ELSEVIER

Fisheries Research 42 (1999) 183–189

FISHERIES RESEARCH

Nematode infection in the whiting *Merlangius merlangus euxinus* off Turkish Coast of the Black Sea

A. Ismen*, F. Bingel

Mustafa Kemal University, Fisheries Faculty, PO Box 23, 31200, Iskenderun, Turkey

Received 2 September 1997; accepted 20 January 1999

Abstract

The endoparasites of whiting, *Merlangius merlangus euxinus* from the Turkish Coast of the Black Sea were investigated during the years 1990–1993. Only the endoparasite, *Hysterothylacium aduncum* (Nematoda: Anisakidae) was recorded in all visceral organs examined. The prevalence and intensity of *H. aduncum* were significantly higher in the warm season (July–August) than in the colder period (January–February) ($P<0.01$). Infection increased significantly with age and length of the fish ($P<0.01$). The relationship between fecundity and length for infected and uninfected fish was calculated as $\log F=2.492 \log L+1.531$ and $\log F=2.611 \log L+1.408$, respectively. No significant difference between infected and uninfected fish was seen in either the fecundity-length data or the condition factor ($P>0.01$). © 1999 Elsevier Science B.V. All rights reserved.

Keywords: Black Sea; *Merlangius merlangus euxinus*; Nematode infection; Fecundity

1. Introduction

Whiting, *Merlangius merlangus euxinus* Nordmann, 1830 (Teleostei, Gadidae) is one of the most abundant and economically important fish species in the Black Sea. The average annual landings by all Black Sea nations during the period 1984–1991 was about 23 000 t (GFCM, 1993). The major component of these landings (on an average 85%) came from the Turkish Black Sea Coast, especially from the eastern part. However, there is no information on spatial and temporal distribution of its parasites in the Black Sea. Such information is almost restricted to British coastal waters and the North Sea. Van den Broek (1978), Potter et al. (1988), Pilcher et al. (1989) and Lang (1990) studied the infection of whiting by four of the most abundant parasites of this species, namely *Lernaeocera branchialis, Clavella adunca, Diclidophora merlangi* and *Cryptocotyle lingua* in the North Sea. Young (1972), Wootten and Waddell (1977) and Smith (1974) recorded the infection of cod and whiting with larval nematodes (*Anisakis* sp. and *Phocanema* sp.).

This paper presents some information on the prevalence and intensity of infection of the whiting by anisakids (Nematoda) off Turkish Black Sea Coast. In addition, the effect of infection with these parasites on whiting fecundity was studied.

*Corresponding author. Fax: +90-326-6427381; e-mail: aismen@mku.edu.tr

PII: S0165-7836(99)00022-3

2. Materials and methods

Samples were collected from 66 sampling stations located along the continental shelf of the Turkish Black Sea Coast during the period 1990–1991, and from three stations (Besikdüzü, Trabzon, Sürmene) in the Eastern Black Sea between June 1992 and May 1993 (Fig. 1). Stations were sampled using bottom trawl nets by R/V BÍLÍM in April 1990 and September 1990. In September 1991 and from June 1992 to May 1993, sampling was performed by R/V SURAT-1. A total of 3223 individuals were examined (Table 1).

Length and body weight were determined to the nearest mm and 0.01 g for all fish. Estimation of age was based almost exclusively on interpretation of otolith structures for the presence of hyaline and opaque zones which are assumed to represent winter and summer growth periods, respectively (Gamble and Messtorff, 1964).

The study of whiting parasites was conducted by examining the stomach, intestine and the body cavity. With practice anisakids may be seen by the naked eye (Wootten and Waddell, 1977). Anisakid species were identified from all the samples. The number and locations of endoparasite present in individual fish were recorded. The data were analysed with respect to parasitic prevalence (percentage of fish infected) and mean intensity (mean number of parasites per fish examined) (Wootten and Waddell, 1977).

