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The Offshore Linefishery of Natal: III: Food and Feeding of the Sparids *Chrysoblephus puniceus* and *Cheimerius nufar*

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THE OFFSHORE LINEFISHERY OF NATAL. III FOOD AND FEEDING OF THE SPARIDS *CHRYSOBLEPHUS PUNICEUS* AND *CHEIMERIUS NUFAR*

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ABSTRACT

The slinger *Chrysoblephus puniceus* (Gilchrist & Thompson, 1908) and the santer *Cheimerius nufar* (Ehrenberg, 1830) are important commercial and recreational linefish of the continental shelf of Natal, South Africa. The organisms consumed by these sparids, their relative importance in the diets and changes in diet related to size of fish, season and area are investigated, using the frequency of occurrence and volumetric methods of analysis.

Chrysoblephus puniceus is an opportunistic predator which feeds mainly on benthic crustaceans and molluscs. There appears to be no correlation between diet and season, but there is a change in diet with increasing size. Diet remains fairly constant along the Natal coast.

Cheimerius nufar is more specialized and is primarily a piscivore, but also feeds on cephalopods and crustaceans. A comparison of the feeding habits of *C. nufar* in the Gulf of Aden region, Natal and the eastern Cape waters of South Africa shows that its diet is similar in these regions. The diet also remains fairly constant along the Natal coast, and from one season to another.

INTRODUCTION

The slinger, *C. puniceus* and the santer, *C. nufar* are important commercial and recreational fish of the continental shelf of Natal, South Africa, comprising 70-80% of the total offshore reef fish catch (Garratt, 1984). They are caught by hook and line in the vicinity of reefs at depths of 12-150 metres.

Very little is known about the community structures and food webs of the offshore reefs of Natal. This paper investigates the feeding habits and food organisms consumed by two of the principal offshore reef fish species.

Regurgitation and stomach eversion hampered this study as they have hampered feeding studies of species living at similar depths throughout the world (Pillay, 1952; Randall & Brock, 1960; Godfriaux, 1970; Colman, 1972; Hecht, 1976; Coetzee & Baird, 1981). However, sufficient material was identified in the buccal cavity, some stomachs and in the intestines to give a good idea of the organisms consumed by *C. puniceus* and *C. nufar* and their relative importance in the diets, as well as to determine changes in diet related to size of fish, season and area.

METHODS

Monthly samples of fish were obtained from five skiboat* launching sites along the Natal coast, viz. Richards Bay, Mvoti River, Park Rynie, Ramsgate and Thompsons Bay (Fig. 1). Data were also collected using the R.V. Meiring Naudé.

* Fishing boats launched through the surf.

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Due to the problem of regurgitation, the contents of the whole alimentary canal were utilized. These data were analysed using the frequency of occurrence method, which expresses the number of fish in which a particular food item is present as a percentage of the total number of fish examined (Ricker, 1971).

Complete alimentary tracts of ten *C. puniceus* were also removed at each station each month and fixed in 10% formalin. These samples were later analysed by the volumetric method, in which the percentage contribution by volume was estimated (Pillay, 1952). A

