Age, growth and food of *Cheimerius nufar* (Ehrenberg, 1820) (Sparidae), collected off St Croix Island, Algoa Bay

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Age and growth of the santer, *Cheimerius nufar*, were determined from otoliths. One hyaline and one opaque ring are laid down yearly. The von Bertalanffy growth function yielded the equation $L_t = 953{,}56\ [1 - e^{-0{,}0654(t + 2{,}6177)}]$. The length-mass relationship $W = 0{,}00005\ L^{2{,}7831}$ was used to determine growth in mass: $W_t = 9\,790{,}24\ [1 - e^{-0{,}0654(t + 2{,}6177)}]^{2{,}7831}$. Stomach and intestine content analyses were done, using a modification of the points method, as well as the frequency of occurrence method. *C. nufar* is primarily a piscivore, but also preys on cephalopods and crustaceans.

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Die ouderdom en groei van die santer, *Cheimerius nufar*, is bepaal met behulp van otoliete. Een hialien- en een opaakring word jaarliks gevorm. Die von Bertalanffy-groeifunksie word beskryf deur die vergelyking $L_t = 953{,}56\ [1 - e^{-0{,}0654(t + 2{,}6177)}]$. Deur gebruik te maak van die lengte-massa verwantskap $W = 0{,}00005\ L^{2{,}7831}$ kan groei in terme van massa uitgedruk word as: $W_t = 9\,790{,}24\ [1 - e^{-0{,}0654(t + 2{,}6177)}]^{2{,}7831}$. Maag- en derminhoude is ondersoek en gekwantifiseer met behulp van 'n metode van gemodifiseerde punte, asook die metode van frekwensie van aanwesigheid. *C. nufar* is primêr visvretend, maar voed ook op koppotige diere en skaaldiere.

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In the past most teleost research in South Africa has been directed towards commercially exploited fish stocks. More recently attention has been called to angling fish stocks and the importance of sport fishery (Van der Elst 1976a, b; Anon. 1979). Few studies however have been made of the biology of angling fish species in South Africa. The Sparidae constitute a large proportion of the angling fish species, and the general biological work done (taxonomic research excluded) is that of Gilchrist (1903, 1916), Talbot (1955), Ahrens (1964), Hutchings (1968), Stander & Nepgen (1968), Penrith (1972), Mehl (1973), Blaber (1974), Robinson (1976), Hecht & Baird (1977), Nepgen (1977), Christensen (1978) and Joubert & Hanekom (1980).

Cheimerius nufar (the santer) is one of the major angling fish species caught off St Croix Island, Algoa Bay. This study describes its age, growth and food.

Materials and Methods

Material for this study was obtained from anglers' catches off St Croix Island (Algoa Bay, South Africa) on a monthly basis for the period December 1975 to February 1978 (Coetzee & Baird 1981).

Age and growth

To determine the age and growth, ring counts were made from the lateral side of the sagitta. The otoliths were immersed in xylene and studied under reflected light against a dark background. All otoliths were read at least three times, with a two-week interval between readings. Fish were aged according to any two readings which coincided. The outer edge of the otoliths was examined on a monthly basis for the presence of either an opaque or a hyaline zone, to establish whether these zones were deposited annually. Growth is described by the von Bertalanffy growth equation (Ricker 1971; Manooch & Huntsman 1977): $L_t = L_\infty\ [1 - e^{-K(t-t_o)}]$, where L_t = length at age t; L_∞ = the maximum theoretical length a fish can attain; K = the rate at which the maximum or asymptotic length is attained; t = age; t_o = time at which the fish would have been zero length if it had always grown in the manner described by the equation. The weighted mean of the total length (TL) values per age class, was used in the calculations.

The maximum theoretical total length (L_∞) was obtained from a Walford plot (Walford 1946) and also calculated by fitting the data by the method of least squares; the latter method was considered to be more accurate. Substituting L_∞ into the length-mass relationship $W = aL^b$ (where W = mass in g, L = length in mm, b = constant) the growth in mass could be expressed by the von Bertalanffy equation: $W_t = W_\infty [1 - e^{-K(t-t_o)}]^b$.

