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Larval Parasitic Nematodes Infecting Marine Crustaceans in Eastern Canada. 3. *Hysterothylacium aduncum*

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ABSTRACT: Third-stage larvae of *Hysterothylacium aduncum* were found infecting the hermit crab *Pagurus acadianus,* the gammaridean amphipod *Proboloides holmesi,* and the caprellid amphipod *Caprella linearis.* Five nematodes were found in 3 infected hermit crabs (100%) collected from the brackish Bras d'Or Lakes, Cape Breton Island, Nova Scotia. One infected hermit crab (0.3%) and 2 specimens of *P. holmesi* (7.7%) on the Scotian Shelf (the continental shelf off Nova Scotia) near Sable Island were each infected with single worms. One specimen of *C. linearis* (0.06%) in the St. Croix River, close to where it enters Passamaquoddy Bay, New Brunswick, was infected with a single nematode. No larva of *H. aduncum* was found in 18,210 amphipods belonging to 32 species other than *P. holmesi* and *C. linearis,* 1,254 mud shrimp (*Crangon septemspinosa*), 1,147 cumaceans, 417 isopods, or 4,819 polychaetes collected near Sable Island nor in 780 other hermit crabs (*P. arcuatus* and *P. pubescens*) collected from various areas on the Scotian Shelf and Georges Bank. Two fourth-stage larvae and one adult female *H. aduncum* were found in 2 amphipods (*Ceradocus torelli*) found among the gut contents of an Atlantic cod collected in the Cabot Strait. The intermediate host list of *Hysterothylacium* spp. compiled by Norris and Overstreet (1976) is updated.

KEY WORDS: *Hysterothylacium aduncum,* intermediate hosts, hermit crab, *Pagurus acadianus,* amphipod, *Proboloides holmesi, Caprella linearis, Ceradocus torelli.*

Nematode species of the genus *Hysterothylacium* (Ascaridoidea: Anisakidae) are extremely common intestinal parasites of teleosts, especially in the marine environment. In North Atlantic waters, *Hysterothylacium aduncum* (Rudolphi, 1802) Deardorff and Overstreet, 1981 (=*Thynnascaris adunca* = *Contracaecum aduncum*), generally is the only species recognized, but the taxonomy is unresolved (Køie, 1993). Off the Pacific and Atlantic coasts of North America, there are at least 76 species of teleost hosts of *H. aduncum* (see Margolis and Arthur, 1979; Love and Moser, 1983).

As with other anisakid nematodes, the life cycle involves an invertebrate intermediate host. Norris and Overstreet (1976) reviewed the known invertebrate hosts reported for *Hysterothylacium* spp. At that time, known hosts consisted of 10 copepods, 5 mysids, 1 isopod, 1 amphipod, 3 euphausiids, 17 decapods, 10 polychaetes, 5 gastropods, 2 cephalopods, 3 cnidarians, 1 ctenophore, 9 chaetognaths, and 1 starfish.

Since 1989, the Canadian Department of Fisheries and Oceans has conducted extensive surveys of invertebrates off Atlantic Canada. During the course of this survey, new intermediate hosts for *H. aduncum* were discovered and are reported herein, along with an update of Norris and Overstreet (1976).

Materials and Methods

Marine invertebrates were collected from various areas off Nova Scotia and New Brunswick using a 0.5-m^2 Van Veen grab, epibenthic sled, scallop dredge, or coarse-meshed plankton net. Animals were collected in the Bras d'Or Lakes, Nova Scotia, from the CSS *Navicula* in August 1989; on the Scotian Shelf from the CSS *Alfred Needler* in February 1989 and 1990 and from the CSS *E. E. Prince* in May 1989 and 1990; on Georges Bank from a commercial scallop dragger in May 1991; and in the St. Croix River, New Brunswick, in June 1993. Collecting sites are shown in Figure 1. In addition, 2 infected amphipods (*Ceradocus torelli*) were removed from the stomach of an Atlantic cod (*Gadus morhua*) (collected from the CSS *Gadus Atlantica* with an otter trawl in the Cabot Strait between Cape Breton Island and Newfoundland, 47°05.5'N, 58°54.1'W) and frozen.

