

Short Communication

The occurrence of larval ascaridoid nematodes in wild-caught and in caged and artificially fed Atlantic cod, *Gadus morhua* L., in Norwegian waters

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ABSTRACT

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Fish farmers have long suspected that farmed cod were less heavily infected with larvae of ascaridoid worms than fish taken in the commercial fisheries. To test this hypothesis, a field experiment was designed to compare the worm burdens of caged and wild-caught fish over a 2-year period. The results showed an increase in the worm burdens of the wild fish but not in the caged fish. It is suggested that the transmission of food-transmitted ascaridoid larvae is broken through artificial feeding, which prevents new infections from establishing in the caged fish. The life expectancy of these worms in cod is probably more than 2 years.

INTRODUCTION

The occurrence of larval ascaridoid nematodes in Atlantic cod, *Gadus morhua*, and other food fish has received much attention in recent years owing to adverse consumer response and the public health significance of the worms (Smith and Wootten, 1978, Oshima, 1987, Bowen, 1990). Attention has focused on species of both whaleworm, *Anisakis* (herringworm in earlier literature), and sealworm, *Pseudoterranova* (codworm in earlier literature). Both genera have a confused taxonomic and nomenclatural history (Smith and Wootten, 1978) and the existence of sibling species has been recognised in recent years (Nascetti et al., 1986, Paggi et al., 1991).

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The Atlantic cod fishery in Norway has been of major importance for centuries, and the occurrence of worms has been of concern to the industry for many years (Agersborg, 1918). In recent times the situation has been described as a chronic cosmetic problem for the industry (Bowen, 1990), with much attention being paid to improved methods of detecting and removing worms from fish fillets in processing plants (Hafsteinsson and Rizvi, 1987). Requests for worm-free blocks or fillets have increased in recent years owing to increased consumption of raw fish dishes in western countries.

Interest in farming Atlantic cod in Norway has grown recently, especially as the commercial fisheries have fared badly in the past decade. Farming is based mainly on the catching of small cod (a little over 30 cm in length; the minimum legal landing size) and placing them in cages where they are grown on using artificial feeding. Ideally, this situation would lead to the complete absence of natural food-transmitted parasites. Therefore, one would expect lower infection levels in farmed cod than in commercially caught cod of the same length. In order to test this hypothesis, an experiment was designed to compare the worm burdens of caged cod and wild-caught cod over a two-year period.

MATERIALS AND METHODS

A total of 1000 Atlantic cod was caught randomly by a commercial fishing vessel in Altafjord (70°N) in October 1988. The cod were transported to Finnmark Research Center in Hammerfest and placed in cages (85 m³) situated 150 m from land over a depth of 30 m. The fish were fed uninfected food (cuttings from the codfillet industry) which had been stored frozen (−30°C) for at least 20 days before use. Every third month during a period of 2 years, 40 fish were sampled at random from the cages. For 1 year, parallel samples were taken from the wild population in Altafjord by a fishing vessel. This was performed in order to observe the fluctuations in infections that occurred in a natural system and compare them with those in the cages. The fish from both sources were immediately placed in marked plastic bags and frozen to −20°C. The flesh and the liver were digested (pepsin 1%, HCl 2%) and incubated at 38–40°C in a shaker for 24 h. Thereafter the material was passed through a 75 mm metal mesh to recover larval nematodes, which were counted and fixed in 70% ethanol for subsequent identification.

