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Nematodes of the Antarctic fishes

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ABSTRACT: Nematodes occurring in the Antarctic bony fishes are reviewed, and keys based on morphological features are presented. Five valid species: *Ascarophis nototheniae* Johnston *et* Mawson, 1945; *Cystidicola beatriceinsleyae* (Holloway *et* Klewer, 1969); *Dichelyne fraseri* (Baylis, 1929); *Hysterothylacium aduncum* (Rudolphi, 1802); *Paranisakiopsis weddelliensis* Rocka, 2002, and one unnamed form, *Capillaria* (*Procapillaria*) sp., have been reported from the Antarctic teleosts. Also, larval anisakids, in the adult stage parasites of marine mammals, birds and fishes, occur commonly in the Antarctic and Subantarctic bony fishes. They belong to *Contracaecum* spp., *Anisakis* spp., *Pseudoterranova decipiens* (Krabbe, 1878) and *Hysterothylacium aduncum.*

Key words: Antarctica, nematodes, bony fishes.

Introduction

Data on the occurrence of nematodes in fishes in the Antarctic are poor in comparison with those on the occurrence of Digenea, Cestoda and Acanthocephala. Only a few nematode species maturing in fishes have been recorded in the Antarctic. They belong to six genera: *Ascarophis* Beneden, 1871; *Capillaria* (*Procapillaria*) Moravec, 1987; *Cystidicola* Fischer, 1798; *Dichelyne* Jägerskiöld, 1902; *Hysterothylacium* Ward *et* Magath, 1917 and *Paranisakiopsis* Yamaguti, 1941 (Baylis 1929, Johnston and Mawson 1945, Holloway *et al*. 1967, Szidat and Graefe 1967, Holloway and Klewer 1969, Holloway and Spence 1980, Lyadov 1985, Rodjuk 1985, Reimer 1987, Gaevskaya *et al*. 1990, Moser and Cowen 1991, Zdzitowiecki and Cielecka 1996, Zdzitowiecki *et al*. 1998, Rocka 1999, 2002; Zdzitowiecki 2001a, b; Walter *et al*. 2002). Meanwhile, various anisakid larvae occur commonly in the Antarctic and Subantarctic teleosts (Linstow 1907, Railliet and Henry 1907, Leiper and Atkinson 1915, Baylis 1929, Johnston 1938, Johnston and Mawson 1943, 1945; Hoogesteger and White 1981, Parukhin and Lyadov 1982, Reimer 1987, Orecchia *et al.* 1983, 1994; Parukhin 1989, Moser and Cowen 1991, Klöser

and Plötz 1992, Klöser *et al.* 1992, Palm *et al*. 1994, 1998; Arduino *et al*. 1995, Mattiucci *et al.* 1995, Gaevskaya and Rodjuk 1997, Palm 1999, Zdzitowiecki and Zadróżny 1999, Zdzitowiecki 2001a, b; Walter *et al*. 2002, Zhu *et al*. 2002).

Material and methods

The material available for the present study was collected by Prof. K. Zdzitowiecki during Antarctic scientific expeditions of the Polish Academy of Sciences in the years: 1977, 1978/79, 1986/87, and during German Expedition ANT XIII/3 in 1996. Additional material was obtained from the Terra Nova Bay (Ross Sea), off Adelie Land, Davis Sea, off the South Orkneys, South Georgia, from Admiralty Bay and off the Heard Island. Fish names are given according to Gon and Heemstra (1990).

Nematodes were fixed in 75% ethanol, stored in glycerin by evaporation of the ethanol/glycerin mixture and examined as whole mounts using light microscope. Part of the material from the Weddell Sea was prepared for SEM. Parasites were postfixed in 1% osmium tetroxide, dehydrated through graded acetone, critically point dried and sputter-coated with gold. They were examined with a Leo-1430 VP scanning microscope at 20–23 KV.

Systematic review of nematodes

Key to the Orders, Families and Genera of nematodes of which adults have been recorded from the Antarctic bony fishes

1a. Caudal papillae few in number. Phasmids absent. Oesophagus forming stichosome. Eggs unsegmented with a plug at either pole . . . . . Order Enoplida, Family Trichuridae, Genus *Capillaria* (*Procapillaria*)

1b. Caudal papillae numerous. Phasmids present. Oesophagus never in form of stichosome. Eggs without polar plugs 2

2a. Anterior end triradiate. Lateral, external labial papillae present. With 2 to 3 pairs of caudal papillae dorsolateral in position. Oesophagus not divided into short muscular and long glandular parts. Parasites of the intestine . . . . . Order Ascaridida 3

2b. Anterior end bilaterally symmetrical. Lateral, external labial papillae absent. Caudal papillae always ventral or ventrolateral in position. Oesophagus divided into anterior muscular part shorter than posterior glandular part. Parasites of the anterior part of the gut or tissues and tissue spaces . . . . . Order Spirurida, Family Cystidicolidae 5

3a. Lips absent or markedly reduced. Pseudobuccal capsule present. Preanal sucker in male present . . . . . Family Cucullanidae, Genus *Dichelyne* (*Cucullanellus*)

3b. Lips well defined, separated by interlabia. Pseudobuccal capsule absent. Preanal sucker in male absent 4

4a. Lips approximately equal in size, wider than long, without dentigerous ridges. Excretory pore near the level of nerve ring. Ventricular appendix present. Intestinal caecum present . . . . . Genus *Hysterothylacium*

4b. Lips longer than wide and narrower towards their bases; dentigerous ridge present. Excretory pore at the base of ventral interlabium. Ventriculus without appendix, intestinal caecum absent . . . . . Genus *Paranisakiopsis*

5a. Anterior portion of pseudolabia narrow, apex conical. Submedian labia and sublabia present. Four pairs of preanal and 5 pairs of postanal papillae present. Spicules unequal . . . . . Genus *Ascarophis*

5b. Each pseudolabium terminating in a knob-like process. Preanal papillae numerous (more than 4 pairs). Spicules dissimilar in form and dimensions . . Genus *Cystidicola*

Order Spirurida
Superfamily Habronematoidea
Family Cystidicolidae (Skrjabin, 1946, subfam.)
Genus *Ascarophis* Beneden, 1871
Ascarophis nototheniae Johnston *et* Mawson, 1945
Fig. 1

Host: *Trematomus centronotus, T. newnesi, T. eulepidotus, T. loennbergii*, *T. nicolai*, *T. scotti*, *T. pennelli*, *Gobionotothen acuta*, *G. gibberifrons, Notothenia coriiceps*, *N. cyanobrancha*, *N. rossii, Paranotothenia magellanica*, *Dissostichus eleginoides*, *Pagothenia bernacchii*, *P. hansoni*, *Nototheniops mizops, N. nudifrons, N. nybelini, N. larseni* (Nototheniidae); *Harpagifer bispinis*, *H. antarcticus* (Harpagiferidae); *Champsocephalus gunnari*, *Cryodraco antarcticus, Chionodraco rastrospinosus, Chaenocephalus aceratus, Pseudochaenichthys georgianus*, *Pagetopsis macropterus, Chaenodraco wilsoni, Chionodraco hamatus* (Channichthyidae); *Parachaenichthys georgianus, P. charcoti, Psilodraco breviceps*, *Racovitzia glacialis, Cygnodraco mawsoni, Prionodraco evansii*, *Gerlachea australis* (Bathydraconidae); *Zanclorhynchus spinifer* (Congiopodidae); *Artedidraco shackletoni* (Artedidraconidae); *Lycodichthys antarcticus*, *L. dearborni* (Zoarcidae).

