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Fish biology

FOOD AND FEEDING BEHAVIOUR OF EEL-COD *MURAENOLEPIS* SP., (*PISCES, GADIFORMES, MURAENOLEPIDIDAE*) FROM THE REGION OF SOUTH GEORGIA

POKARM I ODŻYWIANIE SIĘ *MURAENOLEPIS* SP. (*PISCES, GADIFORMES, MURAENOLEPIDIDAE*) Z REJONU POŁUDNIOWEJ GEORGII

Amphipoda, Cumacea and *Macrura natantia* constituted the basic food component of small eel-cod (< 20 cm). Average sized fish (20–30 cm) fed mostly on *Macrura natantia* and fish; big specimens (> 30 cm) consumed fish, *Euphausiacea* and *Macrura natantia*. Mean filling index decreased with increasing depth of catches, while percentage of "empty" stomachs increased.

INTRODUCTION

Representative of the family *Muraenolepididae* belong to the less known group of Antarctic fish. It was believed until recently that only one species from this family, i.e. *Muraenolepis microps* Lönnberg, 1905, inhabited the region of South Georgia (eg. Andriashev 1965, Permitin 1977). According to the latest source (Chiu and Markle 1990) three *Muraenolepis* species can be found in the shelf of South Georgia: the mentioned *M. microps, M. microcephalus* Norman, 1937, and *M. marmoratus* Günther, 1880. Morphological parameters of the materials collected in 1987/88 and 1988/89 during research cruises of r.v. "Profesor Siedlecki", and especially long lateral line, reaching beyond the anus, suggests that we dealt either with *Muraenolepis marmoratus* or with a totally new species (Kompowski and Rojas 1991, Kompowski and Rojas, 1993). Since systematic status of the fish under study was not certain, it has been defined as *Muraenolepis* sp.

Food and feeding behaviour of the eel-cods are not well known as yet. According to Tomo and Hureau (1985) these fish feed exclusively or almost exclusively on the zooplankton, though this opinion is not confirmed by any studies or literature data. Čečun (1984) performed detailed studies on the food of *M. marmoratus* from the region of Kerguelen archipelago. Studies on these fish feeding in the region of South Georgia

were carried out in 1965–1969 (Permitin and Tarverdijeva 1972), but the authors paid no attention to the effect of depth or the fish size. Almost 20 years elapsed since then during which eel-cods were subjected to heavy fishing even though they are considered to be a by-catch. No studies on their feeding were performed in the meantime, the only exceptions being a paper by Linkowski and Rembiszewski (1978) who examined the content of 4 stomach of *Muraenolepis microps,* and a paper by Targett (1981) who examined 8 stomachs.

The aim of the study was to deepen the knowledge on the feeding of *Muraenolepis* in the region of South Georgia.

MATERIAL AND METHODS

The fish were caught with a bottom trawl in shelf waters of South Georgia during a research trip by r.v. "Profesor Siedlecki", in the period 18 December 1987 – 8 January 1988. Fishing areas were distributed all over the shelf, at the depths 96–420 m (Fig. 1).

Total length and weight of 478 fish were measured. Size of the fish ranged from 9.3 to 44.0 cm. Stomachs were collected and preserved in a formalin solution. Subsequent analyses were made on land. Stomach content was examined under a binocular, sorted into taxons, dried over a blotting paper, and weighed up to 0.001 g.

