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Variation in the incidence of larval nematodes in herring from Canadian Atlantic waters

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Abstract

The incidence and intensity of infestation of herring from Canadian Atlantic waters with larval *Anisakis* varied with locality. Incidence was higher in herring from southwestern and northeastern Nova Scotia (73% and 64%) and the Banquereau-Sable Island area (66%) than in herring from southwestern Newfoundland (30%) and the southern Gulf of St. Lawrence (29%). *Anisakis* incidence increased northwards along western Newfoundland to 61% in the Strait of Belle Isle. There was a southward decrease to 8% in Notre Dame Bay and thence an increase to 48% in herring from eastern Avalon Peninsula. Both the incidence and intensity of infestation increased with fish age (size). The geographic variation in incidence indicates that larval *Anisakis* in herring are useful as biological indicators of stock heterogeneity. The remarkable similarity in *Anisakis* incidence in herring which are fished along southwest Newfoundland in winter, near Magdalen Islands in autumn and spring and near Gaspé in summer supports the view that these various fisheries occur on the same stock complex of herring. The high but similar nematode incidence values for northeastern Nova Scotia and Banquereau-Sable Island areas suggest a possible inshore-offshore migratory pattern on the Scotian Shelf and that these herring probably do not intermingle to any great extent with the more northerly Gulf of St. Lawrence-southwest Newfoundland stocks.

Introduction

Geographical variation in abundance of parasites of marine fish have proven useful in the study of fish populations and migrations. The value of certain parasites as natural biological "tags" in identifying fish from different areas has been demonstrated for several fish species (Templeman, Squires and Fleming, 1957; Sindermann, 1961a; Templeman and Squires, 1960; Kabata, 1963; Margolis, 1963; Templeman and Fleming, 1963).

Both Pacific and Atlantic herring are often infested with larval nematodes or roundworms, generally 20-30 millimetres long and usually found coiled in cysts in the abdominal cavity; sometimes, however, they occur in the musculature. The two types known to occur in herring are Anisakis Dujardin 1845 and Contracaecum Raillet and Henry 1912. In the Northeast Atlantic Khalil (1969) found that Anisakis larvae were more prevalent in adult herring and Contracaecum in juveniles. Bishop and Margolis (1955) reported that British Columbia herring, Clupea pallasi, were frequently infested with Anisakis larvae and that the level of infestation varied with area. Sindermann (1957, 1959) utilized larval nematodes as well as other parasites to determine the degree of intermingling of certain Northwest Atlantic herring stocks, with particular emphasis on the Gulf of Maine and Nova Scotian stocks. Khalil (1969) investigated the incidence of Anisakis larvae in herring from British coastal waters and reported that the degree of infestation varied with locality.

In the autumn of 1968 a survey of the incidence and intensity of infestation of herring, Clupea harengus L., in Canadian Atlantic waters with larval nematodes was initiated to assess the usefulness of such observations in determining the degree of heterogeneity of Canadian Atlantic herring stocks. During the course of the study the nematodes from many herring samples were examined by Mr. J.H.C. Pippy (personal communication) and practically all identified as Anisakis sp.; consequently all nematodes found were recorded as Anisakis larvae although a few may have been Contracaecum. This paper presents the results of that study, with emphasis on herring stocks in the Newfoundland-Labrador area.

Materials and methods

From November 1968 to September 1970 about 11,000 herring, 8500 sexually mature adults and 2500 juveniles, were examined for larval nematodes. Herring samples, usually of 50 fish each, were obtained from catches of purse seines, midwater trawls, gillnets, codtraps and weirs. Most of the samples were thawed and examined after being kept in frozen storage for several weeks, but a few were examined in the fresh condition immediately after capture.

At the start of the study, slicing and candling fillets of about 500 herring, some fresh and some after frozen storage, revealed that less than 1% of the specimens had nematodes in the musculature. Subsequently the examination for larval nematodes was restricted to the body cavity and viscera. The length, sex, stage of maturity and weight of the fish were also recorded and otoliths taken for subsequent age determination. The length used is the greatest total length measured from the tip of the lower jaw to the end of the longest lobe of the caudal fin with the lobe extending posteriorly in line with the body. Length measurement data, recorded to the nearest millimetre, were grouped into 1-cm intervals of the 0.5 cm below (i.e. all lengths ranging from 310 to 319 mm were grouped into the 31-cm interval). The stage of maturity was determined by gross examination of gonads using the various stages of gonadal development as adopted by ICNAF (1964). The ageing techniques are described in Hodder and Parsons (1971).

Results

Nearly all of the nematodes were found encapsulated on the mesenteries, coiled in flat spirals against the intestine, the posterior extension of the stomach and the pyloric caecae, or free in the abdominal cavity (Fig. 1). Practically all of the nematodes measured were in the 20-30 mm size range.

Fig. 1. Larval nematodes encysted in the abdominal cavity of a split herring (X2.5).

Size of herring and infestation

Both the incidence (percentage of fish infested) and the intensity (average number of nematodes per fish) increase with fish size (Fig. 2). No nematodes were found in herring less than 20 cm long and the degree of infestation was less than 20% for the 20- to 30-cm length groups. Herring of these sizes are either immature or maturing for first spawning. The increase in degree of infestation with increasing size is very pronounced for herring over 30 cm in length, which are generally sexually mature.

