CHAPTER 13

Endoparasites of the Cape fur seal *Arctocephalus pusillus pusillus* from the Eastern Cape coast of South Africa

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ABSTRACT

A total of 53 Cape fur seals, *Arctocephalus pusillus pusillus*, collected along the Eastern Cape coast of South Africa between Plettenberg Bay (34˚ 03'S, 23˚ 24'E) and East London (33˚ 03'S, 27˚ 54'E) from 1992 to 1995, was examined for blubber and stomach parasites. Forty three of these seals (81%) harboured stomach parasites, and 13 (25%) harboured blubber parasites. Nine parasite taxa were identified. Helminth species included adult cestodes *Diphyllobothrium* sp., larval cestodes, *Hepatoxylon trichiuri* and *Phyllobothrium delphini*; nematodes, *Anisakis physeteris*, *Anisakis simplex*, *Contracaecum ogmorhini*, *Contracaecum* sp. and *Hysterothylacium* sp. and an acanthocephalan, *Corynosoma* sp. Three of these taxa, *Hepatoxylon trichiuri, Anisakis physeteris*, and *Hysterothylacium* sp., were accidental parasites. Scanning electron microscope examination confirmed the identity of *Contracaecum ogmorhini* and suggests that earlier studies may have incorrectly identified this nematode as *Contracaecum osculatum*. The prevalence and diversity of endoparasitism was higher in older seals. Intensity of infection was generally higher in stranded animals than in healthy animals incidentally captured in trawl nets. The endoparasites found in the present study did not appear to contribute to the mortality of Cape fur seals, at least in the population from which the examined specimens were taken. Although the anisakine nematodes, *Contracaecum* sp. and *Anisakis* sp., are potentially pathogenic, severe pathological changes were limited to small gastric lesions in the stomachs of three individuals.

INTRODUCTION

Ecologists have recently acknowledged the importance of parasites in the dynamics of populations (McCallum & Dobson, 1995). Some pinniped parasites, particularly certain Nematoda, may act as significant pathogens and cause mortality, or render their host more susceptible to other infectious diseases and environmental stresses (Siniff, 1981; Bray, 1986). For example, unusually high burdens of lungworm, *Filaroides decorus*, are responsible for considerable mortality among young Californian sea lions, *Zalophus californianus* (Sweeney & Gilmartin, 1974; Geraci & St. Aubin, 1986). Hookworms, *Uncinaria lucasi*, can cause haemorrhagic enteritis and anaemia, and have been recorded as a major cause of death in northern fur seal pups, *Callorhinus ursinus* (Olsen, 1958; Geraci & St. Aubin, 1986). Anisakine nematodes, *Contracaecum* sp. and *Anisakis* sp., are frequently associated with gross lesions in the gastrointestinal tract and are assumed to be important in the mortality of the northern fur seal (Keyes, 1965) and the Hawaiian monk seal, *Monachus schauinsladi* (Whittow *et al*., 1979). A high degree of pathogenicity of the anisakine nematode, *Pseudo-terranova decipiens*, has been demonstrated experimentally in captive harbour seals, *Phoca vitulina* (McClelland, 1976, 1980*a*). Although the deleterious effects of some pinniped parasites are known, the information is fragmentary (Geraci & St. Aubin, 1986). Because of difficulties involved in conducting longitudinal studies on wild pinniped populations, most parasitic studies have been based on chance findings rather than systematic survey work. Animals may return to sea for considerable periods; weak seals may leave the herd and become more vulnerable to predation; strandings often occur in remote places and fresh carcasses are soon scavenged.

The Cape fur seal, *Arctocephalus pusillus pusillus,* is the only indigenous breeding pinniped in southern Africa. It breeds at 25 colonies from Black Rocks (lat. 33° 50’S, long. 26° 15’E) on the south-east coast of South Africa, to Cape Cross (lat. 21° 46’S, long. 13° 57’E), Namibia. Current population size is estimated to be 1.5 to 2 million (Butterworth & Wickens, 1990). On the south-east coast, where two breeding colonies occur (Seal Island, Mossel Bay; Black Rocks, Algoa Bay), population levels are declining (SFRI, unpubl. data; Stewardson, unpubl. data), underlying the immediate need to document the biology of these top predators and evaluate potential threats.

The Cape fur seal is host to a wide variety of endoparasites: the cestodes *Diphyllobothrium atlanticum*, *Phyllobothrium delphini*, *Anophryocephalus anophrys*, and *Taenia solium*; the nematodes, *Contracaecum* spp. (*ogmorhini* and/or *osculatum*), *Anisakis simplex;* two acanthocephalans, *Corynosoma villosum* and *C. australe* (Rand, 1956, 1959; King, 1964, 1983; Delyamure & Parukhin, 1968; Dailey & Brownell, 1972; Dailey, 1975; Testa & Dailey, 1977; Arundel, 1978; De Graaf *et al*., 1980; Medonca, 1984; Warneke & Shaughnessy, 1985; Pansegrouw, 1990). However, there are few published records of parasite burdens or pathogenicity in this species. Records are largely incomplete, with dispersing juvenile casualties being reported most frequently in the literature.

The present paper documents endoparasites recovered from the blubber and stomach of Eastern Cape fur seals. Parasite taxa are separated into obligate and accidental (aberrant) parasites. The relationship between prevalence of infection and host age is examined; differences between the intensity of infection in animals stranded or caught incidentally as by-catch are investigated; potential transmission pathways of larvae are reviewed, and evidence of pathological manifestations assessed.

MATERIALS AND METHODS

Four females and 49 male Cape fur seals were collected along the Eastern Cape coast of South Africa between Plettenberg Bay (34˚ 03’S, 23˚ 24’E) and East London (33˚ 03’S, 27˚ 54’E), from July 1992 to August 1995 (Fig. 13.1). Fresh carcasses of animals drowned in nets were removed from commercial trawl vessels, and 20 stranded animals were collected from local beaches. Routine necropsies were performed and biological parameters recorded based on recommendations of the Committee on Marine Mammals, American Society of Mammalogists (1967). Each seal was incised ventrally, from the throat to the anus. The subcutaneous blubber layer was systematically dissected. Parallel incisions were made over the entire adipose layer, exposing the underlying muscle. Adipose tissue was manipulated to expose nodules containing encysted cestodes. The seals were dissected further and the stomach opened. Parasites were removed from partially digested food items and from the gastric mucosa. Unattached specimens were collected in a 500 µm mesh sieve. Blubber and stomach parasites were stored in 70% alcohol for subsequent identification.

