Stomach content analyses of *Gilchristella aestuarius* and *Hepsetia breviceps* from the Swartvlei system and Groenvlei, southern Cape

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Over the period October 1978 to April 1979 a total of 180 specimens of the estuarine round-herring *Gilchristella aestuarius* and 218 specimens of the Cape silverside *Hepsetia breviceps* were collected for stomach content analysis in the Swartvlei system and Groenvlei on the southern Cape coast. The diets of these two species were found to be fairly similar, with crustaceans forming their main food source in both water bodies. *G. aestuarius* appears to filter feed throughout most of its length range, although the bigger food items are probably actively caught. Young *H. breviceps* also filter feeds, but it seems to catch most of its food actively as it grows older. Some *H. breviceps* consumed adult polychaetes and tube-dwelling amphipods covered by sand particles, indicating that these were probably removed from the substrate.

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Oor die tydperk Oktober 1978 tot April 1979 is 'n totaal van 180 eksemplare van die rivier-rondeharing *Gilchristella aestuarius* en 218 eksemplare van die Kaapse spierinkie *Hepsetia breviceps* vir maaginhoudontledings in die Swartvleisisteem en Groenvlei aan die Kaapse suidkus versamel. Daar is gevind dat die diëte van hierdie twee spesies redelik eenders is, met Crustacea as die belangrikste voedsel in beide waters. *G. aestuarius* filtreervoed skynbaar oor die grootste gedeelte van sy lengteverspreiding, hoewel die groter voedselitems waarskynlik aktief gevang word. Jong *H. breviceps* filtreervoed ook, maar dit lyk asof meeste van sy voedsel aktief gevang word soos hy ouer word. Sommige *H. breviceps* het volwasse Polychaeta en buisbewonende Amphipoda ingeneem wat met sanddeeltjies oortrek was, wat aandui dat hul waarskynlik uit die substraat verwyder is.

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The estuarine round-herring *Gilchristella aestuarius* (Gilchrist) occurs from the south and east coasts of South Africa to Madagascar, whereas the Cape silverside *Hepsetia breviceps* (Cuv., in C. & V.) is found only along the southern African coast from Port Nolloth to Natal (Smith 1965). Specimens of these two species, which are superficially similar in appearance although they belong to different families, were collected for stomach content analyses from October 1978 to April 1979 in the Swartvlei system and Groenvlei. They usually occur in mixed shoals in these two water bodies which lie on either side of the small town of Sedgefield (34°01′S/22°48′E) on the southern Cape coast (Figure 1). Swartvlei is an estuarine system which closes periodically due to sand-bar formation across its mouth. It was artificially opened on 4 November 1978 and remained open till 4 May 1979. The upper reaches of the estuary form a lake fed by three rivers, namely the Wolwe, Hoogekraal and Karatara. Groenvlei, on the other hand, is a brackish (salinity 2 – 3 ‰) coastal lake isolated from the sea, although connected to it long ago (Martin 1962). It still contains elements of its earlier estuarine fauna, including *G. aestuarius* and *H. breviceps*.

The purpose of this study was to obtain a general idea of the diets of *G. aestuarius* and *H. breviceps*. It forms part of an overall project on the feeding of the fish of the Wilderness Lakes which started in March 1978 with the needlefish *Hyporhamphus capensis* (Coetzee 1981a), and is aimed at establishing the role of the various fish species in the food web of these lakes.

Material and Methods

Daytime collections of *Gilchristella aestuarius* and *Hepsetia breviceps* were made at four localities in the Swartvlei system (Stations 1 to 4) and two in Groenvlei (Stations 5 and 6) during October 1978, December 1978, February 1979 and April 1979 (Figure 1). (Blaber (1979) found that *G. aestuarius* feeds only during daylight hours, reaching a peak during the afternoon.) A seine net with a mesh size of 1 mm was used. Every sampling period a maximum of 20 specimens of each species in each available 1-cm length group was selected, measured and preserved in formalin. The specimens of each species collected at Stations 5 and 6 were combined.

