NOTES ON PARASITE INFESTATION OF INSHORE FISH AT SIGNY ISLAND, SOUTH ORKNEY ISLANDS

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ABSTRACT. Aspects of parasite infestation of the common inshore fish *Notothenia neglecta* and *Notothenia gibberifrons* were investigated. Infestation of acanthocephalan cystacanths in both species was proportional to the weight of the fish. Endoparasite infestation had a small deleterious effect on *N. neglecta*. A condition factor linked to gonad-free body weight varied inversely with size of fish and there was a positive correlation between the condition factor and the level of infestation by endoparasites in the sample of 117 *N. neglecta*.

The reasons for these findings are discussed and the role of inshore fish in the life cycles of the various endoparasites is considered.

ENDOPARASITES of Antarctic vertebrates have been the subject of much descriptive work since the early days of biological research in the Antarctic (Benham, 1909; Leiper and Atkinson, 1914; Harding, 1922; and others). In general, this work has derived from adventitious collections taken incidentally to main research topics. For many of the early collections, relationships with the host species have been inadequately described (Moore, 1938). Baylis (1929) collated knowledge of the distribution of endoparasitic Nematoda and Acanthocephala for Antarctic vertebrates. He showed that many parasites have a wide range of hosts and are widely distributed.

More recently, the parasitic infestation of Antarctic fish has been the subject of a systematic investigation by Siegel (1979), who was attempting to discover whether the parasites were qualitatively or quantitatively sufficiently characteristic to be used as indicators of geographically distinct stocks of fish. He reviewed earlier observations and recorded and analysed the endoparasitic and ectoparasitic infestation of *Pseudochaenichthys georgianus, Champsocephalus gunnari, Dissostichus eleginoides, Chaenocephalus aceratus* and *Chionodraco* sp. collected at widely separated areas in the Scotia Sea. He concluded that he was unable to demonstrate any deleterious effect by the parasites on the condition of the fish but was able to show regional differences in infestation of *C. gunnari, C. aceratus* and *Chionodraco* sp., which he thought to be indicative of different stocks of fish.

Everson (1970*a*) had observed that *Notothenia neglecta* at the South Orkney Islands was often heavily infested with nematodes. In this investigation an attempt was made to determine the most obvious ecto- and endoparasites infesting the four common inshore fish at Signy Island, *Notothenia neglecta, Notothenia gibberifrons, Notothenia rossii* and *Chaenocephalus aceratus*. The variation in numbers of endoparasites in *N. neglecta* and *N. gibberifrons*, and their effects on *N. neglecta* (the most commonly caught inshore fish), were considered.

SAMPLING METHODS

Fish were caught in Borge Bay, Signy Island, at various depths by trammel net; rod and line or hand line using a lure or bait; baited trap; or by hand whilst SCUBA diving (Table I).

Most were killed very soon after capture. Those required alive were kept in open circulation aquaria at the research station. There was a bias towards fish of 250 g and heavier due to catching methods.

Fish were weighed to the nearest 5 g. Standard and head lengths were recorded to the nearest 2 mm. Sex and method of capture were noted with other relevant observations, such as the condition of the gonads. Ectoparasites on all surfaces were counted and numbers and location of endoparasites recorded (Table II).

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TABLE I. SPECIES AND NUMBERS OF FISH EXAMINED

Species	*Total*	*Dates caught*	*Weight* X (g)	±*S.D.*	*Range* (g)
Notothenia neglecta	117	15 February 1972–11 April 1974	871.7	286.3	190–2 750
Notothenia gibberifrons	17	25 February–11 April 1974	368.9	50.6	120– 640
Notothenia rossii	9	25 February–11 April 1974	509.6	215.0	480– 970
Chaenocephalus aceratus	1	25 February 1974	1 480		