Localities: Subantarctic: the Kerguelen subregion – off the Crozet Islands, off the Heard Island, off the Kerguelen Island, off the Macquarie Island (Johnston and Mawson 1945, Parukhin and Lyadov 1982, Parukhin and Zaitsev 1984, Lyadov 1985, Parukhin 1989, Gaevskaya *et al*. 1990, Rocka 1999); West Antarctic: Environs of the South Shetland Islands – shelf around Elephant and Joinville Islands, and Admiralty Bay; open sea shelf and fjords at South Georgia, coastal waters at the South Orkney Islands (Szidat and Graefe 1967, Gaevskaya and Rodjuk 1997, Rocka 1999, Zdzitowiecki and Zadróżny 1999, Zdzitowiecki 2001a); East Antarctic: 64°144′–67°138′S, 62°103′–142°136′E (Johnston and Mawson 1945); McMurdo Sound (Holloway *et al*. 1967, Holloway and Spence 1980); off Adelie

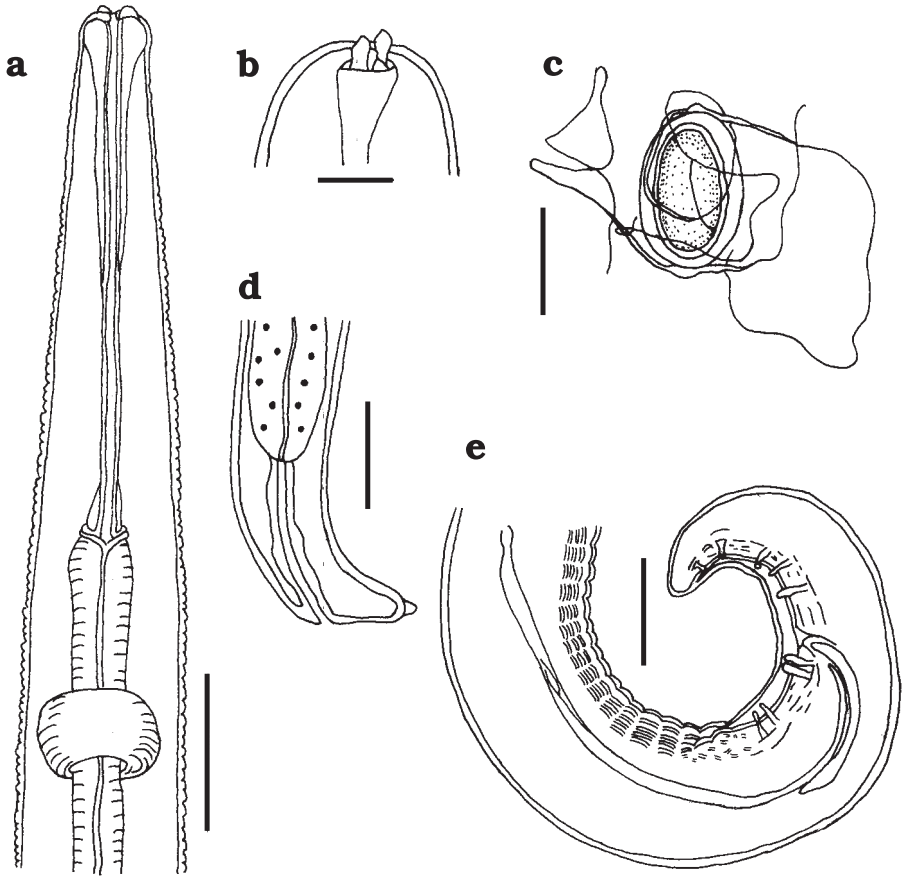

Fig. 1. *Ascarophis nototheniae* (after Holloway *et al.* 1967, modified). **a** – anterior end of female, dorsoventral view, **b** – anterior end of female, lateral view, **c** – mature egg, **d** – posterior end of female, lateral view, **e** – posterior end of male, lateral view. Scale bars = 0.05 mm (a, e, d); 0.01 mm (b); 0.03 mm (c).

Land, Ross Sea (Terra Nova Bay), Davis Sea, the eastern part of the Weddell Sea (Zdzitowiecki *et al.* 1998, Rocka 1999, 2002; Zdzitowiecki 2001b).

Habitat: Mainly stomach, also small intestine and pyloric caeca.

The following description contains the data provided by Johnston and Mawson (1945) and Holloway *et al*. (1967), and is emended by Rocka (1999, 2002). The emendations are based on 51 females and 42 males from *Chaenocephalus aceratus*, *Nototeniops nudifrons*, *Gobionotothen gibberifrons*, *Cryodraco antarcticus* and *Lycodichthys antarcticus* caught at the South Shetlands, South Georgia, South Orkneys, Ross Sea and Weddell Sea.

Female: Body 5.0–24.6 mm long and 0.09–0.22 mm wide. Buccal capsule 0.11–0.20 mm. Muscular oesophagus and glandular oesophagus 0.2–0.6 and 2.18–4.48 mm long, respectively. Entire oesophagus 2.57–4.98 mm long. Nerve

ring and excretory pore 0.13–0.25 and 0.12–0.36 mm from the anterior end, respectively. Tail 0.03–0.08 mm long, with small knob-like terminal projection. Vulva postequatorial, 4.0–7.1 mm from posterior end of the body. Mature eggs, 0.04–0.05 × 0.02–0.03 mm, with two filaments arising from prominent knob at each pole.

Male: Body 3.7–12.2 mm long and 0.02–0.05 mm wide. Buccal capsule 0.1–0.2 mm long. Muscular oesophagus and glandular oesophagus 0.26–0.52 and 1.4–3.9 mm long, respectively. Entire oesophagus 1.7–4.4 mm. Nerve ring and excretory pore 0.12–0.26 and 0.17–0.38 mm from anterior end, respectively. Tail 0.09–0.15 mm long. Caudal alae narrow. Left spicule 0.4–0.6 mm long with sharply pointed distal part; right spicule 0.06–0.12 mm long with blunt distal tip. Area rugosa with approximately 9 longitudinal rows of cuticular elevations. Caudal papillae 9 pairs: 4 pairs preanal, 5 pairs postanal.

Remarks: Besides this species, *Ascarophis chalinurae* Johnston *et* Mawson, 1945 and *Ascarophis lycodichthys* Johnston *et* Mawson, 1945 were described from the Antarctic (Johnston and Mawson 1945). Holloway *et al*. (1967) synonymized *A. lycodichthys* with *A. nototheniae*, due to the lack of specific differentiating features. These authors also considered the generic assignment of *A. chalinurae* is doubtful. Another species, *Ascarophis campbelli* (Chatin, 1885) (= *Spiroptera campbelli* Chatin, 1885), has been described from Subantarctic waters. The only specific measurements given for *A. campbelli* was an average female length of 25 mm. Chatin's description was incomplete and this nematode was placed in the genus *Ascarophis* by Johnston and Mawson (1943). Although these authors suggested that *A. nototheniae* is a junior synonym of *A. campbelli* (Johnston and Mawson 1945), more study is necessary to prove this synonymy. Anyhow, only one valid species, *Ascarophis nototheniae*, occurs in the Antarctic teleosts.

Genus *Cystidicola* Fischer, 1798

Cystidicola beatriceinsleyae (Holloway *et* Klewer, 1969)

Fig. 2

Synonym: *Rhabdochona beatriceinsleyae* Holloway *et* Klewer, 1969.

Host: *Rhigophila* (= *Lycodichthys*) *dearborni*, *Lycodichthys antarcticus* (Zoarcidae).

Localities: McMurdo Sound (Holloway and Klewer 1969), the eastern part of the Weddell Sea (Rocka 2002).

Habitat: Mainly various parts of small intestine, stomach.

The description contains the data provided by Holloway and Klewer (1969) and is emended by Rocka (2002). The emendations are based on 6 females and 3 males from *L. antarcticus* caught in the Weddell Sea.