Food

The alimentary tracts of *C. nufar* were fixed in 10% neutral formalin. Both the stomach and intestine were evaluated for the degree of fullness as: distended, 100% full, 75% full, 50% full, 25% full, empty. All evaluations of the contents excluded the bait used by anglers.

A modification of the points method (Ricker 1971) was used to quantify the alimentary tract contents. A Petri-dish with a 1-mm grid marked on its base was used to quantify the contents. After the food items were sorted and identified to species level wherever possible, each food item was kept in a separate block of the grid marked on the Petri-dish base. By counting the number of blocks a specific item occupied, it would then be expressed as a fraction of the total number of blocks occupied by the complete contents. Large items were macerated and spread out to achieve the same height as the smaller items. After analysing several stomachs (or intestines) in this way, the contribution of each item to the diet was calculated by summing all the fractions of each item and finally expressing it as a percentage of all the stomach (or intestine) contents examined. Supplementary to the modified points method, the frequency of occurrence method (Ricker 1971) was used. In this method the number of fish in which a particular food item is present, is expressed as a percentage of the total number of fish used for analysis.

Results

Length-mass relationship

The length-mass relationship of *C. nufar* is shown in Figure 1. The value of the exponent b is 2,7831 and falls within the range generally found for fish (Ricker 1971).

Length relationships

Figure 2 illustrates the relationships between the total, fork and standard (caudal) lengths of *C. nufar*, as calculated by the method of least squares.

Age and growth

Of the total number of otoliths examined, only 82% (408) were found to give acceptable readings. The nucleus of the sagitta is opaque and a definite seasonal variation in the formation of opaque and hyaline zones is evident on the otolith edge (Figure 3). Opaque zone formation takes place from July to February and the hyaline zones are laid down from March to June. It can therefore be concluded that one opaque zone and one hyaline zone are formed annually. Similar results were obtained for other sparid species by Hecht & Baird (1977) and Nepgen (1977).

Some otoliths showed a thin, but clear hyaline zone in the nucleus which was considered a false band and excluded in the age determinations (Gambell & Messtorff 1963; Bagenal 1974).

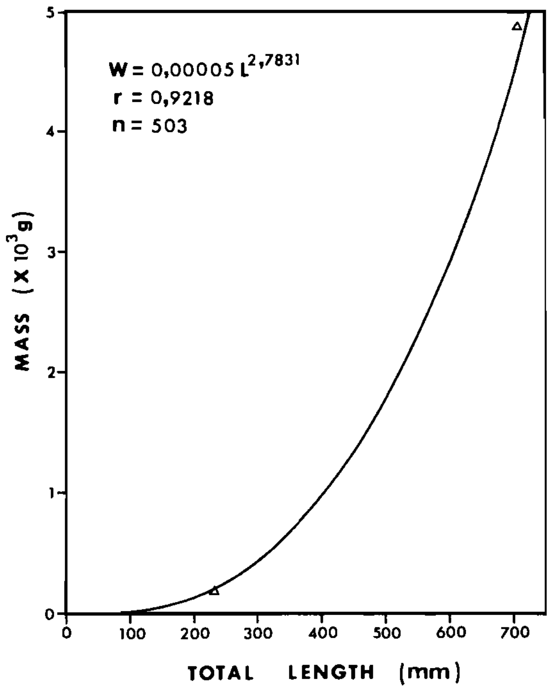

Figure 1 Length-mass relationship for *C. nufar*. Triangles represent length-mass maximum and minimum measurements.