Invertebrates were fixed and preserved in 5% glycerol in 70% ethanol, sorted, identified, and dissected using a stereomicroscope. Nematodes were measured and identified using a compound microscope equipped with a calibrated ocular micrometer or with a calibrated digitizer and drawing tube. All measurements are given as means with the range in parentheses.

Results

Hysterothylacium aduncum was found infecting Acadian hermit crabs (*Pagurus acadianus*), gammaridean amphipods (*Proboloides holmesi*), and caprellid amphipods (*Caprella linearis*) (Table 1). Each amphipod was infected with a single worm, and intensity ranged from 1 to 3 in hermit

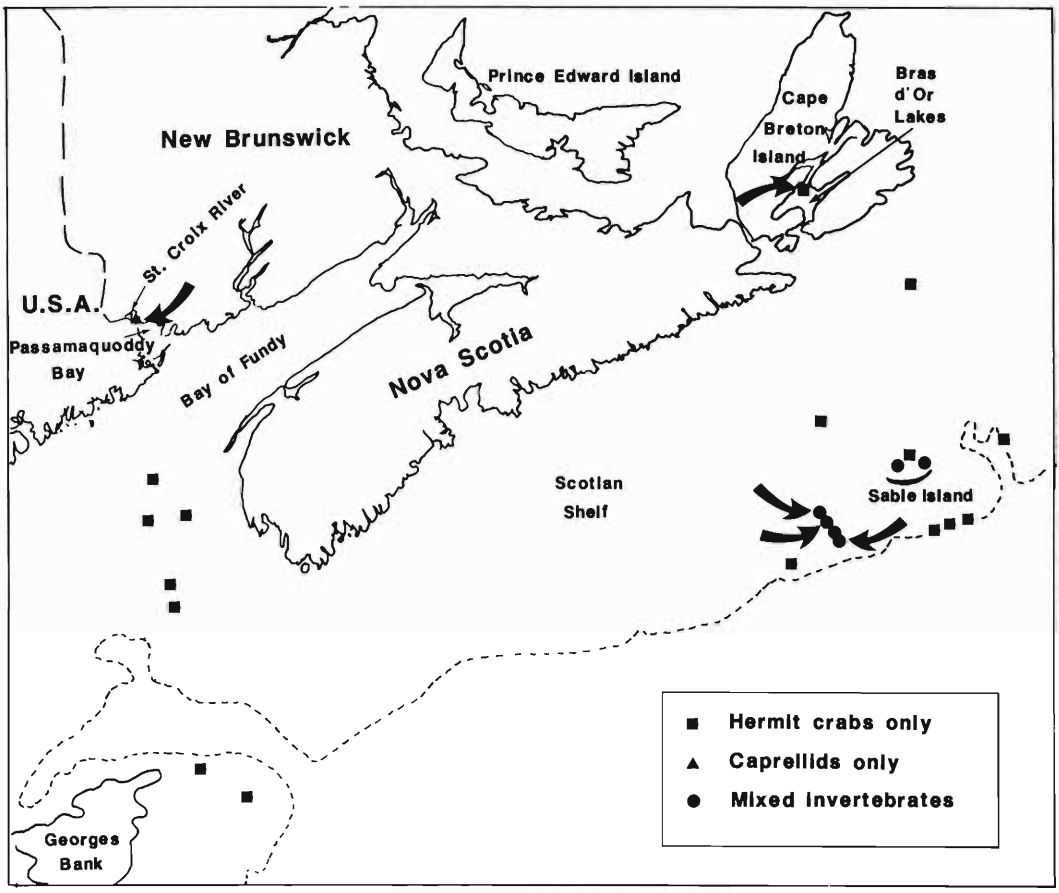

Figure 1. Map depicting invertebrate sampling locations in the Bras d'Or Lakes, on the Scotian Shelf and Georges Bank, Nova Scotia, and on the St. Croix River, New Brunswick. Large arrows indicate where crustaceans infected with *Hysterothylacium aduncum* were found.

crabs. Sites of collection of infected invertebrates are shown in Figure 1. No anisakid was found in 18,210 amphipods belonging to 32 other species, 1,254 mud shrimp (*Crangon septemspinosa*), 1,147 cumaceans, 417 isopods, or 4,819 polychaetes collected in the vicinity of Sable Island in 1989–1990 nor in 74 Acadian hermit crabs from Georges Bank or 780 hairy hermit crabs (*P. arcuatus* and *P. pubescens*) collected from various areas on the Scotian Shelf and Georges Bank.