Female: 15.8–32.2 mm long and 0.10–0.18 mm wide. Buccal capsule 0.15–0.27 mm long. Muscular oesophagus 0.16–0.24 mm and glandular oesophagus 0.64–0.97 mm long. Entire oesophagus 0.8–1.2 mm long. Nerve ring and excre-

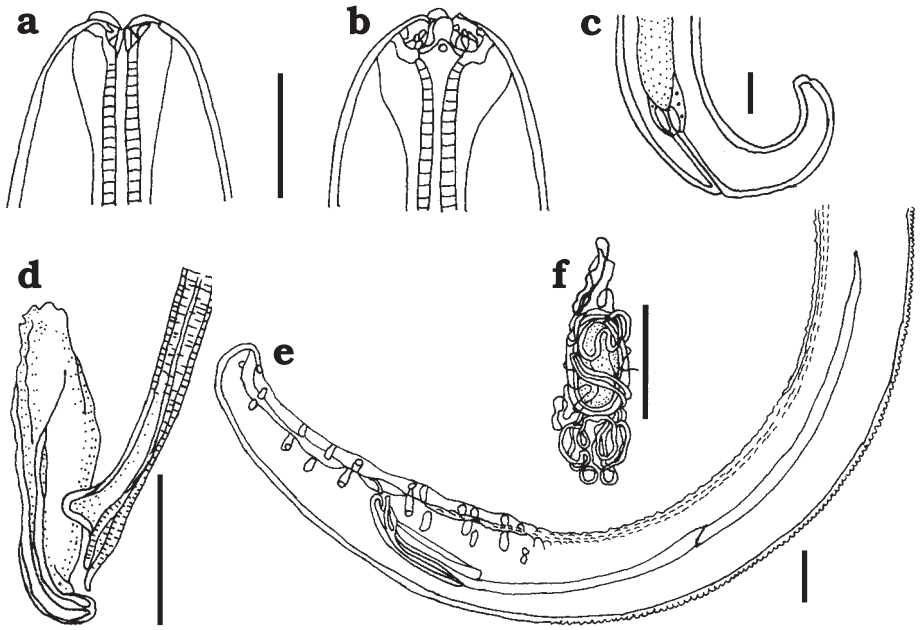

Fig. 2. *Cystidicola beatriceinsleyae* (after Holloway and Klewer, 1969, modified). **a** – anterior end of female, dorsoventral view, **b** – anterior end of female, lateral view, **c** – posterior end of female, lateral view, **d** – entire right spicule and posterior end of left spicule, **e** – posterior end of male, lateral view, **f** – mature egg. Scale bars = 0.03 mm (a, b); 0.05 mm (c–f).

tory pore 0.26–0.32 and 0.33–0.50 mm from the anterior end, respectively. Tail, 0.16–0.24 mm long , curved dorsally, bluntly rounded with a small, ventral indentation near tip. Vulva 8.5–11.3 mm from the posterior end of the body. Eggs 0.042–0.049 × 0.021–0.026 mm with two polar caps, each with two, but up to 4 filaments.

Male: Body 7.9–15.2 mm long and 0.07–0.11 mm wide. Buccal capsule 0.20–0.26 mm long. Muscular oesophagus and glandular oesophagus, 0.19–0.22 and 0.46–0.76 mm long, respectively. Entire oesophagus 0.65–0.98 mm long. Nerve ring and excretory pore 0.26–0.31 and 0.37–0.47 mm from the anterior end, respectively. Tail 0.16–0.29 mm long, bluntly rounded at tip. Posterior end curved ventrally. Caudal alae narrow. Caudal papillae 11 pairs; 6 preanal pairs and 5 postanal pairs. Left spicule 0.47–0.77 mm long, its anterior half tubular whereas posterior half concave, ventrally becoming more alate at the level of right spicule; posterior end cupped with irregular sides. Right spicule, 0.08–0.12 mm long, broad and cup-shaped to deflect left spicule.

Order Ascaridida
Superfamily Ascaridoidea
Family Anisakidae Skrjabin *et* Karokhin, 1945

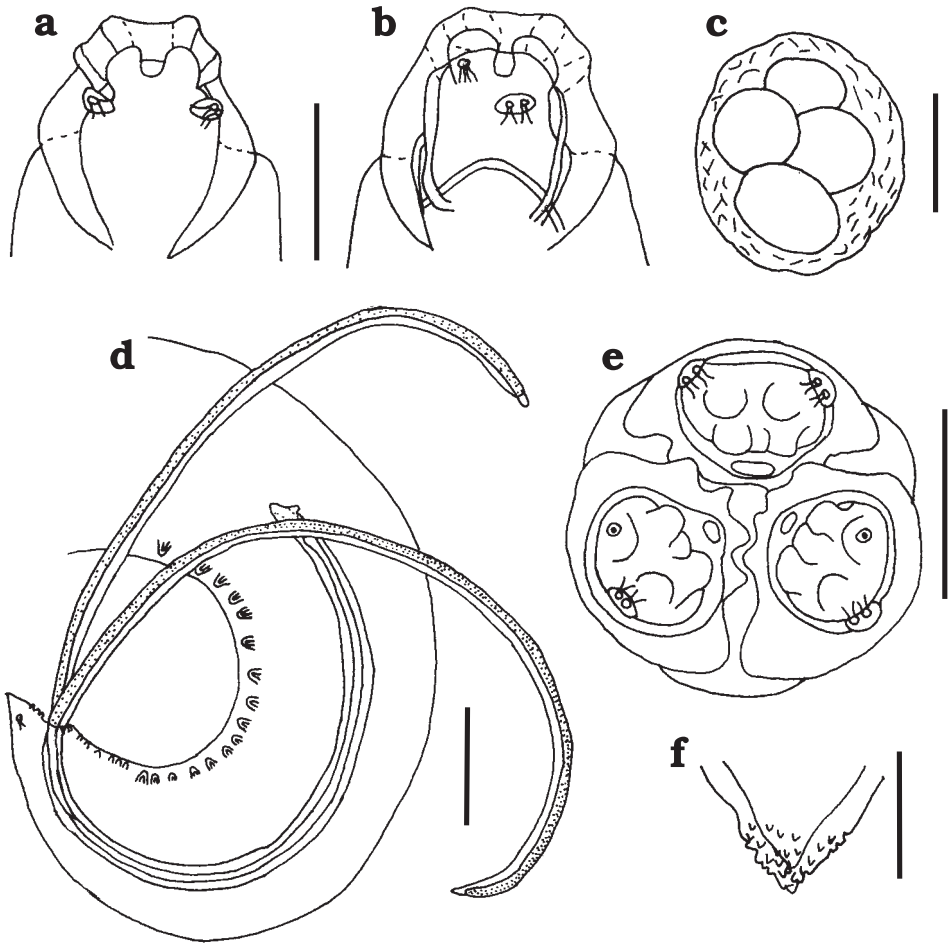

Fig. 3. *Hysterothylacium aduncum* (after Mozgovoj 1953, modified). **a** – anterior end of female, dorsoventral view, **b** – anterior end of female, lateral view, **c** – egg, **d** – posterior end of male, lateral view, **e** – anterior end of female, apical view, **f** – posterior end of female. Scale bars = 0.1 mm (a, b, e); 0.4 mm (f); 0.25 mm (d); 0.03 mm (c).

Genus *Hysterothylacium* Ward *et* Magath, 1917

Hysterothylacium aduncum (Rudolphi, 1802)

Fig. 3

Synonym: *Ascaris adunca* Rudolphi, 1802.

Host: *Dissostichus eleginoides*, *D. mawsoni* (Nototheniidae).

Localities: Environs of the South Shetlands – Admiralty Bay and open sea shelf at the South Shetlands; open sea shelf at Shag Rocks, off South Georgia (Gaevskaya *et al*. 1990, Rokicki *unpubl.*).

Habitat: Stomach and intestine.

Description according to Mozgovoy (1953) and Hartwich (1975).

Female: Body 24.0–48.0 mm long and 0.72–1.40 mm wide. Cervical alae 4.50 × 0.046–0.047 mm. Lips up to 0.15 mm; interlabia up to 0.06 mm long. Nerve ring 0.66–0.90 mm from the anterior end. Oesophagus 2.25–4.12 mm long; ventriculus 0.17–0.18 × 0.16–0.18 mm with an appendix, 0.62–0.87 mm long. Intestinal caecum 0.91–1.56 mm long. Tail 0.28–0.42 mm long, conical with small projection covered with minute spines. Eggs 0.062–0.070 × 0.046–0.047 mm.

Male: Body 18.0–35.0 mm long and 0.43–0.80 mm wide. Cervical alae 4.21 × 0.04 mm. Lips up to 0.15 mm, interlabia up to 0.05 mm long. Nerve ring 0.53 mm from the anterior end. Oesophagus 1.94–3.23 mm long; ventriculus 0.15–0.17 × 0.12–0.14 mm with appendix, 0.54–0.81 mm long. Intestinal caecum 0.65–0.93 mm long. Tail 0.11–0.14 mm long, curved ventrally, conical with projection covered with minute spines. Caudal papillae 29 pairs; 23 preanal pairs, 4 postanal pairs, 2 para-anal pairs. Spicules 2.01–4.65 mm long. Caudal alae absent.

