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Larval ascaridoid nematodes (Anisakidae) in fish from the South Shetland Islands (Southern Ocean)

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Abstract: The aim of this study was to assess the anisakid nematode distribution pattern in the fish collected from the South Shetland Islands. A total of 32 fish species were examined for the presence of nematodes in 1978, 1979, 1981 and 2007/2008. The fish were caught off the South Shetland Islands (Elephant Island, Shishkov Island and in Admiralty Bay – King George Island). Three genera of L_3 larval nematodes were identified: *Anisakis* sp., *Contracaecum* spp. and *Pseudoterranova decipiens*. The infection level was higher on the shelf around the islands than in Admiralty Bay. This is explained by a higher abundance of the final hosts in the region. A comparison of the infection data from 1978/79 and 2007/2008 with data from 1994/96 (Palm *et al*. 1998, 2007) was done. The parameters of infection of *Notothenia coriiceps* and *Lepidonotothen nudifrons* by *Pseudoterranova decipiens* were decreasing within the 30 years period.

Key words: Antarctica, ascaridoid nematodes, fish, long-term change.

Introduction

Anisakid nematodes common in the bone fish in the Antarctic, Subantarctic, and Arctic areas are represented by the following genera: *Anisakis* Dujardin, 1845, *Contracaecum* Railliet *et* Henry, 1912, *Hysterothylacium* Ward *et* Magath, 1917, *Paranisakiopsis* Yamaguti, 1941 and *Pseudoterranova* Mozgovoy, 1951. In Antarctic fish of the South Shetlands more often larvae of *Pseudoterranova decipiens* and *Contracaecum osculatum* were found (Rodjuk 1985; Rocka 2004).

Helminths of the genera *Anisakis*, *Pseudoterranova* and several species of *Contracaecum* finish their life cycles in marine mammals. Antarctic bone fish are known for hosting adult *Hysterothylacium aduncum* (Rudolphi, 1802) and *Paranisakiopsis weddelliensis* Rocka, 2002.

According to Johnston and Mawson (1945) and Mozgovoy (1951), stomachs of Antarctic marine mammals may contain *Anisakis similis* Baylis, 1920 and *A. physeteris* Baylis, 1923. Three species of *Contracaecum* parasitising pinnipeds are known from the Antarctic: *C. osculatum* (Rudolphi, 1802), *C. radiatum* (Linstow, 1907), and *C. mirunga* Nikolskij, 1974.

Nowadays the modern methods such as allozyme markers were used for identification of *Contracaecum radiatum*, *C. mirunga*, and *C. osculatum* D and E in the Antarctic region, and *C. ogmorhini* (*s.s*). in the Subantarctic (Mattiucci and Nascetti 2007). The genetic diversity values estimated for Antarctic populations of the *C. osculatum* complex (*C. osculatum* D and *C. osculatum* E), in *C. radiatum* and *Pseudoterranova decipiens* E have higher level than in different species populations from the Arctic-Boreal region. Also *Anisakis simplex* C from Antarctic and sub-Antarctic populations exhibit significantly higher genetic variability than those from Arctic region (Mattiucci and Nascetti 2007).

Some of the five sibling species of *P. decipiens* (Mattiucci *et al.* 2007) were identified on the basis of both allozyme and morphological evidence. The *Pseudoterranova decipiens* complex is represented by *P. decipiens* E. It was found using allozyme markers (Bullini *et al.* 1997) in the Antarctic Weddell seal.

Anisakis had not been reported from skates in the western and eastern Antarctic (Rocka 2002).

Materials and methods

A total of 924 fish caught off the South Shetland Islands and representing 32 different species from 7 families were examined. 621 fish specimens from Admiralty Bay and representing 18 species from 5 families were studied from December 1978 to December 1979, and from November 2007 to January 2008. These fishes were collected during the Polish Antarctic Expeditions of the Polish Academy of Sciences by K. Zdzitowiecki in 1978/79 and by Z. Laskowski and K. Zdzitowiecki in 2007/2008. The second sample consisting of 303 fish individuals representing 23 species from 7 families was obtained from Russian fisheries research vessels that have caught the fish off Elephant and Shishkov Islands. These fish were examined during November–December 1978, January 1979, and January–March 1981.

Fishes were identified following Gon and Heemstra (1990). The fish names were later adjusted to the Fish Base (www.fishbase.org) terminology (Table 1).