Stomach contents were inspected microscopically and food items identified as far as possible. Counts were car-

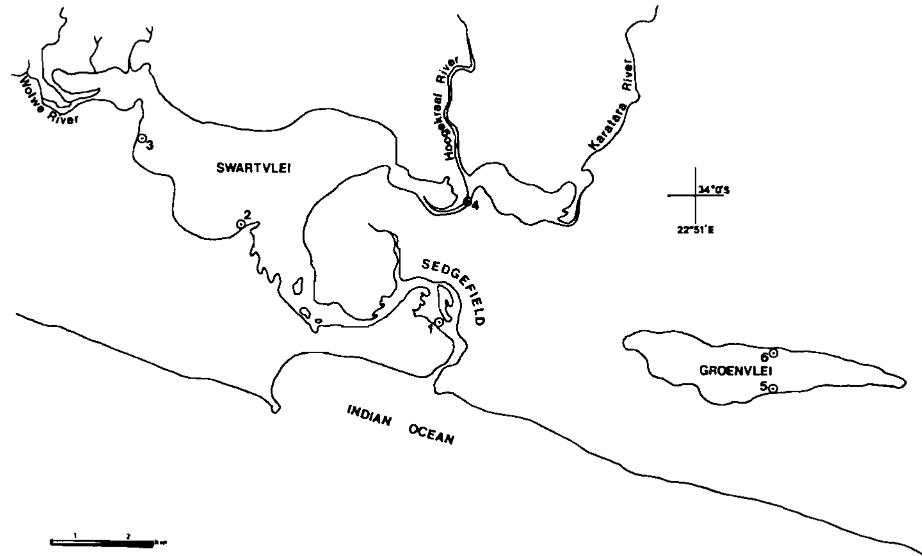

Figure 1 The study area with sampling stations (1 to 6) indicated.

ried out only when the stomach contents were not too badly broken up. The methods of analysis are the same as in Coetzee (1981a), following Hynes (1950).

In the case of *G. aestuarius*, which has a more clearly defined stomach than *H. breviceps*, food items tended to be squashed, and small delicate organisms, including rotifers, were difficult to distinguish. Rotifers, which appeared to be very scarce, were consequently not taken into account during the analyses of *G. aestuarius* stomach contents. Relatively small food items were not as badly damaged in the *H. breviceps* stomachs and rotifers were often found in fish specimens < 2,4 cm in total length. Because rotifers occurred only in the presence of phytoplankton and because of the difficulty in separating these two food items for volumetric estimates, the results for these two categories are combined.

Results

Gilchristella aestuarius

Stomachs of a total of 120 *Gilchristella aestuarius* specimens (TL 2,1 to 5,8 cm) collected in the Swartvlei system, were examined (Figure 2). Of these, nine stomachs were empty. In Groenvlei, 60 specimens (TL 2,4 to 6,6 cm) were collected and stomachs of 17 of these were empty. According to Smith (1965) this species attains a maximum length of about 7,6 cm.

The stomach content data of Stations 3 (n = 35) and 4 (n = 27) are combined in Table 1 because they yielded similar results. Station 1 gave different results, mainly due to its closer proximity to the sea. Specimens collected at Station 1 had a slightly higher mean total length than those at Stations 3 and 4, namely 4,2 cm as opposed to 3,4 cm. No *G. aestuarius* were obtained at Station 2.

Detritus was the most important component (37,3% of the total composition) of the diet of *G. aestuarius* at Station 1 (Table 1). The detrital particles were mixed with relatively large numbers of rod-shaped diatoms, as well as smaller numbers of other diatoms, dinoflagellates (species of *Peridinium, Ceratium, Dinophysis* and *Noctiluca*) and sand particles. The second most important food component was copepod nauplii (27,6% of the total composition) which were usually caked together and difficult to count. Their numbers reached a maximum of 616 in some of the stomachs. Together detritus and copepod nauplii were dominant in 80% of the stomachs collected at Station 1 (Table 1).

At Stations 3 and 4 copepod nauplii formed the main food item (17,4% of the total composition), followed by chironomid larvae (13,5%) and ostracods (12,9%) (Table 1). Lamellibranch veligers were much more abundant in the stomachs of *G. aestuarius* collected at these two stations than at Station 1, whereas gastropod veligers were abundant in stomachs from Station 1 but absent in stomachs from Stations 3 and 4. Coetzee (1981b) found that lamellibranch veligers dominated the planktonic molluscan veligers in the upper reaches of the Swartvlei system, whilst gastropod veligers dominated in the lower reaches.