Remarks: Deardorff and Overstreet (1980) resurrected the genus *Hysterothylacium* to include those species previously considered as members of the junior synonym *Thynnascaris* Dolfus, 1933 and others described in the genus *Contracaecum* Railliet *et* Henry, 1912. Another species, *H. nototheniae* Johnston *et* Mawson, 1945, was found in the Kerguelen subregion, Subantarctic (Johnston and Mawson 1945). The description was based on two immature females and the following measurements were given: body length 41 mm, oesophagus length 3.1 mm, ventricular appendix length 1.8 mm and intestinal caecum length 1.6 mm. This species is poorly defined and its validity is doubtful.

Genus *Paranisakiopsis* Yamaguti, 1941

Paranisakiopsis weddelliensis Rocka, 2002

Figs 4–5

Host: *Macrourus whitsoni* (Macrouridae).

Locality: The eastern part of the Weddell Sea (Rocka 2002).

Holotype, allotype and paratypes deposited in the Institute of Parasitology, Polish Academy of Sciences in Warszawa (Helm. Coll. No. P-155).

Habitat: Pyloric caeca.

Description according to Rocka (2002).

Female: 55.0–62.0 mm long and 0.85–1.55 mm wide near vulva. Head end 0.25–0.27 mm in diameter at base; lips up to 0.2 mm and interlabia up to 0.11 mm long. Oesophagus 3.64–4.00 mm long, 0.25–0.30 and 0.38–0.41 mm wide at its anterior and posterior part, respectively. Ventriculus 0.32 × 0.34 mm. Vulva preequatorial. Tail conical pointed, 0.25–0.46 mm long. Eggs 0.083–0.085 × 0.063–0.065 mm, thin-walled.

Male: 40.0–48.0 mm long and 0.75–1.00 mm wide. Head end 0.23–0.27 mm in diameter at base; lips up to 0.2 mm, interlabia up to 0.14 mm long. Oesophagus 4.2–5.6 mm long, 0.25 and 0.41–0.43 mm wide at its anterior and posterior part, respectively. Ventriculus 0.29–0.43 × 0.38–0.46 mm. Tail 0.25–0.38 mm long,

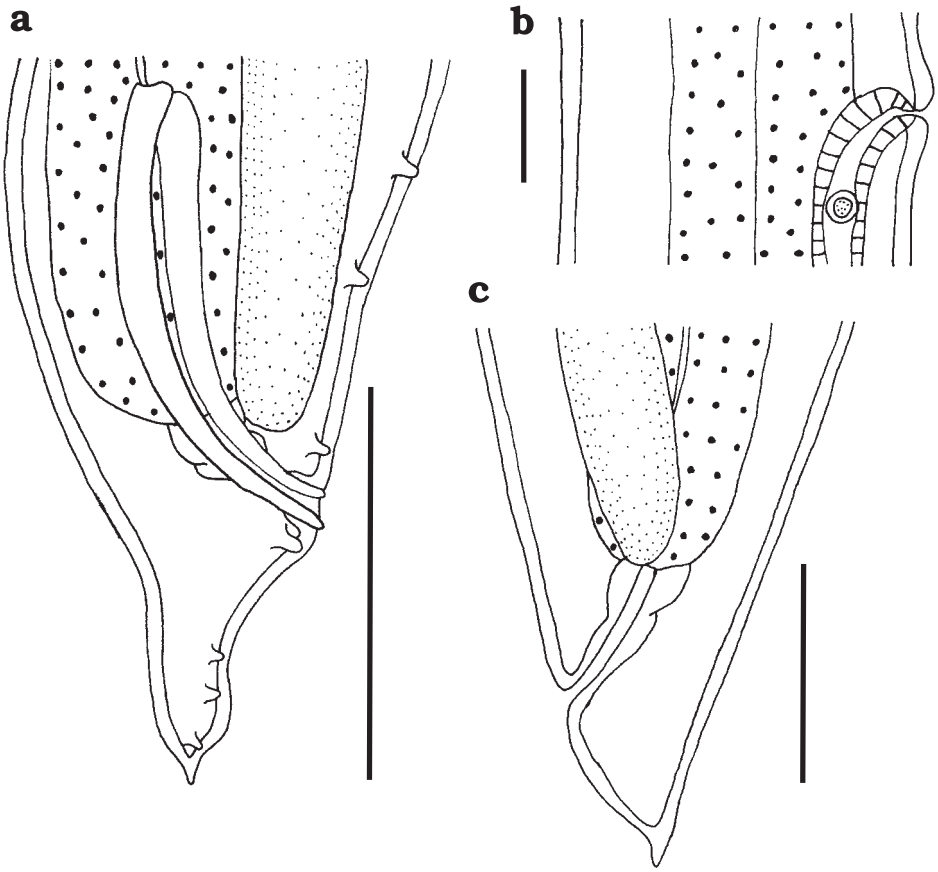

Fig. 4. *Paranisakiopsis weddelliensis* (after Rocka 2002). **a** – posterior end of male, lateral view, **b** – vulva region, **c –** posterior end of female, lateral view. Scale bars = 0.5 mm.

pointed, curved ventrally, narrowed immediately posterior to the first pair of postanal papillae; 8–10 pairs of preanal papillae and 4 pairs of postanal papillae present. First pair of postanals just posterior to cloacal aperture. Spicules equal or subequal, 0.42–0.62 mm long.

Remarks: Two species, *Paranisakiopsis macruri* (Linstow, 1888) and *Paranisakiopsis macruroidei* (Linstow, 1888), were reported from the Subantarctic (Johnston and Mawson 1945). Only females were found and both descriptions were very incomplete. Walter *et al*. (2002) found representatives of the genus *Paranisakiopsis* in *Macrourus whitsoni* from the Weddell Sea and off King George Island and assigned them as *Paranisakiopsis* cf. *australiensis*, but without any morphological data. Originally, *P. australiensis* Johnston *et* Mawson, 1945 was described from *Coelorhynchus australis* from Tasmania. It seems, that *P. weddelliensis* Rocka, 2002 and *Paranisakiopsis* cf. *australiensis* could be the same species.