Cestodes were stained in Mayer’s paracarmine, dehydrated in alcohol and mounted in Canada balsam. Acanthocephalans and nematodes were examined as temporary mounts in Beechwood creosote and lactophenol, respectively. Additional specimens of *Contracaecum* preserved in 4% phosphate buffered formalin solution were rinsed in distilled water and then transferred to 70% alcohol for approximately 5 days. Samples were hydrated in an alcohol series and placed in distilled water where they were cleaned with a fine brush and sonicated. The specimens were then dehydrated in an ethanol series and subject to critical point drying. Anterior and posterior ends of individual nematodes were mounted on stubs with silver dag, sputter-coated with approximately 40 *nm* of gold and viewed using a Hitachi, S-2500 scanning electron microscope.

Endoparasites were identified at the Parasitic Worms Division, The Natural History Museum, London, and the Division of Helminthology, Onderstepoort Veterinary Institute, Pretoria. Nematodes

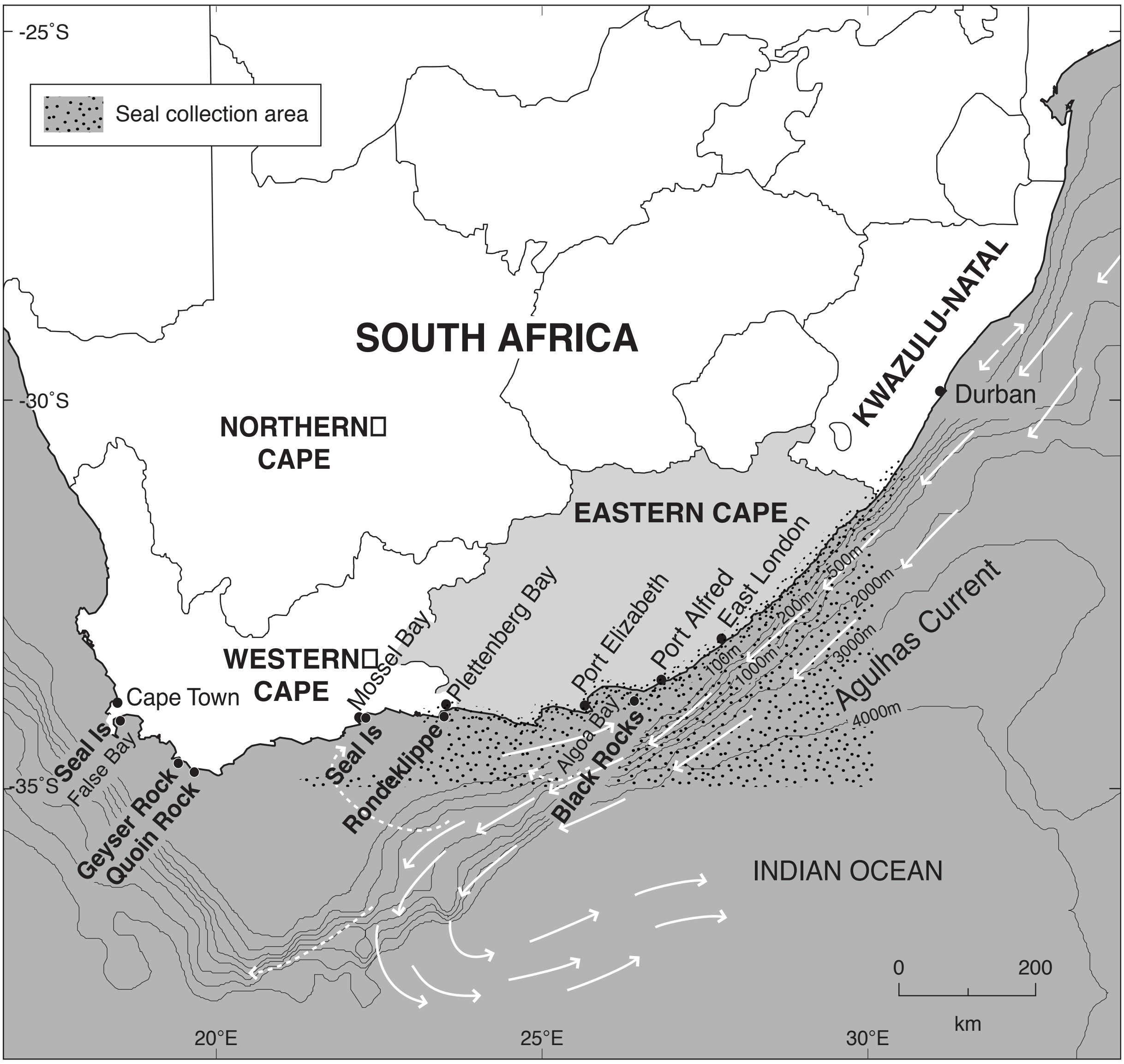

Fig. 13.1 The breeding range of Cape fur seals, *Arctocephalus pusillus pusillus*, along the south coast of southern Africa. Seals (n = 53) were collected from the Eastern Cape coast.

were classified as third- or fourth-stage larvae (L_3 or L_4), adult male or adult female. Total counts (n = 29 seals) were compiled for *Anisakis simplex, Contracaecum ogmorhini,* and *Phyllobothrium delphini*. Specimens were deposited in the Port Elizabeth Museum (PEM), and the Division of Helminthology, Onderstepoort Veterinary Institute, South Africa. Voucher specimens are listed in Appendix 13.1.

Seals were aged from counts of incremental lines observed in the dentine of tooth sections. Upper canines were sectioned longitudinally using a circular diamond saw. Sections were ground down to 280–320 µm, dehydrated, embedded in resin and viewed under a stereomicroscope in polarised light. Interpretation of incremental lines followed Oosthuizen (1997), assuming a birth date of 1 December (Shaughnessy & Best, unpubl. report).

For parasite ecological terminology, the recommendations of Margolis *et al.*, (1982) were used.