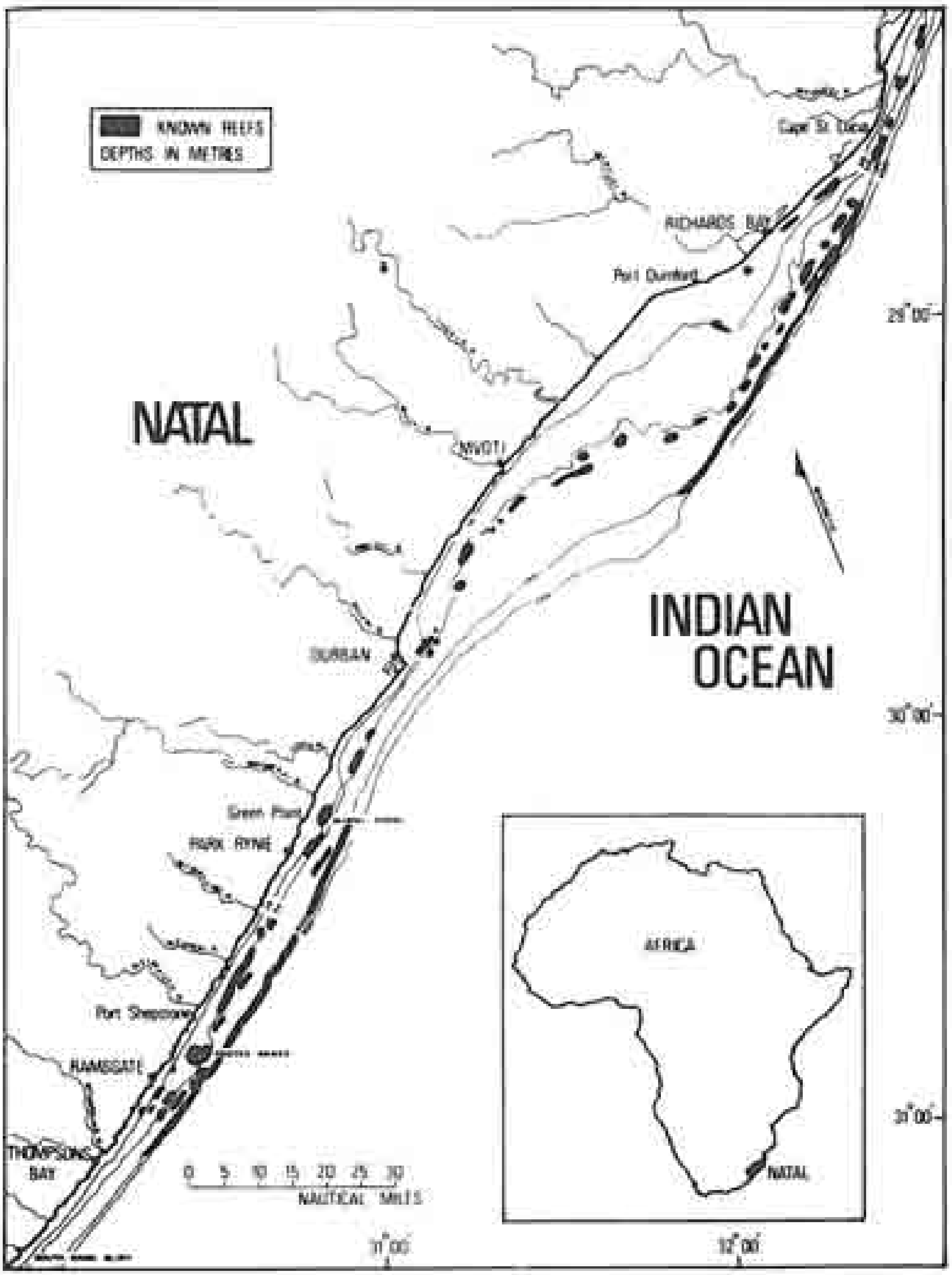

Figure 1. Known linefish reefs off Natal and the Skiboat launching sites from which samples were obtained (◉). Taken from the Hydrographer, South African Navy, Chart SAN 60, 1976.

similar volumetric analysis could not be carried out for *C. nufar* due to the high percentage of stomachs that were everted or empty and because the principal food items of this species were soft bodied animals and readily digested. The feeding analysis of both species, using the percentage occurrence method, are limited to a twelve month period (July 1980 — June 1981), whereas the analysis of *C. puniceus* using the volumetric method, extends over 23 months (August 1979 — June 1981).

To determine if there was a change in the diet of *C. puniceus* with increasing size, samples of fish covering a wide range of sizes had to be collected over as short a time as possible and from within a restricted area. The material required was only obtainable with the use of the R.V. Meiring Naudé. However even with the use of this vessel it was extremely difficult to locate reefs from which the required size range could be caught, resulting in the analysis being based on six samples only from which 417 fish were examined. To investigate differences in diet the fish were divided into three length groups: small (100-200 mm), medium (201-300 mm) and large (> 300 mm), fish smaller than 100 mm being inaccessible to the study.

Similar samples of *C. nufar* could not be obtained and variations in feeding related to size have not been investigated for this species.

To determine whether geographic variations occurred in the diets of *C. puniceus* and *C. nufar* the composition of the diets at each sampling station were determined using the percentage occurrence method. Seasonal changes in diet were investigated by analysing the monthly samples on a seasonal basis.

RESULTS

The food eaten by *C. puniceus* (Table 1)

Over 100 species or higher taxa were identified during this study. Analysis of alimentary contents showed that crustaceans and molluscs formed the main food groups along the Natal coast (Fig. 2) with teleosts and echinoderms (Crinoidea, Ophiuroidea and Echinoidea) making up the greatest proportion of the remainder of food organisms. No single species was predominant in the diet.