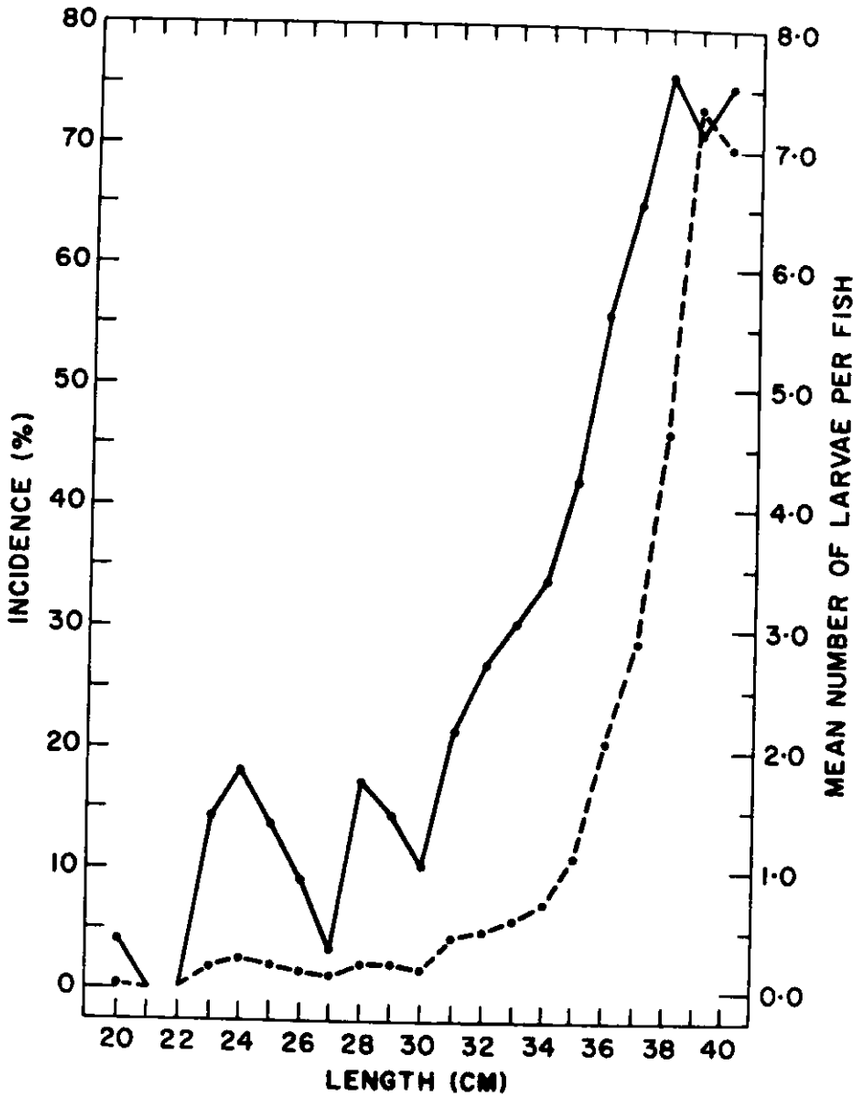

Fig. 2. Relation between the incidence of infestation (solid line), mean number of Anisakis larvae (broken line) and length of herring for all areas combined.

Within areas there is considerable fluctuation in the relation between fish size and both the percentage incidence of infestation and the average number of nematodes per fish; for some areas the relationship is much more evident than for others (Table 1). Generally though, immature herring (< 30 cm long) are less heavily infested than sexually mature adults. Juveniles from Fortune, Placentia and St. Mary's bays, Newfoundland, had a much lower nematode incidence than adult herring

(10, 12 and 11% compared with 43, 32 and 33% respectively). Similarly juveniles from northeastern Nova Scotia had a lower incidence than adults (27% compared with 64%).

Age and infestation

Both the incidence and the intensity of infestation of herring with larval nematodes increase with age (Fig. 3). Herring less than age III have a very low level of infestation in all areas from which specimens were examined. From age III onwards there is a gradual increase in incidence and intensity of infestation with age. The sharp increase from age IX to age X+ occurs because the X+ category includes all specimens of age X and older.