In Groenvlei *G. aestuarius* fed mainly on the tube-dwelling amphipod *Grandidierella lignorum* (63,0% of the total composition) and cyclopoid copepods including *Mesocyclops leuckarti* (20,7%) (Table 2). It is interesting that sand particles were found only in those stomachs in which *G. lignorum* occurred, although 56% of the stomachs contained *G. lignorum* without sand particles. This amphipod builds its tubes in the substrate and on submerged solid objects and plants (Boltt 1969), but can also occur in the water column during daytime, mostly near the bottom of Groenvlei (Coetzee 1980). At night it migrates towards the surface of this lake.

The Crustacea as a group formed the main food of *Gilchristella aestuarius* at all stations in the Swartvlei system, namely volumetrically 43,3%, 67,5% and 60,4% of its diet at Stations 1, 3 and 4 respectively. They were also the main food of this fish in Groenvlei, constituting 94,4% of the diet and dominating in the contents of all the collected stomachs.

Hepsetia breviceps

Stomachs of 129 *H. breviceps* specimens (TL 1,1 to 6,6

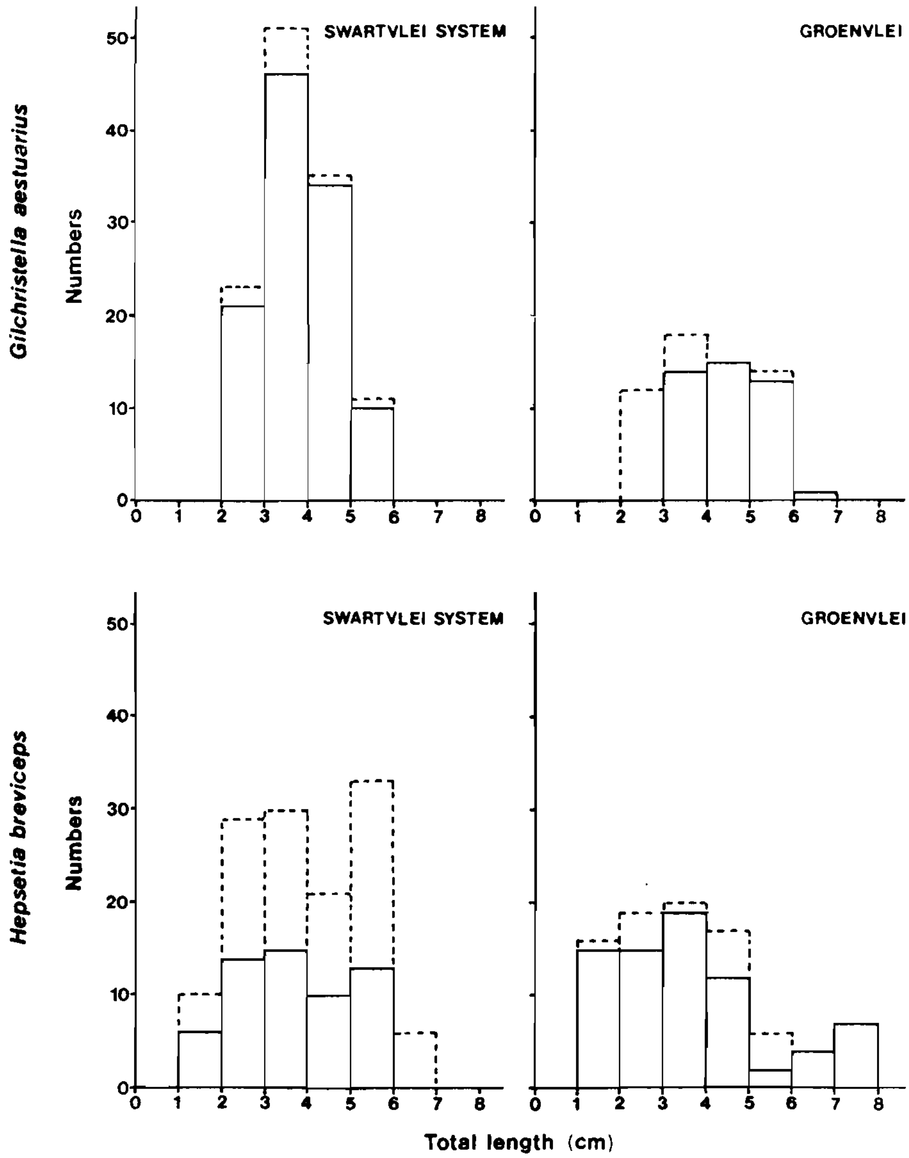

Figure 2 Length distribution of *Gilchristella aestuarius* and *Hepsetia breviceps* collected in the Swartvlei system and Groenvlei from October 1978 to April 1979 (solid line represents fish with stomachs containing food and broken line fish with empty stomachs).

cm) collected in the Swartvlei system, were examined. Of these 71 stomachs were empty or practically empty. The Swartvlei data are therefore restricted to only 58 fish, and the results of Stations 1, 2 and 3 (no specimens were obtained at Station 4) are combined in one table (Table 3). The relatively high incidence of empty stomachs occurred in all length groups, irrespective of month or station (Figure 2), and could indicate a night-time feeding pattern. In Groenvlei 89 specimens (TL 1,3 to 7,5 cm) were collected and stomachs of only 15 of these were empty. This species can reach a maximum length of about 12,7 cm (Smith 1965).