RESULTS

Of the 53 Cape fur seals examined, 43 (81%) harboured stomach parasites and 13 (25%) harboured blubber parasites (Table 13.1). Although identification could not always be made to species level, a total of nine taxa was identified. Helminth species included the cestodes *Diphyllobothrium* sp., *Hepatoxylon trichiuri* and *Phyllobothrium delphini*; the nematodes *Anisakis physeteris*, *Anisakis simplex*, *Contracaecum ogmorhini*, *Contracaecum* sp. and *Hysterothylacium* sp.; and an acanthocephalan, *Corynosoma* sp. The most prevalent species recovered from Cape fur seals were the nematodes, *Contracaecum ogmorhini* (58%) and *Anisakis simplex* (51%), and the larval cestode *Phyllobothrium delphini* (25%) (Table 13. 1).

Table 13.1 ***Endoparasites recovered from the blubber and stomach of Cape fur seals, Arctocephalus pusillus pusillus - prevalence and diversity of infection***

Parasite species	Locality in host	Prevalence[a]	Intensity[b] $\overline{X}$ (range)
Platyhelminthes: Cestoda			
Adult *Diphyllobothrium* sp.	Stomach	1 (2%)	–
Larval *Hepatoxylon trichiuri*	Stomach	4 (8%)	–
Larval *Phyllobothrium delphini*	Blubber	13 (25%)	26 (2–211; *n* = 12)
Aschelminthes: Nematoda			
Anisakis simplex	Stomach	27 (51%)	71 (1–271; *n* = 12)
Anisakis physeteris	Stomach	10 (19%)	–
Contracaecum ogmorhini	Stomach	31 (58%)	17 (2–95; *n* = 20)
Contracaecum sp.	Stomach	1 (2%)	–
Hysterothylacium sp.	Stomach	1 (2%)	–
Acanthocephala:			
Corynosoma sp.	Stomach	1 (2%)	–
Total no. of seals examined: 53[c]			
No. with worms in blubber 13 (25%)			
No. with worms in stomach 43 (81%)			

[a] Prevalence of infection: the percentage of individual seals infected with a particular parasite species divided by the number of seals examined.
[b] Intensity of infection: the number of individuals of a particular parasite species found in each infected seal. Mean values, range and the number of seals on which total worm counts were conducted.
[c] Seal (PEM2379) was not examined for blubber parasites, i.e., 52 examined for blubber parasites.

Cestoda

Three adult worms, *Diphyllobothrium* sp., were recovered from the stomach of a healthy eight-year-old bull. Worms had presumably migrated from the small intestine postmortem (R. Bray, pers. comm.). These specimens are thought to be *D. atlanticum* (see Schmidt, 1986), a species recovered from *A. p. pusillus* previously (Delyamure & Parukhin, 1968; Warneke & Shaughnessy, 1985; Pansegrouw, 1990). Worms were free in the lumen of the stomach.

Plerocercoids of the trypanorhynchan cestode, *Hepatoxylon trichiuri,* were recovered from the stomachs of four adult bulls. The plerocercoids were free in the lumen of the stomach.

The larval tetraphyllideans, *Phyllobothrium delphini,* were found in 13 (25%) of the seals examined. Intensity of infection ranged from two to 211. Plerocercoids were embedded in the subcutaneous blubber (Fig. 13.2), in the caudal ventral abdomen of the host, predominantly around the genitalia.

Nematoda

Anisakis simplex was found in the stomachs of 27 (51%) Cape fur seals. Intensity of infection ranged from one to 271. With the exception of 17 adult worms recovered from a very thin stranded two-year-old cow, and a single specimen from a stranded three-year-old male, all specimens were third- and fourth-stage larvae. Adult worms were predominantly females. Worms were either attached to the stomach mucosa or free in the lumen of the stomach.

Third stage larvae, morphologically similar to *Anisakis physeteris,* were recovered from the stomachs of 10 seals. Larvae were free in the lumen of the stomach.

Contracaecum ogmorhini (Fig. 13.3) was recovered from the stomachs of 31 (58%) Cape fur seals. Intensity of infection ranged from two to 95. Both adults and fourth-stage larvae were found. Adult worms were predominantly females. Unidentified third-stage larvae (*Contracaecum* sp.) were recovered from the stomach of

Table 13. 2 ***Endoparasites recovered from the Cape fur seal, Arctocephalus pusillus pusillus - prevalence of infection and host age***

Age group (years)	No. of seals examined	Total prevalence[a]	No. of parasite taxa $\bar{X}$ (range)
1–2	6	2 (33%)	range 0–1
3–4	6	4 (67%)	1 (0–2)
5–6	7	7 (100%)	3 (2–4)
7–8	24	24 (100%)	2 (1–5)
9–10	6[b]	6 (100%)	2 (1–3)
≥ 11	3	3 (100%)	2 (1–2)
Total	**52**		**9**

[a] Total prevalence of infection: the percentage of individual seals infected with parasites divided by the number of seals examined.
[b] Seal (PEM2379) aged 10 years was excluded from analysis, i.e., blubber parasites not examined.

a seven-year-old cow. Worms were either attached to the stomach mucosa or free in the lumen of the stomach.

Hysterothylacium sp. (one adult female worm) was recovered from the lumen of the stomach of a six-year-old cow.

Acanthocephala

One cystacanth of *Corynosoma* sp. in poor condition, was recovered from the lumen of the stomach of an old bull. Acanthocephalans are generally found in the stomach or small intestine of otariids (Smales, 1986), and also in piscivorous birds. Accidental ingestion seems unlikely (D. Gibson, pers. comm.).