TABLE II. SUMMARY OF OBSERVATIONS MADE ON EACH SPECIES

Month	*n*	*Length* (mm)	*Weight* (g)	*Leeches*	*Cysts*		*Nematodes*		*Acanthocephala hind gut*
					Stomach	*Perivisceral*	*Perivisceral*	*Liver*	
Notothenia neglecta									
December	13	368.9±45.1	1 207.7±417.1	2.5±2.2	24.0±20.0	72.6±49.3	2.4±2.2	9.6± 6.6	5.8± 6.8
January	13	363.5±38.8	1 000.0±351.1	2.2±3.0	19.6±12.7	46.4±38.2	2.3±1.7	11.6± 6.3	3.4± 3.5
February	34	351.8±46.7	1 088.2±437.0	2.7±3.3	18.1±15.3	89.0±74.0	2.9±5.9	12.0±12.4	7.4± 7.2
March	14	332.1±45.8	900.0±401.5	0.7±1.1	6.7± 9.5	55.6±29.7	0.4±0.9	4.1± 4.7	11.1± 6.8
April	7	321.4±28.9	799.3±256.8	0.9±1.1	9.3± 5.9	33.4±25.4	0.9±1.1	8.0± 4.6	10.9± 4.9
June	13	318.8±53.3	781.6±332.7	3.5±3.3	23.7±20.8	50.8±42.5	3.1±3.4	4.8± 5.8	5.9± 4.7
July	12	210.4±26.2	249.6± 90.3	0	1.1± 1.9	12.8±11.8	0.2±0.6	2.9± 2.5	8.1± 8.4
August	11	353.6±48.3	997.4±240.7	1.9±1.92	34.2±24.3	77.6±70.5	0.7±1.2	10.0± 8.7	8.7±11.5
Notothenia rossii									
February	4	325.0±22.0	695.0±193.3	0.3±0.5	25.8±27.1	48.3±27.6	0.8±1.0	5.0± 5.5	5.5± 3.9
March	1	295	550	1	54	33	2	1	0
April	3	306.7±14.4	593±102.6	0.7±0.6	47.7±48.0	41.7±27.8	0.7±1.2	3.3± 1.2	13.0±13.8
July	1	200	190	0	3	2	0	8	5
Notothenia gibberifrons									
February	8	287.5±37.0	357.5± 99.7	0	15.4±18.5	36.1±11.6	1.0±2.1	1.9± 2.9	0.5± 0.8
March	7	301.4±41.6	424.3±176.3	0.1±0.4	2.6±0.4	27.7±19.5	1.43±1.6	0.9± 1.2	0
April	2	287.5± 3.5	325.0± 35.4	0.5±0.7	0	53.0± 9.9	0.5±0.7	1.0± 1.4	0
Chaenocephalus aceratus									
February	1	500	1 480	0	12	78	6	70	15

Results

External parasites

The most obvious ectoparasites on *N. neglecta* were leeches. These were found on the opercula, fins, flanks, especially behind the pectoral fin, inside the mouth and on the snout. Very few leeches were found inside the gill chambers. The size of the leeches varied from 2.5 to 35 mm (Fig. 1).

Antarctic leeches are not easily identified (Sawyer, 1972). Sawyer considered that many of the tentacled pisicolid leeches parasitic on Antarctic trachinoid fishes were first adequately described by Brinkman (1948) as the genus *Trulliobdella*. Sawyer (1972) observed that subsequent descriptions by Dollfus and Euzet (1965) of a similar leech *Antarctobdella tcherniai* and by Szidat and Graefe (1968) of another as *Opthalmobdella bellisioi* both appear to agree well with the characters of the genus *Trulliobdella*.

The leeches found on *N. neglecta* correspond to the description of *Trulliobdella* given by Mann (1962). Some preserved specimens were examined by Sawyer (personal communication), who also considered them to be members of this genus.

No leeches were found on *N. gibberifrons*.

Small colourless trematodes were occasionally seen on the skin surface of some fish, particularly on the flanks or just above the pectoral fin. On some fish they occurred in groups on the snout or just above the eyes. The general description corresponds to *Pseudobenedenia nototheniae* (Johnston, 1931), re-described by Dollfus and Euzet (1965).

There were insufficient data on these organisms to permit further comments on their relation-

Fig. 1. Leeches attached to the pectoral fin of *N. neglecta*.

ships with the fish. However, similar trematodes were found on *N. rossii* but not on *N. gibberifrons* or *C. aceratus*.

Eubrachiella antarctica is an ectoparasitic copepod of fish which has been shown to be widely distributed amongst fish populations in the Scotia Sea (Kock and Möller, 1977). This parasite was not found on specimens during these observations but *E. antarctica* has been observed to occur on *C. aceratus* on a few occasions during earlier collections by us. Siegel (1979) recorded that 8.4% of the specimens he examined from deep water were parasitized by this copepod at the South Orkney Islands.

