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Changes in acanthocephalan infection of the Antarctic fish *Notothenia coriiceps* in Admiralty Bay, King George Island, over 29 years

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Abstract: A comparison between the levels of infection with Acanthocephala of the fish *Notothenia coriiceps* in Admiralty Bay (South Shetland Islands, Antarctic) in 1978/79 and 2007/08 is presented. The same eight acanthocephalan species, three echinorhynchids maturing in fish, *Aspersentis megarhynchus* (dominant species), *Metacanthocephalus johnstoni* (subdominant species) and *M. dalmori* (common species), and five polymorphids maturing in mammals and birds, *Corynosoma hamanni*, *C. pseudohamanni* (both co-dominant species), *C. arctocephali* and *C. bullosum* (both common species), and *C. shackletoni* (rare species), were found. Echinorhynchids were more numerous in 2007/08 (mean abundance 46.54 versus 35.35 in 1978/79), whereas polymorphids more numerous in 1978/79 (mean abundance 74.35 *versus* 36.40 in 2007/08). The overall results therefore demonstrated that echinorhynchids were more numerous than polymorphids in 2007/08 and the reverse was true in 1978/79. This situation is dependent mainly upon the decreased infections with *C. hamanni*, *C. pseudohamanni* and *C. bullosum*, and to a lesser degree upon the increasing of infections with *M. johnstoni*. The decrease of the three *Corynosoma* spp. is possibly associated with the decreasing of populations of final hosts, seals, on the shore of Admiralty Bay in the vicinity of *Arctowski* Station.

Key words: Antarctic, Acanthocephala, Admiralty Bay, change of infection, *Notothenia coriiceps*

Introduction

Notothenia coriiceps Richardson, 1844 (Pisces, Nototheniidae), is one of the most abundant species of fish living in relatively shallow sub-coastal waters (usually less than 200 m) of Western Antarctica, as well as off South Georgia,

Subantarctic islands on the Indian Ocean, Balleny Islands, Adelie Land, in north-western part of the Ross Sea and in the Weddell Sea (Gon and Heemstra 1990). It is a benthic predator and its prey mainly consists of various invertebrates including amphipods, as well as small fish. Simultaneously it is the prey of pinnipeds. According to Palm *et al*. (1998) *N. coriiceps* plays the important role in life cycles of many different parasites including Acanthocephala. The most important data on the infection of this fish with acanthocephalans were published by Johnston and Best (1937), Szidat (1965), Hoogesteger and White (1981), Hoberg (1986), Zdzitowiecki (1986a, 1986b, 2001a), Zdzitowiecki and Rokosz (1986), Zdzitowiecki and White (1992, 1996), Palm *et al*. (1998), Rohde *et al*. (1998), Zdzitowiecki *et al*. (1998) and Zdzitowiecki and Laskowski (2004). The most extensive investigations were carried out in two localities at King George Island (South Shetland Islands): in Admiralty Bay (Zdzitowiecki 1986a, 1986b; Zdzitowiecki and Rokosz 1986) and in Potter Cove (Palm *et al*. 1998). In total 10 acanthocephalan species were recorded in *N. coriiceps* in this area. *N. coriiceps* caught in Admiralty Bay (Fig. 1) in the vicinity of the Polish Academy of Sciences *Arctowski* Station were examined during the entire year (from December 1978 to November 1979) in numbers of not less than 20 specimens during each month, in total 248 specimens. Recently, the present authors worked at the same scientific station during three months (from November 2007 to January 2008) and caught and examined 20 specimens of *N. coriiceps* in each month, in total 60 specimens. The present paper contains a comparison between the results of investigations carried out in the same months and location in 1978/9 and 2007/8.

Material and methods

Recent investigations were carried out using methods similar to those described by Zdzitowiecki (1986a). *N. coriiceps* were caught using a fishing rod or bottom net at a depth of 10–80 meters. The fish were examined just after capture or held alive in a tank with marine water. Samples were checked using a stereomicroscope and alive acanthocephalans were collected. Cystacanths were liberated from cysts found in the body cavity using a water digestive solution (pepsin 1%, HCl 0.4%). Cystacanths occurring in the body cavity and acanthocephalans found in the lumen of intestine were relaxed in fresh water and fixed and stored in 70% ethanol. Most of specimens were determined without clearing using a stereomicroscope; doubtful specimens were dehydrated in graded ethanol, cleared in benzyl alcohol and determined using a light microscope. Determinations of all specimens were done according to the key and descriptions published by Zdzitowiecki (1991). Only infections of fish examined in the same months during previous and present investigations (December 1978, January and November 1979 against November and December 2007, January 2008) were taken for comparison