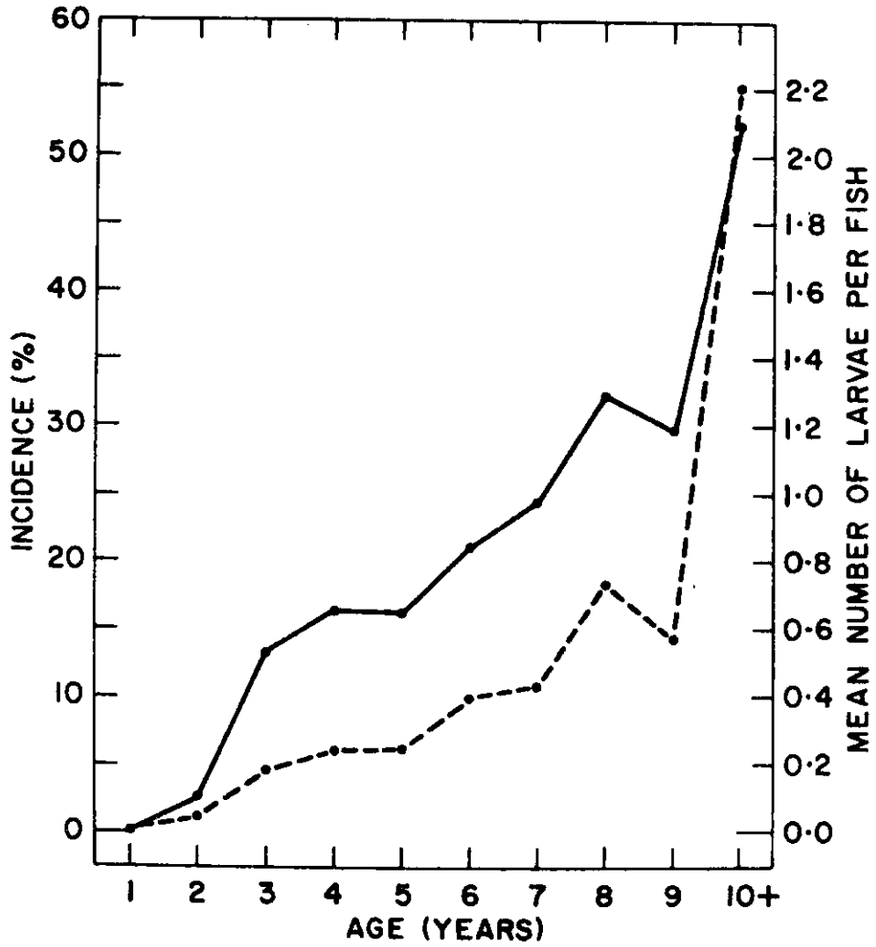

Fig. 3. Relation between the incidence of infestation (solid line), mean number of Anisakis larvae (broken line) and age of herring for all areas combined.

Although the increase in degree of infestation with age is clearly evident for certain areas (e.g. northeastern Nova Scotia and Hawke's Bay), it is less prominent in others (e.g. Placentia and Notre Dame bays) (Table 2).

Geographic variation in incidence

Considerable geographic variation in the level of infestation of sexually mature herring by larval nematodes is evident (Fig. 4 and Table 3).

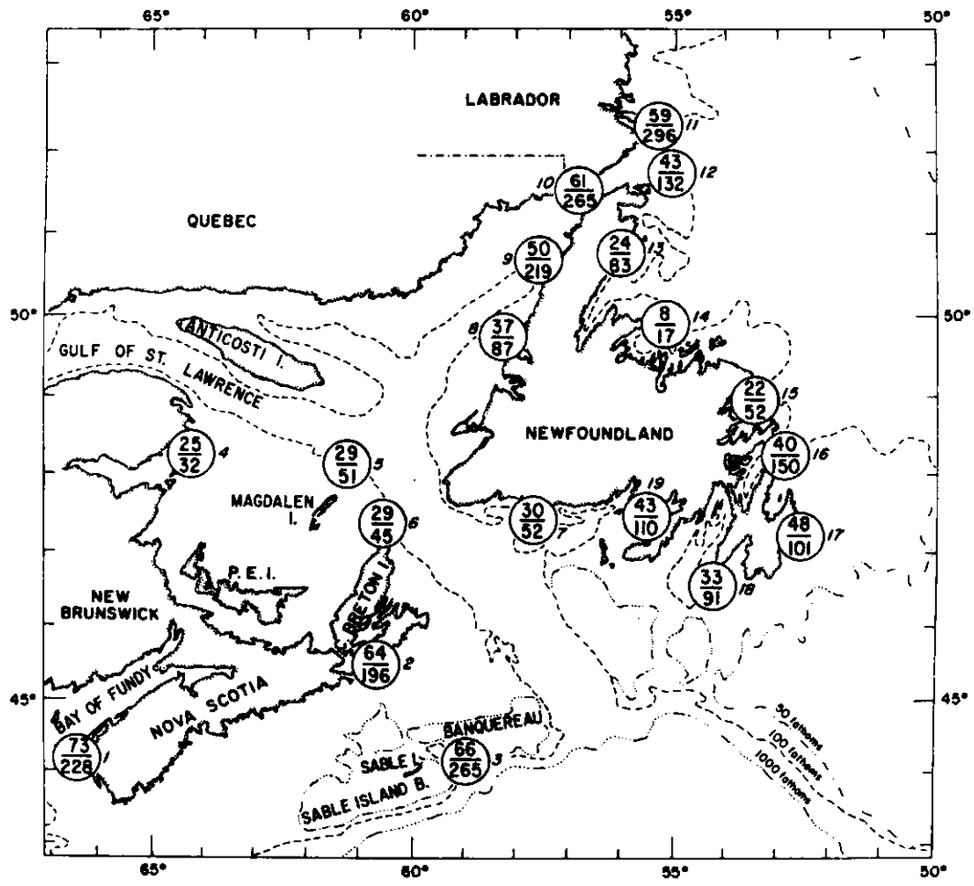

Fig. 4. Geographic variation in the incidence of larval nematodes in adult herring (≥30 cm) from Canadian Atlantic waters, 1968-70. (Within each circle the upper value represents the percentage incidence of infestation and the lower value represents the number of nematodes per 100 herring. The numbers adjacent to the circles correspond with place names in Tables 1-3.)

There is remarkable similarity in both nematode incidence and intensity for herring which are fished near Magdalen Islands in the autumn just prior to the start of the Newfoundland fishery, herring which overwinter along southwestern Newfoundland and herring which are fished between Cape Breton and Magdalen Islands in the spring after the cessation of the Newfoundland fishery. The nematode incidence in herring from Chaleur Bay during summer (based on 44 specimens only) is similar, although slightly lower.