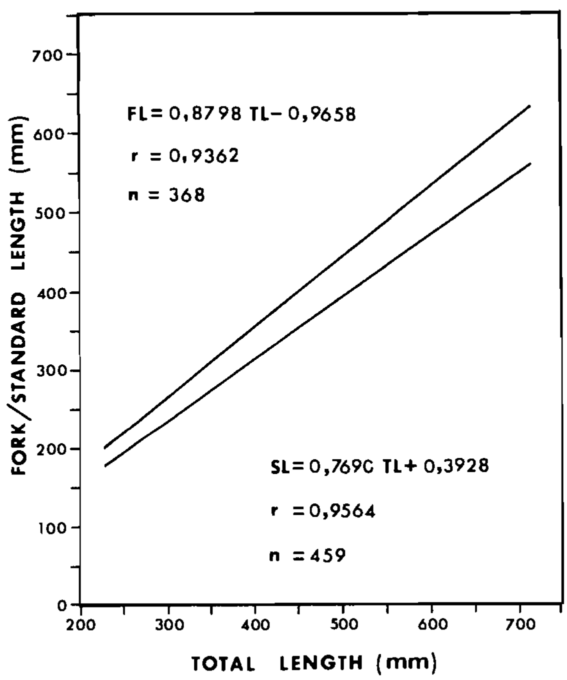

Figure 2 Relationships between total (TL) and fork (FL) length; and between total (TL) and standard (SL) length for *C. nufar*.

Table 1 gives the observed weighted mean lengths and respective age classes used to calculate the von Bertalanffy growth equation. Age classes represented by less than four fish were not included in the calculations. The Walford plot (Figure 4) was also calculated from the weighted mean lengths (see Table 1). Figure 5 illustrates the growth of *C. nufar* graphically, as expressed by the von Bertalanffy equation and the lengths calculated from this function are shown in Table 1.

Growth in mass of *C. nufar* was determined using the relationship $W = 0{,}00005L^{2{,}7831}$ (Figure 1) and is shown in Figure 6.

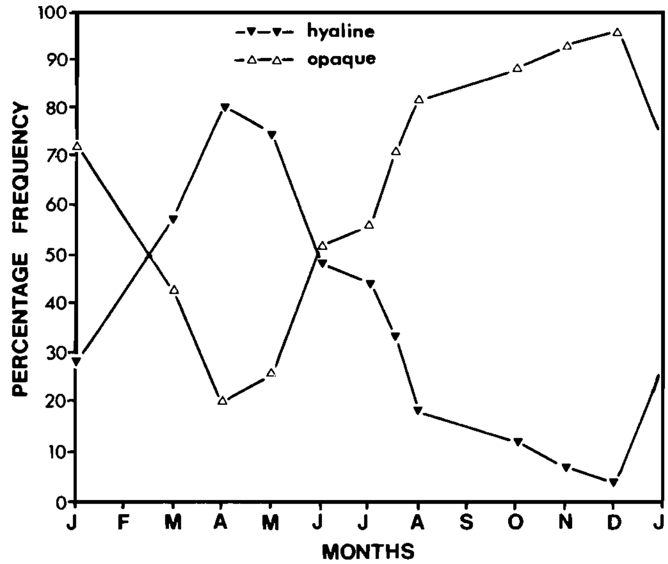

Figure 3 Monthly percentage of otoliths with hyaline and opaque edges.

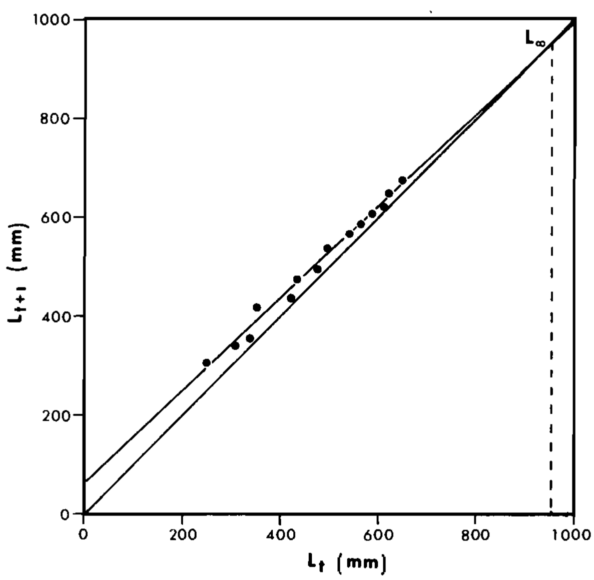

Figure 4 The Walford plot for *C. nufar*.