Table 1

Species composition of the examined fish from the South Shetland Islands

Fish species / Locality	Number of fishes		Fish length (cm)
	Examined	Infected	
Elephant and Shishkov Islands			
Paralepididae			
Notolepis sp.	2	0	30.0–33.0
Myctophidae			
Electrona antarctica (Günter, 1878)	30	1	9.0–18.0
Muraenolepidae			
Muraenolepis microps Lönnberg, 1905	1	1	25.0
Gadidae			
Micromesistius australis Norman, 1937	8	8	43.0–63.0
Nototheniidae			
Dissostichus mawsoni Norman, 1937	4	4	52.0–53.0
Gobionotothen gibberifrons (Lönnberg, 1905)	42	14	28.0–47.0
Lepidonotothen kempi (Norman, 1937)	15	8	32.0–43.0
Nototheniops nybelini (Balushkin, 1976)	17	17	16.0–20.0
Notothenia rossii Richardson, 1844	16	16	38.0–50.0
Pleuragramma antarcticum Boulenger, 1902	10	2	16.5–21.5
Trematomus eulepidotus Regan, 1914	4	4	23.0–32.0
Trematomus lepidorhinus (Pappenheim, 1911)	3	2	15.0–22.0
Harpagiferidae			
Pogonophryne marmorata Norman, 1938	1	1	30.0
Channichthyidae			
Chaenocephalus aceratus Lönnberg, 1906	49	47	10.0–108.0
Chaenodraco wilsoni Regan, 1964	34	8	21.0–24.0
Champsocephalus gunnari Lönnberg, 1905	40	16	32.5–42.0
Chionodraco hamatus (Lönnberg, 1905)	3	0	18.0–19.0
Chionodraco rastrospinosus DeWitt *et* Hureau, 1979	13	7	34.5–42.0
Cryodraco antarcticus Dollo, 1900	3	3	25.5–41.5
Neopagetopsis ionah Nybelin, 1947	2	0	25.0; 27.5
Pagetopsis macropterus (Boulenger, 1907)	2	2	19.0; 20.0
Pseudochaenichthys georgianus Norman, 1937	1	1	51.0
Lycodapodidae			
Lycenchelys aratrirostris Andriashev et Permitin, 1979	3	2	14.5–29.0
Admiralty Bay – King George Island			
Nototheniidae			
Dissostichus mawsoni Norman, 1937	1	1	70.0
Nototheniops nybelini (Balushkin, 1976)	3	3	18.5–19.5
Notothenia rossii Richardson, 1844	73	55	21.0–39.0
Notothenia coriiceps Richardson, 1844	308	270	28.5–45.5

Pleuragramma antarcticum Boulenger, 1902	10	1	10–18
Lepidonotothen nudifrons (Lönnberg, 1905)	36	24	10–16.7
Trematomus newnesi Boulenger, 1902	32	29	12.5–24.0
Trematomus bernacchii Boulenger, 1902	38	33	15.5–30.7
Trematomus hansoni Boulenger, 1902	28	19	19–37
Gobionotothen gibberifrons (Lönnberg, 1905)	40	24	21–36
Channichthyidae			
Chaenocephalus aceratus Lönnberg, 1906	20	20	26.2–61
Champsocephalus gunnari Lönnberg, 1905	16	11	26.2–46.5
Chionodraco rastrospinosus DeWitt et Hureau, 1979	7	6	30.7–42.3
Cryodraco antarcticus Dollo, 1900	1	1	35.5
Bathydraconidae			
Gymnodraco acuticeps Boulenger, 1902	2	0	22.5–22.9
Acanthodraco dewitti Skóra, 1995	1	1	21
Myctophidae			
Gymnoscopelus nicholsi (Gilbert, 1911)	3	0	18–20
Harpagiferidae			
Harpagifer antarcticus Nybelin, 1947	2	0	9–11

Nematodes were isolated from the viscera and preserved in 3% formaldehyde in brine and cleared in glycerin or lactic acid, or were identified during examination under the stereomicroscope and preserved in 70% ethanol. *Anisakis* and *Contracaecum* larvae could not be identified to the species level based on their morphological characters. Identification was aided by the key published by Rocka (2004).

Ecological parameters such as prevalence (P), infection intensity (I), and abundance (A) were used as recommended by Margolis *et al*. (1982).