Herring from northeastern Nova Scotia (Gabarus Bay) and the offshore area (Banquereau and Sable Island banks) have a similar level of infestation, the incidence being more than twice that for the southern Gulf of St. Lawrence and southwest Newfoundland and the intensity being 4 times as large. Adult herring from southwestern Nova Scotia (St. Mary's Bay) are similar in both incidence and intensity to those from northeastern Nova Scotia and the Sable Island-Banquereau area.

Nematode incidence and intensity increase from Bonne Bay northwards along western Newfoundland to the Strait of Belle Isle and southern Labrador. However, the herring samples from the latter areas, taken mostly during the summer, contained larger and older herring than those from Bonne Bay and Hawke's Bay, taken in late autumn.

There is a southward decrease in incidence and intensity from Labrador to Notre Dame Bay where the level of infestation is very low for even the largest and oldest herring (Tables 1 and 2). Southward from Notre Dame Bay to the eastern Avalon Peninsula there is a sixfold increase in both incidence and intensity. However, the intensity in Trinity-Conception Bay samples is considerably higher than in samples from the adjacent areas.

Adult herring from Placentia and St. Mary's bays were virtually identical in both incidence and intensity of infestation and the data for these bays were combined for comparison with other areas. Although the incidence is similar to that for southwestern Newfoundland, the intensity is considerably higher. Fortune Bay herring have only a slightly higher incidence of infestation than herring from southwest Newfoundland, but the intensity is twice as high.

Seasonal and annual variation in infestation

Because of the seasonal nature of the herring fishery in most areas, samples could not be obtained on a year-round basis from a single area to elucidate seasonal trends in nematode abundance. However, a major herring fishery, which occurs along southwestern Newfoundland from November to April (Hodder, 1969, 1970), was intensively sampled for larval nematodes during the 1968-69 and 1969-70 seasons (Fig. 5). Except for December 1968 there was no significant variation in nematode incidence in herring during the overwintering period. The higher-than-average incidence value for December 1968 cannot be attributed to more larger and older herring in the samples for that month, since the average size remained relatively constant throughout the entire season. Sindermann (1957), in a study of seasonal parasitization of herring in the Bay of Fundy, found that the nematode incidence rose sharply in early winter and then stabilized at a somewhat lower level during spring and summer. Bishop and Margolis (1955) reported that the level of infestation in British Columbia herring remained constant throughout the winter for any particular fish age and area.

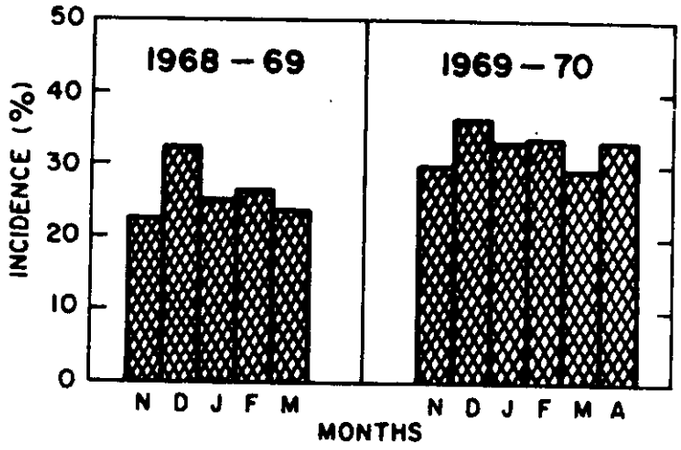

Fig. 5. Incidence of larval nematodes in herring from southwestern Newfoundland by month during the winters of 1968-69 and 1969-70.

In the present study the incidence of infestation of herring with nematodes was on the average slightly higher during the 1969-70 season (33%) than during the 1968-69 season (27%) (Fig. 5 and Table 3). This is probably due to the fact, as reported by Hodder (1970), that the average size (age) of southwest Newfoundland herring was slightly larger in 1969-70 than in 1968-69 (33.2 cm compared with 33.0 cm).

Discussion

The distinct geographic variation in the incidence and intensity of infestation of adult herring from Canadian Atlantic waters with larval Anisakis indicates that this parasite is valuable as a biological indicator of stock heterogeneity. Hodder and Parsons (MS 1970, 1971) compared certain biological characteristics of herring taken at Magdalen Islands in the southern Gulf of St. Lawrence just prior to the start of the Newfoundland fishery in the autumn of 1969 and in the coastal waters of southwestern Newfoundland shortly thereafter. The authors concluded that the samples from Magdalen Islands and along southwestern Newfoundland were derived from the same stock complex and that the winter fishery along southwestern Newfoundland is largely dependent on herring concentrations which migrate eastward out of the southern part of the Gulf of St. Lawrence in the autumn. Subsequent to that study herring were tagged in the inshore waters of southwestern Newfoundland in early March 1970 and, after the termination of the Newfoundland fishery about mid-April, recaptures were made at Magdalen Islands (Hodder and Winters, MS, 1970) and as far west as the Gaspé Peninsula (Winters, 1970), thus confirming the westward movement of the herring schools after they leave the Newfoundland coast in the spring. The similarity in incidence and intensity of Anisakis infestation of herring fished near Magdalen Islands in the fall, herring from southwestern Newfoundland in winter, herring fished between Cape Breton and Magdalen Islands in the spring and near Chaleur Bay-Gaspé during the summer provides further evidence of a seasonal migration of herring eastward from the southern Gulf of St. Lawrence in the autumn to

overwintering areas along southwestern Newfoundland and westward again into the Gulf in the spring.