Fig. 13.2 Larval tetraphyllideans, *Phyllobothrium delphini,* embedded in the subcutaneous blubber of a Cape fur seal, *Arctocephalus pusillus pusillus.*

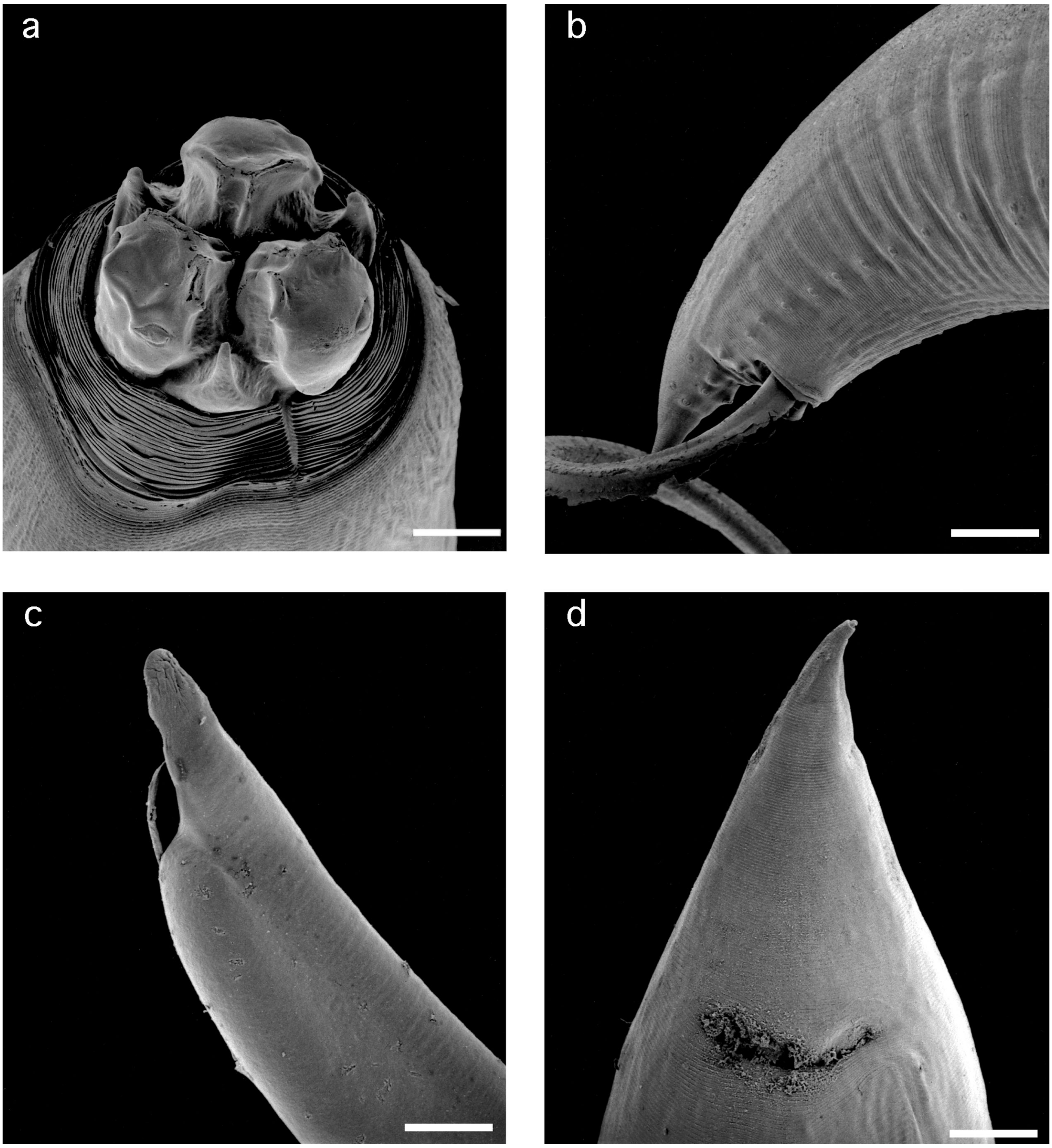

Fig. 13.3 SEM micrographs of *Contracaecum ogmorhini* from the stomach of a Cape fur seal, *Arctocephalus pusillus pusillus*.
(a) Anteroventral view of the head of a male worm. Scale bar: 100µm.
(b) Posterior portion of male worm showing conical tail with protruding spicules. Scale bar: 120µm.
(c) Distal end of spicule. Scale bar: 30µm.
(d) Ventral view of female tail. Scale bar: 150µm.

Prevalence of infection and host age

The total prevalence of infection increased with increasing age of the seals (Table 13.2). Parasites were recovered from 33% of seals in the 1–2 year old age group and 67% in the 3–4 year old age group. All seals ≥ five years of age harboured endoparasites. Younger seals harboured fewer species of parasites (0–1), whereas older seals (≥ five years of age) harboured up to five parasite species (Table 13.2).

Intensity of infection and host age

The relationship between host age and intensity of infection for *Phyllobothrium delphini* and *Anisakis simplex* could not be established as sample size per age group was too small. However, preliminary worm counts suggested that the degree of infection of *Contracaecum ogmorhini* was slightly higher in older animals. Up to 95 nematodes (*Contracaecum ogmorhini)* were found in the stomachs of older seals (mean 12; range 0–95), whereas seals ≤ four years carried less than 30 nematodes (mean eight; range 0–29).

Table 13.3 ***Endoparasites recovered from the Cape fur seal, Arctocephalus pusillus pusillus - comparison between fishery by-catch and stranded seals.*** **All seals are > 5 years of age**

Parasite species	Stranded sub sample Intensity[a] $\bar{X}$ (range)	By-catch sub sample Intensity[a] $\bar{X}$ (range)
Phyllobothrium delphini	42 (0–211, *n* = 12)	8 (0–27, *n* = 18)
Anisakis simplex	271[b]	53 (0–235, *n* = 18)
Contracaecum ogmorhini	19 (0–95, *n* = 12)	15 (0–34, *n* = 18)

[a] Intensity of infection: the number of individuals of a particular parasite species found in each infected seal. Mean values, range and the number of seals on which total worm counts were conducted.

[b] Although *A. simplex* was recovered from two stranded seals (Appendix 13.1), one animal was less than five years of age.

Stranded and fishery by-catch sub samples

Parasite counts were conducted on 18 seals recovered from commercial trawl nets, and 12 seals collected from local beaches. Seals less than five years of age were excluded from analysis. All trawled specimens were in good body condition, i.e., healthy animals netted on feeding grounds. Stranded specimens were generally in poor body condition and/or injured, i.e., fresh carcasses collected from local beaches (Appendix 13.1). Results are presented in Table 13.3. Although some healthy seals carried high numbers of parasites (e.g., 235 *Anisakis simplex* in an eight-year-old male), intensity of infection was generally lower than in stranded animals.

DISCUSSION

Accidental parasites

Nine parasite taxa were recovered from the Cape fur seals, of which *Hepatoxylon trichiuri, Anisakis physeteris* and *Hysterothylacium* sp. were accidental parasites.