Table 1
Numbers of *Merlangius merlangus euxinus* examined by sex and periods

Sample	Male	Female	Total
April 1990	672	783	1455
September 1990	139	140	279
September 1991	120	144	264
June 1992	41	109	150
July 1992	44	87	131
August 1992	38	78	116
October 1992	9	27	36
November 1992	19	20	39
December 1992	51	54	105
January 1993	34	58	92
February 1993	45	74	119
March 1993	51	98	149
April 1993	40	79	119
May 1993	53	116	169
Total	1356	1867	3223

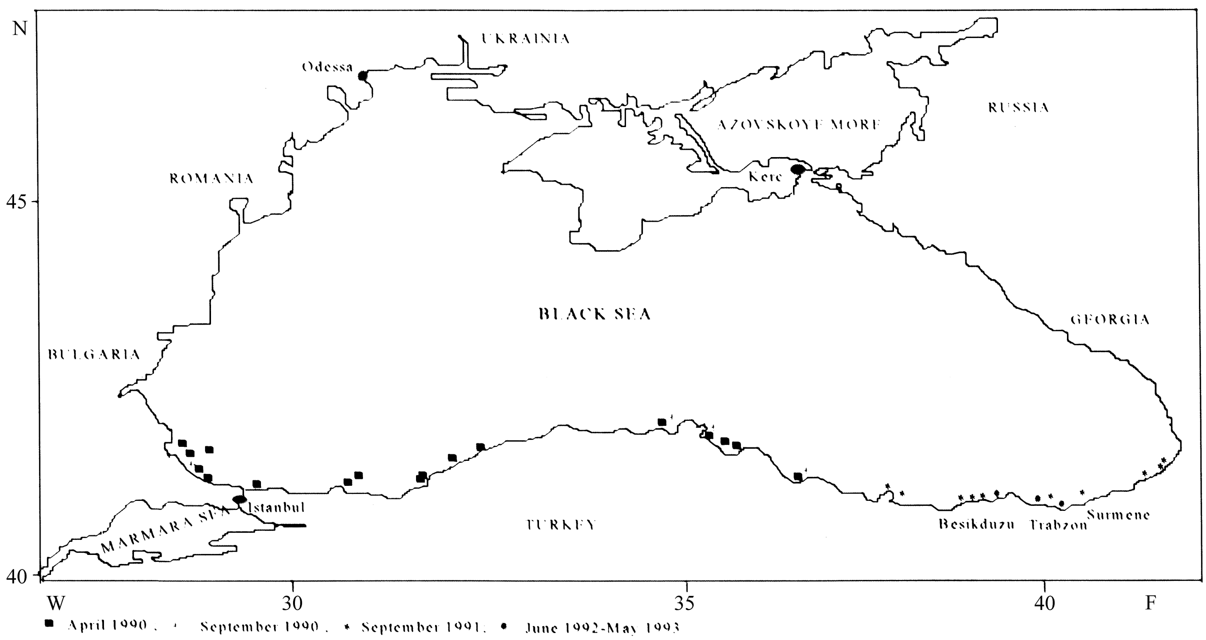

Fig. 1. Location of sampling stations along the Turkish Black Sea Coast.

The condition factors for infected and uninfected whiting were calculated from the monthly samples by the equation W/L^3 (W: body weight (g), L: total length (cm)) in order to determine whether the parasite affects the growth of fish.

Ovaries considered suitable for fecundity estimations, i.e., those that were swollen, creamy in colour and with very few, if any, translucent eggs visible through the ovary wall, were stored in modified Gilson's fluid which broke down the connective tissue and helped to separate the eggs from one another (Holden and Raitt, 1974). The egg numbers were estimated using the volumetric method described by Bagenal (1978). Of 188 ovaries counted, 88 (46.8%) were infected. The length ranges of the infected (13.1–26.5 cm) and the uninfected fish (13.1–25.6 cm) were similar. The data were analysed by least squares regression using log–log (base 10) transformations as described by Hislop and Hall (1974). Analysis of covariance (Rohlf, 1986) was used to test the significance of the differences between regression coefficients.

3. Results

In the endoparasitic examination, only nematodes were recorded in the stomach, intestine and body cavity of all samples examined. All of the nematodes were identified as *Hysterothylacium aduncum*[1] (Anisakidae). There was no significant differences in the prevalence of the nematode between three stations in the eastern Black Sea ($P<0.01$) and therefore the results have been pooled. Table 2 gives the prevalence of nematodes for the different length groups and months.

As can be seen in Table 2, there are significant differences in the prevalence of nematodes between January/February and the other months for the samples of June 1992–May 1993 ($P<0.01$). The highest prevalence (54.8%) was in July/August. After these warm months, there was a decrease in the number of whiting infected and in January/February the lowest value (21.8%) was recorded. With increasing temperature, the prevalence increased again. In April 1990, September 1990 and September 1991, it reached 33.6%, 27.6% and 27.7%, respectively.