Results

The identified L_3 larval nematodes belonged to the family Anisakidae, namely: *Anisakis* sp., *Contracaecum* spp., and *Pseudoterranova decipiens* (Krabbe, 1868). 26 out of 32 fish species harboured nematodes in the viscera (Table 1). Larvae were located on the surface of the organs of the abdominal cavity, with the liver and gonads being the preferred sites.

Anisakis sp. was found in 10 fish species. The highest infestation parameter was recorded for *Micromesistius australis* and *Notothenia rossii* caught off Elephant and Shishkov Islands (Table 2).

Contracaecum spp. was found in 20 fish species. The highest infestation was recorded for *Micromesistius australis*, *Chaenocephalus aceratus* and *Trematomus newnesi* (Table 3). The average abundance (A) of the larvae ranged from 0.06 in *Notothenia rossii* caught off Elephant Island to 329.10 in *Chaenocephalus ace-*

Tabele 2

Prevalence (P), infection intensity (I) and abundance (A) of the infection of fish with *Anisakis* sp. larvae in the South Shetland Islands area

Fish species	Locality/Year	P (%)	I (min–max)	A
Electrona antarctica	Elephant and Shishkov Island 1978, 1979, 1981	3.3	1	2.00
Micromesistius australis		100.0	1–9	5.63
Dissostichus mawsoni		in 2 specimens	1–6	1.75
Lepidonotothen kempi		46.7	1–2	1.14
Notothenia rossii		43.8	7–156	16.31
Trematomus eulepidotus		in 2 specimens	1	0.50
Chionodraco rastrospinosus		7.7	1	0.08
Pseudochaenichthys georgianus		in 1 specimen	1	1.00
Notothenia coriiceps	Admiralty Bay 1978, 1979, 2007, 2008	4.9	1–2	0.05
Notothenia rossii		4.1	1	0.04
Chaenocephalus aceratus		5	1	0.05

ratus from Admiralty Bay. The intensity (I) of infestation ranged from 1 to 716 individuals collected from one fish.

Pseudoterranova decipiens was found in 21 fish species. The highest prevalence was recorded for *Nototheniops nybelini* (100.0% in Admiralty Bay, 94.1% off Elephant and Shishkov Islands), *Chaenocephalus aceratus* (95% in Admiralty Bay), and *Notothenia rossii* (93.8% off Elephant and Shishkov Islands). However, the nematode abundance in *N. nybelini* was much lower than in the other fish species (6.33, 3.53 *versus* 144.5, 56.81) (Table 4).

The prevalence, intensity and abundance of *Anisakis* sp. and *Pseudoterranova decipiens* in *N. rossii* were the highest off Elephant and Shishkov Islands compared with Admiralty Bay (Tables 2, 4). In contrast, the *Contracaecum* spp. infestation in *Chaenocephalus aceratus* was higher in Admiralty Bay than off Elephant and Shishkov Islands. A comparison of the infestation of *Chaenocephalus aceratus* by *Pseudoterranova decipiens* is a bit higher in Admiralty Bay than in open waters off South Shetlands (Table 5).

Discussion

Quantitative parasitological studies are of importance because they provide supplementary information on the biology and ecology of infested fish (Siegel 1980). There is much less information on the occurrence of parasitic nematodes in the Antarctic fish than on the presence of other taxa, such as the Digenea, Cestoda, Acanthocephala, Copepoda, and Isopoda (Zdzitowiecki 1983, 1986a, b, 1988, 1991, 1993, 1997; Zdzitowiecki and Rokosz 1986; Rokicki and Zdzitowiecki 1991; Rocka 2004; Zdzitowiecki and Laskowski 2004; Laskowski and Zdzitowiecki 2005). Dif-

Table 3

Infection indices of *Contracaecum* spp. Larvae (P – prevalence, I – intensity range, A – abundance)

