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FOOD AND FEEDING BEHAVIOUR OF *PARACHAENICHTHYS GEORGIANUS* (FISCHER, 1885) AND *PARACHAENICHTHYS CHARCOTI* (VAILLA NT,1906) (PISCES, *BATHYDRACONIDAE*)

POKARM I ODŻ YWIANIE SIĘ *PARACHAENICHTHYS GEORGIANUS* (FISCHER, 1885) I *PARACHAENICHTHYS CHARCOTI* (VAILLANT, 1906) (PISCES, *BATHYDRACONIDAE*)

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Studies were made on the content of 278 stomachs of *Parachaenichthys georgianus* from the region of South Georgia and 30 stomachs of *Parachaenichthys charcoti* from the region of South Shetlands. Small *P. georgianus* fed mostly on *Mysidacea*, medium-sized on shrimps and fishes, large specimens on fishes. *P. charcoti* fed on fishes, *Mysidacea* and *Euphausiacea*.

INTRODUCTION

Only two species belong to the genus *Parachaenichthys* Boulanger, 1902: *P. georgianus* (Fischer, 1885) – inhabiting waters around South Georgia, and *P.charcoti* (Vaillant, 1906) – inhabiting waters near South Orkneys, South Shetland Islands, and Antarctic Peninsula.

The two species are very little known compared to other species of the order *Notothenioidei*. The literature gives only short descriptions of these species and mentions distribution of the larvae (North and White 1982, Kock 1982a, Efremenko 1983, North 1988, Kellerman 1989) and of adult fish (eg. Permitin 1977, Linkowski and Rembiszewski 1978, Kock 1982b, Sosiński and Skóra 1984, Skóra 1988, Tiedke and Kock 1989). Otoliths of *P. georgianus* and *P. charcoti* were described by Hecht (1987). Broad description of *P. georgianus* reproduction and fecundity was given by Permitin (1973). North and Ward (1989) studied food of the larvae of 4 fish species, in this also of *P. georgianus*. Feeding of older fish was studied by Targett (after Gon, 1990). Owing,

however, to the still inadequate knowledge on P. georgianus, further studies on its food and feeding are needed, and so is the aim of this paper.

MATERIALS AND METHODS

Fish were caught with a bottom trawl in waters surrounding South Georgia, Elphant Island and King George Island, during a scientific cruise of r.v. "Profesor Siedlecki". Catches in the region of South Georgia were made since 18 December 1987 till 8 January 1988. Fishing grounds were distributed all over the island shelf, at the depth of 79–373 m (Fig. 1).

All 766 Parachaenichthys georgianus caught were measured (total length) and 278 were weighed. The latter sample of fish was used in the studies. Stomachs of these were preserved in formalin. In the region of King George Island and Elephant Island, 30 *Parachaenichthys charcoti* were caught in the period since 5 till 11 February 1988, at the depth of 91–279 m (Fig. 2). Stomachs of these fish were also collected. Subsequent analyses were made on land. Stomach content was examined under a binocular and separated to taxons. Length of well preserved prey organisms was measured, the organisms were dried on a blotting paper, and weighed up to 0.001 g. Length of crustaceans was measured from the anterior edge of the eyes to the telson tip, while as

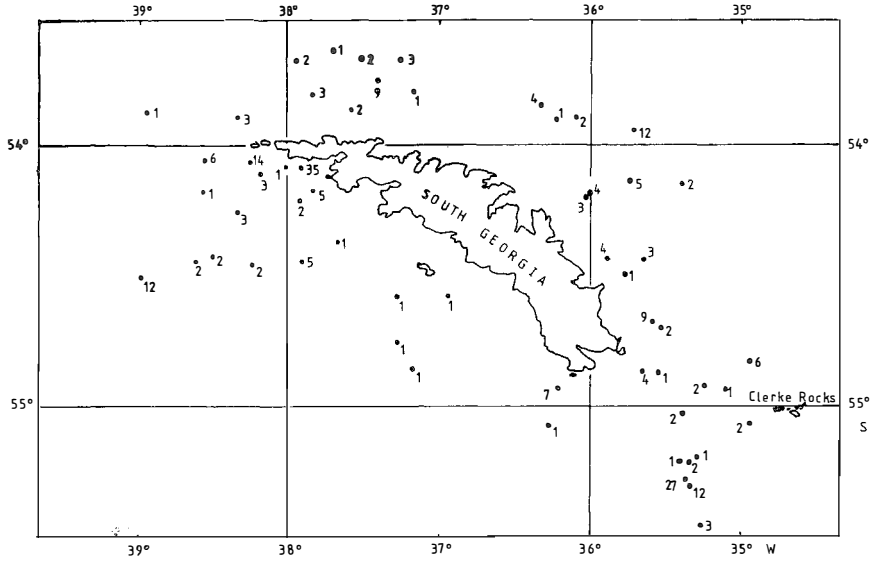

Fig. 1. Distribution of the sampling stations of *Parachaenichthys georgianus* (black points). Numbers represent number of the fish studied