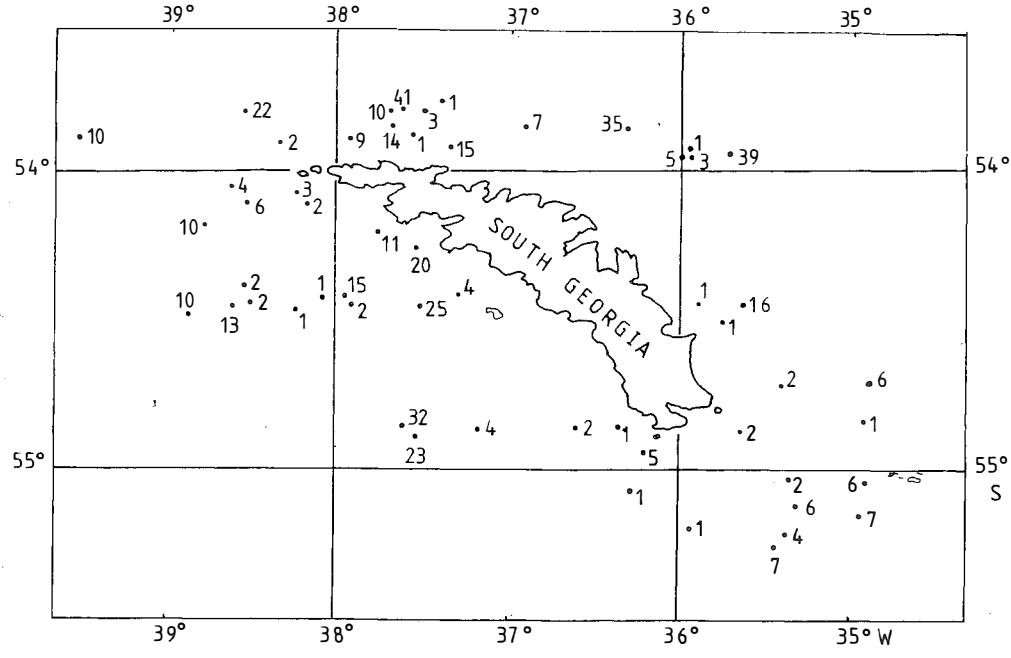

Fig. 1. Sampling locations of Muraenolepis sp. (black points) with figures showing the number of specimens examined

Most stomachs contained highly digested food so that its identification was very difficult or even impossible. Sometimes they were filled with a compact mass of chitine carapaces remnants or fish bones and scales. Therefore, the method of standard weights could not have been used, so the analyses were limited to weight method and frequency of occurrence, although these methods are far less accurate.

Frequency of occurrence of particular food components was determined as % of the stomachs filled with food. Mean filling index was calculated from the equation:

$$\bar{x} \text{ filling index} = \frac{\Sigma \text{ weight of food}}{\Sigma \text{ weight of the fish}} \cdot 10^4$$

taking into account weight of all fish, in this also those with empty stomachs.

RESULTS

Stomach filling

Number of "full" stomachs (i.e. those containing food) related to the total number of stomachs is considered to be an index of the feeding intensity. There were only 30.3% of such stomachs (145 out of 478 examined). Percentage of fish with full stomachs decreased with increasing depth. And thus: at the depth less than 150 m there were 53.5% of fish with full stomachs, at the depth 150–250 m – 32.7%, and at more than 250 m – only 23.8% (Tab. 1). Distribution of mean filling indices was similar – the highest indices were obtained for the fish caught at the depth of less than 150 m. Mean index of filling for these fish amounted to 51.82. Value of this index was 27.34 for the fish caught at 150–250 m, and 13.59 for those caught deeper than 250 m (Tab. 1). Smaller fish had noticeably less filled stomachs than bigger ones, this being so irrespective of the depth of fishing (Tab. 1).

In order to determine possible relationship between the feeding intensity and the time, days (24 h) were divided into six 4-hour periods, and the fish were classified accordingly, depending on the time they were fished out. The results (Tab. 2) are difficult to sum up because most of the fish (326 out of the total of 478) were caught at night and in the morning, i.e. between 20.00 and 8.00 hours. The lowest index of filling was found in fish caught at night (between 20.00 and 4.00 hours) but these results might have been affected by the depth of fishing and size composition of the catches.

In general, filling indices were very low. Mean filling index calculated for all fish under study (478 fish) was only 24.24 (Tab. 1).