The similarity of nematode abundance in herring from northeastern Nova Scotia (Gabarus Bay) and from the Banquereau-Sable Island area suggests the possibility of an inshore-offshore migration of herring on the Nova Scotian shelf. However, the data indicate that herring from these areas probably do not intermingle to any great extent with the southwestern Newfoundland-southern Gulf of St. Lawrence stock complex, since intermixing should produce greater homogeneity in Anisakis incidence than has been found in this investigation. Iles and Tibbo (MS, 1970) suggested that there is an influx of herring through the southern entrance of the Gulf in April which may involve Chedabucto Bay fish and/or herring recorded as caught in quantity in the early months of the year on Banquereau moving towards Cape Breton in the spring. In view of the present results which conflict with this hypothesis, intensive sampling of herring along the southern edge of the Laurentian Channel for Anisakis larvae is suggested to shed further light on the stock interrelationships in this area. Sindermann (1957, 1959) reported that larval nematodes were more abundant along the Nova Scotian coast than in either the Gulf of St. Lawrence or the Gulf of Maine, being more than twice as abundant in Nova Scotian fish as in Georges Bank fish. He also found that larval cestodes, which were common in herring from the southern Gulf of Maine, were less abundant in Nova Scotian fish and completely absent in the Gulf of St. Lawrence. Sindermann (1961b) reported an average incidence of 76% and 64% for adult herring from the outer Nova Scotia coast and the Nova Scotia Fundy coast respectively for 1955-58. These values are similar to those obtained during the present study - 64% for northeastern Nova Scotia herring and 73% for herring from St. Mary's Bay which borders on the Bay of Fundy. The average incidence in the southern Gulf of St. Lawrence during Sindermann's investigation (1955-58) was 22%, ranging from 19% in Chaleur Bay and along the north Gaspé coast to 31% in Northumberland Strait. There appears to have been a slight increase in incidence between 1955-58 and 1969-70.

From nematode abundance it appears that herring along the northwest coast of Newfoundland are relatively distinct from the southwestern Newfoundland-southern Gulf stock complex. Herring which occur during the summer in the Strait of Belle Isle may represent an older portion of the same stock which occurs in Hawke's Bay. The average nematode incidence in Bonne Bay (37%) is not much higher than that along southwestern Newfoundland. Sindermann (1957) reported an incidence of 24% in a sample of herring obtained from Bay of Islands in 1955. Herring from the southern portion of the Newfoundland west coast may contribute to the winter fishery along southwestern Newfoundland.

The low abundance of larval nematodes at all ages in spring spawning herring from Notre Dame Bay suggests that this herring stock is relatively discrete, although it probably intermingles to a certain extent with herring to the north and south in White Bay and Bonavista Bay. The higher nematode abundance in Fortune Bay herring compared with herring from southwestern Newfoundland indicates that Fortune Bay herring, which are almost exclusively spring spawners, do not intermingle to any great extent with the herring stock complex which overwinters along southwestern Newfoundland. Sindermann (1957) found an incidence of 94% in a sample of herring from Fortune Bay in 1956. It is possible that his sample consisted of very large old fish. Tibbo (1957) reported a high proportion of very old herring in Fortune Bay from 1946 to 1948. At that time the average size was 35.6 cm and the average age was 11 years. The average size and age of the adult specimens examined in our study was much less (Tables 1 and 2).

The similarity of incidence and intensity of infestation of herring from Placentia and St. Mary's bays with Anisakis larvae suggests that the samples from these two adjacent bays were derived from the same stock. This was previously indicated by the migration of "red" herring, which had been exposed to phosphorus poisoning in Placentia Bay, into St. Mary's Bay in the spring of 1969 (Unpublished data, St. John's Biological Station).

Relatively little is known of the life cycle of Anisakis nematodes which occur in herring. Marine mammals are the definitive hosts of adult

Anisakis (Baylis, 1920; Baylis and Daubney, 1926; Khalil, 1969). Templeman, Squires and Fleming (1957) list the following final hosts: the common porpoise, Phocoena phocoena L.; the common dolphin, Delphinus delphis L.; the white-beaked dolpin, Lagenorhynchus albirostris Gray; the narwhal, Monodon monoceros L.; the bottle-nosed whale, Hyperoödon ampullatus (Forster); the little piked or minke whale, Balaenoptera acutorostrata Lacépède; the fin whale, Balaenoptera physalus (L.); the sei whale, Balaenoptera borealis Lesson; the false killer whale, Pseudorca crassidens (Owen); the blue whale, Balaenoptera musculus (L.); the white whale, Delphinopterus leveas (Pallas); the walrus, Odobaenus rosmarus. A more extensive list of cetacean hosts is given by Baylis (1932). Sergeant (1962) reported the occurrence of adult Anisakis simplex in the stomachs of pilot or pothead whales, Globicephala melaena (Traill), in Newfoundland waters. Scott and Fisher (1958) found adult Anisakis in the harbour seal Phoca vitulina, the harp seal Phoca groenlandica and the grey seal Halichoerus grypus, in the Canadian area of the western North Atlantic. Van Thiel (1966) also found Anisakis in grey seals on the east coast of Scotland.