Amphipods formed the most important food items of *H. breviceps* in both the Swartvlei system and Groenvlei, namely volumetrically 40,6% and 51,9% of the diets respectively (Table 3). As with *G. aestuarius*, crustaceans again dominated as a group, constituting 63,0% of the *H. breviceps* stomach contents in the Swartvlei system and 62,9% in Groenvlei. Phytoplankton and rotifers also formed a relatively large proportion (22,8%) of the diet of this fish species in Groenvlei. This is due to the abundance of these food items in the stomachs of specimens < 2,4 cm in total length (Table 4).

H. breviceps seems to remove some of its food from the substrate. In the Swartvlei system, for example, the stomach of a 3,0-cm specimen contained, amongst others, one adult polychaete covered by sand particles. The polychaete formed 44% of the stomach contents and the sand particles 25%. This was also observed in the stomach contents of a specimen of 3,7 cm from Groenvlei. In this case the polychaete constituted 35% of the stomach contents and the 77 sand particles covering it 65%. In October, 10 *H. breviceps* (6,7 to 7,5 cm long) were collected in Groenvlei, all containing in their stomachs the tube-dwelling amphipod *Grandidierella lignorum* with numerous sand particles amongst its pereiopods. The 150 *G. lignorum* formed 95,2% of the contents of the 10 stomachs and the sand particles 4,2%.

Discussion

The main differences between the diet of both *Gilchristella aestuarius* and *Hepsetia breviceps* in the Swartvlei system and Groenvlei respectively, can be attributed to the differences in the zooplankton and zoobenthos compositions of these two water bodies. The zooplankton of

Table 1 Composition of the stomach contents of 111 *Gilchristella aestuarius* collected in the Swartvlei system from October 1978 to April 1979 (c = composition, o = occurrence, d = dominance)