Fish species	Locality/Year	P (%)	I (min–max)	A
Micromesistius australis	Elephant and Shishkov Islands 1978, 1979, 1981	100.0	1–6	1.50
Gobionotothen gibberifrons		11.1	1–3	0.21
Lepidonotothen kempi		26.7	1–3	0.53
Notothenia rossii		6.3	1	0.06
Nototheniops nybelini		3.0	1–2	0.24
Pleuragramma antarcticum		in 2 specimens	2–4	3.00
Trematomus eulepidotus		in 1 specimen	3	0.75
Chaenocephalus aceratus		57.1	1–20	2.49
Chaenodraco wilsoni		14.7	1–2	0.21
Champsocephalus gunnari		40.0	1–10	0.65
Chionodraco rastrospinosus		53.8	1–233	21.54
Cryodraco antarcticus		in 1 specimen	3	1.00
Pagetopsis macropterus		in 2 specimens	6	6.00
Lycenchelus aratrirostris		in 2 specimens	1–2	1.50
Notothenia coriiceps	King George Island Admiralty Bay 1978/79, 2007/08	42.5	1–39	1.58
Notothenia rossii		54.8	1–25	3.49
Pleuragramma antarcticum		in 1 specimen	1	0.10
Nototheniops nybelini		in 1 specimen	7	2.33
Trematomus hansoni		50.0	1–13	1.78
Trematomus newnesi		90.6	1–38	8.84
Trematomus bernacchii		68.0	1–10	1.74
Lepidonotothen nudifrons		44.4	1–49	2.53
Gobionotothen gibberifrons		37.5	1–3	0.60
Chaenocephalus aceratus		100	4–716	329.1
Cryodraco antarcticus		in 1 specimen	17	17.00
Chionodraco rastrospinosus		85.7	4–50	18.43
Champsocephalus gunnari		68.8	1–5	1.63
Acanthodraco dewitti		in 1 specimen	4	4.00

ferent ascaridoid genera, e.g. *Anisakis* Dujardin, 1845, *Contracaecum* Railliet *et* Henry, 1912, *Hysterothylacium* Ward *et* Magath, 1917 and *Pseudoterranova* Mozgovoy, 1950, whose adults infect marine mammals, birds and fishes, have been recorded from Antarctic teleosts as the larvae of *Anisakis* (Johnston and Mawson 1945; Mozgovoy 1951), larvae of *Contracaecum* (Klöser *et al.* 1992), larvae of *Hysterothylacium* (Rocka 2002) and larvae of *Pseudoterranova* (Palm *et al.* 1994, 1998; Palm 1999). Morphological species identification of L_3 larval stages of anisakid nematodes occurring in fish is difficult, and the analysis aided by molecular methods indicates the presence of sibling species (Matiucci *et al*. 2007) also in Ant-

Table 4

Infection indices of *Pseudoterranowa decipiens* larvae (P – prevalence, I – intensity range, A – abundance)

Fish species	Locality/Year	P (%)	I (min–max)	A
Muraenolepis microps	Elephant and Shishkov Islands 1978, 1979, 1981	in 1 specimen	1	1.00
Dissostichus mawsoni		in 4 specimens	1–46	25.50
Gobionotothen gibberifrons		23.8	1–7	0.88
Lepidonotothen kempi		6.7	1	0.07
Nototheniops nybelini		94.1	1–10	3.53
Notothenia rossii		93.8	2–201	56.81
Trematomus eulepidotus		in 2 specimens	1–4	1.25
Trematomus lepidorhinus		in 2 specimens	1–2	1.00
Pogonophryne marmorata		in 1 specimen	13	13.00
Chaenocephalus aceratus		40.8	1–212	19.53
Chaenodraco wilsoni		14.7	1–30	1.59
Chionodraco rastrospinosus		15.4	3	0.46
Cryodraco antarcticus		in 1	3	1.00
Lycenchelus aratrirostris		in 2 specimens	1–2	1.00
Notothenia rossii	King George Island Admiralty Bay 1978/79, 2007/09	74	1–75	3.49
Notothenia coriiceps		86.7	1–206	9.03
Trematomus hansoni		42.9	1–21	3.00
Trematomus newnesi		21.9	1	0.22
Trematomus bernacchii		73.7	1–49	4.66
Lepidonotothen nudifrons		47.2	1–8	0.83
Gobionotothen gibberifrons		25.0	1–3	0.35
Nototheniops nybelini		100	3–9	6.33
Dissostichus mawsoni		in 1 specimen	11	11
Chaenocephalus aceratus		95.0	1–244	144.05
Champsocephalus gunnari		in 2 specimens	1–2	0.185
Cryodraco antarcticus		in 1 specimen	7	7
Chionodraco rastrospinosus		71.5	2–30	7.29
Acanthodraco dewitti		in 1 specimen	1	1

arctic waters. Using allozyme markers, Matiucci *et al*. (2007) identified *Anisakis simplex* C from *Mirounga leonina* and *Pseudoterranova decipiens* E has been detected genetically in the Antarctic Weddell seal, *Leptonychotes weddelli* (Bullini *et al.* 1997) from the Antarctic waters. Klöser and Plötz (1992) and Klöser *et al*. (1992) used the morphometric analysis to distinguish between larval *Contracaecum osculatum* and *C. radiatum* in the Weddell Sea comparing the total length with the caecum length – oesophagus length ratio.

