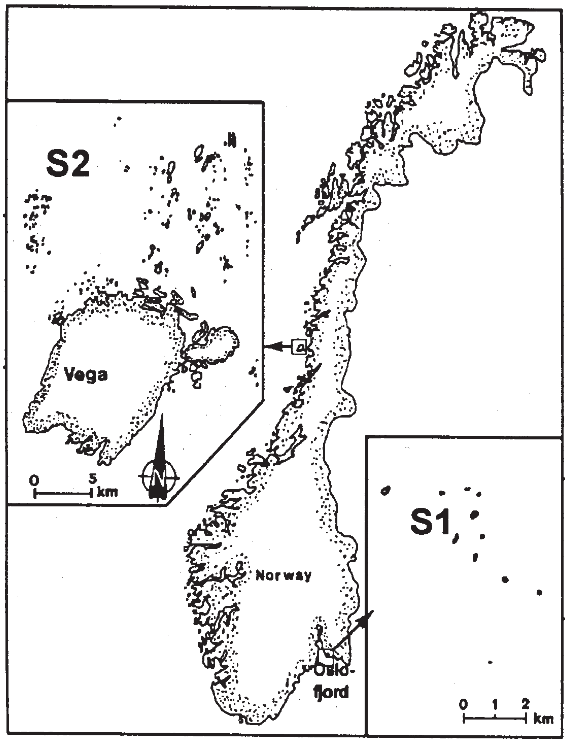

__Fig. 2__. Sampling sites at Hvaler in the eastern outer Oslofjord (S1) and Vega in Nordland, northern Norway (S2).

Table 1. Numbers and age distribution of sculpins examined, and abundance of *P. decipiens.* Prevalence varied between 90% and 100%.

Location	Year	n	Length, cm	Age	Average age	*P. decipiens* abundance	Range
Vega	1990	100	10-31	2-10	6.20	28.05	(1-293)
	1991	97	10-30	3-10	5.60	25.40	(1-281)
	1992	51	11-29	2-8	4.15	9.49	(1-23)
	1994	22	13-25	2-6	3.45	12.40	(3-68)
Hvaler	1991	19	10-32	-	-	19.47	(1-265)
	1992	162	10-43	1-10	4.20	41.55	(1-326)
	1994	51	10-35	2-10	5.56	54.44	(1-424)
	1996	9	19-28	2-6	4.44	57.22	(4-124)

Table 2. Abundance of *P. decipiens* in different age groups of sculpins sampled at Hvaler from 1992 to 1996. ( ) = range.

Age	n	1992 Abund.	s.d.	n	1994 Abund.	s.d.	n	1996 Abund.	s.d.
3+*	33	21.6	29.7	7	9.4	2.9	1	26.0	
4+*	29	56.9	50.6	3	54.6	59.6	3	95.6	
5+	31	69.1	64.0	14	45.6	29.2	2	(30-83)	39.9
6+	8	60.8	46.7	9	66.8	78.1	1	61.0	
7+	7	139.3	145.6	10	63.8	43.2	1	24.0	
8+	2	(28-168)		1	424.0				
≥9+	1	34.0		5	44.8	29.4			

* greatest increase in abundance.

Table 3. Abundance of *P. decipiens* in different age groups of sculpins sampled ay Vega from 1990 to 1994 . ( )=range.

Age	n	1990 Abund.	s.d	n	1991 Abund.	s.d	n	1992 Abund.	s.d	n	1994 Abund.	s.d
3	6	1.2	(0-4)	16	1.1	2.0	9	0.3	0.8	7	2.0	0.5
4	3	10.3	(4-15)	10	1.1	1.4	11	3.9	4.9	6	18.5	9.5
5*	18	10.8	11.9	22	12.5	13.7	5	10.2	7.1	3	34.3	29.1
6*	28	48.7	72.1	22	55.4	57.5	1	216.0	1	25.0		
7	14	18.8	25.7	6	35.2	45.4	1	21.0				
8	4	47.0	(0-76)	6	46.6	48.3	1	100.0				
9	4	73.7	(8-111)	2		(98-281)						

* greatest increase in abundance.

the disparities seemed attributable to differences in the age composition of the samples. When similar age groups were compared, worm abundance was fairly stable from year to year at locations (Tables 2 and 3).