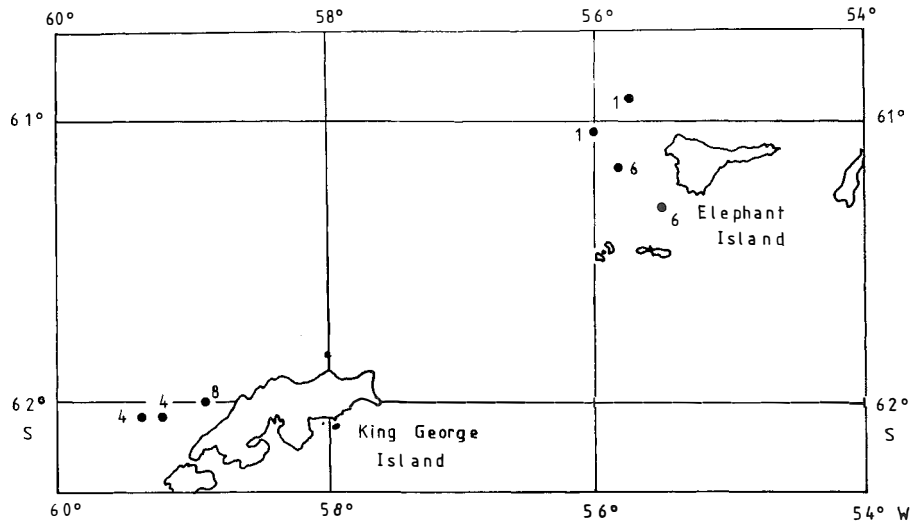

Fig. 2. Distribution of the sampling stations of *Parachaenichthys charcoti.* Denotations as in Fig. 1

regards fish, total length was recorded. Frequency of food components was related to the number of fish with full stomachs. Average index of filling was calculated according to the formula:

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

using total fish weight (fish with empty stomachs inclusive).

RESULTS

Parachenichthys georgianus.

Length

Length of the fish caught was from 11.8 to 59.5 cm. Groups of similar length were readily noticeable (Fig. 3): 12–19 cm (modal value 16 cm), 22–28 cm (modal values 24 and 27 cm), 30–35 cm (modal value 33 cm), and a less defined group with modal value 40–41 cm. Otolith and bone studies (the latter have been dealt with in a separate paper) showed that the length groups corresponded to age in the same way as in other fish.

Vertical distribution of particular length groups (Fig. 3) was not uniform. The smallest fish (12–19 cm) were present in waters down to 250 m depth, and most abundant were at the depths above 150 m. The same was true of fish bigger than 45 cm. Average-sized fish (20–40 cm) were almost exclusively present at depths below 250 m.