The relative importance of these marine mammals as final hosts for the Anisakis larvae which occur in herring is uncertain. Although pilot whales which are the most abundant cetacean in Newfoundland waters in summer harbour adult Anisakis simplex, they feed almost exclusively on the short-finned squid, Illex illecebrosus (LeSueur), and there is little evidence to indicate that herring form an important constituent in their diet (Sergeant, 1962). The common dolphin, Delphinus delphis, is abundant off eastern Nova Scotia in the region of "slope water" at temperatures between 13 and 17 C during the late summer and autumn (Sergeant and Fisher, 1957). The common porpoise, Phocoena phocoena, is abundant in the Passamaquoddy Bay region of the Bay of Fundy each summer, at which time herring is the principal item of diet. The porpoise is well-known elsewhere in the Maritimes and is frequently taken in cod traps in June and July in Newfoundland waters (Sergeant and Fisher, 1957). Another host of adult Anisakis, the minke whale, Balaenoptera acutorostrata, supports a shore-based fishery off eastern Nova Scotia and eastern

Newfoundland, generally from late May to late July in the latter region, during its northward migration. Herring are of minor importance in its diet (Sergeant, 1963). A large population of white whales, Delphinopterus leveas, occurs in the St. Lawrence estuary and has been described by Vladykov (1944). Offshoots of this population sometimes occur in the Bay of Fundy but only rarely along Newfoundland and Labrador.

Templeman, Squires and Fleming (1957) and Scott and Fisher (1958) have described the distribution of harbour, grey and harp seals in the Canadian area of the western North Atlantic. Herring comprise a large portion of the diet of harbour seals in Newfoundland-Labrador waters (Templeman, Squires and Fleming, 1957). However, adult Anisakis occur only rarely in these seals (Scott and Fisher, 1958).

The geographic variation in the incidence and intensity of infestation of adult herring with Anisakis larvae is dependent not only upon the distribution and migrations of the final hosts but also upon the distribution of the first intermediate host, current patterns, herring migrations and particularly the location of herring feeding grounds. Herring may become infested by ingesting the eggs after they are discharged into the sea from a marine mammal. However, most investigators have assumed that infestation occurs as a result of herring feeding upon infested plankton which thus act as the first intermediate host. Anisakis larvae have been reported to occur in the euphausiid Thysanoessa (Polyanskii, 1955). The life span of the larvae in herring is unknown. The increase in incidence and intensity of infestation with increasing age and size of the fish indicates that the larval nematodes accumulate from year to year. Invertebrate organisms such as copepods and euphausiids are the chief food of herring. It is not known which of these invertebrates act as hosts for the larval Anisakis which occur in herring. Consequently, it is difficult to offer an adequate explanation for the specific geographic variation of Anisakis in herring as shown in the present study. Further research into the life cycle of this parasitic nematode may elucidate the reasons for its observed distribution in herring of the western North Atlantic.

Nematode larvae, such as those occurring in herring, can be harmful to man. The first case of so-called "herring-worm disease", later termed "anisakiasis", was observed in Holland in 1955. From 1955 through 1967 149 proven cases were reported in the Netherlands. During 1967 there were 92 cases of "anisakiasis" in Japan. European scientists found that Anisakis larvae could be transmitted to man through eating infested herring either raw or inadequately treated. Following the introduction by the Netherlands government of new regulations for the treatment of herring for human consumption, the number of cases declined dramatically to only 5 proven cases in 1968 (Ruitenberg, MS, 1970). Khalil (1969) and Ruitenberg (MS, 1970) have described the effects of salt and temperature on the survival of Anisakis larvae in herring.

The intensity of infestation of adult herring in the Northwest Atlantic with Anisakis larvae varies with locality, ranging from 0.17 nematodes per fish in Notre Dame Bay to 2.96 nematodes per fish along southern Labrador, but is generally much lower than in herring from British coastal waters (33.1 larvae per fish with 30-50 larvae per herring being frequent) as reported by Khalil (1969). Herring from the west of Scotland and the northwest of Ireland (3.2 and 1.6 nematodes per fish respectively) were considered to have a low level of infestation. The intensity of infestation in herring from southwestern Newfoundland and the southern Gulf of St. Lawrence, where two of the major Canadian herring fisheries are presently concentrated, is very low in comparison with nematode abundance in eastern North Atlantic herring, particularly those from the North Sea. Even the highest intensities in the Canadian area (2.96, 2.65, 2.28, 2.19 and 2.01 nematodes per fish) are comparable to the intensities in herring from Scotland and Ireland, which have been termed low by European investigators. Thus it appears that the relatively low intensity of Anisakis larvae in herring from the Canadian area of the western North Atlantic poses a negligible problem in the utilization of herring for human consumption particularly if the herring are properly treated.

Acknowledgments

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Table 1. Percentage incidence (left) and average number of nematodes per fish (right) in relation to size of herring for the various areas sampled (numbers of fish examined in parenthesis).