Crustacea 1 — Decapoda and Stomatopoda

This group of crustacea constituted the greatest proportion of the diet of *C. puniceus* in both volume and percentage occurrence, comprising 28.3% (by volume) of all food consumed and being present in 82% of the alimentary tracts examined.

Due to a poor systematic knowledge of brachyurans from these depths within the Natal region and as these animals are badly crushed when ingested by *C. puniceus*, the level of identification was extremely low.

Crustacea 2 — Amphipoda, Isopoda, Copepoda, Mysidacea, Euphausiacea and Cirripedia

Three species within these orders were found consistently in the alimentary tract: the mysid *(Gastrosaccus gordonae)* and two amphipods *(Corophium* sp. and *Podocerus* sp.). Although the inclusion of these three species in the diet was sporadic, it was often to the exclusion of all other food organisms in individual fish. This group of crustacea constituted 5.7% of all food consumed and were present in 11.0% of the alimentary tracts examined.

Mollusca 1 — Gastropoda and Bivalvia

Gastropod and bivalve molluscs were the second largest group in the diet of *C. puniceus,* occurring in 58.0% of all fish examined and constituting 15.2% by volume of all food items.

Due to the resistance of their shells to digestion and a good systematic knowledge of these classes along the Natal coast the level of identification was extremely high, with 57 species or higher taxa identified.

Table 1: The composition of the food of *C. puniceus* as determined by the volumetric (n = 1 150) and occurrence (n = 2 313) methods of analysis.

TELEOSTEI:

Sardinops ocellata
Scopelopsis multipunctatus
Myctophum phenogodes
Symbolophorus barnardi
Cynoglossus bilineatus
Malacanthus hoedtii
Anthias sp.
Antennarius coccineus
Caecula or *Callechelys* sp.

ECHINODERMATA 1:

Asteroidea

Astropecten granulatus natalensis

Crinoidea

Tropiometra carinata?
Gislenometra perplexa

ECHINODERMATA 2:

Echinoidea

Salamacis bicolor
Coeloplenrus maillardi

MOLLUSCA 1:

Gastropoda

Diodora elizabethae
Macroschisma africana
Stomatella sulcifera
Tricolia ? capensis
Rissoina crassa
Turritella carinifera (juv.)
T. natalensis (juv.)
Cypraea teres
C. citrina
C. helvola

MOLLUSCA 1: (contd.)

Cypraea spp. (juv.)
Stomatella sulcifera
Lamellaria or *Coriocella sp. (juv.)*
Crepidula porcellana
Tanea areolata
Polinices simae
Cymatidae sp. *(veliconchas)*
Ranella australasia gemmifera
Triphora sp.
Viriola sp.
Tonna sp. *(veliconcha)*
Nassarius formosus
N. pyramidalis filmerae
N. desmoulioides
Pyrene flavafilmera
Pisania n.sp
Engina incarnata
Austromitra rhodarion
Amalda obesa
A. contusa
A. reevei
Ancilla marmorata
Marginella sp.
Volverina ingloria
V. zonata
Volverina sp.
Hyalina lucida
Granula differens
Granulina sp.
Turridae sp. indet.
Clionella tripartita
Bathytoma simplicicingulata
Cavolinia tridentata
C. uncinata
C. longirostris
Philine aperta

MOLLUSCA 1: (contd.)

Bivalvia

Glycymeris connollyi
Neocardia sp.
Sheldonella lateralis
Modiolus ariculatus
Pteria sp.
Electroma physoides
Chlamys fultoni
Lima ? nimbifer
Pinna sp.
Parvicardium turtoni
Timoclea arakana

MOLLUSCA 2:

Cephalopoda

Sepia sp.
Octopus sp.
Abraliopsis sp.
Loligo sp.

BRYOZOA

PYCNOGONIDA:

Pycnogonum forte
Rhopalorhyncnus gracillimum
Nymphon setimanus

INSECTA:

Isoptera

Hodotermes mossambicus

CRUSTACEA 1:

Brachyura

Eurynome aspera
Munida sp.
Macropodia falcifera ?
Leptodius sanguineus ?
Portunus sp.

CRUSTACEA 1: (contd.)

Anomura

Pagurus sp.

Macrura

Scyllarus sp
Sergestes sp.

Stomatopoda

Squilla sp.

CRUSTACEA 2:

Cirripedia

Scalpellum sp.
Balanus sp.

Amphipoda

Corophium sp.
Podocerus sp.
Stegocephalus sp.
Amphilochus sp.