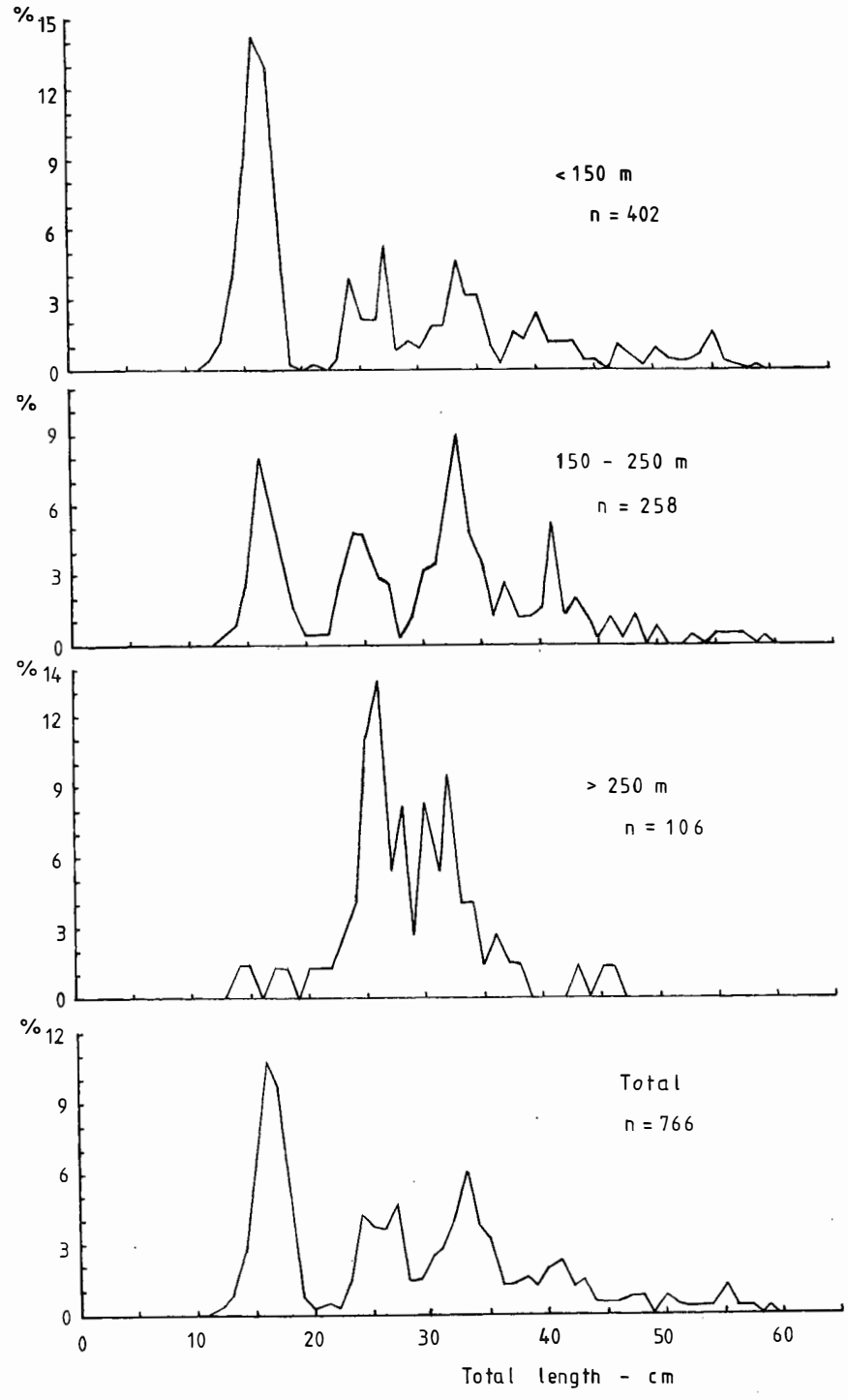

Fig. 3. Length of *Parachaenichthys georgianus* caught at different depths of South Georgia shelf

Intensity of feeding

Intensity of feeding was assessed using the index of filling. In order to establish possible daily pattern of fish feeding, 3-hour periods were analysed. Fish were divided accordingly, depending on the fishing time. The results are presented in Tab. 1. They are not easy to interpret because most fishes were caught at night-time (periods: 0–3, 3–6, 18–21 and 21–24 hours). Nevertheless, it was possible to note that the highest indexes of filling were found during the day and in the evening. There were, however, numerous exceptions to this rule.

Most probably, *Parachaenichthys georgianus* grazed most intensively at daytime, although food was also ingested (less intensively) in other periods. High value of the index of filling for all fish under study (190.96) and low number of fish with empty stomachs (54 out of 278) suggest that *P. georgianus* population was grazing very intensively.

Food composition

Composition of *Parachaenichthys georgianus* diet was rather poor. The fish fed almost exclusively on *Mysidacea*, other fish (*Pisces*), shrimps (*Macrura natantia*) and *Amphipoda. Nototheniops larseni* (Lönnberg 1905) was the most frequently consumed fish. In some cases *Pagothenia hansoni* (Boulenger 1902), *Chaenocephalus aceratus* (Lönnberg 1906) and *Pseudochaenichthys georgianus* Norman, 1937, were found. As regards shrimps, two species: *Notocrangon antarcticus* (Pfeffer 1987) and *Chorismus antarcticus* (Pfeffer 1987) were frequently consumed. Most *Mysidacea* belonged to the genus *Antarctomysis* Coutiére, 1906.

Food composition changed with fish length (Fig. 4 and 5). The smallest *P. georgianus* ($\leq$ 15.0 cm) fed on *Mysidacea* mostly; they were present in 19 out ot 25 full stomachs in this fish length class. These crustaceans represented 76.8% of the stomach content weight. In bigger *P. georgianus* share of *Mysidacea* gradually decreased, giving way to fish and shrimps. The biggest *P. georgianus* ($\geq$ 50.1 cm) fed mostly on fish and shrimps. Shrimps were found in 18 out of 22 full stomachs, representing 50.3% of the stomach content weight. Fish were observed in 19 stomachs (84.4%) and they represented 34.2% of the food weight. On the other hand, *Mysidacea* were found in two stomachs only (9.1%) and represented as little as 14.9% of the food weight.

An attempt was made to determine diet viariability with depth. Data were grouped in three depth classes: $\leq$ 150 m, 150–250 m, and over 250 m (Fig. 6). The results are difficult for the interpretation due to the mentioned uneven vertical distribution of fish in particular length classes. However, food of bigger fish ($>$ 40 cm) was noticeably predominated by shrimps if the fish inhabited shallower waters (less than 150 m depth) and by fish if they inhabited deeper waters.