Area code	Locality	Percentage incidence by 2-cm length groups												Intensity by 2-cm length groups											
		<20	20 21	22 23	24 25	26 27	28 29	30 31	32 33	34 35	36 37	38 39	>39	<20	20 21	22 23	24 25	26 27	28 29	30 31	32 33	34 35	36 37	38 39	>39
1	St. Mary's Bay, N.S.					50.0 (8)	73.5 (34)	70.6 (34)	78.9 (19)	75.0 (4)		100.0 (1)						0.88	1.53	2.50	2.79	3.40		10.00	
2	N.E. Nova Scotia (Gabarus Bay)		0.0 (5)	14.3 (21)	23.9 (71)	27.7 (47)	39.6 (53)	52.9 (70)	76.6 (47)	67.8 (28)	66.7 (6)	100.0 (1)	100.0 (1)		0.00	0.19	0.37	0.51	0.64	1.20	2.62	1.97	3.33	16.00	2.00
3	Banquereau-Sable Island Bank						66.7 (9)	55.6 (9)	56.5 (23)	70.0 (50)	83.3 (6)	100.0 (1)							1.22	2.44	1.96	2.78	6.83	2.00	
5	Magdalen Islands					0.0 (3)	9.1 (22)	15.3 (72)	27.1 (210)	38.6 (179)	50.0 (14)							0.00	0.09	0.20	0.42	0.74	1.43		
7	S.W. Newfoundland					0.0 (6)	15.8 (38)	17.2 (302)	29.4 (779)	32.8 (439)	45.5 (33)							0.00	0.24	0.29	0.46	0.57	1.30		
9	Hawke's Bay, Nfld.				0.0 (6)	5.4 (37)	30.7 (88)	17.2 (93)	45.2 (93)	65.5 (84)	92.1 (38)	100.0 (6)					0.00	0.08	0.40	0.29	0.85	2.17	8.03	17.00	
10	Strait of Belle Isle						0.0 (2)	0.0 (2)	30.0 (10)	60.0 (45)	68.8 (96)	84.1 (44)	100.0 (1)						0.00	0.00	0.80	1.60	2.57	6.61	2.00
11	Southern Labrador							0.0 (1)	42.9 (7)	31.1 (45)	53.9 (65)	71.8 (39)	66.7 (3)							0.00	1.14	0.74	1.49	4.51	20.33
12	Quirpon, Nfld.						20.0 (10)	17.4 (23)	22.8 (57)	24.3 (74)	62.5 (48)	71.4 (7)							0.30	0.22	0.42	0.67	2.35	6.29	
13	Conche, Nfld.					0.0 (4)	8.4 (24)	3.3 (30)	9.5 (42)	12.5 (24)	38.5 (39)	45.4 (11)						0.00	0.12	0.03	0.52	0.17	0.92	2.73	
14	Notre Dame Bay, Nfld.					0.0 (5)	1.9 (104)	3.2 (225)	4.9 (121)	11.7 (85)	37.5 (8)							0.00	0.03	0.06	0.07	0.17	1.63		
15	Bonavista Bay, Nfld.	0.0 (1)		0.0 (1)	0.0 (2)	0.0 (8)	4.2 (48)	9.0 (134)	11.8 (93)	34.4 (61)	44.7 (47)	66.7 (6)		0.00		0.00	0.00	0.00	0.04	0.16	0.24	0.84	1.53	1.33	
16	Trinity and Conception bays, Nfld.						0.0 (31)	15.1 (172)	23.8 (151)	39.2 (79)	62.0 (100)	80.6 (60)							0.00	0.27	0.38	0.93	2.82	5.13	
17	Eastern Avalon Peninsula, Nfld.						0.0 (2)	32.2 (31)	53.4 (30)	50.0 (6)	80.0 (5)								0.00	0.49	0.87	0.67	1.60		
18	St. Mary's Bay, Nfld.	0.0 (30)	2.1 (49)	0.0 (4)		0.0 (2)	13.7 (51)	12.3 (104)	25.2 (139)	36.0 (125)	66.3 (80)	58.3 (12)	100.0 (1)	0.00	0.02	0.00		0.00	0.18	0.17	0.57	0.82	1.91	1.83	6.00
	Placentia Bay, Nfld.			0.0 (1)	0.0 (2)	5.0 (101)	20.0 (10)	26.4 (68)	29.5 (95)	26.0 (104)	51.4 (74)	62.5 (16)	66.7 (3)			0.00	0.00	0.06	0.20	0.41	0.53	0.52	2.03	5.31	2.33
19	Fortune Bay, Nfld.	0.0 (11)	3.9 (26)	0.0 (13)	8.9 (79)	9.8 (41)	20.6 (34)	37.0 (73)	45.3 (86)	60.9 (23)	100.0 (7)	75.0 (4)		0.00	0.04	0.00	0.13	0.09	0.32	0.99	0.89	1.61	2.14	14.00	

Table 2. Percentage incidence (left) and average number of nematodes per fish (right) in relation to age of herring for the various areas sampled (numbers of fish examined in parenthesis).