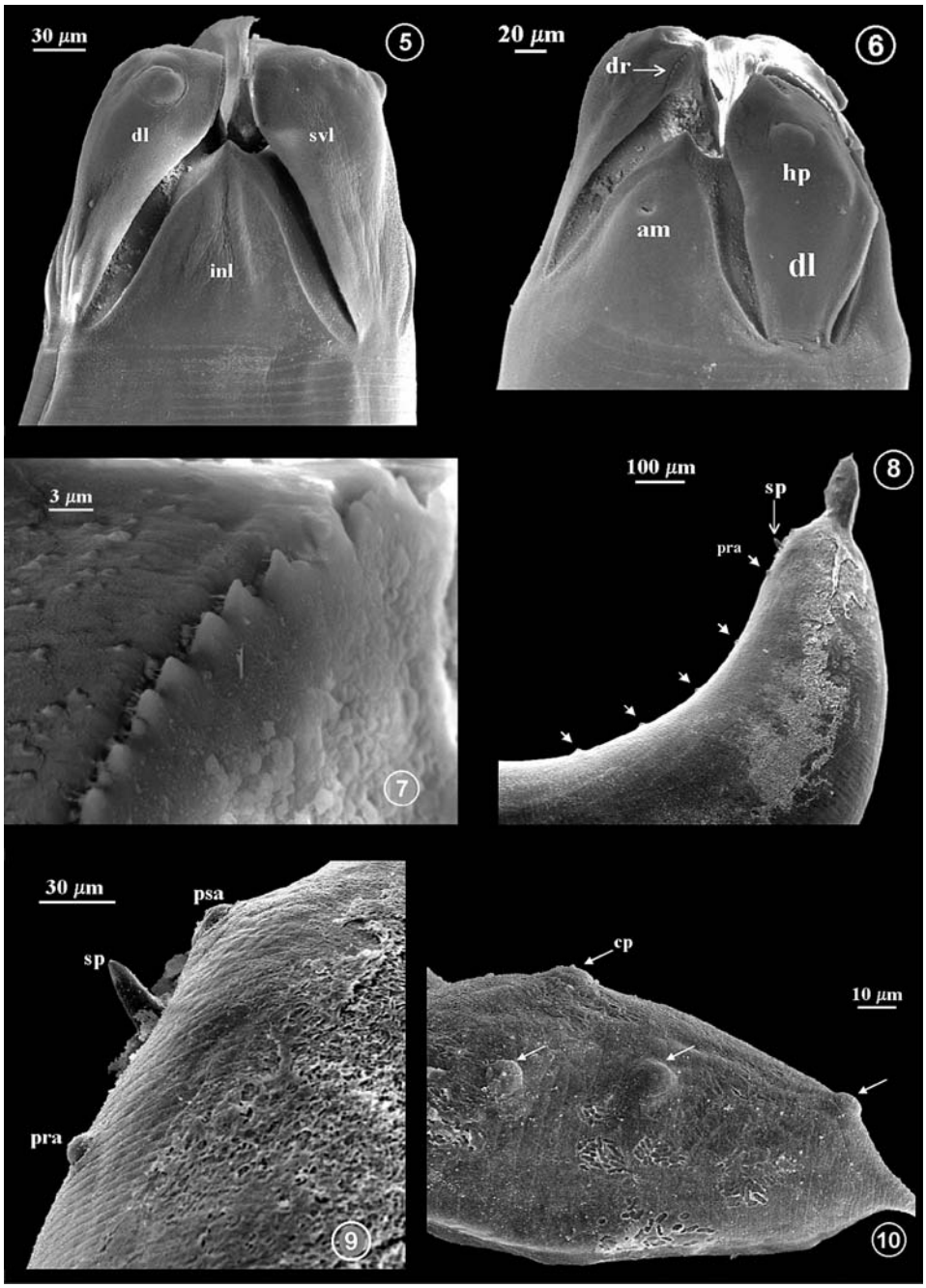

Fig. 5. *Paranisakiopsis weddelliensis*, SEM micrographs. **5 –** anterior end of male, lateral view**, 6 –** anterior end of male, sublateral view, **7 –** dentigerous ridge on lip, **8 –** posterior end of male, lateral view, **9 –** region of cloaca, lateral view, **10** – male tail, subventral view. Abbreviations: am – amphid, cp – caudal papillae, dl – dorsal lip, dr – dentigerous ridge, hp – head papilla, inl – interlabium, pra – preanal papillae, psa – postanal papillae, sp – spicule, svl – subventral lip.

Superfamily Seuratoidea
Family Cucullanidae Cobbold, 1864
Genus *Dichelyne* Jägerskiöld, 1902
Subgenus *Cucullanellus* (after Petter 1974)
Dichelyne (*Cucullanellus*) *fraseri* (Baylis, 1929)
Fig. 6

Synonyms: *Cucullanus fraseri* Baylis, 1929; *Cucullanus fraseri var. nototheniae* Baylis, 1929.

Host: *Chaenocephalus aceratus, Pseudochaenichthys georgianus*, *Channichthys rhinoceratus*, *C. velifer*, *Champsocephalus gunnari* (Channichthyidae); *Gobionotothen gibberifrons*, *G. angustifrons*, *G. acuta*, *Nototheniops nudifrons*, *N. larseni*, *N. mizops*, *N. tchizh*, *Notothenia cyanobrancha, N. rossii, N. coriiceps*, *Lepidonotothen squamifrons*, *L. kempi*, *Pagothenia hansoni*, *Trematomus vicarius*, *Paranotothenia magellanica*, *P. microlepidota*, *Dissostichus eleginoides* (Nototheniidae); *Parachaenichthys georgianus* (Bathydraconidae); *Muraenolepis marmoratus*, (Muraenolepididae); *Harpagifer georgianus* (Harpagiferidae).

Localities: Subantarctic: the Kerguelen subregion – off the Heard Island, off the Kerguelen Island, off the Crozets, off the Macquarie Island, and the Magellanic subregion (Johnston and Mawson, 1945, Lyadov *et al*. 1981, Parukhin and Lyadov 1981, 1982; Parukhin and Zaitsev 1984, Parukhin 1986, 1989; Shandikov and Parukhin 1987, Gaevskaya *et al*. 1990, Zdzitowiecki and Cielecka 1996, Gaevskaya and Rodjuk 1997); West Antarctic: off South Georgia, open sea shelf at Shag Rocks, open sea shelves at the South Shetlands and Joinville Island, coastal waters at the South Orkneys (Baylis 1929, Parukhin and Sysa 1975, Zdzitowiecki 1978, Parukhin and Lyadov 1981, Rodjuk 1985, Reimer 1987, Gaevskaya *et al*. 1990, Zdzitowiecki and Cielecka 1996).

Habitat: Intestine.

Description according to Baylis (1929), and Zdzitowiecki and Cielecka (1996).

Female: Body 3.34–7.34 mm long and 0.22–0.42 mm wide. Pseudobuccal capsule 0.11–0.18 mm wide. Oesophagus 0.61–1.13 mm long. Intestinal caecum 0.26–0.56 mm long. Tail 0.14–0.22 mm, conical. Anterior ovary almost extends beyond the junction of oesophagus and intestine, posterior ovary almost reaches the anus. Uterus amphidelphic. Vulvar opening on a small protuberance. Eggs 0.077–0.103 × 0.042–0.054 mm, thin-shelled, and with small polar protuberance. A pair of phasmids situated midway between anus and posterior end.

Male: Body 3.06–5.55 mm long and 0.16–0.34 mm wide. Posterior part of the body ventrally curved. Pseudobuccal capsule 0.10–0.15 mm wide. Oesophagus 0.55–0.97 mm long. Intestinal caecum 0.16–0.60 mm long. Tail 0.12–0.21 mm long, conical. Spicules 0.67–1.01 mm long with flattened, rounded distal end. Gubernaculum 0.11–0.16 mm long. Caudal papillae 11 pairs; anterior 3 pairs precloacal, 5 pairs near the opening of cloaca, 2 pairs near posterior end as well as a pair of phasmids. Phasmids midway between paracloacal papillae and those of the

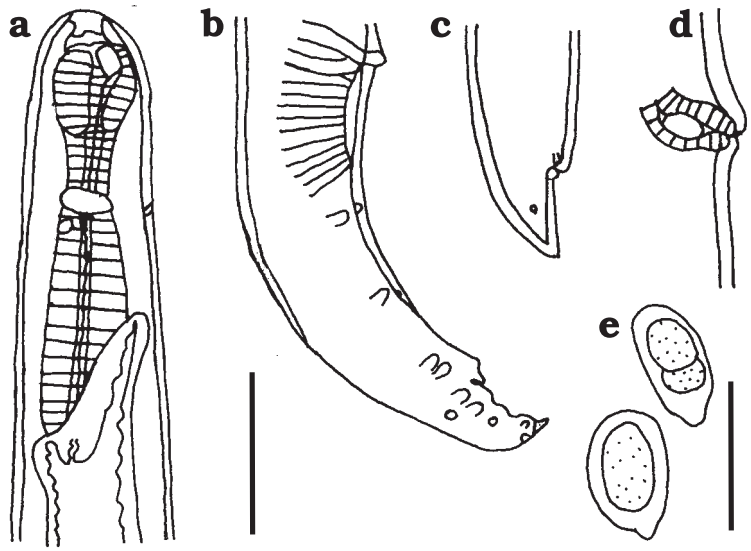

Fig. 6. *Dichelyne (Cucullanellus) fraseri* (after Zdzitowiecki and Cielecka 1996). **a** – anterior end of male, lateral view, **b** – posterior end of male, lateral view, **c** – tail of female, lateral view, **d** – vulva region, **e** – eggs. Scale bars = 0.25 mm (a–d); 0.1 mm (e).

two posterior pairs. Testis extends anteriad nearly beyond, at the level of, or nearly before the junction of oesophagus and intestine.