Table 1

Relationship between the average index of filling for *Parachenichthys georgianus*, time of feeding, and fish length.
a – number of fish studied, b – number of empty stomachs, c – average index of filling

Length classes (cm)		Daily periods (hours)								Totally
		0–3	3–6	6–9	9–12	12–15	15–18	18–21	21–24	
⩽ 15.0	a	10	1	–	1	–	–	1	20	33
	b	4	1	–	–	–	–	–	3	8
	c	109.49	0.0	–	101.19	–	–	375.27	289.36	222.12
15.1–20.0	a	22	3	–	–	1	–	1	25	52
	b	5	–	–	–	–	–	–	4	9
	c	157.43	598.70	–	–	45.2	–	75.0	308.13	244.68
20.1–25.0	a	10	–	1	3	3	1	3	11	32
	b	3	–	–	2	–	–	–	5	10
	c	93.76	–	113.51	105.67	142.86	74.32	493.73	60.35	125.68
25.1–30.0	a	9	2	1	2	1	–	2	8	25
	b	3	1	–	–	–	–	1	2	7
	c	64.75	174.50	537.96	300.16	615.16	–	328.67	88.80	153.51
30.1–35.0	a	9	2	2	8	19	3	5	14	62
	b	1	1	–	–	3	2	–	3	10
	c	131.42	56.05	150.68	143.72	177.37	10.30	297.74	147.41	157.24
35.1–40.0	a	9	5	1	–	1	–	3	3	22
	b	2	1	1	–	–	–	1	1	6
	c	177.12	126.98	0.0	–	134.48	–	119.46	98.84	141.16
40.1–45.00	a	3	4	–	6	3	–	2	5	23
	b	–	–	–	1	1	–	–	1	3
	c	162.27	236.48	–	344.27	248.61	–	88.71	76.98	208.02
45.1–50.0	a	–	–	1	2	–	1	1	1	6
	b	–	–	–	–	–	–	–	–	–
	c	–	–	181.11	239.31	–	410.62	20.46	79.26	205.94
⩾ 50.1	a	9	2	1	4	4	–	3	–	23
	b	–	1	–	–	–	–	–	–	1
	c	221.29	119.18	185.42	217.64	204.55	–	250.29	–	210.79
Total	a	81	19	7	26	32	5	21	87	278
	b	18	5	1	3	4	2	2	19	54
	c	192.30	157.79	166.37	242.14	203.21	241.67	214.62	114.16	190.96

