Vol. 28: 163–167, 1997 | DISEASES OF AQUATIC ORGANISMS Dis Aquat Org | Published March 27

Helminth parasites of the digestive tract of the harbour porpoise *Phocoena phocoena* in Danish waters: a comparative geographical analysis

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ABSTRACT: Most studies of the helminth fauna of the harbour porpoise *Phocoena phocoena* have focused on taxonomy, associated pathologies and surveys reporting prevalence and abundance of the parasite species. This study (1) characterizes the helminth fauna of the digestive tract of the harbour porpoise in Danish waters and (2) examines the influence of some factors structuring helminth communities within the host's geographical range. Seventy digestive tracts (oesophagus, stomachs, duodenal ampulla and intestines) were analysed. We found 5 helminth species (*Anisakis simplex, Hysterothylacium aduncum, Pholeter gastrophilus, Bolbosoma* sp. and *Diphyllobothrium* sp.). Gastric ulcers associated with *A. simplex* were observed in 8 of the 28 porpoises infected with this parasite and gastric cysts produced by *P. gastrophilus* were observed in 2 of 70 porpoises analysed. No other pathologies were observed. The presence of *H. aduncum* and *P. gastrophilus* was the main difference between this study and a previous survey in the same area. Our data were compared with those of other analyses of helminth faunas from different harbour porpoise distribution areas. The geographical analysis suggested the presence of a strong local influence determining the helminth fauna, the cestode *Diphyllobothrium stemmacephalum* being the only species which could be considered as a specialist of the harbour porpoise. The intestinal helminth community of this host represents the most depauperate community recorded so far in a cetacean.

KEY WORDS: Nematoda · Cestoda · Trematoda · Acanthocephala · *Phocoena phocoena* · Cetacea

INTRODUCTION

The harbour porpoise *Phocoena phocoena* (L., 1758) is a small cetacean with coastal habits which is limited to the cold temperate and subarctic waters of the Northern Hemisphere. The species is distributed in 3 isolated areas: the North Pacific, the North Atlantic and the Black Sea (Klinowska 1991). Recently, there has been considerable interest in the harbour porpoise because of fears that the population is declining (International Whaling Commission 1984), mainly as a result of serious levels of incidental fishery mortality in European and North American waters (Donovan & Bjørge 1995).

The majority of helminthological studies of the harbour porpoise have focused on North Atlantic populations and dealt with the taxonomy (Wesenberg-Lund 1947, Arnold & Gaskin 1975, Gibson & Harris 1979), associated pathologies (Smith 1989, Baker & Martin 1992) and surveys reporting the prevalence and abundance of the parasite species (Clausen & Andersen 1988, Lick 1991). This study reports the helminth fauna of the digestive tract (oesophagus, stomach, and intestine) of harbour porpoises in Danish waters. In addition, we have reviewed previous helminthological information throughout the host's range to elucidate the influence of local and historical factors in the helminth community of the digestive tract.

MATERIALS AND METHODS

Seventy harbour porpoises (42 males and 28 females with a wide range of ages: 0 to 12 yr for females and

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0 to 13 yr for males) were collected from strandings or as by-catches between 1988 and 1990. Sixty-seven porpoises were obtained in the Skagerrak, Kattegat and adjacent waters, while only 3 were taken in the North Sea.

Stomachs and intestines were obtained from frozen carcasses and examined for parasites. All stomach compartments were analysed. The intestines were opened longitudinally and surveyed along their whole length. Helminths from the stomach and intestine were collected separately. A total recovery of parasites was attempted. The parasites were extracted from the mucosa or separated from food items using a 600 µm mesh sieve.

Nematodes, acanthocephalans and cestodes were fixed and preserved in 70% ethanol. Stomach cysts were preserved in formalin 10%. All specimens of each species were identified and counted to obtain the prevalence and abundance (terminology of Margolis et al. 1982). Voucher specimens will be deposited in the Parasitic Worm Section of the Natural History Museum in London (ref. no. 1996.10.1.1-4, 1996.10.1.5-14).

A comparative analysis of the harbour porpoise's helminth fauna was made based on all previous surveys available to us. In total, 8 data sets were examined (including this study). Despite the low number of studies available, the data cover the entire distribution of the harbour porpoise (North Atlantic, North Pacific and Black Sea). The comparison was based on prevalences and presence or absence of species, because other information was not available in all cases (see Table 2).

RESULTS

A total of 8110 helminth specimens belonging to 5 species were found: *Anisakis simplex*, *Hysterothylacium aduncum* (Nematoda), *Diphyllobothrium* sp. (Cestoda), *Pholeter gastrophilus* (Trematoda) and *Bolbosoma* sp. (Acanthocephala).

Helminth fauna was clearly dominated by anisakid nematodes both in individual hosts and in the total sample of porpoises (Table 1). *Anisakis simplex* was the most abundant and prevalent species, accounting for 82.6% of all the helminths recovered (Table 1). Gastric ulcers associated with this species were observed in 8 of the 28 porpoises infected with this species. Gastric cysts produced by *Pholeter gastrophilus* appeared in 2 of 70 porpoises analysed. No other parasite-induced pathologies were observed. The other anisakid species, *Hysterothylacium aduncum*, represented 17.32% of all the helminths recovered.