Remarks: Another species, *Dichelyne* (*C.*) *dichelyneformis* (Szidat, 1950), has been described from the Subantarctic. According to Zdzitowiecki and Cielecka (1996) the description of this species was based on a strongly contracted specimens from fishes preserved in formalin and seems to be very similar to some *D. fraseri* collected and fixed using the same method. Possibly, both forms are conspecific, but the final decision needs the reexamination of type-materials and the elaboration of new materials from *Eleginops maclovinus*.

Order Enoplida
Superfamily Trichinelloidea
Family Trichuridae Railliet, 1915
Subfamily Capillariinae Railliet, 1915
Genus *Capillaria* Zeder, 1800
Subgenus *Procapillaria* (after Moravec 1987)
Capillaria (*Procapillaria*) sp.
Fig. 7

Host: *Macrourus whitsoni* (Macrouridae).

Locality: The eastern part of the Weddell Sea (Rocka 2002).

Specimens deposited in the Institute of Parasitology, Polish Academy of Sciences in Warszawa, (Helm. Coll. No. C–154).

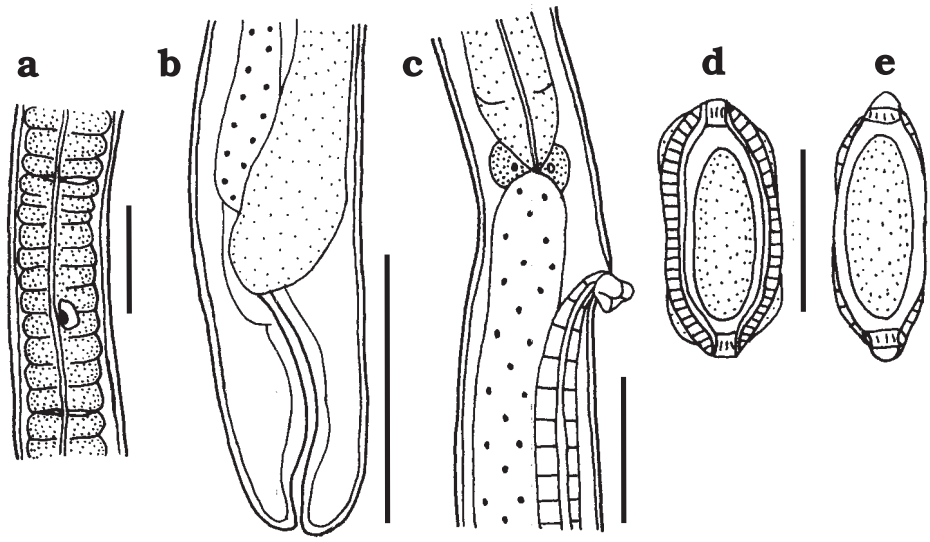

Fig. 7. *Capillaria* (*Procapillaria*) sp. (after Rocka 2002). **a** – stichosome region, **b** – posterior end of female, **c** – vulva region, **d** – mature egg, **e** – immature egg. Scale bars = 0.1 mm.

Habitat: Pyloric caeca.

Description according to Rocka (2002). Only females found. Body 17.6–26.0 mm long and 0.08–0.09 mm wide near vulva. Two lateral and one ventral bacillary bands present. Entire oesophagus 8.9–10.4 mm long; its muscular part 0.40–0.53 mm. Stichosome, 8.5–9.9 mm, composed of 46–49 stichocytes. Vulva 0.04–0.11 mm below level of oesophagus and intestine juncture. Bell-shaped vulvar appendage, 0.04–0.06 × 0.018–0.062 mm, present. Rectum 0.07–0.12 mm long. Anus subterminal, tail 0.009–0.012 mm long. Mature eggs 0.077–0.082 × 0.037–0.042 mm, thin-walled.

Remarks: Walter *et al*. (2002) found adult *Capillaria* sp. in *Macrourus whitsoni* from the Weddell Sea and off King George Island. Probably, *Capillaria* (*Procapillaria*) sp. and his *Capillaria* sp. are the same species.

Review of larval forms

Larvae of nematodes parasitizing in the adult stage marine mammals, birds and fishes occur commonly in the Antarctic and Subantarctic fishes. The larvae are localized in the viscera, the mesentery and the body cavity of hosts. They represent the following genera: *Anisakis* Dujardin, 1845, *Contracaecum* Railliet *et* Henry, 1912, *Hysterothylacium* Ward *et* Magath, 1917 and *Pseudoterranova* Mozgovoy, 1953.

According to Johnston and Mawson (1945) and Nikolskij (1974) three species of the genus *Contracaecum*, *C. osculatum* (Rudolphi, 1802), *C. radiatum* (Lin-

stow, 1907) and *C. mirounga* Nikolskij, 1974, were obtained from pinnipeds in various localities of the Antarctic and Subantarctic.

According to Klöser and Plötz (1992) and Klöser *et al.* (1992), two species parasitic on pinnipeds exist in high Antarctic waters: *C. osculatum* and the endemic *C. radiatum*, whereas the third species, *C. mirounga*, recorded from the Subantarctic and the high Antarctic regions, may probably be off its distributional limits. However, definitive host of *C. mirounga*, elephant seal, occurs commonly in environs of the South Shetlands and South Georgia and larvae of this genus could be found in intermediate and paratenic hosts in these regions. It should be noted, that cystacanths of *Corynosoma bullosum*, specific parasite for elephant seal, have been reported even in the Weddell Sea (Zdzitowiecki 1996).

Johnston and Mawson (1945) recognized five types of *Contracaecum* larvae and considered type IV (short type) and V (long type) from Antarctic fishes as larvae of *C. radiatum* and *C. osculatum*, respectively. Similarly, Klöser *et al.* (1992) used the morphometric analysis to distinguish larval *Contracaecum* from seals and fishes caught in the Weddell Sea and assigned their short type to *C. radiatum* and long type to *C. osculatum*. Two larval types could be separated by relating absolute total length to the ratio of lengths of caecum and oesophagus. The fish-feeding channichthyids: *Cryodraco antarcticus*, *Chionodraco myersi*, *Chionodraco hamatus* and *Chaenocephalus aceratus*, seemed to play an important role as paratenic hosts for *Contracaecum* spp. in the Weddell Sea and environs of the South Shetlands (Klöser *et al.*1992, Zdzitowiecki *unpubl*.).

Isoenzyme studies carried out on *C. osculatum* complex led to the discovery that this taxon includes three biological species in the Atlantic Arctic-Boreal region, namely *C. osculatum* A, B, and C (Nascetti *et al.* 1993). Orecchia *et al.* (1994) analysed the genetic structure of adults and larvae of *C. osculatum* from the Antarctic hosts: Weddell seal, *Chionodraco hamatus*, *Cryodraco antarcticus* (Channichthyidae) and *Trematomus centronotus*, *Notothenia neglecta* (Nototheniidae), and found that two distinct, reproductively isolated species, *C. osculatum* D and E, occur in the Antarctic. These species do not correspond to any of the three species in the Atlantic Arctic-Boreal region. Because morphological characters differing these species were not found, only allozyme analysis provides reliable diagnostic keys for identification of larvae and adults of both sexes of five members of *C. osculatum* complex.

Apparently, some larvae hitherto assigned as *Contracaecum* spp. may belong to *Hysterothylacium aduncum*, parasite of fishes.

According to Johnston and Mawson (1945) and Mozgovoy (1953) two species of the genus *Anisakis*, *A. similis* Baylis, 1920 and *A. physeteris* Baylis, 1923, were found in the stomachs of Antarctic marine mammals. Hence, larval *Anisakis* nematodes collected from Antarctic are composed of two species.

According to Zhu *et al.* (2002), six genetically distinct and reproductively isolated species have been detected within the morphospecies *Pseudoterranova decipiens* (Krabbe, 1878). Palm (1999) stated that one sibling species, *P. decipiens* E,

occurs in Antarctic waters and the Weddell seal is its main definitive host. Larvae of *P. decipiens* E are numerous in fishes in the West Antarctic and in the Subantarctic, but quite rare in the Weddell Sea (Johnston and Mawson 1945, Gaevskaya and Rodjuk 1997, Palm *et al*. 1994, 1998; Palm 1999, Zdzitowiecki 2001a).