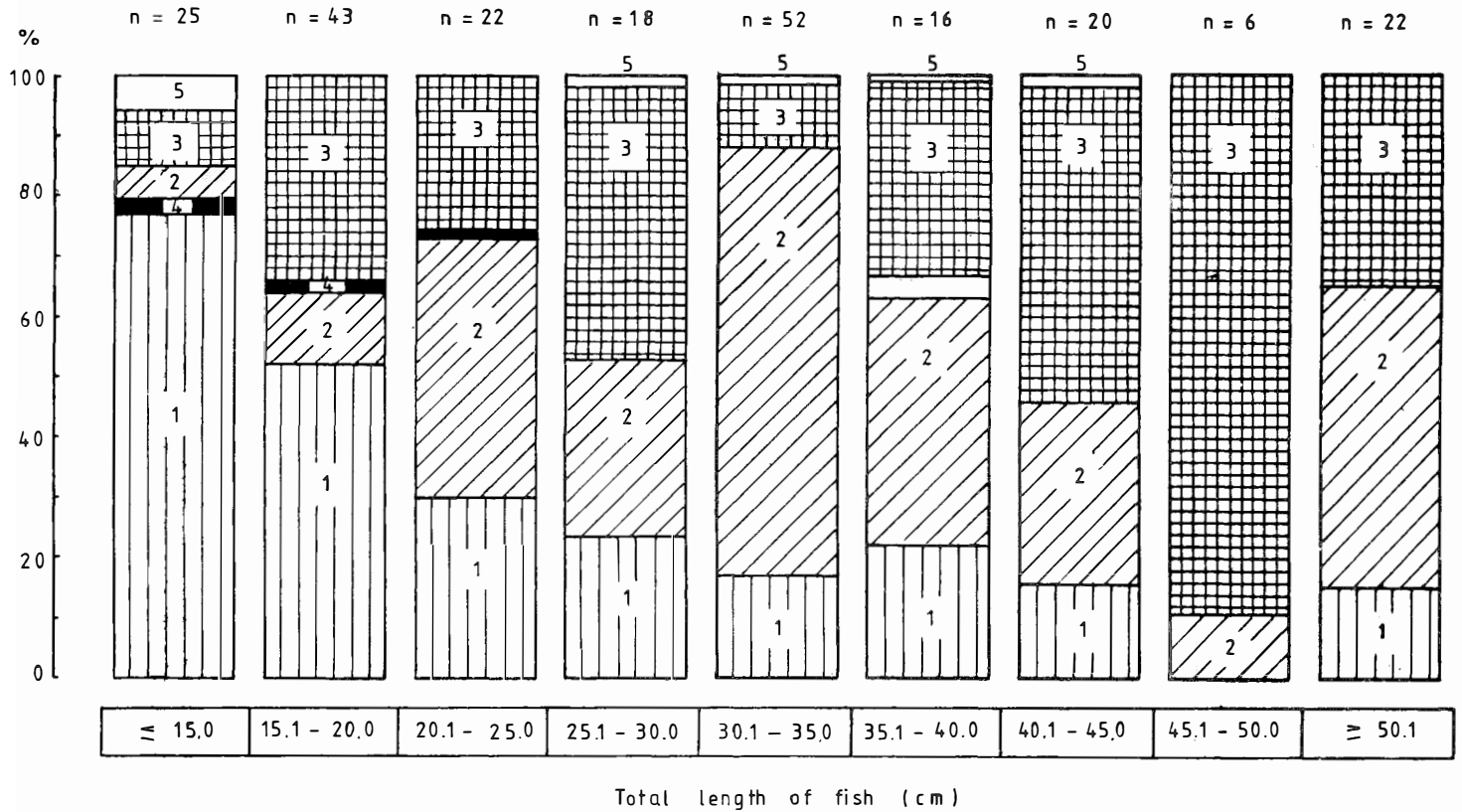

Fig. 4. Changes in the food composition of *Parachaenichthys georgianus* in relation to fish length. In percentages of stomach content weight.
1. *Mysidacea*, 2. *Macrura natantia*, 3. *Pisces*, 4. *Amphipoda*, 5. other and unidentifield

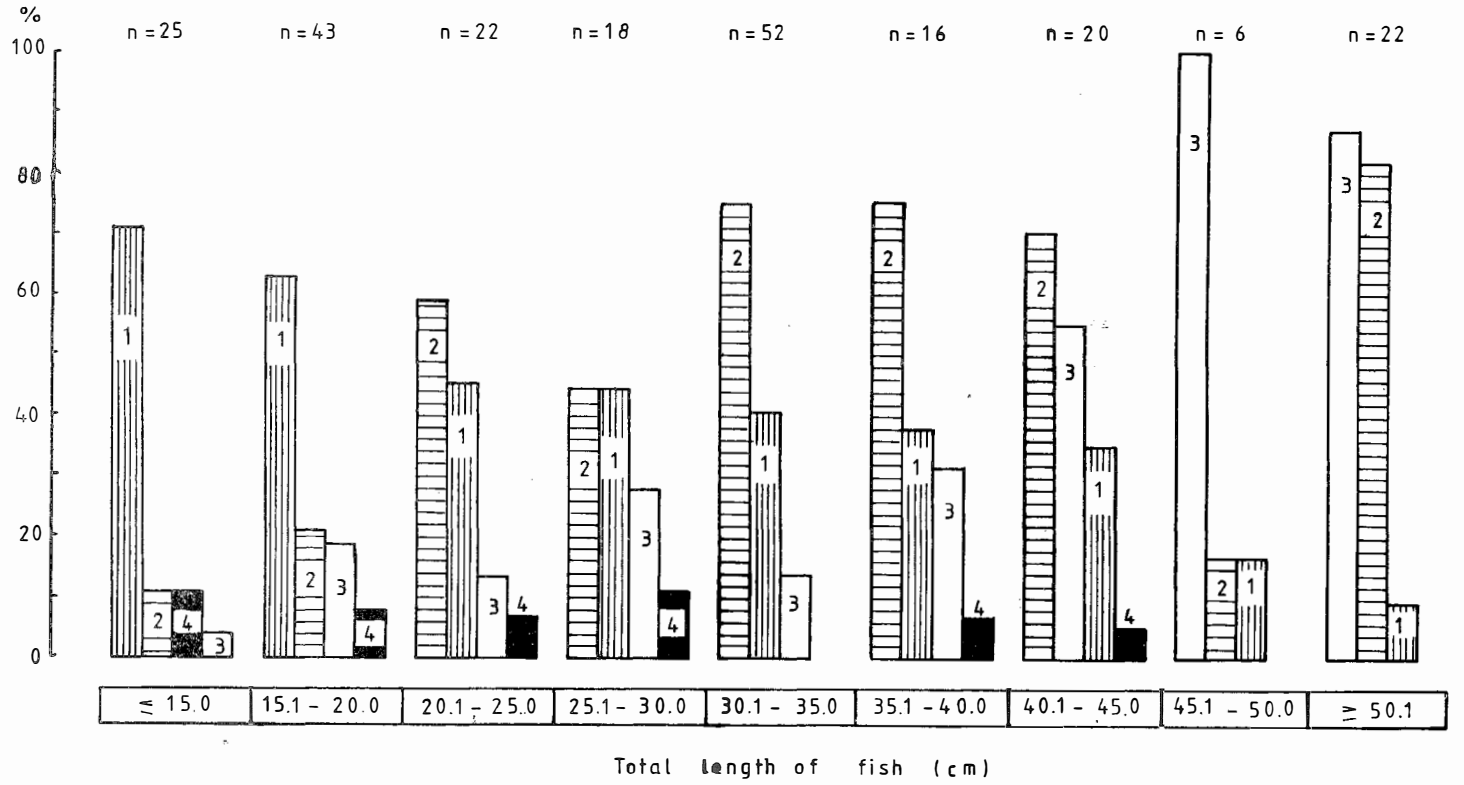

Fig. 5. Changes in the food composition of *Parachaenichthys georgianus* in relation to fish length. In frequency of occurrence.
1. *Mysidacea*, 2. *Macrura natantia*, 3. *Pisces*, 4. *Amphipoda*