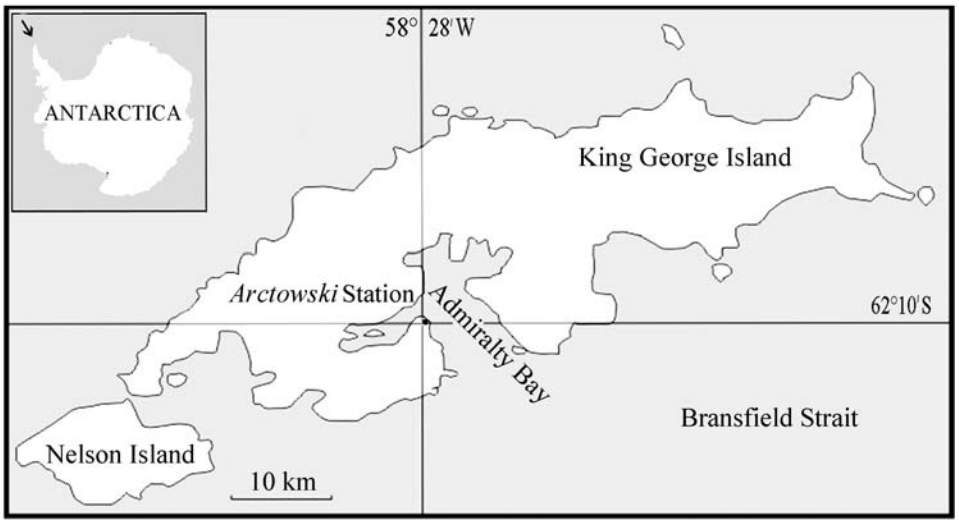

Fig. 1 Location of Admiralty Bay.

of previous and recent results of investigations. Standard length (SL) of fish examined in 1978/79 was 24.4–44.0 cm (mean 32.93 cm) and that of fish examined in 2007/08 was 25.0–40.5 cm (mean 31.49 cm). Each sample contained 60 fishes (20 specimens in each month). Three indices of infection are given: prevalence (percent of infected fish), maximum intensity and mean abundance (mean number of

Table 1

Infection with Acanthocephala of *Notothenia coriiceps* in Admiralty Bay in November–January 1978–1979 and 2007–2008 (n = 60 and 60)

Parasite	1978–1979			2007–2008		
	Prevalence %	Maximum Intensity	Mean Abundance	Prevalence %	Maximum Intensity	Mean Abundance
Echinorhynchida	98	127	35.35	100	212	46.54
Aspersentis megarhynchus	98	126	32.47	100	149	34.37
Metacanthocephalus dalmori	28	16	1.23	15	26	0.97
M. johnstoni	53	13	1.65	85	85	11.20
Polymorphida	100	538	74.35	100	236	36.40
Corynosoma arctocephali	13	38	0.78	42	9	1.02
C. bullosum	40	4	0.68	10	2	0.12
C. hamanni	95	131	30.17	97	91	15.77
C. pseudohamanni	100	405	42.68	97	142	19.32
C. shackletoni	3	1	0.03	10	3	0.18
Total	100	550	109.70	100	246	82.93