A higher prevalence of ascaridoid nematode infestation in different fish species depends on the availability of the final hosts in the region and the parasite's

Table 5

Infection of fish species collected off South Shetland Islands by *Pseudoterranova decipiens* in different studies. Explanations: a – Admiralty Bay (present study), b – Elephant and Shishkov Islands (present study), c – King George and Elephant Islands (Palm *et al.* 1998, 2007), d – Admiralty Bay (present study); n – number of specimens examined, P – prevalence, I – intensity range

Fish species	1978/79 a			1978/81 b			1994/96 c			2007/08 d		
	n	P (%)	I	n	P(%)	I	n	P(%)	I	n	P(%)	I
Notothenia coriiceps	248	94	1–206	–	–	–	50	56	1–58	60	53	1–28
Chaenocephalus aceratus	20	95.0	1–244	49	40.8	1–212	21	95	2–194	–	–	–
Gobionothothen gibberifrons	40	25	1–3	42	23.8	1–7	12	75	1–4	–	–	–
Lepidonotothen nudifrons	29	52	1–8	–	–	–	40	43	1–2	7	29	1

ability to complete its life cycle (Klöser *et al*. 1992; Palm *et al*. 1994; Palm 1999). It also may be related to the food ingested and to the layer of the water column inhabited (bottom versus pelagic) (Walter *et al*. 2002; Palm *et al*. 2007). The infestation dynamics is strongly fish species- and area-specific. *Micromesistius australis* showed a high level of infestation with *Anisakis* sp. and *Contracaecum* spp., while *Nototheniops nybelini*, *Chaenocephalus aceratus* and *Notothenia rossii* were heavily infested with *Pseudoterranova decipiens*. In the fish caught in November–December 1994 and 1996 in deep waters off King George and Elephant Islands, Palm *et al.* (2007) have found a higher prevalence and intensity of *P. decipiens* infestation for *Gobionothothen gibberifrons* than those revealed by the present study; for *Notothenia coriiceps* and *Lepidonotothen nudifrons* parameters of infections decreased from 1978/79 until 2007/8. Infections prevalence for *Chaenocephalus aceratus* changed from 49% in Elephant and Shishkov Islands to 95% in Admiralty Bay (1978/79) and off King George and Elephant Islands (Palm *et al.* 2007), maximum intensity has a value of about 200. (Table 5).

The prevalence, intensity of infection and abundance of *Anisakis* sp. was higher on the shelf off the South Shetlands than in Admiralty Bay (King George Island) (Table 2). On the other hand, the prevalence, infection intensity and abundance of *Contracaecum* spp. in *Chaenocephalus aceratus* were higher in Admiralty Bay (Table 2). This pattern is associated with the distribution of the main definitive hosts (see above) of these parasites, i.e., whales in the former and Weddell seals in the latter. This study demonstrated high levels of fish infection with ascaridoid larvae; it is obvious that the range of different fish species plays an important role as parasite transmitters of nematode larvae to the Antarctic mammals. Weddell seals, common in Admiralty Bay, are heavily infected with nematodes (Zdzitowiecki 1993).

The anisakids found in the present study occur also in fish caught off adjacent islands. In certain areas of the Scotia Sea the infestation rate reached 100%, with more than 200 larvae of *Contracaecum* spp. per adult *Chaenocephalus aceratus* being recorded (Siegel 1980). Similarly, a higher level of *Contracaecum osculatum* D infestation was found in the Ross Sea in *Chionodraco hamatus*, respectivelly P = 100% and I = 30–209 (Mattiucci and Nascetti 2007). The same species caught off Adelie Land was infested with *Contracaecum* spp. at an intensity that ranged within 475–969. Intensities similar to those found in the materials examined in this study were reported for *Ch. aceratus* in Admiralty Bay (4–716) and in *Ch. rastrospinosus* off Elephant and Shishkov Islands (1–233). The level of fish infestation with L_3 ascaridoid nematodes in Admiralty Bay and on the shelf off the South Shetlands is associated with parasite accumulation by larger predatory fish. The composition of the fish fauna in Admiralty Bay differs from that on the shelf off South Shetlands and is dominated by small and young individuals (Skóra 1992).

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