Hepatoxylon trichiuri

Plerocercoids of *Hepatoxylon trichiuri* were recovered from the stomachs of four adult bulls. The bulls had been feeding on *Trachurus trachurus*, *Lepidopus caudatus* and *Merluccius* sp. In southern African waters, *H. trichiuri* has been recorded in Cape hakes, *Merluccius capensis* and *M. paradoxus* (Botha, 1986), and kingklip, *Genypterus capensis* (Payne, 1986). Although the entire life history of this cestode has yet to be elucidated, *H. trichiuri* is presumably transferred up the food chain through copepod crustaceans to teleosts (intermediate hosts) (Botha, 1986). Adult worms have been found in *Lamna nasus* (Dollfus, 1942), *Isurus oxyrinchus* (Dollfus, 1942; Beveridge & Campbell, 1996) and *Carcharodon carcharias* (Beveridge & Campbell, 1996).

Anisakis physeteris

Third stage larvae, morphologically similar to *Anisakis physeteris,* were recovered from the stomachs of 10 seals. *Anisakis physeteris,* a cetacean parasite (Davey, 1971), has not been recorded in *Arctocephalus* previously. This suggests that Cape fur seals often ingest infected fish and/or squid species also eaten by east coast cetaceans, e.g., *Kogia breviceps* and *K. simus* (Ross, 1984).

Hysterothylacium sp.

One adult female worm, *Hysterothylacium* sp.*,* was recovered from the stomach of a six-year-old cow. In the adult stages, *Hysterothylacium* is normally found in the gut of marine fish (Anderson, 1992); therefore, infection was accidental. Although the undigested remains of *Merluccius* spp. were found in the stomach of the seal, according to Botha (1986), *Hysterothylacium* is not a known parasite of Cape hakes. No other dietary remains were found.

Life cycles and pathogenicity of obligate endoparasites

Diphyllobothrium spp.

Adult *Diphyllobothrium* spp. are found in fish-eating birds and mammals (Bray *et al.*, 1994). *Diphyll-obothrium atlanticum* is the only valid record of a pseudophyllidean cestode for *A. p. pusillus,* and is usually found in the posterior 50 cm of the small intestine, and the entire length of the large intestine; the primary site of infection appears to be the middle and anterior third of the large intestine (Pansegrouw, 1990). In Cape fur seals from Namibia, the prevalence of *D. atlanticum* is 65% (84 seals examined), with no significant differences in the prevalence between male and female hosts (Pansegrouw, 1990).

In marine mammals, infection presumably occurs through the ingestion of the secondary intermediate host, an infested teleost. However, the only known life cycles are those of *Diphyllobothrium latum, D. dendriticum and D. sebago* (e.g., Vik, 1964; Weber, 1991).

Diphyllobothrium species have been implicated in human infection in countries where fish is consumed raw, slightly cooked or salted; when ingested by humans, larvae may invade the gastrointestinal tract and cause disease (Geraci & St. Aubin, 1986; Oshima & Kliks, 1986). Although the pathological significance of *Diphyllobothrium* infections in pinnipeds has not been established clearly, infection with mature worms is usually innocuous (e.g., Rees, 1967; Arundel, 1978). In severe cases, parasites can encyst in the colonic wall, obstruct the lumen of the gut and/or may prevent weight gain (Sweeney, 1973; Clausen, 1978; Arundel, 1978; Cordes & O'Hara, 1979; Geraci & St Aubin, 1986).

Phyllobothrium delphini

Larval *Phyllobothrium delphini* has been recorded from a range of cetacean and pinniped hosts (Testa & Dailey, 1977; Schmidt, 1986), including *Arctocephalus pusillus doriferus* (see Arundel, 1978; Warneke & Shaughnessy, 1985), *Arctocephalus tropicalis* (see King, 1964; Bester, 1989; Stewardson, unpubl. data) and *A. p. pusillus* (Pansegrouw, 1990; present study). The plerocercoids observed in the present study were concentrated in the abdominal blubber. The same pattern of distribution was observed in Cape fur seals from Namibia (Pansegrouw, 1990). In Namibia, the prevalence of pleroceroids in Cape fur seals is 75% (90 seals examined) with no significant differences in the prevalence between male and female hosts (Pansegrouw, 1990). This is much higher than the overall prevalence for Eastern Cape seals (25%), possibly reflecting differences in the age and/or diet of individual hosts.

How marine mammals become infected with *Phyllobothrium delphini* is still a matter of conjecture; however infection may occur through the procercoid taken with a teleost or squid that had recently fed on an infected crustacean (Testa & Dailey, 1977). *Phyllobothrium delphini* presumably complete their life cycle in white sharks *Carcharodon carcharias*, and mackerel sharks *Isurus oxyrhynchus* (Arundel, 1978). Along the south-east coast of southern Africa, white sharks frequently prey on Cape fur seals; attacks are usually from behind, thus the seal is initially bitten on the lower body (Stewardson, unpubl. data). Concentration of larvae within the vulnerable abdominal tissues may reflect migration from the gut and provide some advantages in transmission to sharks (Geraci & St. Aubin, 1986).

Infection is a focal chronic inflammation with an acute suppurative component surrounding encysted larvae (R. Norman, pers. comm.), which may have some metabolic cost to the animal, e.g., in females, heavy infection of the abdominal blubber, near the mammary glands, may possibly retard lactation and affect pup growth (Pansegrouw, 1990). Although some seals carried large numbers of larvae, animals were generally in good body condition and did not appear to be adversely affected by the infection.

Anisakis simplex

Anisakis simplex is a cosmopolitan species found in all sub-families of pinnipeds (Arundel, 1978); it is a known parasite of *Arctocephalus pusillus doriferus* (see Arundel, 1978; Warneke & Shaughnessy, 1985), *A. tropicalis* (see Shaughnessy & Ross, 1980; Bester, 1989; Stewardson, unpubl. data), *A. australis* (see Davey, 1971) and *A. p. pusillus* (Pansegrouw, 1990; present study). In Namibia, the prevalence of *Anisakis simplex* in Cape fur seals was 91% (11 seals examined), with a higher prevalence of nematode infection in males than in females (Pansegrouw, 1990). This is much higher than the overall prevalence for Eastern Cape seals (51%).