Internal parasites

Immature nematodes were found on the surface and in superficial tracks or tunnels in the liver. Juvenile stages of *Phocanema, Contracaecum* and possibly *Anisakis* were found on 92% of all the *N. neglecta* livers examined. Immature nematodes in the body cavity or mesenteries occurred in 54% of the fish.

Cystocanths of one or more species of Acanthocephala were found in nearly all the nototheniid fish examined. They were frequently clumped into triangular masses measuring 10–20 mm by 5 mm especially in the larger fish. The mesenteries were the main area of infestation and the highest infestation of 288 cysts occurred in a *N. neglecta* weighing 1 953 g.

Edmonds (1954) and Baylis (1929) described these cysts on various species of Antarctic fish and the cysts found at Signy Island appear to be either *Corynosoma bullosum* or *C. hammani*.

Mature Acanthocephala were found in the rectum of 83% of *N. neglecta* but in only 17% of *N. gibberifrons*. The worms were all in the size range 3–7 mm in length and agreed with the description of *Rhadinorhynchus wheeleri* by Baylis (1929). Baylis (1929) and Edmonds (1954) believed that this is the same species as *Aspersentis austrinus* described by Van Cleave (1929).

Analysis of the Various Endoparasite Infestations

To investigate the variation of infestation of nematodes with the size of the fish, a log/log plot of mean number of nematodes per 2 cm size group of *N. neglecta* (Fig. 2) produced the following relationship:

$$Y = 2.376X - 6.185 \ (r = 0.8914)$$

where Y axis $\log_e$ is mean number of nematodes per 2 cm size class and X axis $\log_e$ is mean fish standard length.

Similar relationships were obtained using the data from the sample of 117 *N. neglecta* for male and female fish separately but when compared, using Student's t test, there was no significant difference between the sexes at 5% significance level.

When the mean number of cystacanths per 2 cm size class of *N. neglecta* was plotted against the standard length, after $\log_e$ transformation of both axes, it produced the following relationship (Fig. 2):

$$Y = 3.167X - 6.965 (r = 0.9547).$$

When the data for male and female fish were separated as before, the relationship was not significantly different at the 5% level.

When the mean number of cystacanths per 2 cm size class was plotted against the gonad-free weight of fish, obtained by correcting whole weights by an index correction for seasonal gonad development using the data obtained by Everson (1970*b*), the following result was obtained (Fig. 3):

$$Y = 0.109X - 12.533 \ (r = 0.966).$$

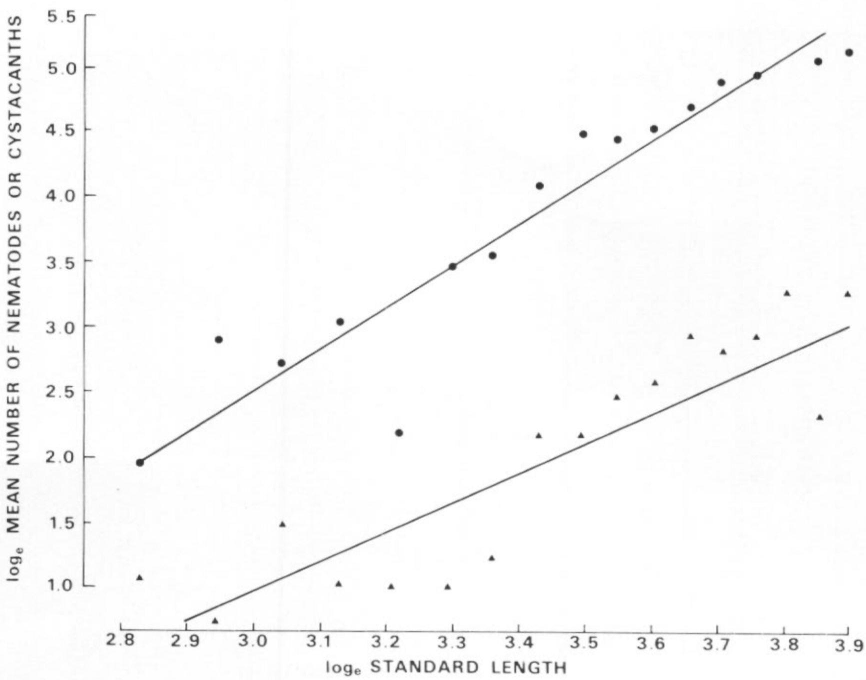

Fig. 2. *Notothenia neglecta*. Mean number of nematodes and mean number of cysts versus standard length, both axes transposed to log$_e$.
● Cysts. $Y = 3.167X - 6.965$, $r = 0.9547$.
▲ Nematodes. $Y = 2.376X - 6.185$, $r = 0.8914$.