Food composition

Food spectrum of ell-cods is very wide (Tab. 3). Shrimps were the dominating food component. They were observed in 26.9% of full stomachs. These crustaceans re-

Table 1

Relationship between filling of *Muraenolepis* sp. stomachs with food and fish size class and depth of fishing

Length class (cm)	Number of fish examined	In this:				Mean filling index
		"full"		"empty"		
		n	%	n	%	
Depth < 150 m						
< 20	9	4	44.4	5	55.6	48.65
20–30	15	8	53.3	7	46.7	37.40
> 30	4	3	75.0	1	25.1	72.86
Total	28	15	53.6	13	46.4	51.82
Depth 150–250 m						
< 20	34	5	14.7	29	85.3	4.54
20–30	149	48	32.2	101	67.8	27.07
> 30	74	31	41.9	43	58.1	28.99
Total	257	84	32.7	173	67.3	27.34
Depth > 250 m						
< 20	47	15	31.9	32	68.1	9.38
20–30	130	27	20.8	103	79.2	10.82
> 30	16	4	25.0	12	75.0	23.49
Total	193	46	23.8	147	76.2	13.59
All depths together						
< 20	90	24	26.7	66	73.3	10.07
20–30	294	83	28.2	211	71.8	21.00
> 30	94	38	40.4	56	59.6	29.69
Total	478	145	30.3	333	69.7	24.24

Table 2

Relationship between filling of *Muraenolepis* sp. stomachs with food and fish size and period of the day

Length class (cm)	Number of fish examined	In this:				Mean filling index
		"full"		"empty"		
		n	%	n	%	
0–4						
< 20	27	8	29.6	19	70.4	10.52
20–30	85	32	37.6	53	62.4	20.04
> 30	37	15	40.5	22	59.5	16.18
Total	149	55	36.9	94	63.1	17.91
4–8						
< 20	4	–	0.0	4	100.0	0.0
20–30	36	15	41.7	21	58.3	50.02
> 30	26	13	50.0	13	50.0	49.01
Total	66	28	42.4	38	57.6	48.81
8–12						
< 20	6	–	0.0	6	100.0	0.0
20–30	50	11	22.0	39	78.0	16.24
> 30	8	2	25.0	6	75.0	26.01
Total	64	13	20.3	51	79.7	18.58
12–16						
< 20	8	4	50.0	4	50.0	31.63
20–30	18	8	44.4	10	55.6	30.18
> 30	1	–	0.0	1	100.0	0.0
Total	27	12	44.4	15	55.6	27.02
16–20						
< 20	23	6	26.1	17	73.9	10.32
20–30	29	5	17.2	24	82.8	12.53
> 30	9	3	33.3	6	66.7	55.84
Total	61	14	23.0	47	77.0	30.44
20–24						
< 20	22	6	27.3	16	72.7	6.89
20–30	76	12	15.8	64	84.2	10.13
> 30	13	5	38.5	8	61.5	15.81
Total	111	23	20.7	88	79.3	11.51
General	478	145	30.3	333	69.7	24.24

Table 3

Composition of the food of *Muraenolepis* sp. in the region of South Georgia,
a – frequency of occurrence, b – % of food weight. In parentheses (line a) – number of full stomachs examined

Food components		Length class			Total
		< 20 cm	20–30 cm	> 30 cm	
Pisces	a	4.2 (1)	12.0 (10)	23.7 (9)	13.8 (20)
	b	6.6	21.1	33.5	27.6
Macrura natantia	a	8.3 (2)	30.1 (25)	31.6 (12)	26.9 (39)
	b	17.7	34.9	15.2	23.7
Euphausiacea	a	4.2 (1)	13.3 (11)	21.1 (8)	13.8 (20)
	b	4.4	23.0	34.1	28.6
Ophiuroidea	a	4.2 (1)	7.2 (6)	15.8 (6)	9.0 (13)
	b	1.7	3.2	6.7	5.1
Isopoda	a	8.3 (2)	16.9 (14)	21.1 (8)	16.6 (24)
	b	5.6	5.2	3.6	4.3
Polychaeta	a	16.7 (4)	1.2 (1)	7.9 (3)	5.5 (8)
	b	15.3	0.2	3.2	2.2
Amphipoda	a	33.3 (8)	24.1 (20)	7.9 (3)	21.4 (31)
	b	19.7	3.5	0.8	2.4
Cumacea	a	16.7 (4)	–	2.6 (1)	3.4 (5)
	b	17.2	–	1.3	1.2
Pantopoda	a	4.2 (1)	4.8 (4)	2.6 (1)	4.1 (6)
	b	4.2	1.3	0.1	0.7
Crustacea – remains	a	16.7 (4)	19.3 (16)	15.8 (6)	17.9 (26)
	b	7.6	6.8	6.7	3.7
Unidentified	a	–	4.8 (4)	5.3 (2)	4.1 (6)
	b	–	0.8	0.3	0.5
Number of stomachs examined		90	294	94	478
In this "full"		24	83	38	145