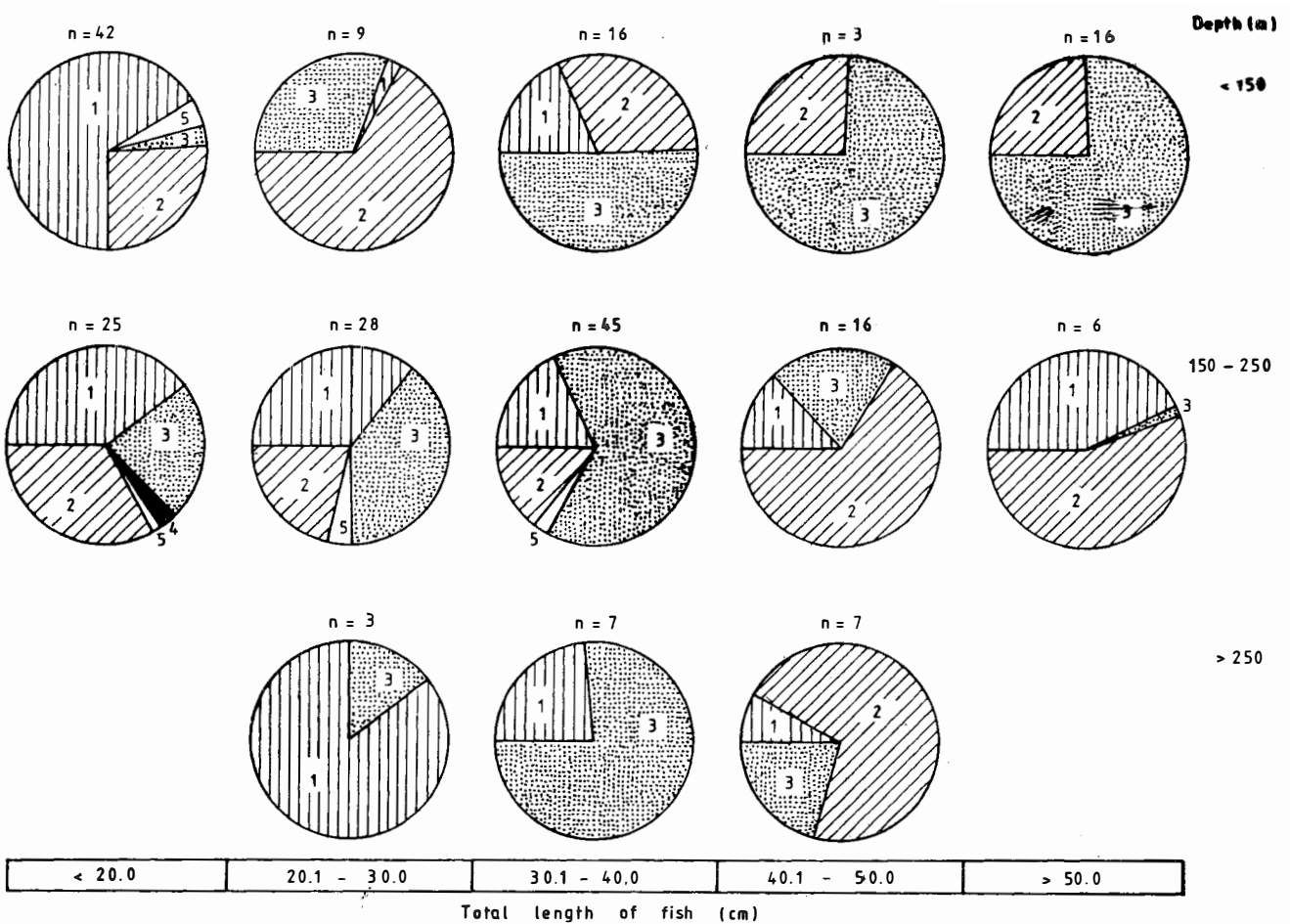

Fig. 6. Changes in the food composition of *Parachaenichthys georgianus* in relation to fish length and sampling depth.
1. *Mysidacea*, 2. *Pisces*, 3. *Macrura natantia*, 4. *Amphipoda*, 5. Other and unidentified

Table 2

Length of prey organisms in the stomachs of *Parachaenichthys georgianus* of different length

Length classess of *Parachaenichthys georgianus* (total length , cm)	Prey length (mm)								
	Pisces			*Macrura natantia*			*Mysidacea*		
	range	$\bar{x}$	n	range	$\bar{x}$	n	range	$\bar{x}$	n
⩽ 15.0	–	–	–	20–30	25.0	3	10–35	24.8	25
15.1–20.0	38–75	59.7	6	20–45	30.0	5	15–40	30.1	37
20.1–25.0	–	75.0	1	–	25.0	9	15–35	22.2	45
25.1–30.0	35–90	66.0	5	35–75	38.1	8	25–40	33.0	20
30.1–35.0	40–85	58.3	3	30–75	53.8	41	20–40	30.6	93
35.1–40.0	–	–	–	40–70	54.7	19	35–40	35.3	58
40.1–45.0	80–140	113.3	6	25–80	54.9	14	12–40	31.1	110
45.1–50.0	65–140	100.3	2	30–70	50.0	5	–	25.0	1
⩾ 50.1	35–140	48.6	36	25–70	46.5	196	30–40	37.4	214
Totally	35–140	60.6	59	20–80	47.1	300	10–40	32.7	603

Length of prey

Tab. 2 presents length of prey consumed by *P. georgianus* in particular length classes.