Table 1 Mean observed length (mm), calculated total fish length (mm) and calculated mass (g) at age of *Cheimerius nufar*

Age (yrs)	Observed mean length (mm)	SD	n	Calculated length (mm)	Calculated mass (g)
1				200,9	128,4
2	247,0	13,1	37	248,6	232,1
3	302,7	26,7	94	293,2	367,5
4	339,2	23,6	93	335,0	532,6
5	350,9	33,6	28	374,2	724,5
6	419,1	33,7	30	410,8	939,9
7	433,5	21,6	28	445,2	1175,3
8	470,8	33,8	13	477,4	1427,3
9	494,6	47,4	19	507,5	1692,5
10	539,6	31,2	17	535,8	1967,7
11	563,4	31,8	10	562,2	2250,2
12	582,0	29,7	13	587,0	2537,1
13	603,3	25,8	5	610,2	2826,2
14	618,8	37,7	4	631,9	3115,4
15	646,6	48,3	7	652,3	3402,9
16	673,7	31,4	5	671,4	3687,1
17	624,0		1	689,3	3966,6
18	663,0		2	706,0	4240,5
19				721,6	4507,8
20	685,0		1	736,3	4767,7
21				750,1	5019,7
22	705,0		1	763,1	5263,3

SD: standard deviation. n: number of fish. Note: age classes with $n < 4$ were not used in the determination of the von Bertalanffy equation.

Food

A total of 244 alimentary tracts was collected from fish of the size-range 250 mm to 650 mm total length. As a result of the invagination of the cardiac stomach during capture, 54,9% of the stomachs were found to be empty and these were excluded from the analysis. Of the remaining

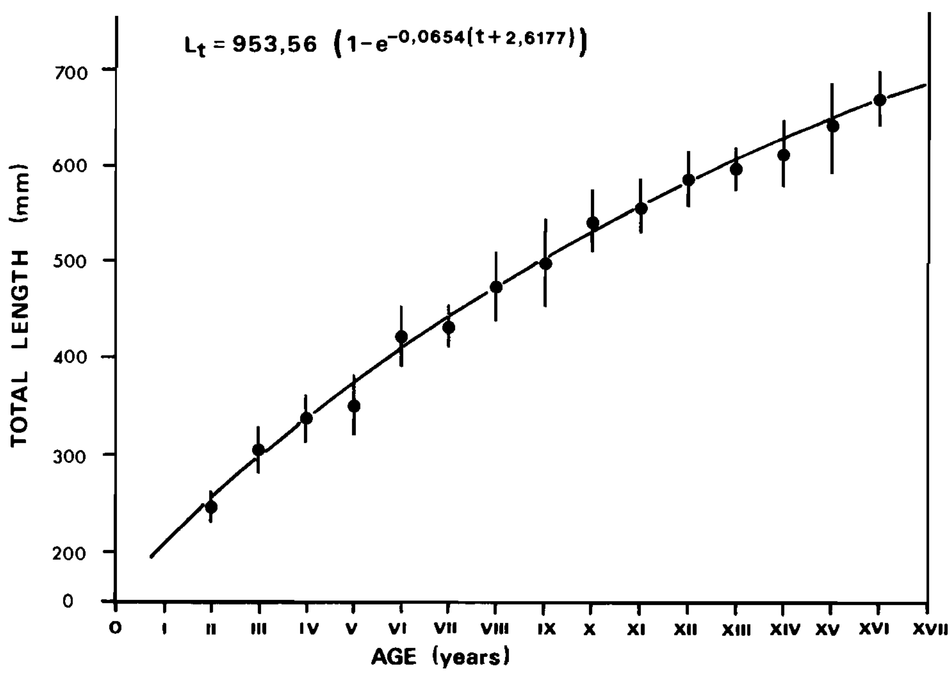

Figure 5 Von Bertalanffy growth curve of *C. nufar*. ● = weighted mean length at age (observed) ⧫ = standard deviation.