RESULTS

The results of the regression analyses of the abundance data in wild fish show an increase in the abundance of worms from the liver with the length of the fish (Fig. 1). However, the corresponding data for nematodes found in the flesh do not show an increase for samples obtained in April 1989 and

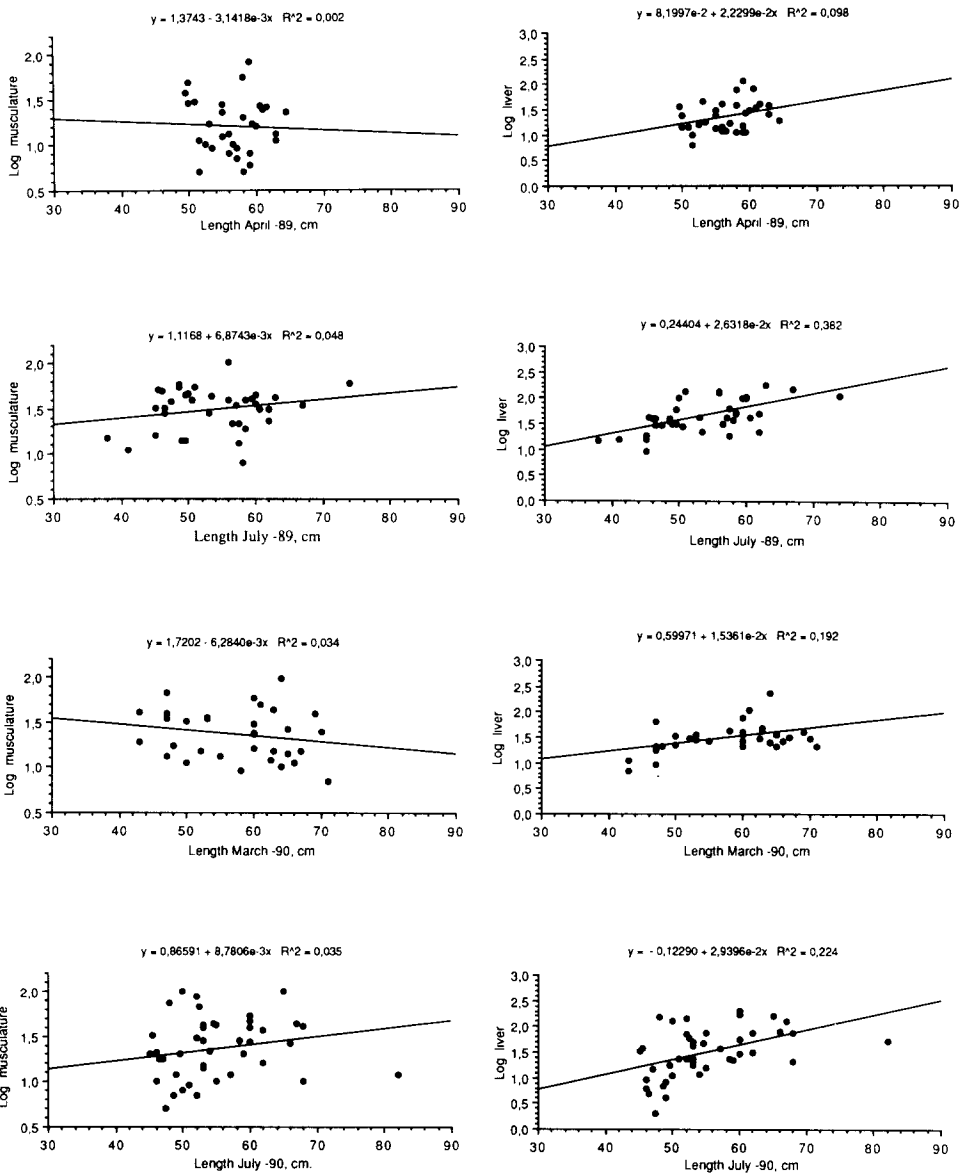


Fig. 1. The abundance of ascaridoid nematodes in the liver and the musculature at four different sampling points (April 1989, July 1989, March 1990, July 1990) in wild-caught fish, with increasing length.