According to Palm *et al*. (1994) the prevalence and intensity of infection of fishes with *P. decipiens* in the Weddell Sea are low compared with those reported from the northern hemisphere. The reason for such low worm burden might be cold water temperatures which may considerably slow down the development of eggs and larvae; water temperatures under 0°C do not harm the L3 in fish, but the negative effects of such temperatures on the survival rate of the 1 and 2 larval stages cannot be excluded. However, Palm *et al*. (1994) have not considered low water temperature as the decisive factor for the survival of the Antarctic parasite population.

Another significant factor leading to low infection rates in the high Antarctic could be the presence of the floating shelf-ice, limiting the areas of shallow waters typical for other coastal regions. In the Weddell Sea only benthic and bentho-pelagic fish species were found to harbour *P. decipiens* larvae, while an earlier investigation on pelagic species *Pleuragramma antarcticum* from the same area yielded no parasite larvae (Bartsch 1985). In the Weddell Sea benthic or bentho-pelagic species occur in deeper waters due to the above mentioned shelf-ice extension. Such fishes (as third intermediate hosts) may be not predated by Weddell seals, what would hinder the quick transmission of nematodes to the final host. Much more attention must be paid to studying invertebrate intermediate hosts as the "weak" point in the life cycle of *P. decipiens*. Klöser *et al*. (1992) believe that the regulation of *Contracaecum* populations in the same area must be expected to take place in the first but not in the second intermediate or final host. The use of pelagic hosts by *C. radiatum* may perhaps be considered as an adaptation to conditions of perennially ice-covered seas. This would explain higher total numbers of the endemic *C. radiatum* (pelagic life cycle) than of *C. osculatum* (benthic life cycle) in the Weddell seals and the fish. Consequently, for *P. decipiens* with a benthic life cycle, its more difficult access to the first and second invertebrate intermediate hosts can be assumed to be the most important reason for reduced infection rates of fish and Weddell seals. Reports from lower Antarctic latitudes, where the coastal zone is not ice-covered, indicate a higher abundance of *P. decipiens* there (Linstow 1907, Baylis 1937, Johnston 1938). In such situation, completion of the life cycle of *P. decipiens* in high Antarctic latitudes will only be guaranteed by at least one obligatory highly infected fish species. This role is taken by the bathydraconid, *Cygnodraco mawsoni*. It is interesting to note that in the case of the much more abundant *C. osculatum* in seals and fish from the same area, this crucial role is occupied by channichthyids (Klöser *et al*. 1992). This might explain the success of transmission of *C. osculatum* compared with *P. decipiens*, both having a benthic life cycle.

Based on morphological features larvae of four anisakid genera occurring in Antarctic fishes are distinguished without doubts.

Key to anisakid larval forms in Antarctic fishes

1a. Caeca absent . . . . . *Anisakis* spp.

1b. Caeca present 2

2a. Only intestinal caecum directed anteriad present . . . . . *Pseudoterranova decipiens*

2b. Both, intestinal directed anteriad and ventrical directed posteriad caeca present . . . 3

3a. Excretory pore at the base of subventral lips . . . . . *Contracaecum* 4

3b. Excretory pore at the level of nerve ring . . . . . *Hysterothylacium aduncum*

4a. Length ratio: oesophagus to caecum: 2.02–2.13 . . . . . *Contracaecum radiatum*

4b. Length ratio: oesophagus to caecum: 1.57–1.68 . . . . . *Contracaecum osculatum*

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References

ARDUINO P., NASCETTI G., CIANCHI R., PLÖTZ J., MATTIUCCI S., D'AMELIO S., PAGGI L., ORECCHIA P. and BULLINI L. 1995. Isozyme variation and taxonomic rank of *Contracaecum radiatum* (v. Linstow, 1907) from the Antarctic Ocean (Nematoda, Ascaridoidea). Systematic Parasitology 30: 1–9.

BARTSCH A. 1985. Vergleichende Untersuchungen zum Parasitenbefall von *Pleuragramma antarcticum* und *Trematomus scotti* (Pisces: Nototheniidae) aus der östlichen und südlichen Weddell-See (Antarktis). MSc thesis, University of Bochum.

BAYLIS H.A. 1929. Parasitic Nematoda and Acanthocephala collected in 1925-7. Discovery Reports 1: 541–560.

BAYLIS H.A. 1937. On the ascarids parasitic in seals, with special reference to the genus *Contracaecum*. Parasitology 29: 121–130.

DEARDORFF T.L. and OVERSTREET R.M. 1980. Review of *Hysterothylacium* and *Iheringascaris* (both previously = *Thynnascaris*) (Nematoda: Anisakidae) from the northern Gulf of Mexico. Proceedings of the Helminthological Society of Washington 93: 1035–1079.

GAEVSKAYA A.V. and RODJUK G.N. 1997. Ecological-geographical characters of parasite fauna of muraenolepids (Pisces: Muraenolepididae). Ekologiya Morya 46: 28–31.

GAEVSKAYA A.V., RODJUK G.N. and PARUKHIN A.M. 1990. Peculiarities and formation of parasitofauna of the Patagonian toothfish *Dissostichus eleginoides*. Biologiya Morya 4: 23–28 (in Russian).

GON O. and HEEMSTRA P.C. (eds.) 1990. *Fishes of the Southern Ocean*. J.L.B. Smith Institute of Ichthyology, Grahamstown; 462 pp.

HARTWICH G. 1975. Parasitic nematodes of vertebrates. I. Rhabditida und Ascaridida. Die Tierwelt Deutschlands 62: 256 pp.

HOOGESTEGER J.N. and WHITE M.G. 1981. Notes on parasite infestation of inshore fish at Signy Island, South Orkney Islands. British Antarctic Survey Bulletin 54: 23–31.

HOLLOWAY H.L. and KLEWER H.L. 1969. *Rhabdochona beatriceinsleyae* n. sp. (Nematoda: Spriruridea: Rhabdochonidae), from the Antarctic zoarcid, *Rhigophila dearborni*. Transactions of the American Microscopical Society 88: 460–471.

HOLLOWAY H.L. and SPENCE J.A. 1980. Ecology of animal parasites in McMurdo Sound, Antarctica. Comparative Physiology and Ecology 5: 262–284.

HOLLOWAY H.L., KLEWER H.L. and HUSAIN A. 1967. Notes on the genus *Ascarophis* Beneden, 1871, in Antarctic fishes. Proceedings of the Helminthological Society of Washington 34: 222–227.

JOHNSTON T.H. 1938. Parasitic Nematoda. Australasian Antarctic Expedition 1911-14. Scientific Reports, Series C, 10: 1–31.

JOHNSTON T.H. and MAWSON P.M. 1943. Some ascarid nematodes from Australian marine fish. Transactions of the Royal Society of the South Australia 66: 71–73.

JOHNSTON T.H. and MAWSON P.M. 1945. Parasitic nematodes. Reports B.A.N.Z. Antarctic Research Expedition, Series B, 8: 73–160.

KLÖSER H. and PLÖTZ J. 1992. Morphological distinction between adult *Contracaecum radiatum* and *Contracaecum osculatum* (Nematoda, Anisakidae) from the Weddell seal (*Leptonychotes weddelli*). Zoologica Scripta 21: 129–132.

KLÖSER H., PLÖTZ J., PALM H., BARTSCH A. and HUBOLD G. 1992. Adjustment of anisakid nematode life cycles to the high Antarctic food web as shown by *Contracaecum radiatum* and *C. osculatum* in the Weddell Sea. Antarctic Science 4: 171–178.

LEIPER R.T. and ATKINSON E.L. 1915. Parasitic worms, with a note on a free-living nematode. British Antarctic Terra-Nova Expedition, Natural History Report, Zoology 2: 19–60.

LINSTOW O. 1907. Nematodes of the Scottish National Antarctic Expedition. Proceedings of the Royal Society of Edinburgh 26: 464–472.

LYADOV V.N. 1985. Zoogeographical characteristics of the helminths of fishes from the Antarctic zone of the World Ocean. *In*: W.J. Hargis Jr. (ed.), *Parasitology and pathology of marine organisms of the World Ocean. NOAA Technical Reports NMFS* 25; 41–43.

LYADOV V.N., PARUKHIN A.M. and MIRONOVA V.A. 1981. Helminth fauna of fishes of the family Chaenichthyidae from the region of Kerguelen Islands. Zoologicheskij Zhurnal 60: 142–144 (in Russian).