The role of pinnipeds in transmitting *Anisakis simplex* to commercially valuable fish in Europe and Japan, is of considerable economic and medical importance (Smith & Wootten, 1978; Desowitz, 1986; Geraci & St. Aubin, 1986; Malouf, 1986; Oshima & Kliks, 1986; Huang & Bussieras, 1988). Infected commercial fish and squid may cause anisakiasi in humans if eaten raw, slightly cooked or salted. Unlike *Diphyllobothrium* sp., the larval form can persist temporarily in the human gastrointestinal tract (Oshima & Kliks, 1986).

In marine mammals, anisakids may cause inflammation and/or ulceration of the stomach, gastritis, enteritis, diarrhoea, dehydration and anaemia (Wallach, 1972; Cattan *et al*., 1976; Stroud & Roffe, 1979; McClelland, 1980*a*; Geraci & St. Aubin, 1986; Bester, 1989; Smith, 1989; Pansegrouw, 1990; Brattey & Ni, 1992). Chronic infection may lead to perforation of the alimentary tract, peritonitis and death (Young & Lowe, 1969; Geraci & St. Aubin, 1986). In the present study, small gastric lesions, associated with larval *A. simplex* and *Contracaecum ogmorhini*, were observed in three adult animals. These animals were otherwise in good condition (incidental by catch). Nodules resembling small ulcers associated with *Contracaecum* sp. have been reported in Cape fur seals from Sinclair Island, and appear to be common in older males (Rand, 1959).

Eggs of *Anisakis simplex*, passed in the faeces of marine mammals, develop into free-swimming sheathed second-stage larvae (Smith & Wootten, 1978). Larvae are ingested by the first intermediate host (copepods, euphausiids and decapods) and develop into third-stage larvae (Polyanskii, 1961; Van Thiel, 1966; Smith, 1971; Beverley-Burton & Pippy, 1978) which are eaten by the second intermediate host (teleost fish or squid) (Clarke, 1966; Anderson, 1992). Transmission of infective larvae to pinnipeds and cetacea (definitive hosts) occurs through the consumption of infected fish, crustaceans or squid (Anderson, 1992). In marine mammals, infective larvae and adult worms are normally found free in the stomach or attached to the gastric mucosa (Geraci & St. Aubin, 1986).

Dominant prey species of the Cape fur seal (David, 1987; Stewardson, unpubl. data), Cape hake and anchovy (*Engraulis capensis*), are known to carry *Anisakis* larvae (Hennig, 1974; Botha, 1986). Cape hake feed extensively on euphausiids when young and have a piscivorous and cannibalistic diet as adults (Botha, 1980). As the prevalence of larval infection in Cape hakes is high, we suggest that this teleost is a likely source of infection in the seals examined. Cape fur seals do not appear to contribute significantly in the transmission of *A. simplex* to commercially valuable fish off the Eastern Cape coast (e.g., only two debilitated seals harboured adult worms). Cetacea are presumably the most common host to species of *Anisakis* (Young, 1972; Smith & Wootten, 1978).

Contracaecum ogmorhini

Contracaecum 'osculatum' has been reported in *Arctocephalus p. pusillus* (Rand, 1956, 1959; Dailey & Brownell, 1972; Warneke & Shaughnessy, 1985), *A. p. doriferus* (Delyamure, 1968; Dailey & Brownell, 1972; Arundel, 1978; Warneke & Shaughnessy, 1985), *A. tropicalis* (Dailey & Brownell, 1972; Shaughnessy & Ross, 1980; Bester, 1989), *A. forsteri* (Arundel, 1978) and *A. australis* (Delyamure, 1968; Dailey & Brownell, 1972). In Namibia, the prevalence of *Contracaecum* spp. in Cape fur seals is 100% (11 seals examined), with a higher prevalence of nematode infection in males than in females (Pansegrouw, 1990). This is much higher than the overall prevalence for Eastern Cape seals (58%).

Until recently, *Contracaecum osculatum* was thought to have a worldwide distribution. However, studies by Fagerholm & Gibson (1987) found that *C. osculatum* is essentially a parasite of phocids, and *C. ogmorhini* is essentially a parasite of otariids, specifically *Zalophus californianus, Eumetopias jubatus* and *A. tropicalis.* Therefore, there is considerable doubt associated with the above records (Fagerholm & Gibson, 1987). In the present study, it was possible to distinguish *C. ogmorhini* by examining the distribution of pre- and post-cloacal papillae in the male using SEM, according to Fagerholm & Gibson's criteria (1987). Unlike *C. osculatum,* male *C. ogmorhini* have two rows of 23–49 subventral precloacal papillae and seven postcloacal pairs of papillae (Fagerholm & Gibson, 1987). The postcloacal pairs are arranged as follows: two large subventral pairs close to the cloaca, side by side; two subventral pairs and two sublateral pairs in the posterior half of the tail, and a single sublateral pair (Fagerholm & Gibson, 1987). SEM micrographs of *C. ogmorhini* are presented in Fig. 13.3 *Contracaecum* sp. recovered from *Arctocephalus tropicalis* stranded along the south-east coast of South Africa (1992–1994), were also identified as *C. ogmorhini* (i.e., 14 seals collected by Stewardson; parasites identified by Fourie). We therefore suggest that the above records (Rand, 1956, 1959; Delyamure, 1968; Dailey & Brownell, 1972; Arundel, 1978; Warneke & Shaughnessy, 1985; Bester, 1989) are probably *C. ogmorhini* and not *C. 'osculatum'* (but see Pansegrouw, 1990).

The life cycle of *Contracaecum ogmorhini* is not known, but is presumably similar to *C. osculatum baicalensis* (see Mozgovi & Ryzhikov, 1950) in which larvae are transferred through the sand hopper *Macrohectopus branickii* (intermediate host) and the yellow goby *Cottomephorus grewingki* (paratenic host), to the Baikal seal *Phoca sibirica* (definitive host) (Delyamure, 1968). The cycle may be completed with an optional invertebrate paratenic host and a single fish intermediate host (Anderson, 1992; Køie & Fagerholm, 1995).

Small gastric lesions, associated with *C. ogmorhini* (adults), were observed in three animals; however, gross pathological changes were minimal. *Contracaecum ogmorhini* may be responsible for abnormal tissue migration such as brain infestation in the Californian sea lion (Flores-Barroeta *et al.*, 1961) and, in extreme cases, may cause severe ulceration and death (Geraci & St. Aubin, 1986).

Corynosoma sp.

