



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 L₃ larval nematodes were identified: *Anisakis* sp., *Contra-caecum* 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, *Contra-caecum* Railliet *et* Henry, 1912, *Hysterothylacium* Ward *et* Magath, 1917, *Paranisakiopsis* Yamaguti, 1941 and *Pseudoterranova* Mozgovoy, 1951. In Ant-

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

<i>Pleuragramma antarcticum</i> Boulenger, 1902	10	1	10–18
<i>Lepidonotothen nudifrons</i> (Lönnberg, 1905)	36	24	10–16.7
<i>Trematomus newnesi</i> Boulenger, 1902	32	29	12.5–24.0
<i>Trematomus bernacchii</i> Boulenger, 1902	38	33	15.5–30.7
<i>Trematomus hansonii</i> Boulenger, 1902	28	19	19–37
<i>Gobionotothen gibberifrons</i> (Lönnberg, 1905)	40	24	21–36
Channichthyidae			
<i>Chaenocephalus aceratus</i> Lönnberg, 1906	20	20	26.2–61
<i>Champocephalus gunnari</i> Lönnberg, 1905	16	11	26.2–46.5
<i>Chionodraco rastrospinosus</i> DeWitt et Hureau, 1979	7	6	30.7–42.3
<i>Cryodraco antarcticus</i> Dollo, 1900	1	1	35.5
Bathypodidae			
<i>Gymnodraco acuticeps</i> Boulenger, 1902	2	0	22.5–22.9
<i>Acanthodraco dewitti</i> Skóra, 1995	1	1	21
Myctophidae			
<i>Gymnoscopelus nicholsi</i> (Gilbert, 1911)	3	0	18–20
Harpagiferidae			
<i>Harpagifer antarcticus</i> 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 L₃ 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
<i>Electrona antarctica</i>	Elephant and Shishkov Island 1978, 1979, 1981	3.3	1	2.00
<i>Micromesistius australis</i>		100.0	1–9	5.63
<i>Dissostichus mawsoni</i>		in 2 specimens	1–6	1.75
<i>Lepidonotothen kempi</i>		46.7	1–2	1.14
<i>Notothenia rossii</i>		43.8	7–156	16.31
<i>Trematomus eulepidotus</i>		in 2 specimens	1	0.50
<i>Chionodraco rastrospinosus</i>		7.7	1	0.08
<i>Pseudochaenichthys georgianus</i>		in 1 specimen	1	1.00
<i>Notothenia coriiceps</i>	Admiralty Bay 1978, 1979, 2007, 2008	4.9	1–2	0.05
<i>Notothenia rossii</i>		4.1	1	0.04
<i>Chaenocephalus aceratus</i>		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
<i>Micromesistius australis</i>	Elephant and Shishkov Islands 1978, 1979, 1981	100.0	1–6	1.50
<i>Gobionotothen gibberifrons</i>		11.1	1–3	0.21
<i>Lepidonotothen kempfi</i>		26.7	1–3	0.53
<i>Notothenia rossii</i>		6.3	1	0.06
<i>Nototheniops nybelini</i>		3.0	1–2	0.24
<i>Pleuragramma antarcticum</i>		in 2 specimens	2–4	3.00
<i>Trematomus eulepidotus</i>		in 1 specimen	3	0.75
<i>Chaenocephalus aceratus</i>		57.1	1–20	2.49
<i>Chaenodraco wilsoni</i>		14.7	1–2	0.21
<i>Champsocephalus gunnari</i>		40.0	1–10	0.65
<i>Chionodraco rastrospinosus</i>		53.8	1–233	21.54
<i>Cryodraco antarcticus</i>		in 1 specimen	3	1.00
<i>Pagetopsis macropterus</i>		in 2 specimens	6	6.00
<i>Lycenchelus aratrirostris</i>		in 2 specimens	1–2	1.50
<i>Notothenia coriiceps</i>	King George Island Admiralty Bay 1978/79, 2007/08	42.5	1–39	1.58
<i>Notothenia rossii</i>		54.8	1–25	3.49
<i>Pleuragramma antarcticum</i>		in 1 specimen	1	0.10
<i>Nototheniops nybelini</i>		in 1 specimen	7	2.33
<i>Trematomus hansonii</i>		50.0	1–13	1.78
<i>Trematomus newnesi</i>		90.6	1–38	8.84
<i>Trematomus bernacchii</i>		68.0	1–10	1.74
<i>Lepidonotothen nudifrons</i>		44.4	1–49	2.53
<i>Gobionotothen gibberifrons</i>		37.5	1–3	0.60
<i>Chaenocephalus aceratus</i>		100	4–716	329.1
<i>Cryodraco antarcticus</i>		in 1 specimen	17	17.00
<i>Chionodraco rastrospinosus</i>		85.7	4–50	18.43
<i>Champsocephalus gunnari</i>		68.8	1–5	1.63
<i>Acanthodraco dewitti</i>		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 L₃ 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 *Pseudoterranova decipiens* larvae (P – prevalence, I – intensity range, A – abundance)