The quantitative contribution of the remaining species was low (Table 1). Only 1 adult female of *Bolbosoma* sp. and 2 *Diphyllobothrium* sp. specimens were found in the stomach and intestines, respectively. The condition of this material precluded identification at specific level. However, based on morphological resemblances and previous biogeographical evidence, *Diphyllobothrium* sp. may likely correspond to *D. stemmacephalum*.

The geographical analysis reveals that *Anisakis simplex* is the most widely distributed species, appearing in 7 of the 8 surveys. In addition, this species seems common in most of the localities, its prevalence being over 40% in 4 localities (Table 2).

Other species seem to be common locally but they are absent in certain areas. For example, other anisakid nematodes (*Pseudoterranova decipiens*, Krabbe, 1878; *Contracaecum osculatum*, Rudolphi, 1802; *Phocascaris* sp., Myers, 1957; and *Hysterothylacium aduncum*) had a prevalence >30% only in some areas of the North Atlantic. Likewise, the stomach trematode *Pholeter gastrophilus* (Kossack, 1910) has been recorded only in 3 localities (British coast, Danish waters and the Black Sea). *Diphyllobothrium stemmacephalum*, the most frequently recorded intestinal helminth, shows a high prevalence (40%) only in the Black Sea. The digeneans of the genus *Hadwenius* have been reported only in porpoises from the Pacific.

Table 1. Helminth parasites of the digestive tract of the harbour porpoise *Phocoena phocoena* from Danish waters. Dominance is expressed as the percentage of worm individuals of a particular species with respect to the total number of worms of all species

Helminth species	Site	Prevalence (%)	Abundance ($\bar{x}$ ± SD)	Abundance range	Dominance (%) Per host ($\bar{x}$ ± SD)	Dominance (%) Whole sample
Nematoda						
Anisakis simplex	Stomach, intestine	51.42	95.49 ± 369.03	0–2812	48.19 ± 48.09	82.6
Hysterothylacium aduncum	Stomach, intestine	45.71	20.36 ± 69.90	0–439	49.36 ± 47.82	17.32
Acanthocephala						
Bolbosoma sp.	Stomach	1.42	0.01 ± 0.12	0–1	0.01 ± 0.08	0.01
Cestoda						
Diphyllobothrium sp.	Intestine	2.85	0.03 ± 0.17	0–1	2.43 ± 14.58	0.02
Trematoda						
Pholeter gastrophilus	Stomach	2.85	–	–	–	–

Table 2. Geographical comparison of the helminth fauna of the digestive tract of the harbour porpoise. Data given are given as prevalences (%)

Helminth species	Locality (literature sources given below)								
	NE Pacific[a]	SE Newfoundland[b]	Azov Black Sea[c]	E North Sea[d]	W Baltic Sea[d]	SE Scotland[e]	British waters[f]	Danish waters[g]	Danish waters[h]
N	4	80	76	53	47	7	41	149	70
Anisakis simplex	50.0	47.5	–	13.2	34	42.9	43.0	16.8	38.6
Contracaecum osculatum	–	83.8	–	–	–	–	–	–	–
Pseudoterranova decipiens	–	–	–	13.2	–	–	–	–	–
Phocascaris sp.	–	30.0	–	–	–	–	–	–	–
Pholeter gastrophilus	–	–	31	–	–	–	34.0	–	2.8
Hadwenius mironovi	25.0	–	–	–	–	–	–	–	–
Hadwenius nipponicus	50.0	–	–	–	–	–	–	–	–
Bolbosoma sp.	25.0	6.9*	–	–	–	–	–	–	1.4
Tetrabothrius sp.	–	1.3	–	–	–	–	–	–	–
Diphyllobothrium sp.	–	–	–	–	–	–	–	–	–
Diphyllobothrium stemmacephalum	–	6.9*	40	–	–	–	–	0.6	2.9

Sources: [a]Dailey & Stroud (1978); [b]Brattey & Stenson (1995); [c]Krivokhizhin & Birkun (1994); [d]Lick (1991); [e]Young (1972); [f]Baker & Martin (1992); [g]Clausen & Andersen (1988); [h]Present study

*N = 29 for the intestinal species

Bolbosoma sp. and the cestode *Tetrabothrius* sp. have only been recorded occassionally and with a low prevalence (Table 2).

DISCUSSION

The results of this study are consistent with previous surveys in the same area (Clausen & Andersen 1988), the exceptions being *Hysterothylacium aduncum* and *Pholeter gastrophilus*, which are reported here. The definitive hosts of this nematode are various fish species, mainly gadids (Berland 1961), which in turn constitute an important part of the porpoises' diet in Danish waters (Aarefjord 1993). Thus, we consider that *H. aduncum* is an accidental parasite whose presence in the porpoises results from the ingestion of infected fish. For this reason, we have not regarded this species as a part of the helminth community of the harbour porpoises and it was consequently not included in the global comparison.