Copepoda

Pleuromamma xiphias

Isopoda

Paracilacea sp.

Mysidacea

Gastrosaccus gordonae

Euphausiacea

Euphausia similis
Euphausia sp.

ANNELIDA:

Marphysa sp.
Aphroditidae sp.

PORIFERA:

Tetraxonida

Tethya sp.

ALGAE:

Rhodophyta

Amphiroa ephedraea
A. dilatata
Ceramium sp.
Metamastophora sp.
Amansia sp.

Mollusca 2 — Cephalopoda

Although cephalopods constituted 6.9% by volume of all food items, they were found in only 2% of the fish examined and their presence in the diet of *C. puniceus* was sporadic. Of the four identified, whole juvenile *Octopus* sp. were the most prominent.

Mollusca 3 — Pteropoda *(Cavolinis tridentata)*

This food organism appeared briefly in the diet of *C. puniceus* between December 1980 and February 1981 when it constituted a small but significant part of the diet.

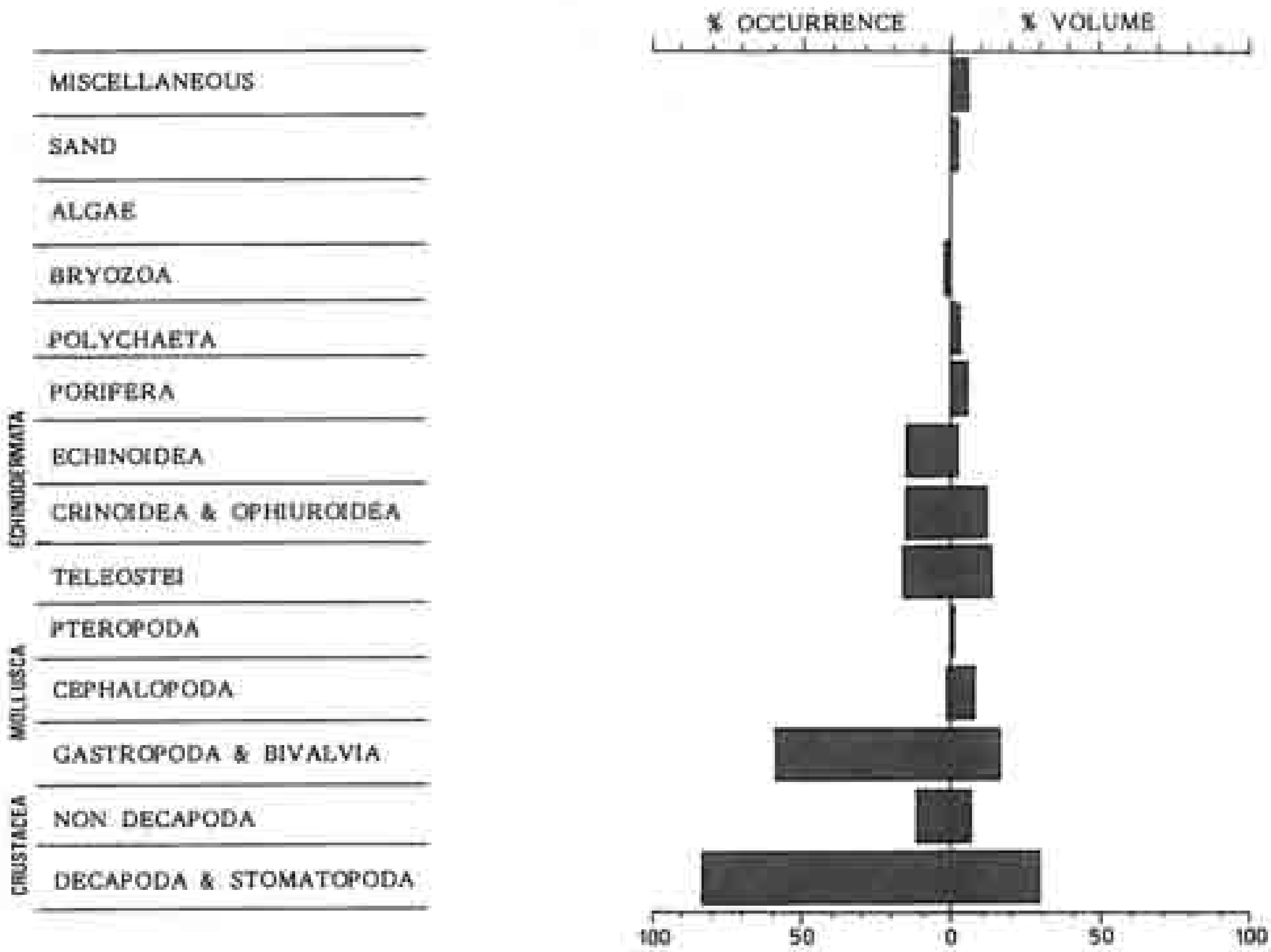

Figure 2. The composition of the food of *C. puniceus* using the occurrence (n=2313) and volumetric (n=1150) methods of analysis.