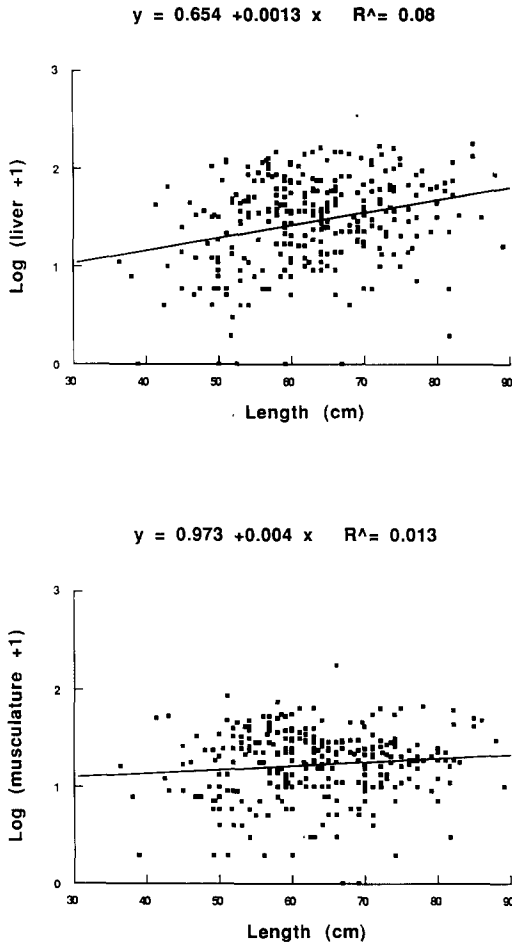


Fig. 2. The abundance of ascaridoid nematodes in the liver and the musculature from cod kept and fed in cages, with increasing length.

March 1990. Figure 2 gives the regression analyses of the abundance of worms from the liver and the musculature in the caged cod with the length of the fish. The abundance in the liver increased significantly with length ($R^2=0.08$), while the corresponding figure from the musculature was not significant ($R^2=0.013$). Figure 3 shows the development of worm infections in the caged fish with time. An ANOVA analysis (Tukey HSD) gave no significant differences in mean density between the eight different samples, either in the flesh or in the liver. Figure 4 gives the increase in length and weight of the caged cod. The data analysis was performed with the Systat (Wilkinson, 1989) and Statview (Abacus Concepts, 1987) statistical packages.

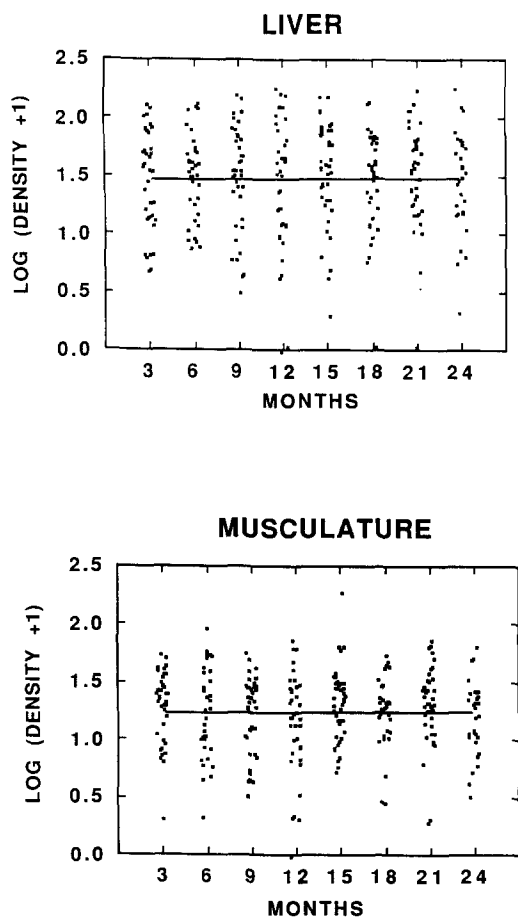


Fig. 3. The density (log. trans.) of ascaridoid nematodes in the liver and the musculature from cod kept and fed in cages, with increasing time.