Hvaler

Sealworm abundance peaked in 4 year old sculpins from Hvaler (Table 2). Abundance fluctuated in older fish, but there were not sufficient numbers of the latter to permit analysis. Since abundance within corresponding age groups were similar from year to year, fish from different sampling years were pooled for analysis of sealworm abundance/host-length relations within given host age groups. Sealworm abundances were greatest in the largest fish in all age groups containing enough fish to permit analysis (3 to 5) (Table 4).

Table 4. Variation of sealworm abundance with host length at Hvaler and Vega between 1991 and 1996.

Age Location	Size (cm.)	n	3+ Avg P.d. (s.d.)	n	4+ Avg P.d. (s.d.)	n	5+ Avg P.d. (s.d.)	n	6+ Avg P.d. (s.d.)	n	7+ Avg P.d. (s.d.)	n	≥8+ Avg P.d. (s.d.)
Hvaler	10-15	15	8.9 (21.5)										
	16-20	5	4.6 (4.5)	1	0								
	21-25	18	26.4 (25.6)	17	42.2 (31.5)	17	35.4 (21.1)	7	59.7 (32.0)	7	40.6 (27.7)		
	26-30	3	48.6 (44.1)	24	52.2 (40.1)	24	67.1 (41.4)	8	79.2 (48.6)	7	145.4 (143.0)	3	188.0 (205.6)
	≥31		2 116-238	4	153.3 (124.3)	4	85.3 (50.6)	4	63.5 (70.3)				
Vega	10-15					8	14.0 (15.5)	8	5.4 (3.5)				
	16-20					10	11.4 (13.6)	10	17.2 (19.2)	4	6.8 (4.9)		
	21-25					22	12.3 (10.4)	24	39.2 (46.0)	8	31.8 (30.1)		
	26-30					4	14.8 (6.1)	9	98.1 (74.0)	3	44.6 (46.5)		

Table 5. Variation of *P. decipiens* abundance with host age in selected year classes of sculpins sampled at Hvaler and Vega.

Location	Year	Year class	Age	n	Abundance	s.d.
Hvaler	1992	1985	7+	7	139.0	145.6
	1994	1985	≥9	5	44.8	29.5
	1990	1987	3+	5	0.4	-
	1992	1987	5+	31	69.1	64.0
	1994	1987	7+	10	63.8	43.2
	1992	1988	4+	28	56.9	50.6
	1994	1988	6+	7	66.8	78.1
	1992	1989	3+	33	21.6	29.8
	1994	1989	5+	31	45.6*	29.2
	1996	1989	7+	1	24.0	-
Vega	1990	1984	6+	28	48.7	72.1
	1991	1984	7+	6	35.2	45.4
	1990	1985	5+	18	10.8	11.7
	1991	1985	6+	22	55.4*	57.5
	1992	1985	7+	1	21.0	-
	1990	1987	3+	4	2.0	(0-2)[1]
	1991	1987	4+	10	1.1	1.4
	1992	1987	5+	5	10.2	7.2

[1] Range
* significant increase from the year before

Infections in given year classes of fish increased significantly between the age of three and five ($P<0.001$) (Table 5) and then tended to fluctuate, but again there were not enough data to verify the latter. The maximum intensity found was 444 worms in a 7-year old sculpin, 29 cm in length.