The helminth communities in individual hosts depend on the parasites in the host population (host specialists) and those in the host community (host generalists) (Holmes 1987). In the gut of the harbour porpoise, the geographical comparison suggests that the communities are dominated by generalists in all the areas analysed. *Anisakis simplex* was the most common species in almost all localities, being recorded in more than 30 cetacean and 12 pinniped species (Kagei 1969, Young & Lowe 1969, Davey 1971, Margolis & Arai 1989). However, electrophoretic studies (Nascetti et al. 1986) have shown various sibling species of *A. simplex* and therefore records may refer to different species. Further biogeographical studies are neccesary to evaluate the degree of specialisation of each *A. simplex* sibling species. In any case, the absence of *Anisakis* spp. in the Black Sea might be due to the particular physical and chemical characteristics of this area (Tomczak & Godfrey 1994). Likewise, the trematode *Pholeter gastrophilus* is a well-known generalist of odontocetes (see Raga 1994 and references therein).

The influence of sympatric hosts in determining the helminth communities of the harbour porpoises is evident in some localities of the North Atlantic (southwestern Newfoundland and eastern North Sea; Table 2). In these areas, different anisakids of seals (*Contracaecum osculatum*, *Phocascaris* sp. and *Pseudoterranova decipiens*) were reported from porpoises. Brattey & Stenson (1995) related a high number of *C. osculatum* in the porpoises of southwestern Newfoundland with the abundance of several phocid species (*Halichoerus grypus*, *Phoca groenlandica*, *Cystophora cristata*) in the area. These authors suggested that the harbour porpoise is an accidental host of *C. osculatum* and *Phocascaris* sp., since all the specimens found were larvae.

The acanthocephalans of the genus *Bolbosoma* and tetrabothriid cestodes have been recorded mainly in pelagic cetaceans (Hoberg 1987, Hoberg et al. 1993). In these studies, the presence of *Bolbosoma* sp. in North Pacific and North Atlantic localities and of *Tetrabothrius* sp. off Newfoundland may result from occasional exchanges with pelagic hosts. These data are consistent with the suggested importance of the local host assemblage in shaping the helminth communities of the harbour porpoise. The 2 species of the genus *Hadwenius* (*H. mironovi* and *H. nipponicus*) have been

recorded so far only in North Pacific porpoises (Ching & Robinson 1959, Dailey & Stroud 1978). The biogeographical data available on these 2 species are at present scarce, making it difficult to establish their degree of host specialisation. However, *H. mironovi* has been reported in belugas (*Delphinapterus leucas*) in the North Atlantic (Adams & Rausch 1989) and the North Pacific (Krotov & Delyamure 1952, Delyamure 1964) and *H. nipponicus* in Dall's porpoises (*Phocoenoides dalli*) in the North Pacific (Yamaguti 1951). This evidence at least suggests that these 2 species are not strict host specialists, although we cannot rule out the possibility that they are local specialists in Pacific porpoises. However, if this were the case, the absence of the parasites in the other localities would strongly indicate that this has not been a long host-parasite association.

Our analyses show that *Diphyllobothrium stemmacephalum* is the most common intestinal species of this host (Table 2). This species has been occasionally reported in other cetaceans, such as the long-finned pilot whale *Globicephala melas* and the bottlenose dolphin *Tursiops truncatus* (Balbuena & Raga 1993a), but published records suggest that the harbour porpoise is the most comon host [see historical accounts in Delyamure (1955), Delyamure et al. (1985) and Andersen (1987)]. Therefore, *D. stemmacephalum* might be the only host specialist of the digestive tract of the harbour porpoise, at least in the North Atlantic and Black Sea populations (Table 2). Although further evidence is needed, it seems that this species has not colonised the porpoises in the North Pacific. In fact, *D. stemmacephalum* is possibly absent in these waters, previous records in Japanese waters being questionable (see Balbuena & Raga 1993a).

The evidence brought forward here reveals a strong local influence in the shaping of the helminth communities of the digestive tract of the harbour porpoise, depending mostly on the presence of sympatric hosts, particularly marine mammals. This contrasts with the lung-worm communities of the harbour porpoise, which seem primarily determined by a long host-parasite co-evolutionary association (Balbuena et al. 1994). The harbour porpoise has one of the most species-poor helminth communities, specifically in the intestine, compared with other cetaceans (Wazura et al. 1986, Balbuena & Raga 1993b, Aznar et al. 1994). However, additional data from other cetaceans are required to establish the reason for such species differences.

Acknowledgements. We are grateful to Dr Mercedes Fernández for assistance with parasite collection and to Dr David Gibson and Ms Eileen Harris from the Natural History Museum (UK) for their help with species determination. This study was supported by the Danish Goverment (Projekt Marsvin) and DGICYT from the Spanish Government (Project No. PB92-875).

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Responsible Subject Editor: M. D. Dailey, Gunnison, Colorado, USA

Manuscript first received: June 24, 1996
Revised version accepted: November 1, 1996