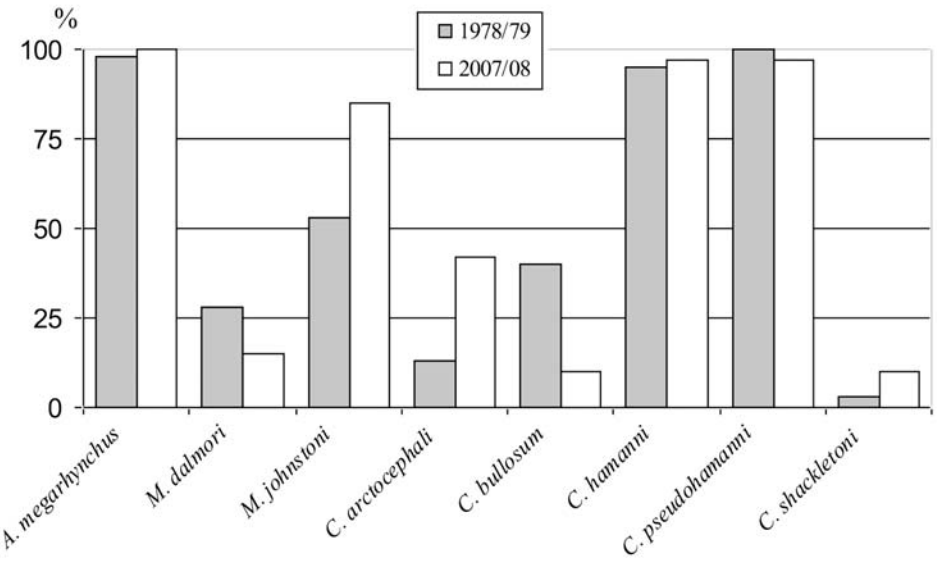

Fig. 2. Prevalence of infection of Acanthocephala in *Notothenia coriiceps* in Admiralty Bay in 1978/79 and 2007/08.

acanthocephalans per host examined) (Table 1). Prevalence of infection with each acanthocephalan species is shown in Fig. 2. The prevalence was used for classification of species into dominant (95–100%), subdominant (51-94%), common (10–50%), rare (4–10%) and sporadic (below 4%). Kolmogorov-Smirnov and Shapiro-Wilks' W test for distribution of variables data was performed. The Mann-Whitney U test was used to compare levels of infections data between two research seasons: 1978/9 and 2007/8. Statistical analysis was performed with the software package STATISTICA 6.1.

Results

The same eight species of Acanthocephala were found in *N. coriiceps* during the previous and recent investigations. Three species of echinorhynchids, *Aspersentis megarhynchus* (Linstow, 1892) (synonym *A. austrinus* Van Cleave, 1929), *Metacanthocephalus dalmori* Zdzitowiecki, 1983 and *M. johnstoni* Zdzitowiecki, 1983, occurred in the lumen of intestine. Five species of polymorphids, *Corynosoma arctocephali* Zdzitowiecki, 1984, *C. bullosum* (Linstow, 1892), *C. hamanni* (Linstow, 1892), *C. pseudohamanni* Zdzitowiecki, 1984 and *C. shackletoni* Zdzitowiecki, 1978, occurred in the cystacanth stage of development in cysts in the body cavity. Indices of infection are shown in Table 1. Three species, *A. megarhynchus*, *C. hamanni* and *C. pseudohamanni* were co-dominants (prevalence 95%

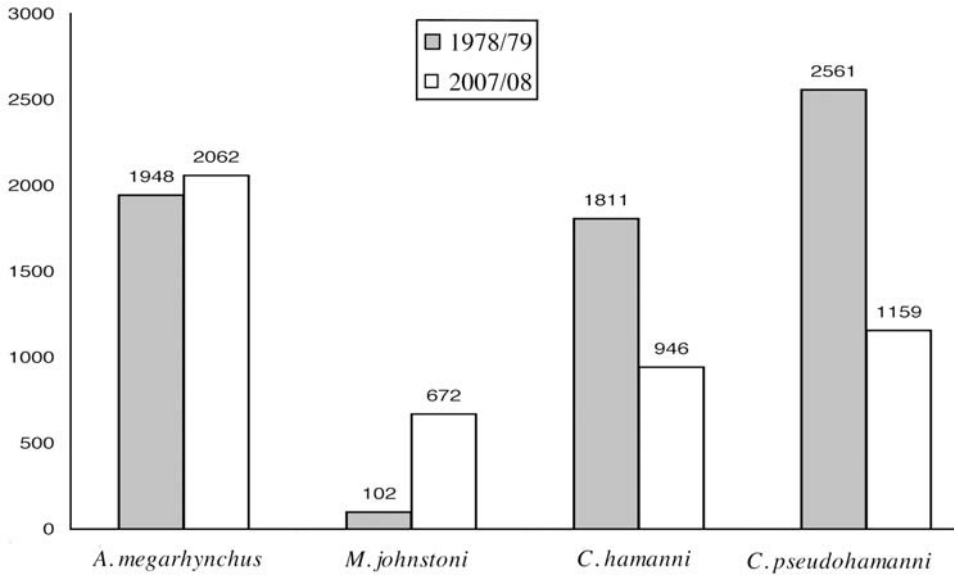

Fig. 3. Numbers of dominant and sub-dominant acanthocephalans in *Notothenia coriiceps* (Admiralty Bay) in 1978/79 and 2007/08.

to100%). *M. johnstoni* was found to be sub-dominant (prevalence 53% in 1978/79 and 85% in 2007/08). The prevalence of remaining species was less than 50% (Table 1, Fig. 2). Also mean abundance of three dominant and one sub-dominant species of parasites were considerably larger than those of other species.