One acanthocephalan cystacanth in poor condition, *Corynosoma* sp., was recovered from the stomach of an old bull. *Corynosoma* sp. (e.g., *C. australe*, *C. villosum* and *C. strumosum*) have been previously recorded in the small intestine of *Arctocephalus* sp. (King, 1964; Delyamure & Parukhin, 1968; Arundel, 1978; Shaughnessy & Ross, 1980; Smales, 1986; Pansegrouw, 1990). This species is most likely to be *C. australe* (see Pansegrouw, 1990). In Cape fur seals from Namibia, the prevalence of *C. australe* is 93% (88 seals examined), with no significant differences in the prevalence between male and female hosts (Pansegrouw, 1990).

The development and life cycles of *Corynosoma* have been reviewed by Schmidt (1985). Fusiform eggs, passed through faeces, are ingested by crustaceans (first intermediate host), during which time the acanthella develops and transforms into a cystacanth capable of infecting the definitive host. A paratenic host (i.e., fish) is required for transmission to the definitive host. When the fish is ingested by a seal (definitive host), the cystacanth develops into the adult worm which attaches itself to the wall of the small intestine (Arundel, 1978). The semi-digested remains of *Trachurus trachurus capensis*, *Merluccius* spp., *Scomber japonicus* and *Zenopsis* sp. were recovered from the stomachs of the seals; however, the likely paratenic host could not be established.

Although acanthocephalans may cause lesions that enable other pathogens to become established (Pansegrouw, 1990), the report by Arundel (1978) of an absence of gross lesions in the intestine of *Arctocephalus p. doriferus,* infected with large numbers of *Corynosoma australe,* suggests that infection is not generally detrimental to the host.

Prevalence of infection and host age

The total prevalence of endoparasitism in Cape fur seals increased with host age, from 33% in animals one to two-years of age, up to 100% in animals ≥ five years of age. Similar findings were reported by Lick (1989) who examined the stomachs of 274 harbour seals from the German and Danish Wadden Sea; in these seals, the total prevalence of stomach nematodes increased from 28% in animals less than one-year of age, to 80% in 1–2 years olds, and to 95% in animals more than two-years old. Stomach nematodes infect young harbour seals soon after weaning (4–6 weeks of age). Older seals target highly infected fish species such as *Osmerus eperlanus*, resulting in a high infection rate. However, the rate of infection in 1–2 year-olds is lower than expected and may be attributed to different feeding behaviours (consuming non-infected versus infected fish) or the development of partial resistance (Lick, 1989).

Cape fur seal pups are weaned at 8–12 months and are unlikely to ingest infected fish/cephalopods until they are at least four months of age, when they supplement their milk diet with solids. As the young seals mature, their dietary preferences expand according to experience and opportunities offered (Rand, 1959). Older seals presumably have a greater chance of ingesting infective larvae because of age-related changes in the size or quantity of prey items consumed (Brattey & Ni, 1992). Increased capacity of the stomach among larger seals may enable several species of parasites to occupy the same habitat (Crompton & Joyner, 1980; Brattey & Ni, 1992).

Intensity of infection and host age

Up to 95 nematodes (*Contracaecum ogmorhini)* were found in the stomachs of older seals, whereas seals ≤ four years carried less than 30 nematodes. Similar findings were reported by Rand (1959) who found that adult Cape fur seals harboured as many as 100 nematodes (*Contracaecum* sp.) and yearlings usually carried between 5–10. In harbour seals from the German and Danish Wadden Sea, the intensity of stomach nematodes (*Anisakis simplex; Contracaecum* sp*; Porrocaecum decipiens*) also increased with increasing age of seals (Lick, 1989). Harbour seals less than one year of age usually carried 1–10 nematodes, whereas seals older than two years of age carried as many as 159 nematodes (Lick, 1989).

The intensity of stomach nematodes in older Cape fur seals (*Anisakis simplex* up to 271, and *Contracaecum ogmorhini* up to 95) was not unusually high compared with seals from other regions. For example, high numbers of *Contracaecum* sp. have been reported in Grey seals, *Halichoerus grypus*, from Nova Scotia (*c*. 17 000 nematodes; McClelland, 1980*a*), and in Weddell seals, *Leptonychotes weddellii,* from Antarctica (*c*. 122 000 nematodes; Klöser *et al*., 1992). In subantarctic fur seals from Gough Island, stomach nematodes, *Anisakis simplex, Contracaecum* sp. *and Phyllobothrium decipiens*, ranged between 1–505 (Bester, 1989). In Cape fur seals from Namibia, the mean number of stomach nematodes, *Anisakis simplex, Contracaecum* sp. was 54, with numbers ranging from 0–1 004 (Pansegrouw, 1990).

Stranded and fishery by-catch sub samples

Preliminary observations indicate that in animals ≥ 5 years of age the intensity of infection was generally lower in healthy seals (by-catch) than in stranded animals. Although no histopathological studies were conducted on the stranded animals, gross observations did not suggest that parasitism was a contributing cause of death. Furthermore, several healthy animals (by-catch) had higher parasite burdens than stranded animals and showed no signs of weight loss or emaciation. It is likely that injuries or illness may have prevented seals from capturing adequate food (i.e., stranded sub samples). As their body conditions deteriorated, individuals would have become more vulnerable to disease, resident parasites and predation. In an environment which places heavy demands on thermoregulation, respiration and mobility, these animals would have soon died (see Geraci & St. Aubin, 1986).

Sixty two per cent of stranded seals had food contents in their stomach; however only 15% had fresh remains (i.e., flesh attached to either cephalopod beaks or skeletal material). Therefore, values reported here must be considered as a minimum parasite burden. Other factors which may have reduced observed parasite burdens in healthy and/or stranded seals include regurgitation of undigested otoliths and cephalopod beaks (Stewardson, pers. obs); vomiting during trawl capture or stranding (Lick, 1989); fasting during the annual moult (McClelland, 1980*b*), and postmortem migration of parasites through the nostrils, mouth or rectum (Myers, 1960).