Fish ingested by *P. georgianus* were 35–140 mm long ($\bar{x}$ = 60.6 mm) No trend was noted of increasing prey length with increasing predator length. On the other hand, upper limit of prey increased from 75 mm in predators 15.1–20.0 cm to 140 mm in case of predators longer than 40 cm. Lower limit of prey length for *P. georgianus* 15.1–20.0 cm long was almost the same (38 mm) as for *P. georgianus* over 50.1 cm in length (35 mm).

Length of shrimps (found in *P. georgianus* stomachs ranged from 20 to 80 mm ($\bar{x}$ = 47.1 mm). Average length of these crustaneans increased with predator length, from 25.0 mm in case of fish ≤15.0 cm long to 53.8 mm in case of fish 30.1–35.0 cm long. As regards bigger fish (over 35 cm in length), average length of ingested shrimps remained unchanged. Upper limit of ingested shrimps was 30 mm for predators belonging to ≤ 15.0 cm class, increased to 75 mm for fish length class 25.1–30.0 cm, and then did not change being 75–80 mm. Lower limit of prey size changed without any trend. However, it was almost the same for small predators (20 mm) as for big ones (25 mm).

Length of *Mysidacea* consumed by *P. georgianus* was 10–40 mm ($\bar{x}$ = 32.7 mm). Average length of these crustaceans as well as lower size limit changed randomly. On the other hand, upper size limit remained the same: 35–40 mm.

Prey of very different sizes were frequently found in the same stomach. For instance, *Nototheniops larseni* 100 mm long was found together with *Mysidacea* 25–35 mm long.

Parachaenichthys charcoti

Materials were not numerous and embraced mostly juvenile fish. In view of this, no size-classes were distinguished, and no attention was paid to the depth of sampling (Tab. 3). In the region of Elephant Island, *Mysidacea* predominated in the fish diet. They were present in 8 out of 13 full stomachs (61.6%) and constituted 26.3% of the food weight. These *Mysidacea* belonged to the genus *Antarctomysis* Coutiere, 1906. Their length was 10–40 mm. *Euphasiacea* were the second important component of *P. charcoti* diet. They represented 64.8% of the food weight, being present in 4 food tracts (30.8%). Length of these organisms was 45–50 mm. They were probably *Euphasia superba* Dana, 1852, but this is not certain as they were considerably digested.

Fishes predominated in the diet of *P. charcoti* caught in the region of King George Island. They represented 89.5% of the stomach content weight. Unfortunately it was impossible to determine their length and species due to high degree of digestion. Brown nematodes, about 25 mm in length, were frequently found in *P. charcoti* peritoneum.

Table 3

Composition of the food of *Parachaenichthys charcoti* in the region of Elephant Island and King George Island

Total length of the fish under study (cm)	Elephant Island		King George Island	
	range	$\bar{x}$	range	$\bar{x}$
	12.3–26.1	16.9	12.8–40.0	24.7
Number of analysed stomach	14		16	
in this full	13		9	
Food composition				
A. Frequency in % of the number of full stomach				
Mysidacea	61.6		11.1	
Euphausiacea	30.8		22.2	
Pisces	7.7		77.8	
Other and unidentified	7.7		11.1	
B. % of the stomach content weight				
Mysidacea	26.3		1.5	
Euphausiacea	64.8		8.5	
Pisces	7.8		89.5	
Other and unidentified	1.1		0.5	

DISCUSSION

Mysidacea, Macrura natantia and fishes constituted the most important components of *Parachaenichthys georgianus* diet, which is in a good accordance with the observation made by Targett (after Gon, 1990).

Mysidaceae, basic food item of juvenile *P. georgianus,* belonged to the genus *Antarctomysis,* most probably to the species *Antarctomysis maxima* (Holt et Tattersall, 1906). This species is very common in the region of South Georgia. *A. maxima* keeps close to the bottom at daytime, and floats in the water column at night, but only single specimens are then present in the upper water layer (Kock 1981). Permitin and Tarverdijeva (1972) classified *Mysidacea* as nectobenthos. In the region of South Georgia these crustaceans are grazed upon by benthic fish, such as *Raja georgiana* or *Chaeno-*

cephalus aceratus, as well as bentho-pelagic ones: *Champsocephalus gunnari, Nototheniops larseni* and *Psilodraco breviceps* (Permitin and Tarverdijeva 1972, Kock 1981, Chojnacki and Pietrucha 1987, Kompowski 1992).