MATTIUCCI S., NASCETTI G., PAGGI L., BELLIGOLI P. and BULLINI L. 1995. Occurrence of *Contracaecum osculatum* D, *C. osculatum* E and *C. radiatum* (Nematoda: Anisakidae) in fish hosts from Terra Nova Bay, Ross Sea (Antarctic). Abstracts of IVth International Symposium of Fish Parasitology, Műnich, October 3-7, 1995; 24.

MORAVEC F. 1987. Revision of capillariid nematodes (subfamily Capillarinae) parasitic in fishes. Studie Československá Akademie Věd 3, Academia, Praha; 141 pp.

MOSER M. and COWEN R.K. 1991. The effects of periodic eutrophication on parasitism and stock identification of *Trematomus bernacchii* (Pisces: Nototheniidae) in McMurdo Sound, Antarctica. Journal of Parasitology 77: 551–556.

MOZGOVOY A.A. 1953. Ascaridata of animals and man, and the diseases caused by them. *Osnovy nematodologii*. II. Izdatielstvo AN SSSR, Moskva; 616 pp (in Russian).

NASCETTI G., CIANCHI R., MATTIUCCI S., D'AMELIO S., ORECCHIA P., PAGGI L., BRATTEY J., BERLAND B., SMITH J.W. and BULLINI L. 1993. Three sibling species within *Contracaecum osculatum* (Nematoda, Ascaridida) from Atlantic Arctic-Boreal region: reproductive isolation and host preferences. International Journal for Parasitology 23: 105–120.

NIKOLSKIJ O.L. 1974. *Contracaecum mirounga* sp. n. (Nematoda: Anisakidae), a new nematode of the elephant seal from the Antarctic. Izvestija Tikhookeanskogo Nauchno-Issledovatelskogo Instituta Rybnogo Khozjajstva i Okeanografii 83: 107–109 (in Russian).

ORECCHIA P., PAGGI L., NASCETTI G., BULLINI L. and MATIUCCI S. 1983. Genetic differentiation between *Anisakis simplex* A, *A. simplex* B and *A. physeteris* (Ascaridida: Anisakidae). Parassitologia 25: 311–312.

ORECCHIA P., MATTIUCCI S., D'AMELIO S., PAGGI L., PLÖTZ J., CIANCHI R., NASCETTI G., ARDUINO P. and BULLINI L. 1994. Two new members in the *Contracaecum osculatum* complex (Nematoda, Ascaridoidea) from the Antarctic. International Journal for Parasitology 24: 367–377.

PALM H.W. 1999. Ecology of *Pseudoterranova decipiens* (Krabbe, 1878) (Nematoda: Anisakidae) from Antarctic waters. Parasitology Research 85: 638–646.

PALM H.W., ANDERSEN K. and Klöser H. 1994. Occurrence of *Pseudoterranova decipiens* (Nematoda) in fish from the southeastern Weddell Sea (Antarctic). Polar Biology 14: 539–544.

PALM H.W., REIMANN N., SPINDLER M. and PLÖTZ J. 1998. The role of the rock cod *Notothenia coriiceps* Richardson, 1844 in the life-cycle of Antarctic parasites. Polar Biology 19: 399–406.

PARUKHIN A.M. 1986. Peculiarities of commercial nototheniid fish helminth fauna in subantarctic sector of Indian Ocean. Vestnik Zoologii 3: 6–9 (in Russian).

PARUKHIN A.M. 1989. *Parasitic worms of bottom fishes of southern seas*. Naukova Dumka, Kiev; 145 pp (in Russian).

PARUKHIN A.M. and LYADOV V.N. 1981. Parasitofauna of Notothenioidei from waters of the Atlantic and Indian Oceans. Vestnik Zoologii 3: 90–94 (in Russian).

PARUKHIN A.M. and LYADOV V.N. 1982. Helminth fauna of food Nototheniidae fishes from Kerguelen region. Ekologiya Morya 10: 49–56 (in Russian).

PARUKHIN A.M. and SYSA V.N. 1975. The question of infection of fish of the suborder Notothenioidei of subantarctic waters. Trudy Nauchnoj Konferencii Parazitologov USSR 2, Naukova Dumka, Kiev; 97–99 (in Russian).

PARUKHIN A.M. and ZAITSEV A.K. 1984. The infection by helminths of different age *Notothenia squamifrons* in the subantarctic part of the Indian Ocean. Nauchnye Doklady Vysshej Shkoly, Biologicheskije Nauki 10: 34–37 (in Russian).

RAILLIET M.A. and HENRY A. 1907. Némathelminthes parasites. Expédition Antarctique Française (Charcot), 1907: 1–16.

REIMER L.V. 1987. Helminthen von Fischen der Antarktis. Fischerei-Forschung, Rostock 25: 36–40.

ROCKA A. 1999. Biometrical variability and occurrence of *Ascarophis nototheniae* (Nematoda, Cystidicolidae), a parasitic nematode of Antarctic and subantarctic fishes. Acta Parasitologica 44: 188–192.

ROCKA A. 2002. Nematodes of fishes of the Weddell Sea (Antarctic). Acta Parasitologica 47: 294–299.

RODJUK G.N. 1985. Parasitic fauna of the fishes of the Atlantic part of the Antarctic (South Georgia Island and South Shetland Isles). *In*: W.J. Hargis Jr. (ed.), *Parasitology and pathology of marine organisms of the World Ocean. NOAA Technical Reports NMFS* 25; 31–32.

SHANDIKOV G.A. and PARUKHIN A.M. 1987. Population structure of nototheniops, *Nototheniops tchizh*, of the Ob' and Lena Banks (the Indian-Ocean Center of the Antarctic Ocean). Voprosy Ikhtiologii 27: 558–568 (in Russian).

SZIDAT L. and GRAEFE G. 1967. Estudios sobre la fauna de parásitos de peces antárticos. II. Los parásitos de *Parachaenichthys charcoti*. Servicio de Hidrografia Naval, Secretaria de Marina, Republica Argentina, Publico H, 911; 27 pp.

WALTER T., PALM H.W., PIEPIORKA S. and RÜCKERT S. 2002. Parasites of the Antarctic rattail *Macrourus whitsoni* (Regan, 1913) (Macrouridae, Gadiformes). Polar Biology 25: 633–640.

ZDZITOWIECKI K. 1978. Wstępne badania nad pasożytami ryb okolic Południowych Szetlandów i Południowej Georgii. Kosmos 6: 651–659.

ZDZITOWIECKI K. 1996. Acanthocephala in fish in the Weddell Sea (Antarctic). Acta Parasitologica 41: 199–203.

ZDZITOWIECKI K. 2001a. Occurrence of endoparasitic worms in a fish, *Parachaenichthys charcoti* (Bathydraconidae), off the South Shetland Islands (Antarctica). Acta Parasitologica 46: 18–23.

ZDZITOWIECKI K. 2001b. New data on the occurrence of fish endoparasitic worms off Adelie Land, Antarctica. Polish Polar Research 22: 159–165.

ZDZITOWIECKI K. and CIELECKA D. 1996. Morphology and occurrence of *Dichelyne* (*Cucullanellus*) *fraseri* (Baylis, 1929), a parasitic nematode of Antarctic and sub-Antarctic fishes. Acta Parasitologica 41: 30–37.

ZDZITOWIECKI K. and ZADRÓŻNY T. 1999. Endoparasitic worms of *Harpagifer antarcticus* Nybelin, 1947 off the South Shetland Islands (Antarctic). Acta Parasitologica 44: 125–130.

ZDZITOWIECKI K., ROCKA A., PISANO E. and OZOUF-COSTAZ C. 1998. A list of fish parasitic worms collected off Adelie Land (Antarctic). Acta Parasitologica 43: 71–74.

ZHU X.Q., D'AMELIO S., PALM H.W., PAGGI L., GEORGE-NASCIMENTO M. and GASSER R.B. 2002. SSCP-based identification of members within the *Pseudoterranova decipiens* complex (Nematoda: Ascaridoidea: Anisakidae) using genetic markers in the internal transcribed spacers of ribosomal DNA. Parasitology 124: 615–623.

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