	Station 1 (n = 49)				Stations 3 and 4 (n = 62)			
	n	% c	% o	% d	n	% c	% o	% d
Sand particles		1,1	59	0		0,5	40	0
Detritus		37,3	57	47		4,8	13	3
Protozoa								
Peridinium sp.		0,1	29	0				
Foraminifera	42	1,0	14	2				
Algae								
Chara sp.						0,3	8	0
Lamprothamnium papulosum						<0,05	2	0
Aquatic macrophytes		0,9	8	2		1,2	11	2
Nematoda	260	0,4	59	0	106	0,8	35	0
Crustacea								
Cladocera								
Evadne sp.	1	<0,05	2	0				
Ostracoda	4	<0,05	4	0	682	12,9	63	16
Copepoda								
Nauplii		27,6	63	33		17,4	55	23
Pseudodiaptomus hessei	18	0,7	12	0	6	0,7	8	0
Acartia natalensis					32	2,0	8	2
Unidentified calanoids		0,3	6	0				
Halicyclops sp.	7	0,4	10	0	10	0,1	8	0
Oithona spp.	134	0,6	4	0				
Oncaea sp.	3	<0,05	4	0				
Ergasilidae					65	1,2	11	0
Unidentified cyclopoids					11	0,2	6	0
Harpacticoida		3,1	92	0	319	5,1	63	0
Tegastidae	1	<0,05	2	0				
Cirripedia								
Nauplii	2	<0,05	2	0				
Cypris larvae	36	0,8	20	0				
Isopoda								
Exosphaeroma hylecoetes						0,1	2	0
Pseudosphaeroma barnardi					9	0,8	5	0
Unidentified juveniles						2,1	19	2
Amphipoda								
Corophium triaenonyx	19	3,0	10	4	72	5,8	21	6
Grandidierella lignorum	5	1,0	6	0	22	1,7	8	2
Melita zeylanica	2	<0,05	4	0	78	3,0	8	3
Afrochiltonia capensis					322	4,6	11	5
Unidentified juveniles					9	2,4	8	2
Unidentified pieces		5,5	10	6		1,1	6	2
Tanaidacea								
Apseudes digitalis					80	2,2	6	5
Decapoda								
Zoea larvae					6	1,0	3	2
Unidentified larvae		0,3	2	0				
Insecta								
Chironomidae larvae	810	8,1	67	0		13,5	65	13
Terrestrial insects	2	0,4	4	0				
Pupae	22	1,1	4	2				
Arachnida								
Araneida	1	<0,05	2	0				
Mollusca								
Lamellibranch veligers	9	<0,05	8	0	2240	7,5	69	6
Gastropod veligers	1394	5,9	45	4				
Musculus virgiliae					11	0,4	8	0
Invertebrate eggs?					50	0,6	6	0
Unidentified digested animal material						5,8	11	8

Table 2 Composition of the stomach contents of 154 *Gilchristella aestuarius* collected in the Swartvlei system and Groenvlei from October 1978 to April 1979 (c = composition, o = occurrence, d = dominance)

	Swartvlei (n = 111)				Groenvlei (n = 43)			
	n	% c	% o	% d	n	% c	% o	% d
Sand particles		0,8	49	0		2,3	26	0
Detritus		19,1	32	23		0,1	2	0
Protozoa								
Peridinium sp.		<0,05	13	0				
Foraminifera	42	0,5	6	1				
Algae								
Chara sp.		0,2	5	0				
Lamprothamnium papulosum		<0,05	1	0				
Aquatic macrophytes		1,1	10	2				
Nematoda	366	0,6	46	0				
Crustacea								
Cladocera								
Daphniidae						5,8	33	5
Evadne sp.	1	<0,05	1	0				
Ostracoda	686	7,2	37	9	66	4,7	49	5
Copepoda								
Nauplii		21,9	59	27	8	<0,05	12	0
Pseudodiaptomus hessei	24	0,7	10	0				
Acartia natalensis	32	1,1	5	1				
Unidentified calanoids		0,1	3	0	3	0,1	7	0
Halicyclops sp.	17	0,2	9	0				
Oithona spp.	134	0,2	2	0				
Oncaea sp.	3	<0,05	2	0				
Ergasilidae	65	0,7	6	0				
Unidentified cyclopoids	11	0,1	4	0	2057	20,7	35	23
Harpacticoida		4,2	76	0	43	0,1	21	0
Tegastidae	1	<0,05	1	0				
Cirripedia								
Nauplii	2	<0,05	1	0				
Cypris larvae	36	0,4	9	0				
Isopoda								
Exosphaeroma hylecoetes		0,1	1	0				
Pseudosphaeroma barnardi	9	0,4	3	0				
Unidentified juveniles		1,2	11	1				
Amphipoda								
Corophium triaenonyx	91	4,5	16	5				
Grandidierella lignorum	27	1,4	7	1		63,0	81	67
Melita zeylanica	80	1,7	6	2				
Afrochiltonia capensis	322	2,6	6	3				
Unidentified juveniles	9	1,3	5	1				
Unidentified pieces		3,0	8	4				
Tanaidacea								
Apseudes digitalis	80	1,2	4	3				
Decapoda								
Zoea larvae	6	0,5	2	1				
Unidentified larvae		0,2	1	0				
Insecta								
Chironomidae larvae		11,2	66	7	16	0,6	21	0
Trichoptera larvae					6	0,4	7	0
Odonata nymphs						1,4	7	0
Terrestrial insects	2	0,2	2	0	1	0,1	2	0
Pupae	22	0,5	2	1	2	0,7	5	0
Arachnida								
Araneida	1	<0,05	1	0				
Mollusca								
Lamellibranch veligers	2249	4,2	42	4				
Gastropod veligers	1394	2,6	20	2				
Musculus virgiliae	11	0,2	5	0				
Invertebrate eggs?	50	0,3	4	0				
Unidentified digested animal material		3,2	7	5				