Shrimps (*Macrura natantia*) were most frequent in the diet of average-sized and big *P. georgianus*. Most of them belonged to the species *Notocrangon antarcticus* (Pfeffer, 1887). According to Zarienkova (1968) this species is eurybenthic; it is found at the depths of 15–1320 m. *N. antarcticus* is consumed by many other Antarctic fish from the region of South Georgia, both typically benthic (*Raja georgiania, Notothenia gibberifrons, Chaenocephalus aceratus*) and pelagic or bentho-pelagic (*Dissostichus eleginoides,Notothenia marmorata*) (Tarverdijeva 1972, Permitin and Tarverdijeva 1972).

Fishes represented the main food bulk of big *Parachaenichthys georgianus. Nototheniops larseni* (Lonneberg 1905) was most frequently eaten. *N. larseni* is classified by some authors (Naumov and Permitin 1973, Baluškin 1976, Andriasev 1986) as "secondary pelagic", i.e. of benthic origin, recently adapted to pelagic habitat. *N. larseni* is fairly important in the diet of a number of Antarctic fish, both benthic – such as *Chaenocephalus aceratus* (Kock 1981, Chojnacki and Pietrucha 1987) and bentho-pelagic – such as *Dissostichus eleginoides* (Tarverdijeva 1972).

All the above data suggest that *Parachaenichthys georgianus* feeds in near-bottom waters. This is supported by the lack of typical benthic organisms in the diet, such as *Echinodermata* and *Polychaeta,* which are intensively grazed upon by a benthic fish *Notothenia gibberifrons* (Kompowski 1985). On the other hand, *P. georgianus* did not eat *Euphausia superba,* a typically pelagic crustacean, grazed upon by a number of pelagic fish of Antarctica.

It is interesting that adult *Parachaenichthys georgianus* are consumed by typically pelagic *Dissostichus eleginoides* (Tarverdijeva, 1972) as well as benthic *Chaenocephalus aceratus* (Kock, 1981). Larvae, postlarvae and juvenile *P. georgianus* are consumed by *Pseudochaenichthys georgianus* (Kock, 1981).

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POKARM I ODŻYWIANIE SIĘ *PARACHAENICHTHYS GEORGIANUS* (FISCHER, 1885) I *PARACHAENICHTHYS CHARCOTI* (VAILLANT, 1906) *PISCES, BATHYDRACONIDAE*

STRESZCZENIE

Zbadano zawartość żołądków 278 *Parachaenichthys georgianus* o długości całkowitej od 11,8 do 59,5 cm, złowionych przy pomocy włoka dennego na głębokościach od 79 do 373 m w okresie od 18 grudnia 1987 r. do 8 stycznia 1988 r. na szelfie Południowej Georgii oraz 30 osobników *P. charcoti* o długości całkowitej od 12,3—40,0 cm, złowionych przy pomocy włoka dennego na głębokościach 91—279 m w okresie od 5 do 11 lutego na szelfie Elephant Is. i King George Is. (rys. 1, 2 i 3).

Największe wartości współczynnika napełnienia *P. georgianus* występowały na ogół w porze dziennej i wieczorem. Prawdopodobnie jednak *P. georgianus* żeruje okrągłą dobę z mniejszą lub większą intensywnością. Wysoka wartość współczynnika napełnienia obliczonego dla wszystkich zbadanych ryb (190.96) oraz mała liczebność ryb z pustym żołądkiem (54 na 278 zbadanych) świadczą o tym, że w okresie badań populacja *P. georgianus* intensywnie żerowała (tab. 1).

Spektrum pokarmowe *P. georgianus* składa się prawie wyłącznie z *Mysidacea,* ryb, krewetek i *Amphipoda* (rys. 4 i 5). Wśród ryb dominującym gatunkiem był Notothenіops larseni (Lönnberg, 1905). Wśród krewetek dominowały dwa gatunki: *Notocrangon antarcticus* (Pfeffer, 1887) oraz *Chorismus antarcticus* (Pfeffer, 1987). Większość *Mysidacea* należała do rodzaju *Antarctomysis* Countière, 1906.

Skład pokarmu zmieniał się z długością *P. georgianus.* Najmniejsze osobniki (≤ 15,0 cm) odżywiały się głównie *Mysidacea.* Natomiast największe ze zbadanych ryb (≥ 50,1 cm) odżywiały się głównie krewetkami i rybami. Długość ofiar wahała się w granicach 35—140 mm (ryby), 20—80 mm (krewetki) i 10—40 mm (*Mysidacea*) — tab. 2. W żołądku tej samej ryby występowały dość często ofiary o bardzo zróżnicowanej wielkości. Na przykład razem z *Notothenіops larseni* o długości 10 cm obserwowano *Mysidacea* o długości 2— 3,5 cm. U dużych osobników *P. georgianus* (> 40 cm) zaobserwowano zmienność składu pokarmu zależną od głębokości morza: powyżej 150 m dominowały w pokarmie krewetki, na większych głębokościach ryby (rys. 6).

Dominującymi składnikami pokarmu *P. charcoti* były w rejonie Elephant Is. *Euphausiacea* i *Mysidacea,* zaś w rejonie King George Is. ryby i *Euphasiacea* (tab. 3).

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