It was also found that infestation varied directly with weight in *N. gibberifrons* using weights uncorrected for gonad development (Fig. 4):

$$Y = 0.151X - 8.67 \ (r = 0.967).$$

Effects of the Major Endoparasite Groups on the Fish

Infestation of *N. neglecta* by cystacanths and immature nematodes was directly correlated with size of the fish. Considerable variation in numbers of endoparasites existed in similar-sized fish. To attempt to quantify the effect that these two parasite groups had on *N. neglecta*, a condition factor K (Le Cren, 1951) was calculated for all *N. neglecta* as follows:

$$K = 100W/L^3,$$

where W = weight in g corrected for gonad size, and L = standard length in cm.

However, with the large variation in infestation, the sample of 117 *N. neglecta* was too small to show a statistically significant relationship between the size of fish, the level of infestation and condition factor. Nevertheless, it was found that, using data from Everson (1970*b*) for a much larger sample of fish, there was a small variation in condition factor between male and female *N. neglecta* (Fig. 5) and that the condition factor in both sexes decreased with increase in size.

$$\text{Female } Y = -0.017X + 2.737 \ (r = 0.433),$$
$$\text{Male } Y = -0.024X + 2.805 \ (r = 0.478).$$

The relative infestation was next considered, i.e. the condition factor and the parasite number

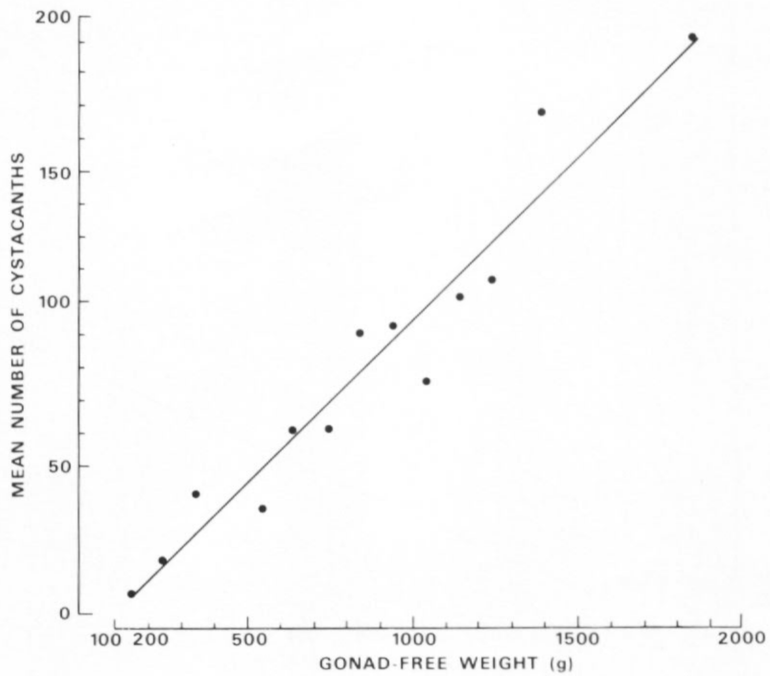

Fig. 3. *Notothenia neglecta*. Mean numbers of cysts versus gonad-free body weight. Number of cysts per 100 g weight classes.
● $Y = 0.109X - 12.533$, $r = 0.966$.

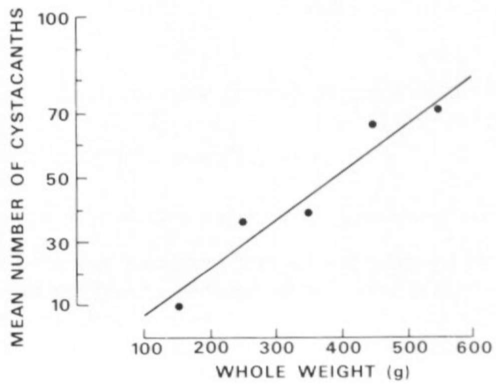

Fig. 4. *Notothenia gibberifrons*. Number of cystacanths versus whole weight. Mean number of cysts per 100 g weight classes.
● $Y = 0.151X - 8.67$, $r = 0.967$.

per unit weight of the fish, or the weight of fish per parasite. The latter expression was chosen as it produced convenient whole numbers.