Analysis of regression indicated that there was a clear positive relationship between length of fish and prevalence of nematodes except in July/August 1992, January/February 1993 and March/April 1993 ($P<0.01$). The overall prevalence rose from 32.7% to 90% with an increase in length from 7/8 to >25 cm (Table 2).

The prevalence of infection of different age groups is shown in Table 3. Analysis of regression of the prevalence–age data indicated a significant relationship between the level of infection and age of the host ($P<0.01$). The overall prevalence rose from 28.7% in I age group to 51.7% in >V age group.

Prevalences and mean intensities of nematodes in all samples are shown in Table 4. The analysis of intensity levels has demonstrated considerable changes in parasite levels between January/February and the other months in the Turkish Black Sea Coasts. The lowest mean intensity was recorded in January/February (0.35 parasites per fish), and the highest values were found in July/August and November/December. The highest number of nematodes in one fish (at length 9.5 cm, nematode number 32; at length 14.5 cm, nematode number 38) also occurred in April 1990 samples.

3.1. *The effects of infection with anisakids on whiting fecundity*

The fecundities of infected and uninfected fish are plotted against length in Fig. 2, showing a curvilinear relationship. An appropriate form for the relationship observed is fecundity=$a\times\text{length}^b$. The values of the parameters a and b were estimated by carrying out an ordinary least squares regression of log fecundity on log length. Log fecundity/log length regression equations for the two groups of fish are:

$$\text{infected fish}: \ \log F = 2.492 \log L + 1.531,$$

$$\text{uninfected fish}: \ \log F = 2.611 \log L + 1.408.$$

A comparison of the two equations indicated no significant difference between the two slopes and intercepts ($P>0.01$). The confidence limits of the slope (infected fish: 2.492; uninfected fish: 2.611) are ± 0.435 and 0.396, respectively.

[1]Kindly identified by Dr. T. Lang from Bufo fur Fischereiokologie-Lab., Cuxhaven, Germany.

Table 2
The prevalence of nematodes in the visceral organs of whiting *Merlangius merlangus euxinus* from the Turkish Black Sea Coast (values in parentheses are the numbers of fish examined)

	Length groups (cm)										
	7/8	9/10	11/12	13/14	15/16	17/18	19/20	21/22	23/24	>25	Total
April 1990	21.4 (145)	32.1 (299)	36.6 (560)	32.3 (288)	35.4 (96)	34.3 (35)	53.8 (26)	60.0 (5)	100 (1)	– (–)	33.6 (1455)
September 1990	17.0 (47)	25.5 (153)	28.8 (50)	41.2 (17)	87.5 (8)	50.0 (4)	– (–)	– (–)	– (–)	– (–)	27.6 (279)
September 1991	– (–)	7.6 (13)	15.7 (70)	29.4 (51)	32.8 (61)	31.9 (47)	41.7 (12)	40.0 (5)	– (–)	80.0 (5)	27.7 (264)
May/June 1992	25.0 (16)	20.9 (43)	20.8 (24)	32.1 (56)	47.6 (63)	42.9 (63)	56.7 (30)	57.9 (19)	60.0 (5)	– (–)	44.8 (319)
July/August 1992	100 (2)	39.3 (28)	65.6 (32)	41.0 (39)	65.5 (55)	50.8 (61)	64.3 (28)	50.0 (2)	– (–)	– (–)	54.8 (247)
November/December 1992	– (–)	36.4 (11)	58.3 (24)	35.5 (62)	46.2 (39)	45.8 (24)	71.4 (7)	100 (1)	– (–)	– (–)	52.1 (144)
January/February 1993	– (–)	25.0 (12)	12.2 (41)	30.9 (68)	17.1 (70)	23.5 (17)	33.3 (3)	– (–)	– (–)	– (–)	21.8 (211)
March/April 1993	0.0 (1)	66.7 (6)	47.8 (46)	38.6 (57)	32.5 (80)	46.4 (56)	41.7 (12)	40.0 (5)	0.0 (2)	100 (4)	41.4 (268)

Table 3
The prevalence of nematodes in each age group of whiting from the Turkish Black Sea Coast (values in parentheses are the numbers examined)