Table 3 Composition of the stomach contents of 132 *Hepsetia breviceps* collected in the Swartvlei system and Groenvlei from October 1978 to April 1979 (c = composition, o = occurrence, d = dominance)

	Swartvlei (n = 58)				Groenvlei (n = 74)			
	n	% c	% o	% d	n	% c	% o	% d
Sand particles		2,7	24	2		3,2	28	1
Phytoplankton + Rotifera		8,3	10	10		22,8	34	27
Algae								
Chara sp.						0,1	1	0
Filamentous algae						0,5	7	0
Aquatic macrophytes		0,9	10	0		6,1	12	5
Nematoda	16	1,5	5	2				
Polychaeta	2	0,9	3	2		0,5	1	0
Crustacea								
Cladocera								
Daphniidae						7,8	24	4
Chydoridae					4	0,1	4	0
Ostracoda		7,1	29	5	13	1,2	16	1
Copepoda								
Nauplii					10	<0,05	4	0
Cyclopoid copepodites					43	0,5	14	0
Harpacticoida	95	3,5	35	3	2	<0,05	3	0
Cirripedia								
Cypris larvae	3	0,4	3	0				
Isopoda								
Exosphaeroma hylecoetes		10,3	24	9				
Pseudosphaeroma barnardi	1	0,3	2	0		1,4	1	1
Anthurid juveniles	1	0,3	2	0				
Amphipoda								
Corophium triaenonyx		13,0	29	10				
Grandidierella lignorum		6,5	14	10		51,9	58	55
Melita zeylanica	32	6,6	17	9				
Afrochiltonia capensis	1	0,1	2	0				
Unidentified pieces		14,4	24	21				
Decapoda								
Zoea larvae	22	0,5	5	0				
Insecta								
Chironomidae larvae		4,2	31	2	7	0,1	5	0
Chironomidae pupae					10	0,7	1	1
Other pupae	1	0,1	2					
Terrestrial insects	27	6,5	10	7	13	1,1	3	1
Arachnida								
Araneida					2	0,4	1	0
Hydracarina					17	0,4	4	0
Mollusca								
Lamellibranch veligers	692	4,1	26	2				
Gastropod veligers	987	5,0	21	5				
Musculus virgiliae	5	2,0	7	0				
Osteichthyes								
Eggs	4	1,0	3	2				
Aves								
Pieces of feather						1,3	1	1

the Swartvlei system is typically estuarine with marine visitors when the mouth is open and the tides push up into the estuary (Grindley & Wooldridge 1973; Coetzee 1978, 1981b), whereas Groenvlei contains a combination of freshwater organisms and elements of an earlier estuarine fauna (Martin 1960; Coetzee 1980).

In Lake St Lucia on the Natal coast, Blaber (1979) found *G. aestuarius* to be a non-selective zooplankton filter-feeder which ingests food in proportion to its abundance. Although some of the food items consumed by *G. aestuarius* in the Swartvlei system and Groenvlei were not zooplanktonic, this non-selective method of filter-feeding appears to apply to these two water bodies as well. At Station 1 in the Swartvlei estuary, for example, the main food items were detritus and copepod nauplii, whilst gastropod veligers were numerically very abundant (Table 1). Coetzee (1978, 1981b) found that copepod nauplii and gastropod veligers were numerically (46,7% and 45,2% respectively) the most important zooplankton organisms in the Swartvlei estuary. The turbulence caus-