All specimens of *H. aduncum* possessed a boring tooth, an intestinal cecum, a short ventriculus, a ventricular appendix, and an excretory

Table 1. Prevalence (%) and mean intensity (M.I. = mean number/infected host) of *Hysterothylacium aduncum* in invertebrates collected in eastern Canada.

Species	*N*	P (%)	M.I.	Site
Pagurus acadianus	3	100	1.7	Bras d'Or Lakes
Benedict, 1901	331	0.3	1.0	Scotian Shelf
Proboloides holmesi	26	7.7	1.0	Scotian Shelf
Bousfield, 1973				
Caprella linearis	1,664	0.06	1.0	St. Croix River
(Linnaeus, 1767)				

Table 2. New invertebrate hosts for marine species of *Hysterothylacium* published since Norris and Overstreet (1976). Species previously recorded as natural or experimental hosts of any species of *Hysterothylacium* in Norris and Overstreet (1976) are omitted here.

Host	Parasite	Locality	Source
Cnidaria			
Aglantha digitale	*Hysterothylacium* sp.	Oslofjord	Svendsen, 1990
Ctenopora			
Mnemiopsis mccardyi	*H. aduncum*	Black Sea	Gaevskaya and Mordvinova, 1993
Arthropoda			
Copepoda			
Acartia bifilosa	*Hysterothylacium* sp.	Baltic Sea	Zander et al., 1994
Acartia tonsa	*H. aduncum*	Experimental	Køie, 1993
Calanus sinicus	*Thynnascaris* sp.	East China Sea	Shimazu, 1982
Centropages hamatus	*C. aduncum*	Experimental	Val'ter et al., 1979
	Hysterothylacium sp.	Baltic Sea	Zander et al., 1994
Centropages typicus	*Hysterothylacium* sp.	Oslofjord	Svendsen, 1990
Cyclospina sp.	*C. aduncum*	Experimental	Val'ter et al., 1979
Eurytemora hirundoides	*Hysterothylacium* sp.	Baltic Sea	Zander et al., 1994
Oncaea borealis	*C. aduncum*	Experimental	Val'ter et al., 1979
Pseudocalanus elongatus	*H. aduncum*	Black Sea	Solonchenko and Kovaleva, 1985
Mysidacea			
Mysis stenolepis	*H. aduncum*	Bras d'Or Lakes	Jackson, 1995
Neomysis integer	*H. aduncum*	Ythan estuary	Gibson, 1972
	H. aduncum	Isefjord	Køie, 1993
Neomysis intermedia	*H. aduncum*	Lake Toro	Yoshinaga et al., 1987b
Neomysis japonica	*H. haze*	Experimental	Yoshinaga et al., 1989
Isopoda			
Idothea sp.	*H. aduncum*	Isefjord	Køie, 1993
Jaera albifrons	*Hysterothylacium* sp.	Baltic Sea	Zander et al., 1994
		Experimental	Køie, 1993
Sphaeroma rugicauda	*H. aduncum*	Experimental	Køie, 1993
Amphipoda			
Amphithoe valida	*H. haze*	Experimental	Yoshinaga et al., 1989
Anisogammarus kygi	*H. aduncum*	Salmon hatchery, Japan	Moravec and Nagasawa, 1986
Calliopius laeviusculus	*Hysterothylacium* sp.	Baltic Sea	Zander et al., 1994
Caprella linearis	*H. aduncum*	St. Croix River	This study

Table 2. Continued.