	Age group (year)					
	I	II	III	IV	>V	Total
April 1990	32.6 (922)	33.6 (431)	39.8 (83)	57.9 (19)	– (–)	(1455)
September 1990	25.7 (257)	40.0 (15)	71.4 (7)	– (–)	– (–)	(279)
September 1991	14.1 (92)	34.2 (117)	28.9 (45)	40.0 (5)	80.0 (5)	(264)
May/June 1992	21.5 (65)	35.0 (80)	43.7 (135)	66.7 (37)	0 (2)	(319)
July/August 1992	50.0 (52)	57.3 (82)	54.5 (112)	0 (1)	– (–)	(247)
November/December 1992	47.9 (71)	47.6 (59)	76.9 (13)	100 (1)	– (–)	(144)
January/February 1993	11.1 (18)	20.2 (109)	26.2 (84)	– (–)	– (–)	(211)
March/April 1993	26.7 (15)	42.6 (115)	40.6 (128)	33.3 (6)	75.0 (4)	(268)

Table 4
Prevalences and mean intensities of infection of whiting from all samples for each sex and pooled data

	Sample no.			Prevalence (%)			Mean intensity		
	M	F	Total	M	F	Total	M	F	Total
April 1990	672	783	1455	31.5	35.4	33.6	0.68	0.93	0.81
September 1990	139	140	279	30.2	25.0	27.6	0.51	0.50	0.50
September 1991	120	144	264	23.3	31.3	27.7	0.51	0.73	0.63
May/June 1992	94	225	319	38.3	47.6	44.8	0.69	1.17	1.03
July/August 1992	82	165	247	54.9	54.8	54.8	1.43	1.38	1.40
November/December 1992	70	74	144	54.3	50.0	52.1	1.16	1.73	1.45
January/February 1993	79	132	211	25.3	19.7	21.8	0.42	0.30	0.35
March/April 1993	91	177	268	40.7	41.8	41.4	0.96	0.93	0.94

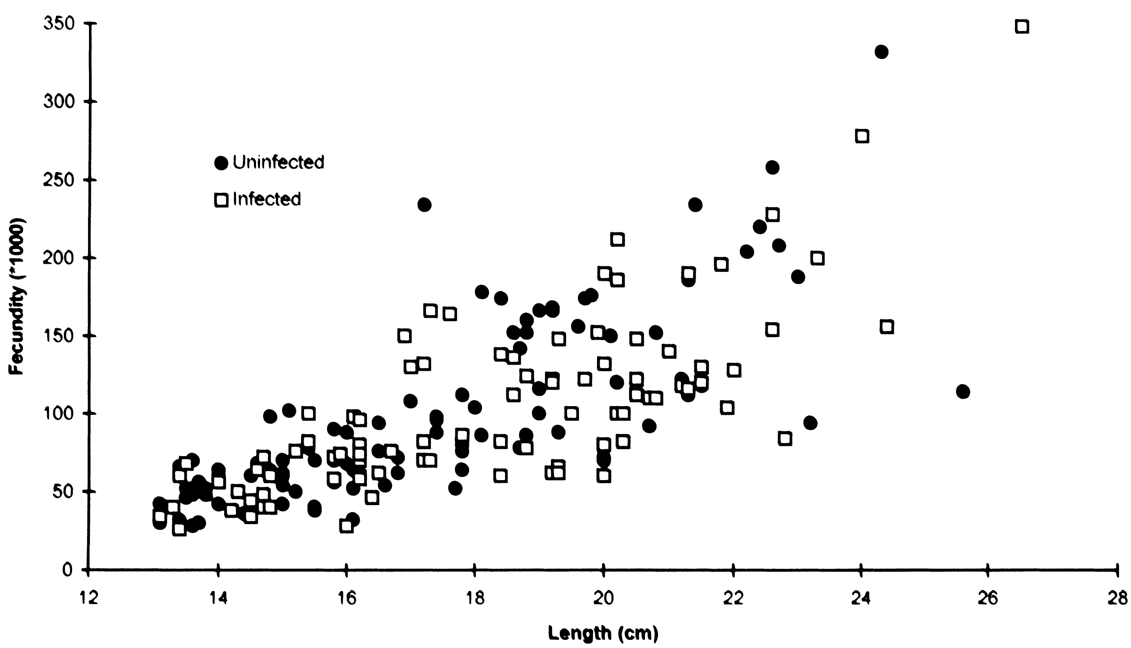

Fig. 2. Relationship between fecundity and length for whiting infected and uninfected from the Turkish Black Sea Coast for 1990–1993.