CONCLUSION

The data presented in this study provides the first published records of *Anisakis simplex* and *Contracaecum ogmorhini* for Cape fur seals, and supplement earlier studies, providing additional records of known obligate parasites, *Diphyllobothrium* sp., *Phyllobothrium delphini, Contracaecum* sp. and *Corynosoma* sp. Accidental parasites, *Hepatoxylon trichiuri*, *Anisakis physeteris* and *Hysterothylacium* sp., have not been recorded previously. Scanning electron microscope studies confirmed the identity of *Contracaecum ogmorhini* and suggested that earlier studies may have incorrectly identified this nematode as *Contracaecum osculatum*. The majority of seals examined had stomach parasites and infection was higher among older animals. We suggest that anisakid infection is transmitted to Cape fur seals largely through Cape hakes. The potential transmission pathway of *Diphyllobothrium* sp. could not be established.

The endoparasites isolated in the present study did not appear to contribute to the mortality of Cape fur seals, at least in the population from which our specimens were taken. Although the anisakid nematodes, *Contracaecum* and *Anisakis*, are potentially pathogenic (Desowitz, 1986), no severe pathological conditions were found, other than small gastric lesions in the stomach of three individuals. It is likely that anisakid nematodes are more harmful to diseased or captive seals under stress (Brattey & Ni, 1992). Intensity of infection was generally higher in stranded seals than in healthy seals, captured in commercial trawl nets. Weak and/or injured seals are presumably more vulnerable to parasitism.

Sex and age bias (i.e., predominance of older males in the sample) prevented detailed analysis of the intensity of infection and host age; therefore, ongoing systematic surveys are required. Histopathological studies (patterns of degenerative, inflammatory, and proliferative changes of infected pinniped tissues) are also needed to link parasitism with morbidity and mortality of individuals and populations.

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Appendix 13.1 ***Endoparasites recovered from the Cape fur seal, Arctocephalus pusillus pusillus***

Accession no.[a]	Sex	Date Collected	Species isolated	By-catch	Stranded[b]
1999	M	20 July 1992	*Anisakis simplex* (Rudolphi, 1809) *Anisakis physeteris* (Baylis, 1923) *Contracaecum ogmorhini* (Johnston & Mawson, 1941) *Hepatoxylon trichiuri (*Holten, 1802) *Phyllobothrium delphini* (Bosc, 1802)	Bc	
2000	M	21 July 1992	*A. simplex* *A. physeteris* *C. ogmorhini*	Bc	
2001	M	21 July 1992	*C. ogmorhini*	Bc	
2002	M	22 July 1992	*A. simplex* *A. physeteris*	Bc	
2003	M	24 July 1992	*A. simplex* *C. ogmorhini*	Bc	
2004	M	25 July 1992	*A. simplex* *A. physeteris* *C. ogmorhini* *Corynosoma* spp.	Bc	
2005	M	11 August 1992	*A. simplex*	Bc	
2006	M	13 August 1992	*A. physeteris*	Bc	
2007*	M	14 August 1992	*C. ogmorhini* *A. simplex*	Bc	
2008	M	14 August 1992	*A. simplex* *A. physeteris* *C. ogmorhini* *Hysterothylacium* sp.	Bc	
2009	M	22 August 1992	*C. ogmorhini* *H. trichiuri*	Bc	
2010	M	22 August 1992	*A. simplex* *A. physeteris* *C. ogmorhini* *H. trichiuri*	Bc	
2011	M	8 September 1992	*A. simplex* *C. ogmorhini* *H. trichiuri*	Bc	
2012	M	9 September 1992	*A. simplex* *C. ogmorhini* *Contracaecum* sp.	Bc	
2013	M	14 September 1992	*A. simplex* *A. physeteris* *C. ogmorhini*	Bc	
2014	M	25 September 1992	*A. simplex* *A. physeteris*	Bc	
2015	F	3 November 1992	*A. simplex* *A. physeteris*	Bc	

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Accession no.[a]		**Sex**	**Date Collected**	**Species isolated**	**By-catch**	**Stranded**[b]
2035*	M		11 March 1993	*A. simplex*		St (I)
2046*	M		19 May 1993	*C. ogmorhini*	Bc	
2047*	M		20 May 1993	*A. simplex*	Bc	
				C. ogmorhini		
2048*	M		20 May 1993	*C. ogmorhini*	Bc	
				A. simplex		
2051*	M		28 June 1993	*Diphyllobothrium* sp.	Bc	
				A. simplex		
2052*	M		28 June 1993	*A. simplex*	Bc	
2053*	M		28 June 1993	*P. delphini*	Bc	
				A. simplex		
				C. ogmorhini		
2054*	M		29 June 1993	*A. simplex*	Bc	
2055*	M		29 June 1993	*A. simplex*	Bc	
2082*	M		19 July 1993	*P. delphini*	Bc	
				A. simplex		
				C. ogmorhini		
2087*	M		17 August 1993	*C. ogmorhini*		St
				P. delphini		
2134*	M		28 December 1993	*C. ogmorhini*		St (I)
2137*	M		5 January 1994	*C. ogmorhini*		St
				P. delphini		
2143*	M		21 January 1994	*P. delphini*		St (I)
				C. ogmorhini		
2186*	M		7 April 1994	*C. ogmorhini*		St (I)
2191*	M		4 May 1994	*C. ogmorhini*		St
2197*	M		12 July 1994	*C. ogmorhini*		St (I)
2203*	M		18 July 1994	*C. ogmorhini*		St (I)
				P. delphini		
2204*	F		23 July 1994	*C. ogmorhini*	Bc	
2253*	M		27 August 1994	*P. delphini*	Bc	
2254*	M		27 August 1994	*C. ogmorhini*	Bc	
				A. *simplex*		
2256*	M		17 September 1994	*P. delphini*	Bc	
				C. ogmorhini		
2257*	M		7 October 1994	*C. ogmorhini*	Bc	
				A. simplex		
2258*	M		8 October 1994	*P. delphini*	Bc	
2348*	M		14 November 1994	*C. ogmorhini*	Bc	
2350*	F		13 December 1994	*A. simplex*		St
2379*	M		12 April 1995	*C. ogmorhini*		St
2400*	M		13 July 1995	*P. delphini*	Bc	
				A. simplex		
2406*	M		25 July 1995	*P. delphini*		St (I)
2411*	M		24 August 1995	*P. delphini*		St

[a] Accession no., Port Elizabeth Museum (PEM) specimen accession number.
[b] St, stranded seals; St (I), stranded seals with injury, e.g., gun shot wounds, shark bites etc.
* Specimens deposited with the Division of Helminthology, Onderstepoort Veterinary Institute.