Differences between infections with dominant and sub-dominant acanthocephalan species in two periods of investigations (1978/79 against 2007/08) based on frequencies are shown in Fig. 3. These differences are large for *M. johnstoni*, *C. hamanni* and *C. pseudohamanni*, but low for *A. megarhynchus*. When summing up infections with representatives of two acanthocephalan orders, it was clear that polymorphids were more numerous in 1978/79 (68% of all acanthocephalans, mean abundance 74.35) and considerably less numerous in 2007/08 (44%, mean abundance 36.40). It is plausible that this is the result of decreasing of infections with *C. hamanni*, *C. pseudohamanni* and *C. bullosum*, and increasing infections with *M. johnstoni*. The mean abundance of all echinorhynchids increased from 35.35 to 46.54. Opposite trends of infections with other, more rare species of each order were not important for the total result. It should be noted that 100% of hosts were infected with polymorphids and only one host specimen examined in November 1979 was free of echinorhynchids.

All analysed data are not normally distributed (Kolmogorov-Smirnov and Shapiro-Wilks' W test). The Mann-Whitney U test was used to compare levels of infections data between two research seasons: 1978/9 and 2007/8. The changes of the infection were statistically significant ($p < 0.05$) for five acanthocephalan

species: *M. johnstoni*, *C. bullosum*, *C. hamanni*, *C. pseudohamanni* and *C. arctocephali*. For the rest of the species (*A. megarhynchus*, *M. dalmori* and *C. shackletoni*) changes in level of infection between the two research periods were not statistically significant.

Discussion

It is probable that all acanthocephalans occurring in fish in Admiralty Bay use amphipods as intermediate hosts. Cystacanths of *Aspersentis megarhynchus*, C*orynosoma bullosum*, *C. hamanni* and *C. pseudohamanni* were found in amphipods in Admiralty Bay (Zdzitowiecki 2001b; Zdzitowiecki and Presler 2001), and *C. pseudohamanni* and *Metacanthocephalus johnstoni* at the Antarctic Peninsula (Hoberg 1986; Laskowski *et al.* 2010). Antarctic echinorhynchids have two hosts (intermediate – amphipods and definitive – fish). The observed increase of infections with echinorhynchids could be a result of better food condition for amphipods and fish (organic pollution from scientific station and sea vessels) and decreased presence of predator (seals) pression. Increasing number of *Cheirimedon femoratus* specimens (intermediate hosts for *C. pseudohamanni* and *M. johnstoni*) near scientific station was observed in previous research (unpublished data of K. Zdzitowiecki).

Antarctic polymorphids of the genus *Corynosoma* have not less than three hosts (intermediate – amphipods, paratenic – one or more fish and definitive – seals, fur seals or penguins). The level of infections of fish is dependent upon the abundance of definitive hosts. Compared to 1979, southern elephant seals, *Mirounga leonina,* (final hosts of *C. bullosum*) and Weddell seals, *Leptonychotes weddellii,* (final hosts of *C. hamanni* and *C. pseudohamanni*) are presently less numerous at the shore close to *Arctowski* Station.

In the Admiralty Bay southern elephant seals represent one of the most numerous seal species breeding regularly (Salwicka and Rakusa-Suszczewski 2002). On the entire western shore of Admiralty Bay the numbers of specimens fluctuate from year to year; however a strong decreasing tendency was observed at the shore close to *Arctowski* Station. The disappearance of breeding groups close to the station has also been observed (Chwedorzewska and Korczak 2010). In Admiralty Bay, Weddell seals occur in small numbers throughout the year (Rakusa-Suszczewski 1993). According to Myrcha and Teliga (1980) in February 1978 over 120 specimens were found in the investigated area, while in 2008 only four specimens were observed (Chwedorzewska and Korczak 2010). Overall, the number of Weddell seals in this area dropped drastically.