Teleostei

Teleosts appeared sporadically in the diet of *C. puniceus* but in many instances represented a large proportion of the food consumed. Occasional high percentage volume compositions (up to 71%) were due to the large size of the fish prey, such as *Sardinops ocellata, Scopelopsis multipunctatus, Myctophum phenogodes* and *Symbolophorus barnardi*, or to vast quantities of larval or juvenile fishes. When the latter were abundant in an area, a high percentage of *C. puniceus* fed almost exclusively on them.

Echinodermata 1 — Crinoidea and Ophiuroidea

Crinoids and ophiuroids were evident in fewer fish than were teleosts and constituted a correspondingly smaller proportion of the diet by volume (Fig. 2). However, they occurred throughout the year.

Unfortunately these animals were so badly crushed by *C. puniceus* that in most instances a distinction could not be made between the two groups.

Echinodermata 2 — Echinoidea

Echinoidea constituted only 2.8% by volume of the food consumed by *C. puniceus* but were evident in 15% of alimentary tracts. As these animals were badly macerated, the occurrence method of analysis probably represents a more accurate assessment of their importance than the volumetric method.

Porifera

A single species of sponge *(Tethya* sp.) occurred in the diet of *C. puniceus*. The sponge occurred frequently in the contents of the alimentary tract and constituted 26% by volume of the total diet during April and August 1980.

Annelida — Polychaeta

Polychaete remains, most of which were in an advanced state of digestion and could not be identified below ordinal level, were evident in the alimentary tract of *C. puniceus* during two months only (September 1980 & February 1981). No polychaetes were identified as such in the field.

Polychaetes contributed 2.5% to the volume of food consumed by *C. puniceus* and represented a surprisingly high percentage of the total food consumed in September 1980 (31%).

Bryozoa

Bryozoans occurred infrequently in the diet of *C. puniceus* and their contribution to the total amount of food consumed remained low throughout the study period.

Algae — Rhodophyta

Five species of algae were identified from the alimentary tract of *C. puniceus* (Table 1), but as their contribution to the total diet remained infrequent and extremely low throughout the study period, it is assumed that they were incidental and ingested merely in association with food organisms.

Sand

Sand and shell particles were infrequently ingested by *C. puniceus*, but during certain months they contributed significantly to the total amount of material ingested.

Miscellaneous

This category includes unidentifiable material, fish scales, fish eggs, elasmobranch egg casings, hard coral and the termite *Hodotermes mossambicus*, the last named representing 60% by volume of the food consumed by *C. puniceus* during October 1979. These termites were found in an isolated sample on the lower south coast of Natal.

Variation in feeding among *C. puniceus* of different sizes

Marked differences in diet existed between 'small', 'medium' and 'large' individuals of *C. puniceus* (Fig. 3).

The diet of small *C. puniceus* consisted mainly of the two groups of crustaceans, which were almost evenly represented, and of echinoderms, also almost evenly represented by brittle/feather stars and sea urchins. Molluscs and bryozoans made up the bulk of the remainder of food items with teleosts and porifera being almost insignificant in the diet (Fig. 3i). The Crustacea 1 group found in small individuals was represented almost entirely by small brachyurans and macrurans and there was an increase in the size of these animals with an increase in length of fish.