The condition factors for two groups of fish were calculated and a comparison indicated no significant difference between the slopes and the intercepts ($P>0.01$). The condition factors were 0.636 and 0.644 for infected and uninfected whiting, respectively.

4. Discussion

Anisakids, and particularly larval anisakids, are among the most common nematodes of marine fishes. They cause pathological symptoms and possibly mortalities, and reduce the commercial value of fish (Kinne, 1984).

The prevalence of nematodes in the stomach and intestine found here is high when compared with results given by Gordon (1977). He found that the prevalence of nematodes in the stomachs of similarly sized whiting in the west coast of Scotland was under 38%. However, the prevalence of nematodes in the Black Sea whiting falls into the lower limits of the range (about 60%) obtained by Nagabhushanam (1964) from whiting of similar size in the Isle of Man waters. By examining the whole gut of fish from the same area, Shotter (1973) found that over 90% of whiting contained nematodes.

In the present study, a seasonal change in the prevalence of nematodes was found. Neither Nagabhushanam (1964) nor Shotter (1973) working in the same area recorded seasonal differences. Gordon (1977) observed a seasonal change detecting a decline in prevalence during cold months. The highest prevalence on the examined whiting was recorded in July/August. Avsar (1993) working on Black Sea sprat found that the prevalence of nematodes in January was relatively lower than that for warm periods (May/September). Although different fish species were examined for the prevalence of nematodes, there is good agreement between the results obtained in the present study and those found by Gordon (1977) and Avsar (1993).

When comparing the total lengths of whiting in 1 cm length class intervals with the prevalence of nematodes, the results revealed a clear prevalence–length relationship except in July/August 1992, January/February 1993 and March/April 1993 ($P<0.01$). The overall prevalence of nematodes rose from 32.7% to 90% with an increase in length from 7/8 to >25 cm. There was also a stronger correlation between the age of fish and the prevalence. For almost all months, the prevalence increased with fish age, and overall rose from 28.7% in I age group to 51.7% in >V age group. Gordon (1977) reported the prevalence of nematodes for different length groups and months, and did not find a prevalence–length relationship for whiting. Wootten and Waddell (1977) stated that accumulation of larval nematodes with increasing age and length of whiting probably occurs because nematodes are long-lived and are continually acquired by most fish throughout their lives. In addition, larger and older fish consume greater quantities of food which will probably result in larger numbers of larval nematodes being ingested. Køie (1993), provided a detailed account of the life cycle of *H. aduncum* from eelpout, stated that further development in the fish host are apparently dependent only on the length of the larva. Thus, a two-host cycle occurs, when fishes ingest crustaceans harbouring third-stage larvae longer than 3 mm, and a cycle of three (or more) hosts when fishes ingest third-stage larvae less than 3 mm long. Depending on the size of the larva, non-crustacean invertebrates and fishes may act as obligate second intermediate or transport hosts. Fishes, especially predatory fishes such as gadoids, are the definitive hosts. Potter et al. (1988) recorded that whilst prevalence in young whiting was approximately 5–30%, prevalence in 1+ and older fish was often very high, with over 90% of whiting being infected in most months. Avsar (1993) stated that the prevalence of nematodes generally increased with increasing age of the Black Sea sprat. Elkin (1955, cf. Gordon, 1977) found a low prevalence of nematodes in older whiting off the Irish Coast. The variations observed between the studies on parasite infections with respect to age and length of the fish are possibly due to differences in the geographical distribution of the invertebrate and vertebrate hosts of the parasites (Wootten and Waddell, 1977).

A seasonal difference in the intensity of infection was found in this study. However, no comparison could be made as no other literature exists about the infection of Black Sea whiting with endoparasites. The only comparable study is that of Shotter (1973) who examined whiting parasites in the Isle of Man. In general terms, Shotter's findings on seasonality parallel those of the present study, namely, that the intensity of infection with *H. aduncum* is higher in summer than in winter. Avsar (1993) did not mention any seasonality of endoparasites. However, considering that whiting prey mainly upon sprat, this would lead to the conclusion that whiting probably become infected by eating infected sprat since, as Kinne (1984) underlines, such infections mostly occur as a result of ingesting infected food.

The present study did not show that the parasite caused any significant effect on the condition and the fecundity of fish. However, the studies made on the effects of *H. aduncum* on various other species of marine fish showed a reduction on the condition of fish by the parasites (Kinne, 1984).