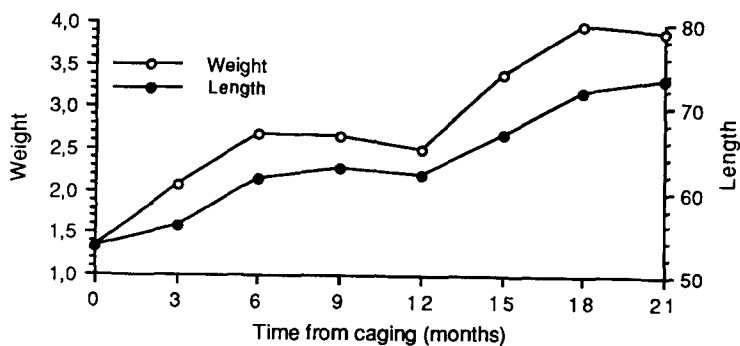


Fig. 4. The length and weight of cod kept and fed in cages.

DISCUSSION

Previous studies show that ascaridoid larvae accumulate in marine fish with age, as a result of their longer lifespan, predatory behaviour and increased feeding (Polyanskii, 1966; Smith, 1984a). It was therefore assumed that fish caught from the wild stock would show an increase in the abundance of worms with length. The results from the liver (Fig. 1) support this assumption, but the results from the flesh did not show an increase in abundance with age for two sampling points. Templeman et al. (1957) found a general increase in numbers of nematodes in the flesh of cod with increasing length. However, in two areas where infections were low, no significant increase was found. Because of different methods of detecting the worms (candling table versus digestion of the flesh) it is impossible to compare the intensity figures given by Templeman with ours.

Two (April 1989, March 1990) of our samples showed a decrease in intensity of worms from the flesh. This may be because they were taken in spring, when the Atlantic cod from the Barents Sea make a spawning migration to the north-west coast of Norway. The Altafjord is very close to the Barents Sea, and therefore fish in these samples may have been a mixture of the local stock and the spawning stock from the Barents Sea. Similar effects have been suggested for *Anisakis* in herring from the Baltic (Grabda, 1974).

The abundance of worms from the liver of the caged cod showed an increase with length, while no significant difference was found in the musculature. This result probably reflects the fact that the caged cod were randomly caught, which gave different sizes and accordingly different intensities of infections. However, despite a strong increase in growth within the cage (Fig. 4), no significant differences in density were obtained (Fig. 3).

Ascaridoid infections in marine fish are food-transmitted. Feeding cod artificially in cages with uninfected food was expected to reduce the transmission rate of these worms, thus stabilizing or decreasing the infections in the cod during a 2-year period. A decrease in intensity would be due to natural mortality in the infrapopulations of worms already infecting the fish. The results from the eight samples of cod from the cages showed that there were no significant differences in mean intensity during the 2-year period for nematodes both in the liver and the flesh (Fig. 3). This indicates that the cod had avoided new infections, or that the immigration-death process was in equilibrium. Since no dead or dying nematodes were observed in the fish tissue, it seems a reasonable conclusion that the transmission rate of nematodes to caged fish was reduced to near zero. A decrease in intensity of infection was not observed, which suggests a life-span of at least 2 years for these worms. Kulachkova (1980) claimed that the third-stage larvae of *Anisakis simplex* live for only about a year in herring. This work was challenged by Smith (1983) in a discussion of the life-history of *Anisakis simplex*, and Smith

(1984a) also gave evidence that these nematodes are capable of living for at least 3 years in herring.

The present paper deals with pooled data from five genera of nematodes (*Hysterothylacium*, *Contracaecum*, *Phocascaris*, *Pseudoterranova* and *Anisakis*), but it must be acknowledged that the different species of nematodes should be separated because pooled data might mask more specific trends, especially in the flesh of the fish. Smith (1984b) suggested that cod belonged to a group of marine teleosts where *Anisakis simplex* showed a lower microhabitat specificity, including both the body cavity and the flesh. The main first intermediate hosts for this nematode are euphausiids, which are pelagic and an important food item for another group of teleosts (herring and mackerel). Smith stated that cod belonged to a group which primarily feed on fish and mainly acquired infections of *A. simplex* at second-hand, and thus should be regarded as 'accidental' fish hosts. The first intermediate hosts for *Pseudoterranova decipiens* have been found by experimental infections to be benthic and epibenthic, belonging to the Harpacticoida and Cyclopoida (McClelland, 1982). Cod kept in a caged situation are prevented from both feeding on benthos and also from predating on other fish.