Area code	Locality	Percentage incidence by age (years)										Intensity by age (years)									
		1	2	3	4	5	6	7	8	9	10+	1	2	3	4	5	6	7	8	9	10+
2	N.E. Nova Scotia (Gabarus Bay)		6.7 (15)	22.2 (117)	32.4 (34)	33.3 (9)	52.7 (74)	63.6 (33)	81.8 (22)	64.7 (17)	75.0 (28)		0.13	0.32	0.62	0.44	0.95	1.48	3.59	2.71	2.68
3	Sable Island Bank						66.7 (3)	50.0 (4)	71.4 (7)	75.0 (12)	95.5 (22)						3.67	2.00	3.43	2.67	3.95
5	Magdalen Islands			0.0 (7)	9.1 (22)	10.8 (37)	28.8 (80)	25.9 (81)	30.6 (111)	25.5 (55)	44.9 (107)			0.00	0.14	0.11	0.38	0.43	0.51	0.49	0.93
7	S.W. Newfoundland		0.0 (1)	0.0 (2)	0.0 (7)	13.0 (23)	27.3 (77)	46.5 (71)	34.7 (121)	37.8 (74)	35.1 (74)		0.00	0.00	0.00	0.30	0.43	0.62	0.51	0.50	0.61
9	Hawke's Bay, Nfld.		6.3 (16)	22.2 (72)	16.7 (96)	35.9 (39)	35.9 (39)	54.6 (22)	45.5 (33)	63.9 (36)	78.9 (90)		0.13	0.29	0.22	0.51	0.56	0.86	1.15	1.56	5.87
10	Strait of Belle Isle					0.0 (2)		40.0 (15)	63.6 (11)	30.0 (10)	73.5 (162)					0.00		0.93	1.18	0.90	3.60
11	Southern Labrador						33.3 (3)	100.0 (4)	22.2 (9)	23.1 (13)	55.0 (131)						0.33	2.8	0.78	0.69	2.65
12	Quirpon, Nfld.				28.6 (7)	16.7 (6)	24.0 (50)	28.6 (14)	26.1 (23)	6.7 (30)	51.1 (90)				0.29	0.33	0.44	0.64	0.78	0.10	2.06
13	Conche, Nfld.			11.1 (9)	16.7 (6)	8.3 (12)	2.7 (37)	15.4 (13)	3.2 (31)	0.0 (8)	39.7 (58)			0.22	0.17	0.08	0.11	0.23	0.48	0.00	1.21
14	Notre Dame Bay, Nfld.				0.0 (8)	0.0 (6)	5.5 (73)	2.3 (263)	5.9 (17)	3.4 (59)	12.5 (120)				0.00	0.00	0.14	0.02	0.06	0.03	0.27
15	Bonavista Bay, Nfld.	0.0 (1)	0.0 (3)	0.0 (7)	0.0 (1)	0.0 (23)	11.3 (150)	11.5 (52)	8.3 (48)	20.8 (24)	43.0 (93)	0.00	0.00	0.00	0.00	0.00	0.25	0.12	0.17	0.38	1.26
16	Trinity and Conception bays, Nfld.			0.0 (1)	0.0 (18)	7.1 (14)	12.0 (225)	31.7 (82)	43.3 (30)	33.3 (30)	64.8 (193)			0.00	0.00	0.14	0.22	0.54	0.83	0.67	3.27
17	Eastern Avalon Peninsula, Nfld.				40.0 (5)		0.0 (1)	38.8 (49)	50.0 (8)	100.0 (1)	70.0 (10)				0.60	-	0.00	0.59	0.88	2.00	1.20
18	St. Mary's Bay, Nfld.		1.2 (84)	0.0 (1)	18.5 (54)	0.0 (5)	20.4 (162)	21.2 (52)	33.3 (21)	25.0 (40)	50.6 (178)		0.01	0.00	0.24	0.00	0.35	0.56	0.76	0.48	1.44
	Placentia Bay, Nfld.		0.0 (1)	5.7 (106)	0.0 (9)	40.0 (5)	26.3 (118)	27.3 (22)	16.7 (12)	23.1 (26)	44.6 (175)		0.00	0.07	0.00	0.40	0.42	0.50	0.17	0.38	1.72
19	Fortune Bay, Nfld.	0.0 (6)	2.6 (39)	8.1 (123)	22.2 (36)	100.0 (1)	36.2 (127)	58.6 (29)	50.0 (4)	80.0 (5)	74.1 (27)	0.00	0.03	0.11	0.36	2.00	0.89	1.14	0.50	1.60	3.63

ble 3. Geographic variation in the incidence of larval nematodes in adult herring (230 cm) from Canadian Atlantic waters, 1968-70.

Area code	Locality	No. of adult herring examined	Percentage of herring infected	No. of nematodes per 100 herring
1	St. Mary's Bay, N.S.	100	73	228
2	N.E. Nova Scotia	153	64	196
3	Banquereau-Sable Island Bank	98	66	265
4	Chaleur Bay-Gaspé	44	25	32
5	Magdalen Islands	500	29	51
6	North of Cape Breton Island	500	29	45
7	Southwest Newfoundland - 1968-69	1939	27	51
	1969-70	1660	33	54
	1968-70	3599	30	53
8	Bonne Bay, Nfld.	150	37	87
9	Hawke's Bay, Nfld.	313	50	219
10	Strait of Belle Isle	250	61	265
11	Southern Labrador	110	59	296
12	Quirpon, Nfld.	306	43	132
13	Conche, Nfld.	108	24	83
14	Notre Dame Bay, Nfld.	549	8	17
15	Bonavista Bay, Nfld.	530	22	52
16	Trinity and Conception bays, Nfld.	513	40	150
17	Eastern Avalon Peninsula, Nfld.	267	48	101
18	St. Mary's and Placentia bays, Nfld.	983	33	91
19	Fortune Bay, Nfld.	470	43	110