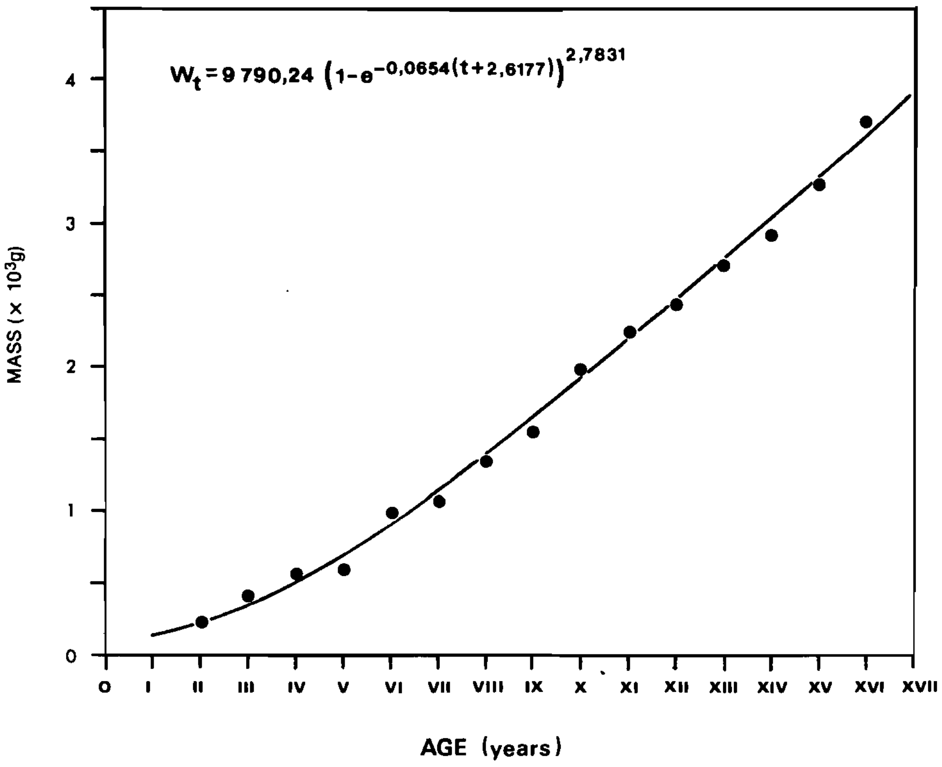

Figure 6 Growth in mass of *C. nufar*, determined from the von Bertalanffy growth equation. ● = mass at age (calculated).

110 alimentary tracts examined, 41,8% of the stomachs and 16,4% of the intestines were empty. The percentage of stomachs and intestines in various degrees of fullness are illustrated in Figure 7.

Table 2 and Figure 8 show the composition of stomach and intestine contents of *C. nufar*. The points method showed a predominance of fish in the stomachs, which constituted 39,3% of the contents. Cephalopods constituted 24,1% and crustaceans 1,6% respectively (Table 2). A similar trend is evident for *C. nufar* caught in the Gulf of Aden region (Druzhinin 1975), as illustrated in Figure 8. Calculating the frequency of occurrence of food items from data presented by Druzhinin (1975: Table 10), it is shown that fish occurred in 61,7% of the stomachs, crustaceans in 22,4% and cephalopods in 6,6%. In comparison, 59,6% of the stomachs of *C. nufar* caught off St Croix Island, contained fish, 9,6% contained crustaceans, whilst 31,0% contained cephalopods (Table 2 and Figure 8).

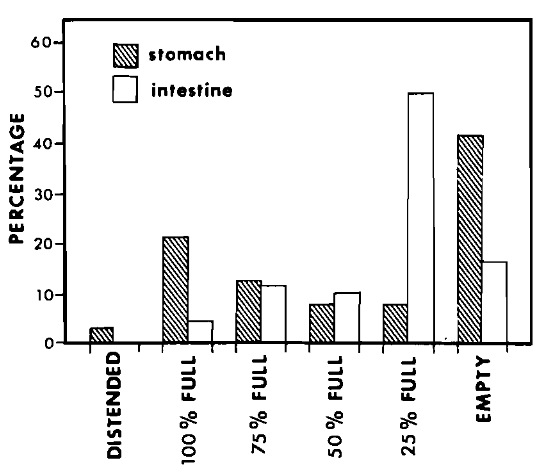

Figure 7 Percentage of stomachs and intestines in various degrees of fullness, for the 110 fish examined.