Vega

At Vega *P. decipiens* abundance increased up to age 6 in 1990 and 1991. Abundance appeared to remain high in older fish, but sample sizes were low and abundance after age 6 was not significantly different from other age groups. In all age groups with adequate data to permit analysis (5 and 6), abundance increased significantly with host length (data from all sample years pooled) (Table 4). Within given age classes (Table 3), there was a significant increase ($P < 0.001$) in sealworm abundance between age 5 and 6. The maximum intensity found was 293 worms in a 6-year old sculpin 26 cm in length.

Growth and diet of sculpins

Hvaler sculpins grew more rapidly than those from Vega (Fig. 3). A preliminary analysis of stomach contents showed some differences between sculpins from Hvaler and Vega (Fig. 4).

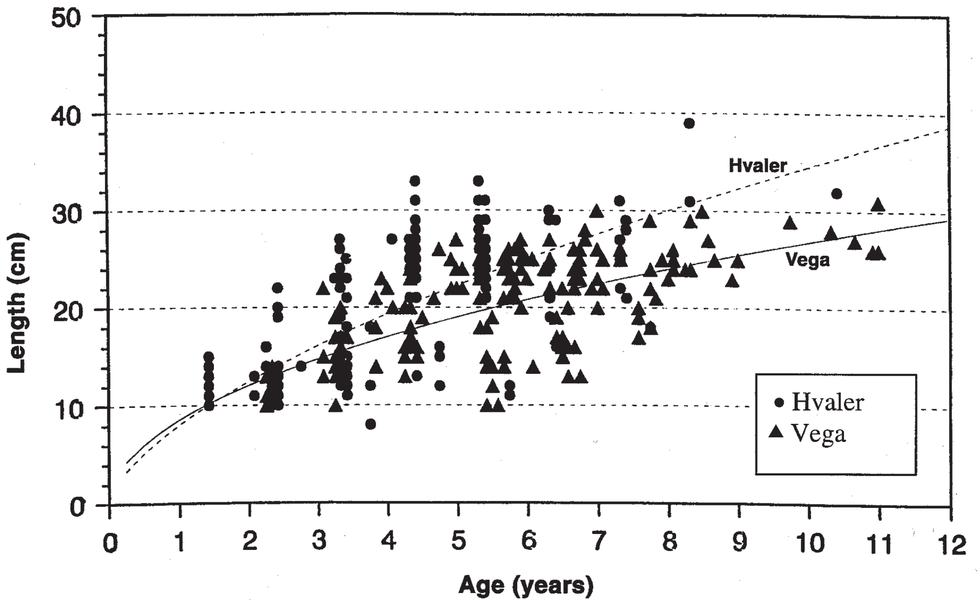

Fig. 3
Length (cm) at age (years) of sculpins caught at Hvaler and Vega between 1990 and 1993. Age corresponds to date when the fish was caught, assuming January as date of birth.