presented 23.7% of the stomach content weight. A few best preserved specimens were determined to the species: it was Notograngon antarcticus, very abundant in the waters of South Georgia. *Euphausiacea* also represented an important food component: as much as 28.6% of the food weight, but these organisms were present in only 13.8% of the fish with full stomachs. A few better preserved specimens allowed for determining these organism as *Euphasia superba.* In view of considerable role of *Euphasia superba,* i.e. of the Antarctic krill, in Antarctic ecosystems, it is worth presenting more detailed data on the occurrence of this crustacean in Muraenolepis food. It was found in the stomachs of fish originating from three hauls only. Stomachs of three fish caught in two hauls in north-east part of the shelf contained each only one specimen of krill. Mass occurrence of this organism in the fish food was noted only in the case of fishes originating from one haul in south-west part of the shelf (54°15′ S, 37°33′ W), at the depth of 221–228 m. The haul lasted from 6.50 to 7.20 hours of the local time. 20 eel cods were examined, of total length 23.6–37.4 cm. Out of these, 14 fish had full stomachs, and krill constituted about 95% of the food weight. Mean filling index for these fish was much higher than the one calculated for all fish examined. It amounted to 94.34, and when only the fish with full stomachs were taken into consideration – to as much as 137.44. Fishes were an equally important item of the food of *Muraenolepis.* They represented 27.6% of the food weight but were present in only 13.8% of the fish with full stomachs (Tab. 3). Ctenoidal scales and bones suggest that these fish belonged to *Nototheniidae* family. In some cases it was possible to identify the remnants as *Nototheniops larseni. Ophiuroidea, Isopoda, Polychaeta, Amphipoda, Cumacea* and *Pantopoda* represented other food items.

Composition of the food changed noticeably with the fish length (Tab. 3). The smallest eel cods (< 20 cm) consumed mostly *Amphipoda,* which dominated with respect to the food weight (19.7%) as well as the frequency of occurrence (33.3%). *Cumacea, Polychaeta* and small *Macrura natantia* were also consumed. Fishes represented a small percentage (6.6% of food weight) in the food of eel cods in this size class. *Muraenolepis* of average size (20–30 cm in length) fed mostly on shrimps, which represented 34.9% of the food weight, and were found in 30.1% of the stomachs. Fish and Euphausiacea were also found. These three groups of the food items constituted almost 80% of the food of Muraenolepis in this size class. Food of bigger eel cods (> 30 cm) was also represented in about 80% by the three groups of the food items, but in this size class fishes and Euphasiacea dominated in the food instead of shrimps (Tab. 3).

DISCUSSION

High percentage of empty stomachs does not necessarily mean that the fish under study fed less intensively. This phenomenon might have also been caused by fish vomiting when hauled from deep waters to the surface, due to rapid decrease of the

pressure. This assumption may be confirmed by the fact that the percentage of fish with "full" stomachs as well as the mean filling index decreased with increase depth of the catches. Vomiting was observed also in the case of other Antarctic fish, most of all in Chaenocephalus aceratus (Permitin and Tarvedijeva 1972, Kock 1981, Kompowski 1990). However, in the studies on Muraenolepis from the region of South Georgia, carried out in 1965–1969 by Permitin and Tarverdijeva (op. cit.), the percentage of fish with full stomachs was much higher (65.5–80.0%). Hence, it is also possible that low intensity of feeding was also the reason for a high number of fish with empty stomachs.

The results showed that the food of Muraenolepis consisted of benthic organisms, such as Ophiuroidea, Pantopoda, Polychaeta, Isopoda, Cumacea, and partly Amphipoda and Macrura natantia, as well as of nekton organisms (fish and shrimps) and plankton (Euphasiacea). This suggest that the fish under study is able to uptake the food directly from the bottom – as proved by the presence of sand in the fish stomachs (it was not mentioned in Tab. 3 as it is not a food item) – as well as from the water column, most probably in the near-bottom zone.