Fish species	Locality/Year	P (%)	I (min–max)	A
<i>Muraenolepis microps</i>	Elephant and Shishkov Islands 1978, 1979, 1981	in 1 specimen	1	1.00
<i>Dissostichus mawsoni</i>		in 4 specimens	1–46	25.50
<i>Gobionotothen gibberifrons</i>		23.8	1–7	0.88
<i>Lepidonotothen kempi</i>		6.7	1	0.07
<i>Nototheniops nybelini</i>		94.1	1–10	3.53
<i>Notothenia rossii</i>		93.8	2–201	56.81
<i>Trematomus eulepidotus</i>		in 2 specimens	1–4	1.25
<i>Trematomus lepidorhinus</i>		in 2 specimens	1–2	1.00
<i>Pogonophryne marmorata</i>		in 1 specimen	13	13.00
<i>Chaenocephalus aceratus</i>		40.8	1–212	19.53
<i>Chaenodraco wilsoni</i>		14.7	1–30	1.59
<i>Chionodraco rastrospinosus</i>		15.4	3	0.46
<i>Cryodraco antarcticus</i>		in 1	3	1.00
<i>Lycenchelus aratrirostris</i>		in 2 specimens	1–2	1.00
<i>Notothenia rossii</i>		King George Island Admiralty Bay 1978/79, 2007/09	74	1–75
<i>Notothenia coriiceps</i>	86.7		1–206	9.03
<i>Trematomus hansonii</i>	42.9		1–21	3.00
<i>Trematomus newnesi</i>	21.9		1	0.22
<i>Trematomus bernacchii</i>	73.7		1–49	4.66
<i>Lepidonotothen nudifrons</i>	47.2		1–8	0.83
<i>Gobionotothen gibberifrons</i>	25.0		1–3	0.35
<i>Nototheniops nybelini</i>	100		3–9	6.33
<i>Dissostichus mawsoni</i>	in 1 specimen		11	11
<i>Chaenocephalus aceratus</i>	95.0		1–244	144.05
<i>Champsocephalus gunnari</i>	in 2 specimens		1–2	0.185
<i>Cryodraco antarcticus</i>	in 1 specimen		7	7
<i>Chionodraco rastrospinosus</i>	71.5		2–30	7.29
<i>Acanthodraco dewitti</i>	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 osculatatum* 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
<i>Notothenia coriiceps</i>	248	94	1–206	–	–	–	50	56	1–58	60	53	1–28
<i>Chaenocephalus aceratus</i>	20	95.0	1–244	49	40.8	1–212	21	95	2–194	–	–	–
<i>Gobionothen gibberifrons</i>	40	25	1–3	42	23.8	1–7	12	75	1–4	–	–	–
<i>Lepidonotothen nudifrons</i>	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 *Gobionothen 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*, respectively $P = 100\%$ and $I = 30\text{--}209$ (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. rastrorpinosus* 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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