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REFERENCES

- Abacus Concepts, 1987. Statview II. Abacus Concepts, Berkely, CA, pp. 139–151.
- Agersborg, H.P.K., 1918. Nematodes in marketable fishes. *Science*, 48: 493–495.
- Bowen, W.D. (Editor), 1990. Population Biology of Sealworm (*Pseudoterranova decipiens*) in Relation to its Intermediate and Seal Hosts. *Can. Bull. Fish. Aquat. Sci.*, Vol. 222, 306 pp.
- Grabda, J., 1974. The dynamics of nematode larvae, *Anisakis simplex* Rud., invasion in the south-western Baltic herring (*Clupea harengus* L.). *Acta Ichthyol. Piscatoria*, 4: 3–21.
- Hafsteinsson, H. and Rizvi, S.S.H., 1987. A review of the sealworm problem: biology, implications and solutions. *J. Food Prot.*, 50: 70–84.
- Kulachkova, V.G., 1980. Infection of White-Sea herring with larval *Anisakis* sp. (Nematoda, Ascaridata). *Parazitol. Sb.* 29: 126–142 (in Russian).
- McClelland, G., 1982. *Phocanema decipens*: (Nematoda: Anisakinae). Experimental infections in marine copepods. *Can. J. Zool.*, 60: 502–509.
- Nascetti, G., Paggi, L., Orecchia, P., Smith, J.W., Mattiucci, J. and Bullini, L., 1986. Electrophoretic studies on the *Anisakis simplex* complex (Ascaridida: Anisakidae) from the Mediterranean and the North East Atlantic. *Int. J. Parasitol.*, 16: 633–640.
- Oshima, T., 1987. Anisakiasis – is the sushi bar guilty? *Parasitol. Today*, 3: 44–48.

- Paggi, L. et al., 1991. Genetic evidence for three species within *Pseudoterranova decipiens* (Nematoda, Ascaridida, Ascaridoidea) in the North Atlantic and Norwegian and Barents Seas. *Int. J. Parasitol.*, 21: 195–212.
- Polyanskii, Yu.I., 1966. Parasites of the fish of the Barents Sea. *Trans. Zool. Inst. Acad. Sci. U.S.S.R.*, 19: 112–117. (Translated by Israel Prog. for Scientific Translations, Jerusalem.)
- Smith, J.W., 1983. *Anisakis simplex* (Rudolphi, 1809, det. Krabbe, 1878) (Nematoda: Ascaridoidea): morphology and morphometry of larva from euphausiids and fish: a review of the life-history and the ecology. *J. Helminthol.*, 57: 205–224.
- Smith, J.W., 1984a. *Anisakis simplex* (Rudolphi, 1809 det. Krabbe, 1878): length distribution and variability of L3 of known minimum age from herring *Clupea harengus* L. *J. Helminthol.*, 58: 337–340.
- Smith, J.W., 1984b. The abundance of *Anisakis simplex* L3 in the body cavity and flesh of marine teleosts. *Int. J. Parasitol.*, 14(5): 491–495.
- Smith J.W. and Wootten, R., 1978. *Anisakis* and anisakiasis. *Adv. Parasitol.*, 16: 93–163.
- Templeman, W., Squires, H.J. and Fleming A.M., 1957. Nematodes in the fillets of cod and other fishes in Newfoundland and neighbouring areas. *J. Fish. Res. Board Can.*, 14: 831–894.
- Wilkinson, 1989. SYSTAT: The System for Statistics. SYSTAT, Evanston, IL, 638 pp.