Host	Parasite	Locality	Source
Corophium bonelli	*H. aduncum*	Experimental	Køie, 1993
Corophium uenoi	*H. haze*	Experimental	Yoshinaga et al., 1989
Gammarus finmarchicus	*Hysterothylacium* sp.	Baltic Sea	Zander et al., 1994
Gammarus oceanicus	*H. aduncum*	Baltic Sea	Fagerholm, 1982
Gammarus salinus	*Hysterothylacium* sp.	Baltic Sea	Zander et al., 1994
Gammarus zaddachi	*Hysterothylacium* sp.	Baltic Sea	Zander et al., 1994
Grandidierella japonica	*Hysterothylacium* sp.	Baltic Sea	Zander et al., 1994
Microdeutopus gryllotalpa	*H. aduncum*	Experimental	Køie, 1993
Parathemisto abyssorum	*H. haze*	Experimental	Yoshinaga et al., 1989
	Hysterothylacium sp.	Oslofjord	Svendsen, 1990
Proboloides holmesi	*H. aduncum*	Scotian Shelf	This study
Euphausiacea			
Thysanoëssa inermis	*Hysterothylacium* sp.	Scotland	Smith, 1983
Decapoda			
Callinectes sapidus	*H. reliquens*	Gulf of Mexico	Deardorff and Overstreet, 1981
Calocaris macandreae	*H. aduncum*	Irish Sea	Calderon-Perez, 1986
Carcinus mediterraneus	*C. filiforme* (s.i.)	Black Sea	Naidenova and Mordvinova, 1985
Crangon vulgaris	*H. aduncum*	Ythan estuary	Gibson, 1972
Munidia gregaria	*T. adunca*	New Zealand	Hurst, 1984
Pagurus acadianus	*H. aduncum*	Bras d'Or Lakes; Scotian Shelf	This study
Chaetognatha			
Eukrohnia hamata	*Contracaecum* sp.	Argentine Sea	Mazzoni, 1986
Sagitta crassa	*Thynnascaris* sp.	Inland Sea of Japan	Shimazu, 1982
Sagitta gazellae	*T. adunca*	New Zealand	Hurst, 1984
	Contracaecum sp.	Argentine Sea	Mazzoni, 1986
Sagitta minima	*T. adunca*	New Zealand	Hurst, 1984
Sagitta nagae	*Thynnascaris* sp.	East China Sea	Shimazu, 1982
Sagitta tasmanica	*T. adunca*	New Zealand	Hurst, 1984
	Contracaecum sp.	Argentine Sea	Mazzoni, 1986
Echinodermata			
Ophiopholis aculeatus	*H. aduncum*	Øreslund	Køie, 1993
Ophiura albida	*H. aduncum*	Øreslund	Køie, 1993

pore situated near the nerve ring. Worms were divisible into 2 size groups: <3.5 mm and >10 mm. Small worms had a conical tail, and larger ones had a bulbous tail terminating in a spine. Similar developmental changes occurred in third-stage larvae of *H. aduncum* in Køie's (1993) laboratory study. The nematodes averaged 5.35 (1.35–11.72) mm in length and 0.094 (0.048–0.180) mm in width at the nerve ring. The mean length of the esophagous was 0.747 (0.207–1.473) mm, the intestinal cecum 0.303 (0.055–0.722) mm, the ventricular appendix 0.194 (0.073–0.850) mm, and the tail 0.091 (0.067–0.118) mm. The ratio of cecal to ventricular appendix lengths was 1:0.96–3.30. The nerve ring averaged 0.194 (0.096–0.299) mm from the anterior end. Voucher specimens (CMNPA 1995-0085–0089) are deposited in the Canadian Museum of Nature (P.O. Box 3443, Station D, Ottawa, Ontario, Canada K1P 6P4). In addition, 2 fourth-stage larvae, 33.3 and 35.5 mm in length, and 1 adult female *H. aduncum,* 42.4 mm in length, were found in 2 amphipods (*C. torelli*) removed from the stomach of a cod collected in the Cabot Strait. The 3 nematodes each had 3 large lips with short interlabia and a spinous tail. The adult measured 0.483 mm in width, its esophagus 1.952 mm, ventriculus 0.203 mm, intestinal cecum 1.537 mm, ventricular appendix 0.775 mm, and tail 0.343 mm in length, and its nerve ring was 0.508 mm from the anterior end. The other 2 nematodes were too badly decomposed to make measurements of internal structures. No specimens of *C. torelli* were collected in the invertebrate sampling program.