The same is true for the leopard seal, *Hydrurga leptonyx* (host of *C. hamanni*, *C. pseudohamanni* and *C. arctocephali*). Leopard seals have been observed on the pack ice and in the water of Admiralty Bay every year usually staying from Sep-

tember to January. Their numbers have been reported highest in October or November with only single specimens recorded in other months. The abundance of this seal was highly variable between the years 1978 – 2008. Maximum numbers were observed in 1978, about 60 specimens (Myrcha and Teliga 1980) and in 1994 – 67 specimens (Ciaputa 1996). Since 1994 a significant decrease of the leopard seal population has been observed (Salwicka and Rakusa-Suszczewski 2002). From 2005 to 2008 the maximum number of these seals observed in Admiralty Bay was only three specimens each year (unpublished data of Korczak-Abshire 2008).

Antarctic fur seals, *Arctocephalus gazella,* (main definitive hosts of *C. arctocephali*) are numerous but only in the Antarctic summer and autumn, and rather at the shore of the open sea than at the shore of Admiralty Bay. Antarctic fur seals were almost completely exterminated in the 19th century, but have rebuilt their population under protection (Jabłoński *et al*.1987). Antarctic fur seals do not breed in Admiralty Bay, but regularly visit the area (Salwicka and Rakusa-Suszczewski 2002). In 1978 only 285 specimens were observed, mainly in the area close to the mouth of Admiralty Bay facing the Bransfield Strait (Myrcha and Teliga 1980). Since 1988, when the lowest number of specimens was recorded (only 148) (Rakusa-Suszczewski 1993), the fur seal population grew to reach 2926 specimens in 2006 (unpublished data of Angiel 2006) and the populations reached the inner oases of Admiralty Bay. It is possible that parallel rebuilding of parasites took place during the time and could be the reason for an increased number of cystacanths of *C. arctocephali* in fish (Zdzitowiecki 1987).

Zdzitowiecki (1985) and Hoberg (1986) established the gentoo penguin (*Pygoscelis papa*) as the only final host of *C. shackletoni*. The abundance of the gentoo penguin population in Admiralty Bay has been fluctuating in the 29 years between the first study and the current one. Population size reached 3703 breeding pairs in 1979 and then dropped to 1406 pairs in 1996. Presently, the population is similar to that in 1979 and reached 3093 breeding pairs (unpublished data of Korczak-Abshire 2008). However, gentoo penguins rookery very close to *Arctowski* Station disappeared and nests of these penguins are presently numerous *c.* 2 km from *Arctowski* Station (Chwedorzewska and Korczak 2010). *C. shackletoni* is much more rare in fish than each of other *Corynosoma* species occurring in the area of present investigations and an increased level of infection with this parasite could be accidental. It is illustrated by number of cystacanths of *C. shackletoni* in *N. coriiceps* in both studied periods respectively, 2 specimens in 1978/9 and 11 specimens in 2007/8.

The total number of acanthocephalan species recorded in fish in Admiralty Bay was eleven (Zdzitowiecki and Rokosz 1986), including ten species recorded in *N. coriiceps*. Three echinorhynchids absent in new investigations are sporadic in this area. Only five specimens of *Heterosentis heteracanthus* (Linstow, 1896) were found in four hosts, including three parasites in two *N. coriiceps* examined in

May 1979. Single specimens were found in *Notothenia rossii* in May and in *Gobionotothen gibberifrons* in November 1979. *H. heteracanthus* is much more abundant at Tierra del Fuego (sub-Antarctica) (Linstow 1896; Laskowski and Zdzitowiecki 2009) and at South Georgia (Zdzitowiecki 1987, 1990; Zdzitowiecki and White 1992). The most rare species in Admiralty Bay is *Echinorhynchus petrotschenkoi* (Rodjuk, 1984), synonym *E. nototheniae* Zdzitowiecki, 1986. Only two single specimens were found in *N. coriiceps* in April and in *Trematomus hansoni* in May 1979. The main hosts of this species at South Georgia and in the Weddell Sea are Notothenioidei and Gadiformes (Rodjuk 1984, 1986; Zdzitowiecki 1989, 1996). The last species, *Metacanthocephalus campbelli* (Leiper *et* Atkinson, 1914), was found in Admiralty Bay only in *Trematomus bernacchii* and *Parachaenichthys charcoti* (Zdzitowiecki 1986b). However, this species was recorded by various authors in many sites around the Antarctic in different notothenioids including *N. coriiceps* at the Adelie Land (Zdzitowiecki *et al*. 1998; Zdzitowiecki 2001a).

Palm *et al.* (1998) found five species of echinorhynchids and undetermined cystacanths of *Corynosoma* spp. in *N. coriiceps* at the Potter Cove (King George Island). The infection rates were, with exception for *E. petrotschenkoi*, lower than in Admiralty Bay.

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