So far, the only paper discussing food of *Muraenolepis* from the region of South Georgia is the one by Permitin and Tarverdijeva (1972). The results obtained by these authors agree with our results only in a part. In both cases *Macrura natantia* was the dominating food item, and less so also *Isopoda* and *Amphipoda*. The differences refer to smaller percentage of *Euphausiacea* in case of the study by the two mentioned authors, who classified these organism as of secondary importance, while they underlined considerable role of *Mysidacea*. In the present study *Mysidacea* were not found in the food of *Muraenolepis*. This observation is very interesting, the more so that parallel studies on the food of *Parachaenichthys georgianus* and *Psilodraco breviceps* (Kompowski, 1992a,b) showed that *Mysidacea* (mostly *Antarctomysis* sp.) were one of the main food components of the latter fishes. What is more, no *Euphausiacea* were found in the food of *Parachaenichthys georgianus*. The three fish species were all caught with a bottom trawl used over the same area and many samples were collected from the same hauls.

According to Permitin and Tarverdijeva (1972) Euphausiacea were a secondary food for Muraenolepis. This does not negate the results obtained in this study as krill was found only in stomachs of the fish originating from three hauls, and was numerous only in fish from one haul (out of 58 hauls from which Muraenolepis samples were collected). Obviously, feeding eel cods found a near-bottom aggregation of krill. Naumov and Permitin (1973) showed that krill sometimes constituted food of typically benthic fish in the region of the Scotia Sea, such as *Notothenia (Gobionotothen) gibberifrons*.

Food composition of *Muraenolepis* changed with fish size. Small fishes consumed mainly zoobenthos, while bigger ones were ichthyophagous. Hence, it is possible that

lower percentage of fishes in the food of Muraenolepis studied by Permitin and Tarverdijeva might have been due to different proportion of bigger fish in the samples. The food of *Muraenolepis marmoratus* in the region of Kerguelena archipelago consisted mainly of fish, while bottom organisms: Isopoda, Decapoda and Polychaeta, represented about 1/3 of the food weight (Čečun, 1984).

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POKARM I ODŻYWIANIE SIĘ *MURAENOLEPIS* SP. (*PISCES, MURAENOLEPIDAE*) Z REJONU PD. GEORGII

STRESZCZENIE

Zbadano treść żołądków 478 *Muraenolepis* sp. o długości całkowitej od 9,3—44,0 cm, złowionych przy pomocy włoka dennego na głębokościach od 96 do 420 m w okresie od 18 grudnia 1987 r. do 8 stycznia 1988 r. na szelfie Pd. Georgii (rys. 1).

Napełnienie żołądków malało wraz ze wzrostem głębokości, na której ryby złowiono (tab. 1), co jest przypuszczalnie związane ze zwracaniem pokarmu przez ryby wyciągane ze znacznych głębokości. Niezależnie od głębokości połowu, ryby mniejsze miały słabiej napełnione żołądki niż ryby większe. Ilość ryb z pustymi żołądkami była bardzo duża (69,7%), zaś średni współczynnik napełnienia obliczony dla wszystkich badanych ryb bardzo niski (27,34). Najniższe wartości współczynnika napełnienia zaobserwowano w godzinach nocnych (tab. 2).

Spectrum pokarmowe *Muraenolepis* sp. jest szerokie i składa się zarówno z organizmów należących do bentosu (*Ophiuroidea, Polychaeta, Pantopoda, Isopoda, Cumacea, Amphipoda*) jak i z nektonu (ryby i *Macrura natantia*) oraz z planktonu (*Euphausiacea*) — tab. 3.

Wraz ze wzrostem długości badanych ryb zmieniał się skład pokarmu. Pokarm ryb < 20 cm składał się z *Amphipoda, Cumacea, Polychaeta* i drobnych *Macrura natantia*. Osobniki o długości 20—30 cm odżywiały się głównie *Macrura natantia*, a także rybami. Osobniki > 30 cm odżywiały się rybami, *Euphausiacea* oraz *Macrura natantia* (tab. 3).

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