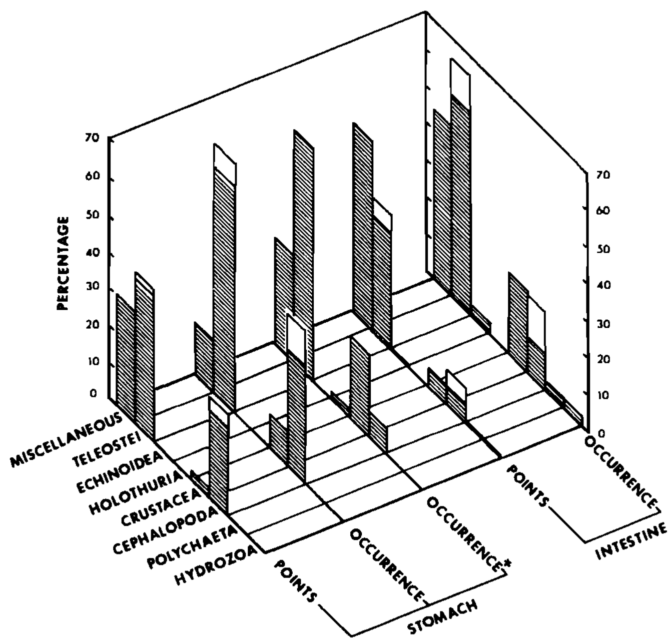

Figure 8 Composition of stomach and intestine contents of *C. nufar* (see Table 2). Unshaded areas of the diagram represent unidentified remains of uncertain origin. *Compiled from Table 10, Druzhinin (1975), for the Gulf of Aden region.

The content of the intestinal tract exhibits similar trends to that of the stomach (Table 2, Figure 8). Fish occurred in 54,6% of the intestines and comprised 31,8% of the food volume. Cephalapoda constituted only 4,5% of the intestine contents, which is approximately 20% less than that found in the stomachs, whereas crustaceans constituted 4,3% of the contents and occurred in 22,7% of the intestines (Table 2).

Table 2 The composition of 64 stomach and 92 intestine contents of *Cheimerius nufar*

Food component	Points method				Occurrence method			
	Stomach composition		Intestine composition		Stomach composition		Intestine composition	
	%	Total %	%	Total %	%	Total %	%	Total %
Hydrozoa			present	present			2,3	2,3
Polychaeta (Sedentaria)			0,06	0,06			2,3	2,3
Cephalopoda		24,1		4,5		31,0		9,1
Loligo spp.	4,8		1,2		11,9		2,3	
Octopus granulatus	1,6		1,2		2,4		2,3	
Unidentified Cephalopoda	17,7		2,1		16,7		4,5	
Unidentified Cephalopoda remains?	3,2	3,2	4,1	4,1	9,5	9,5	11,4	11,4
Crustacea		1,6		4,3		9,6		22,7
Balanus spp.			0,04				2,3	
Callianassa kraussi			1,0				2,3	
Plagusia chabrus			3,2				6,8	
Isopoda, Amphipoda	present		0,01		4,8		6,8	
Unidentified Crustacea	1,6		0,07		4,8		4,5	
Echinoidea				0,04				2,3
Parechnius angulosus			0,04				2,3	
Teleostei		39,3		31,8		59,6		54,6
Batrichthys apiatus	0,7				2,4			
Batrachoididae larvae?	1,0		1,2		2,4		2,3	
Cheilodactylus fasciatus	0,8				2,4			
Sardinops ocellata	6,6				9,5			
Sphyraena spp. (juvenile)	2,1				4,8			
Unidentified larval fish	4,6				7,1			
Unidentified Teleostei	23,5		30,6		31,0		52,3	
Unidentified fish remains?	1,6	1,6	4,9	4,9	4,8	4,8	9,1	9,1
Miscellaneous (Unidentified remains of unknown origin)	30,2	30,2	50,2	50,2	14,3	14,3	45,5	45,5

Discussion

Age and growth

Information on the age and growth of Sparidae is limited, although contributions have been made by Akazaki (1960), Kasahara, Hirand & Ohshima (1960), Jan Wojiechowski (1972), Druzhinin (1975), Hecht & Baird (1977), Manooch & Huntsman (1977) and Nepgen (1977).