This is the first report of each of these crustaceans as intermediate hosts for *H. aduncum.* New invertebrate host records of marine species of *Hysterothylacium* published since the synopsis of Norris and Overstreet (1976) are listed in Table 2.

The only other parasitic nematode found infecting the invertebrates examined was a single unidentifiable spirurid in a specimen of the gammaridean amphipod *Lembos websteri* collected near Sable Island.

Discussion

Hysterothylacium spp. are among the most widespread parasites in the marine environment, being found in numerous fish species as well as in over 100 invertebrate species from 7 phyla (see Norris and Overstreet, 1976; Table 2, this study). Chaetognaths and decapods are very common hosts. Køie (1993) suggested that at least 1 intermediate host, a crustacean, is required for transmission of *H. aduncum* to fish. Noncrustacean hosts are successfully infected by consuming infected copepods (Køie, 1993).

Results herein and elsewhere suggest that *H. aduncum* is extremely common in the brackish Bras d'Or Lakes, with high abundances also being detected in mysids and chaetognaths (Jackson, 1995). The high water temperatures and confined nature of the lakes may create a focus of infection, allowing for greatly accelerated transmission. In contrast, infections in macroinvertebrates on the Scotian Shelf were extremely low. Other hermit crabs (*Clibanarius vittatus*) have also been reported elsewhere as hosts for *Hysterothylacium* sp. (Norris and Overstreet, 1976).

Reports of amphipods as hosts for *Hysterothylacium* spp. are becoming more common, and 14 different species have been documented (Table 2) since the synopsis of Norris and Overstreet (1976). Prevalence in amphipods in this study was much lower than in hermit crabs, with only 0.01% of 18,236 amphipods examined from Sable Island Bank being infected. It is curious that only *P. holmesi* was infected on Sable Island Bank. Little is known of the ecology of this species, other than it can be found in association with hydroids and ectoprocts (Bousfield, 1973), as are caprellids, which were infected in the St. Croix River. For some unknown reason, they may be exposed more often to infective stages of *H. aduncum.* Given the wide range of known invertebrate hosts of *H. aduncum,* it is unlikely that some sort of phylogenetic host specificity is involved.

It cannot be stated for certain that the *C. torelli* acts as an intermediate host because the fourth-stage and adult nematodes found may have been parasitic in the cod and migrated into the amphipods after ingestion by the fish. Other anisakid nematodes such as *Goezia minuta* Chandler, 1935, and *Iheringascaris inguies* (Linton, 1901) Deardorff and Overstreet, 1981, are known to occur in partially digested food items in the stomachs of their fish hosts (Deardorff and Overstreet, 1980b, 1981). However, large invertebrates previously have been reported infected with adult *Hysterothylacium* sp. (Margolis and Butler, 1954). On the Scotian Shelf, third- and fouth-stage larvae were found in the mysids *Er-*

ythrops erythropthalma and *Mysis mixta* and the shrimp *Crangon septemspinosa* recovered from flatfish stomachs (Martell and McClelland, 1995).

Infected crustaceans were found in both brackish (Bras d'Or Lakes, St. Croix River) and marine (Scotian Shelf) environments. Transmission of *H. aduncum* can also occur in freshwater habitats (Yoshinaga et al., 1987a, b). Similarly, *Hysterothylacium religuens* (Norris and Overstreet, 1975) Deardorff and Overstreet, 1981, is found in habitats of varying salinity, although Deardorff and Overstreet (1980a) presented evidence suggesting that this species is transmitted only in highly saline environments. The euryhaline tolerance of *H. aduncum,* together with its lack of specificity for intermediate and definitive hosts, no doubt contributes to its broad geographic distribution, being found in both the Atlantic and Pacific oceans, in both the northern and southern hemispheres.

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1996 Beltsville Symposium

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