Thus, two linear regressions of *K* were plotted. The first was a regression of *K* against weight of fish per acanthocephalan cystocanth and the second a plot of *K* against the weight of fish per endoparasite total (nematodes, acanthocephalan cysts and mature acanthocephalans in the hind gut).

Weight per cyst X, condition factor Y, first regression $Y = 0.005X + 2.16$ ($r = 0.588$), and the second, with weight per total number of endoparasites on the X axis,

$$Y = 0.0149X + 2.06\ (r = 0.731)\ \text{(Table III)}.$$

A similar treatment of data of weight of fish per nematode against K did not produce a meaningful correlation.

Discussion

The observations of the dominant ecto- and endoparasites on fish at Signy Island show that *N. neglecta* is a definitive host of the acanthocephalan *Aspersentis austrinus (Rhadinorhynchus wheeleri). N. neglecta* is a secondary host for the acanthocephalans *Corynosoma hammani* and *C. bullosum,* and also for immature nematodes of the genera *Phocanema, Contracaecum* and possibly *Anisakis*.

Bone (1972) found acanthocephalan cystocanths in the body cavity of the large Antarctic amphipod *Bovallia gigantea* in four out of 150 specimens and M. G. Richardson (personal communication) also found similar cystacanths in other inshore amphipods, mainly *Pontogeneia antarctica*. Amphipods are a major part of the diet of *N. neglecta* (Everson, 1970*b*). It is evident that *N. neglecta* is a typical demersal Antarctic fish which is infested with a wide range of parasites.

It is rare to find free-living leeches in trawl samples. Whilst diving in macro-algal beds in Borge Bay, Signy Island, which are frequented by *N. neglecta* during the day, leeches were not observed. No free-living leeches were found in Van Veen grab samples from the same area. The detachment of leeches from *N. neglecta* in the aquarium and the reduced frequency from net-caught fish was noted; this may lead to difficulties when analysing samples caught in trawls. It is possible that leeches are more easily detached from a stressed fish during the winter months.

The condition factor K varies in adult fish with gonad development, stomach contents, sex and degree of maturity (Le Cren, 1951). Seasonal effects of gonad development were minimized in Fig. 5 and Table III by using a condition factor linked to gonad-free weights and show apparent small reductions in condition owing to endoparasite burden. In *N. neglecta,* Everson (1970*b*) also found a small seasonal variation in liver weight.

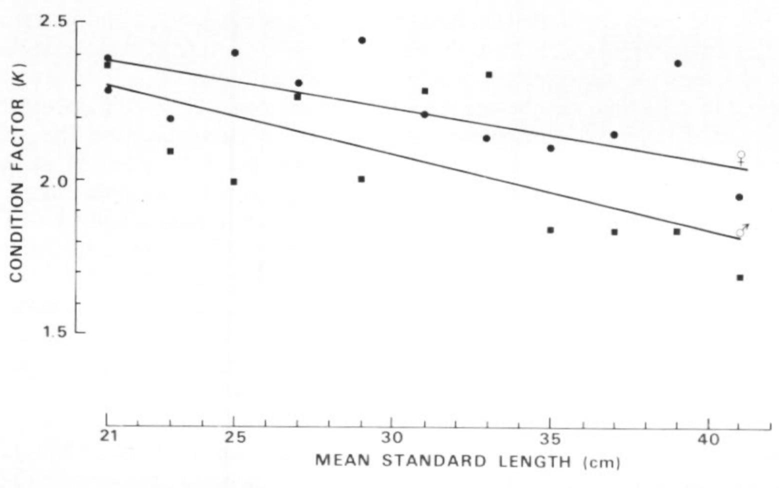

Fig. 5. *Notothenia neglecta*. Fitness factor K versus standard length Ls for male and female fish. Mean length of 2 cm size classes. From large sample obtained by Everson (1970*b*).