The von Bertalanffy growth function yielded an L_∞ value of 953,56 mm total length. Assuming growth as described by the von Bertalanffy equation, the results obtained for *C. nufar* caught off St Croix Island are comparable with those of Druzhinin (1975), recorded for the same species in the Gulf of Aden region. Fish from the latter area are, however, somewhat larger at age. For instance, L_∞ calculated from Druzhinin's Table 5 yielded a fork length of 961 mm as compared to a fork length of 838 mm from the present study (refer Figure 2 for length interconversions). This variation in size could possibly be attributed to the difference in temperature between the Gulf of Aden and the Algoa Bay regions. The growth of *C. nufar* in terms of mass (from the von Bertalanffy function) yielded a W_∞ of 9,79 kg which is not unrealistic, as the maximum recorded mass of *C. nufar* is 7 kg (South African Angling Records as at 1st January 1978: Anon. 1978).

A lack of data points for the older age classes is unfortunate and can be attributed to a decrease in abundance of large fish. Nevertheless, the growth of *C. nufar* is satisfactorily described by the von Bertalanffy growth equation presented.

Food

Dietary studies of fish can provide information on the availability of food, the interrelationships between species and the trophic structure of the ecosystem (Quasim 1972; Hickey 1975; Ellis, Wiens, Rodell & Anway 1976). In this investigation, the contents of the whole alimentary tract (stomach and intestine) of *C. nufar* were examined. Most authors of dietary studies only examine the stomach contents and not the contents of the intestinal tract.

Although the intestine contents are usually well digested, analysis thereof can give invaluable information on fish that regurgitate their food (or where invagination of the stomach occurs) during capture. Despite the fact that the majority of intestines of *C. nufar* were only 25% full, the results show that the intestine contents are comparable with the stomach contents. A few differences are evident between the contents of the stomach and intestines.

The stomachs had a greater proportion of cephalopods (24,1%; points method) and a lesser proportion of crustaceans (1,4%) when compared with the intestinal tract (cephalopods 4,5% and crustaceans 4,3%). This difference could be attributed to the difficulty of positively identifying cephalopods (few remaining hard parts) as opposed to fish and crustaceans in the semi-digested food. Pieces of indigestible crustacean exoskeletons accumulate in the hind part of the alimentary tract before being excreted and this could account for the higher incidence of crustaceans in the intestines, as compared to that of the stomachs. Less important food components, such as hydroids and polychaetes, were present in the intestine contents, but not in the stomach contents. Intestine analysis can therefore be used to supplement stomach analysis and thus further elucidate the trend of major prey organisms, as well as providing a more complete picture of the diet.

The occurrence method, when compared with the points method, shows a high incidence of hydroids, polychaetes, echinoids, isopods and amphipods in the alimentary tract, although their contribution in terms of volume and/or mass is minimal. This over-emphasis of the contribution of small organisms is an inherent drawback of the frequency of occurrence method (Ricker 1971), but this was the only method available to compare the results obtained with the results calculated from Druzhinin (1975). The volumetric nature of the modified points method used in the present study lends itself to a more accurate evaluation of the importance of the prey organisms.

Both carnivorous and omnivorous species are found in the family Sparidae (Smith 1953; Talbot 1955; Ahrens 1964; Hutchings 1968; Blaber 1974; Christensen 1978; Nepgen 1977; Joubert & Hanekom 1980). *Argyrozona argyrozona* shows a preference for crustaceans followed by teleosts and cephalopods (Nepgen 1976). Other species of the subfamily Denticinae also show carnivorous behaviour (Smith 1953; Ahrens 1964). Analysis of the alimentary tract contents of *C. nufar* (subfamily Denticinae) indicates that this species is an opportunistic feeder, preying on benthic and nektonic organisms. Primarily the santer is a piscivore, but it also preys on cephalopods and crustaceans.

The analysis of anglers' catches off St Croix Island indicated that *Cheimerius nufar* was the second most important species caught (Coetzee & Baird 1981) and due to its presence in high numbers, it must play an important role as predator in the Island's trophic food web.

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