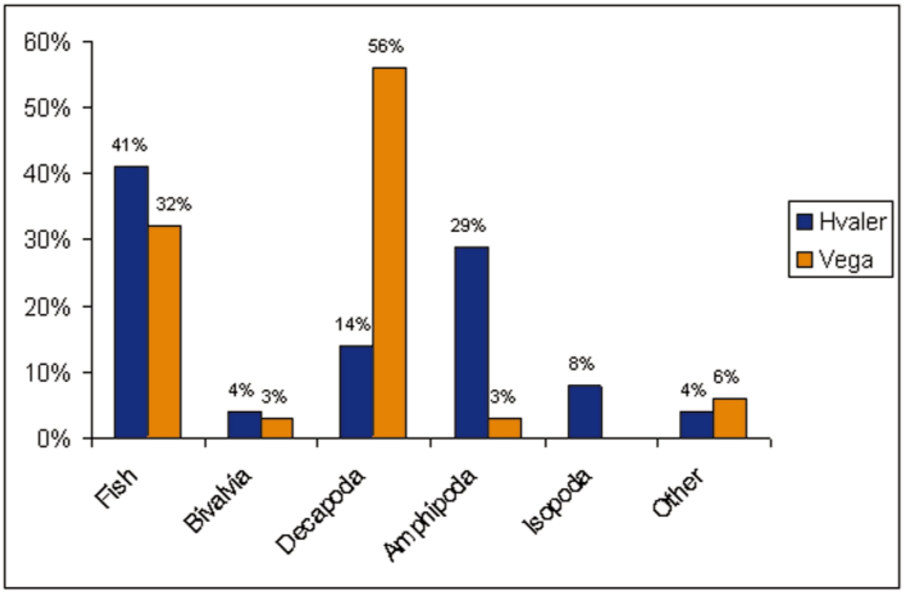

Fig. 4
Frequencies of food items in the stomachs of sculpins from Hvaler (n=40) and Vega (n=35).

Fish were among the most frequently exploited prey at both Hvaler and Vega,with the frequency in the diets of sculpins from the two sites being 41% and 32% respectively. However, while at Hvaler amphipods were the next most common prey items (*F*=29%), they were rarely consumed at Vega (*F*=3%). Decapods were by far the most common prey items at Vega, appearing in 56% of the stomachs. The main difference between fish from the two sites is therefore their relative consumption of amphipods and decapods.

DISCUSSION

Several authors have observed that sealworm infections in shorthorn or common sculpin are among the heaviest in fish species occurring in the vicinity of seal haul-out sites (Haukson 1992, Jensen and Andersen 1992, Kerstan 1992, Aspholm *et al.* 1995). In the present study, the distributions of sealworms in sculpin populations at Hvaler and Vega were overdispersed, and infection levels found in sculpins from Hvaler were higher than those reported elsewhere (Lamp 1966, Ennis 1970, Haukson 1992, Kerstan 1992, Aspholm *et al*. 1995). Since the sculpin is a stationary species and only migrates to somewhat deeper water during the winter (Pethon 1985) it might be useful as an indicator species for monitoring *P. decipiens* infections in areas with grey and/or common seals.

In the sculpin populations surveyed in the present study, sealworm abundance increased with host age as the fish matured, but fluctuated in older hosts. This pattern is often observed in helminth infections (Anderson and Gordon 1982, Kennedy 1984). Infection peaked, however, at 4 years in sculpins from Hvaler and at 6 years in the slower growing fish at Vega.

Fish appeared with about the same frequency in sculpin stomachs at both sites, but the diets of the two populations differed in regard to frequencies of occurrence of decapods and amphipods. The latter, common invertebrate hosts for sealworms (Marcogliese 1993), were rarely consumed by sculpins at Vega,, but were one of the 2 most common prey items at Hvaler. Decapods were by far the most common prey at Vega while seldom consumed at Hvaler. Hence the occurrence of heavier sealworm infection in the Hvaler population might be attributable to more frequent consumption of amphipods.

Very few studies have examined the relationships between host length or weight within given age groups and parasite abundance. Halvorsen and Andersen (1984) found that infection parameters of plerocercoids of the cestode *Diphyllobothrium ditremum* in Arctic char (*Salvelinus alpinus* L.) did not increase significantly with host weight within given host age groups. However, a tendency towards heavier fish having higher infections was seen. In the present study, sealworm parameters increased significantly with increasing host length within some host age groups. There were not sufficient numbers of sculpins, however, to permit statistical test of infection trends in the youngest and the oldest fish. The relationship between host size and sealworm levels thus seems clearly evident, with bigger fish in given age groups consistently carrying greater number of worms than smaller fish of the same age. This confirms the model developed for cod (des Clers 1989) of a simple accumulation from infected prey.

A negative impact of parasites on host growth and survival has been discussed for several parasite - fish host systems, both in farmed and natural host populations (Sindermann 1987, des Clers 1990). It is, however, difficult to assess the effects of parasites on host mortality in natural populations. In the present study an apparent decline in sealworm infection parameters in older fish, although it could not be tested statistically, might be an indication of parasite induced host mortality. This aspect will be addressed in a future paper.

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