Table 4 Composition of the stomach contents of *Hepsetia breviceps* < 2,4 cm in total length collected in the Swartvlei system and Groenvlei from October 1978 to April 1979 (c = composition, o = occurrence, d = dominance)

	Swartvlei (n = 11)				Groenvlei (n = 25)			
	n	% c	% o	% d	n	% c	% o	% d
Sand particles	14	1,2	18	0				
Phytoplankton + Rotifera		43,8	64	55		67,3	96	80
Aquatic macrophytes		0,4	9	0				
Nematoda	9	6,0	9	9				
Polychaeta	1	1,0	9	0				
Crustacea								
Cladocera								
Daphniidae						19,2	68	8
Chydoridae					4	0,4	12	0
Ostracoda	1	0,7	9	0	3	2,5	12	4
Copepoda								
Nauplii					10	0,4	12	0
Cyclopoid copepodites					43	1,4	40	0
Harpacticoida					2	<0,05	8	0
Isopoda								
Pseudosphaeroma barnardi						4,0	4	4
Amphipoda								
Corophium triaenonyx	4	8,2	18	9				
Grandidierella lignorum		4,1	9	9		1,0	4	0
Melita zeylanica	1	1,1	9	0				
Unidentified pieces		8,4	9	9				
Decapoda								
Zoea larvae	1	0,1	9	0				
Insecta								
Chironomidae larvae		3,9	18	0	7	0,2	16	0
Mollusca								
Lamellibranch veligers	308	12,5	82	0				
Gastropod veligers	116	8,1	9	9				
Osteichthyes								
Eggs	1	0,5	9	0				
Aves								
Pieces of feather						3,9	4	4

ed by the tides moving in and out of the estuary would maintain a high concentration of suspended detrital particles, thus accounting for their abundance in the stomachs. In Groenvlei, where Coetzee (1978, 1980) found cyclopoid copepods to dominate the zooplankton (61,2% of the total numbers), cyclopoids were numerically the most abundant food items in the *G. aestuarius* stomachs, although volumetrically the amphipod *Grandidierella lignorum* dominated (Table 2).

There seems to be little dietary change with an increase in size in *G. aestuarius*. In the Swartvlei system relatively small food items, such as copepod nauplii, often dominated the stomach contents of fish up to 4,5 cm long, and wer still abundant in fish nearly 5,0 cm long. In general, larger fish appear to consume a higher proportion of larger food items, some of which are probably actively captured and not filtered out. Both *G. aestuarius* and *Hepsetia breviceps* have been observed chasing and catching larger prey organisms in aquaria (pers. obs.).

The diet of *H. breviceps* changes as the fish grows, and it seems as if the method of feeding changes from filter-feeding to an active capturing of prey. Relatively small food items, including phytoplankton organisms, rotifers, copepod nauplii and molluscan veligers were abundant only in the stomachs of specimens up to about 3,5 cm long in the Swartvlei system and 2,5 cm in Groenvlei. In the stomachs of specimens ⩾ 5 cm (n = 13 in both water bodies) these smaller organisms were absent and larger organisms such as adult ostracods, isopods, amphipods, insects and molluscs dominated, forming 93,4% and 90,6% of the stomach contents in the Swartvlei system and Groenvlei respectively. As previously mentioned, larger fish also seem to remove some of their food from the substrate.

G. aestuarius and *H. breviceps* are much preyed upon in estuaries by various piscivorous fish and birds (Smith 1965; Whitfield & Blaber 1978a, 1978b). In the Swartvlei system they have been found (pers. obs.) in the stomachs of estuarine fish such as leervis (*Lichia amia*), kob (*Argyrosomus hololepidotus*), elf (*Pomatomus saltatrix*) and tenpounder (*Elops machnata*), and in Groenvlei in the stomachs of the introduced freshwater fish, largemouth bass (*Micropterus salmoides*). *Gilchristella aestuarius* and *Hepsetia breviceps* therefore form important links in food chains mainly between the rich invertebrate fauna of the Swartvlei system and Groenvlei on the one hand, and piscivorous fish and birds on the other hand, allowing some of the energy stored in the zooplankton and zoobenthos to be transferred to the top of the food web in these two water bodies.

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