Acknowledgements

This work was carried out within the framework of the project ''Stock Assessment Studies for the Turkish Black Sea Coast'' sponsored by NATO-Science for Stability Program, Turkish Scientific and Technical Research Council (TUBITAK) and Turkish State Planning Office. I would like to extend my sincere thanks to Prof. U. Unluata, Director of the Institute of Marine Sciences, Middle East Technical University, for providing facilities. I thank the crews of R/V BÍLÍM and R/V SURAT-1 for their help in sample collection.

References

Avsar, D., 1993. The biology and population dynamical parameters of the sprat (*Sprattus sprattus phalericus* RISSO) on the Southern Coast of the Black Sea. Ph.D. Thesis, Institute of Marine Sciences, Middle East Technical University, Turkey, 240 pp.

Bagenal, T.B., 1978. Fecundity. In: Methods for Assessment of Fish Production in Fresh Waters. IBP Handbook, 3rd ed., vol. 3. Blackwell Scientific Publications, London, pp. 166–178.

Gamble, R., Messtorff, J., 1964. Age determination in the whiting (*Merlangius merlangus* L.) by means of the otoliths. J. du Conseil 28, 393–404.

GFCM, 1993. Statistical Bulletin, no. 9. Nominal Catches 1979–1991. FAO Bulletin of Fishery Statistics, Rome.

Gordon, J.D.M., 1977. The fish populations in inshore waters of the west coast of Scotland. The food and feeding of the whiting, *Merlangius merlangus*. J. Fish. Biol. 11, 513–529.

Hislop, J.R.G., Hall, W.B., 1974. The fecundity of whiting, *Merlangius merlangus* L., in the North Sea, the Minch and at Iceland. J. Cons. Int. Explor. Mer. 36(1), 42–49.

Holden, M.J., Raitt, D.F.S. (Eds.), 1974. Manual of fisheries science. Part 2 – Methods of Resource Investigation and Their Application. FAO Fish. Tech. Rap. (115), Rev. 1, 214 pp.

Kinne, O., 1984. Diseases of Marine Animals. Introduction, Pisces, vol. IV, Part 1. Germany, p. 541.

Køie, M., 1993. Aspects of the life cycle and morphology of *Hysterothylacium aduncum* (Rudolphi, 1802) (Nematoda, Ascaridoidea, Anisakidae). Can. J. Zool. 71, 1289–1296.

Lang, T., 1990. Infestation of North Sea Whiting, *Merlangius merlangus* L., with externally visible parasites. ICES, C.M./E: 31, Ref. G, pp. 1–23.

Nagabhushanam, A.K., 1964. On the biology of the whiting, *Gadus merlangus*, Ín Manx waters. J. Mar. Biol. Ass. UK 44, 177–202.

Pilcher, M.W., Whitfield, P.J., Riley, J.D., 1989. Seasonal and regional infestation characteristics of three ectoparasites of whiting, *Merlangius merlangus* L., in the North Sea. J. Fish. Biol. 35, 97–110.

Potter, I.C., Gardner, D.C., Claridge, P.N., 1988. Age composition, movements, meristics and parasites of the whiting, *Merlangius merlangus*, in the Severn estuary and Bristol Channel. J. Mar. Biol. Ass. UK 68, 295–313.

Rohlf, F.J., 1986. Biom. A package of statistical programs to accompany the text Biometry. State University of New York, USA, 108 pp.

Shotter, R.A., 1973. Changes in the parasitic fauna of whiting, *Odontogadus merlangus* L., with age and sex of host, season, and from different areas in the vicinity of the Isle of Man. J. Fish Biol. 5, 559–573.

Smith, J.W., 1974. Experimental transfer of *Anisakis* sp. larvae (Nematode: Ascaridae) from one fish host to another. J. Helminth. 48, 229–234.

Van den Broek, W.L.F., 1978. The effects of *Lernaeocera branchialis* on the *Merlangius merlangus* population in the Medway estuary. J. Fish Biol. 13, 709–713.

Wootten, R., Waddell, I.F., 1977. Studies on the biology of larval nematodes from the musculature of cod and whiting in Scottish waters. J. Cons. int. Explor. Mer. 37(3), 266–273.

Young, P.C., 1972. The relationship between the presence of larval Anisakine nematodes in cod and marine mammals in British waters. J. Appl. Ecol. 9, 459–486.