● $Y = -0.017X + 2.737$, $r = -0.443$.

■ $Y = -0.024X + 2.805$, $r = 0.478$.

TABLE III. EFFECTS OF THE DOMINANT ENDOPARASITES ON THE SAMPLE OF 117 *Notothenia neglecta*

Weight per cyst (g)	*Mean weight* (g)	*Mean fitness factor K*	*Fitness factor range*	*Number of fish*	*S.D. K (Y)*	*S.D. weight (X)*	*Regression line* $Y = mx+b$
0– 5	3	2.21	1.44–2.65	5			
6–10	8	2.14	1.66–2.56	24	0.117	14.87	$Y = 0.005X+2.16$
11–15	13	2.25	1.60–3.69	27			
16–20	18	2.31	1.91–2.94	15			
21–25	23	2.29	1.85–3.53	11			$r = 0.588$
26–30	28	2.38	1.84–3.00	10			
31–35	33	2.15	1.78–2.60	3			
36–40	38	2.19	1.62–3.16	8			
51–55	53	2.53	2.26–2.38	9			
Weight per total (g)							
0.0– 3.99	2	2.32	1.96–2.66	4			
4.0– 4.99	4.5	1.89	1.73–2.31	4	0.221	10.83	$Y = 0.0149X+2.06$
5.0– 5.99	5.5	2.06	1.44–2.52	7			
6.0– 6.99	6.5	2.12	1.78–2.73	12			$r = 0.731$
7.0– 7.99	7.5	2.30	1.66–2.94	10			
8.0– 8.99	8.5	2.30	1.82–3.69	14			
9.0– 9.99	9.5	2.24	1.79–2.81	8			
10.0–11.99	11	2.34	1.60–3.16	19			
12.0–13.99	13	2.14	1.62–2.39	11			
14.0–16.99	15.5	2.42	1.82–3.54	10			
17.0–19.99	18.5	2.00	1.85–2.20	8			
20.0–24.99	22.5	2.36	1.92–2.83	5			
25.0–29.99	27.5	2.44	2.20–3.30	4			
44	44	2.83	—	1			

Condition factor *K* versus weight of fish per acanthocephalan cyst, and condition factor *K* versus weight of fish per acanthocephalan cyst and immature Nematoda.

Multi-factorial analysis would be necessary to determine the true parasitic burden on *N. neglecta* and to separate and measure the effects of the various endo- and ectoparasitic groups.

Baylis (1929) and Edmonds (1954) reviewed the hosts of recognized endoparasites. Antarctic fish are clearly vectors of importance in the life cycles of a number of Antarctic vertebrates and invertebrates, although the mechanisms of infestation are unknown.

It is of interest to note that vertebrates feeding predominantly on krill (*Euphausia* spp.) have a relatively reduced diversity of endoparasites which is probably because the specialized diet reduces their opportunity to act as hosts or vectors within the ecosystem. Most channichthyids are both demersal and piscivorous, and therefore may support a wide range of parasites. However, *Champsocephalus gunnari* feeds on pelagic crustaceans, mainly krill (Permitin and Tarverdieva, 1972), and so would be expected to have reduced endoparasitic infestation. Siegel (1979) was unable to find nematode or acanthocephalan infestations in this species, although ectoparasitic infestations were as extensive as for other channichthyids. Channichthyids are normally nektonic during their early life history and feed at this stage predominantly on pelagic crustaceans before adopting a more omnivorous diet during subsequent demersal development. Siegel (1979) demonstrated that both *C. aceratus* and *Chionodraco* sp. are virtually free of nematode parasites before becoming demersal. His studies on *C. aceratus* at South Georgia have demonstrated a dramatic increase of endoparasites from the infestation-free planktotrophic stages at <20 cm length to 80–100% infestation in the demersal piscivorous >30 cm length stages. The difference in size between the smaller infestation-free and the larger but infested *C. aceratus* is equivalent to the increase in size during 1 year's growth (personal communication from K.-H. Kock).

Nektonic fingerlings of *N. rossii* and *N. neglecta* caught in the Scotia Sea during the recent British Antarctic Survey offshore biological cruise (Bonner and others, 1978) were found to feed on small pelagic Crustacea, mainly copepods and euphausiids. These species were also demonstrated to be free of macroscopic endoparasites during their early life history and so parallel the observations made for the channichthyids.

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