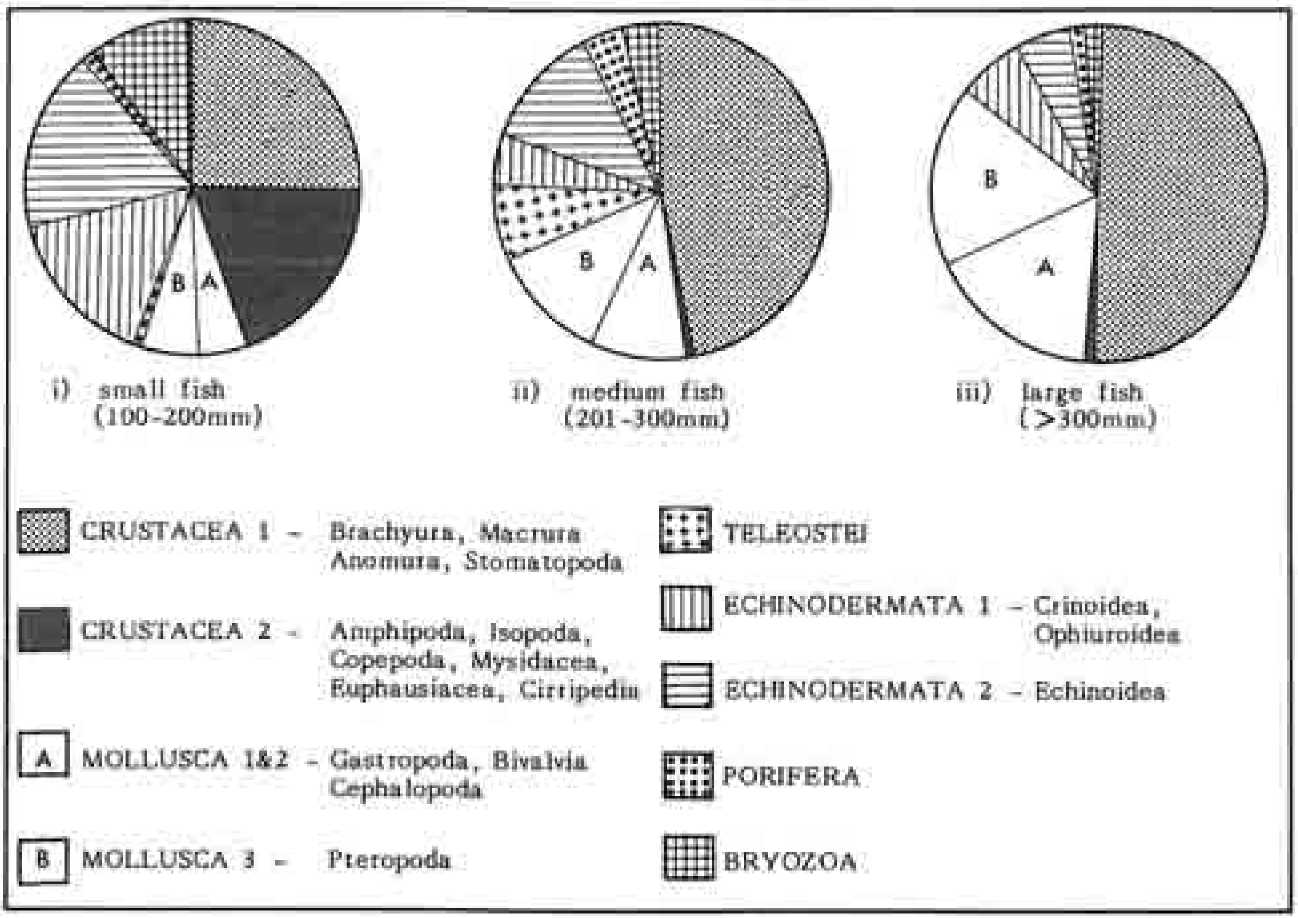

Figure 3. The percentage volume composition of the food of *C. puniceus* per size category.

A major change in diet occurred between small and medium *C. puniceus*. A large proportion of the diet of medium fishes consisted of representatives of the Crustacea 1 group with the Crustacea 2 group being almost insignificant (Fig. 3ii). Molluscs, which were almost evenly represented by the Gastropoda-Bivalvia-Cephalopoda group and *Cavolinis tridentata* were consumed in larger quantities by these fishes, as were teleosts which represented 7.83% of the diet. There was a reduction in the amount of Echinodermata and Bryozoa consumed, but an increase in Porifera.

The change in diet between medium and large *C. puniceus* was not as marked, but rather progressed in the same direction, with the Crustacea 1 group representing an even greater proportion of the diet, the Crustacea 2 group remaining insignificant and the remainder of the diet consisting mostly of Mollusca, with Echinodermata, Porifera and Bryozoa assuming less importance (Fig. 3iii).

Geographic and seasonal variations in the diet of *C. puniceus*

Representatives of the Crustacea 1 group and gastropod/bivalve molluscs formed the principal food organisms at each station along the coast (Fig. 4).

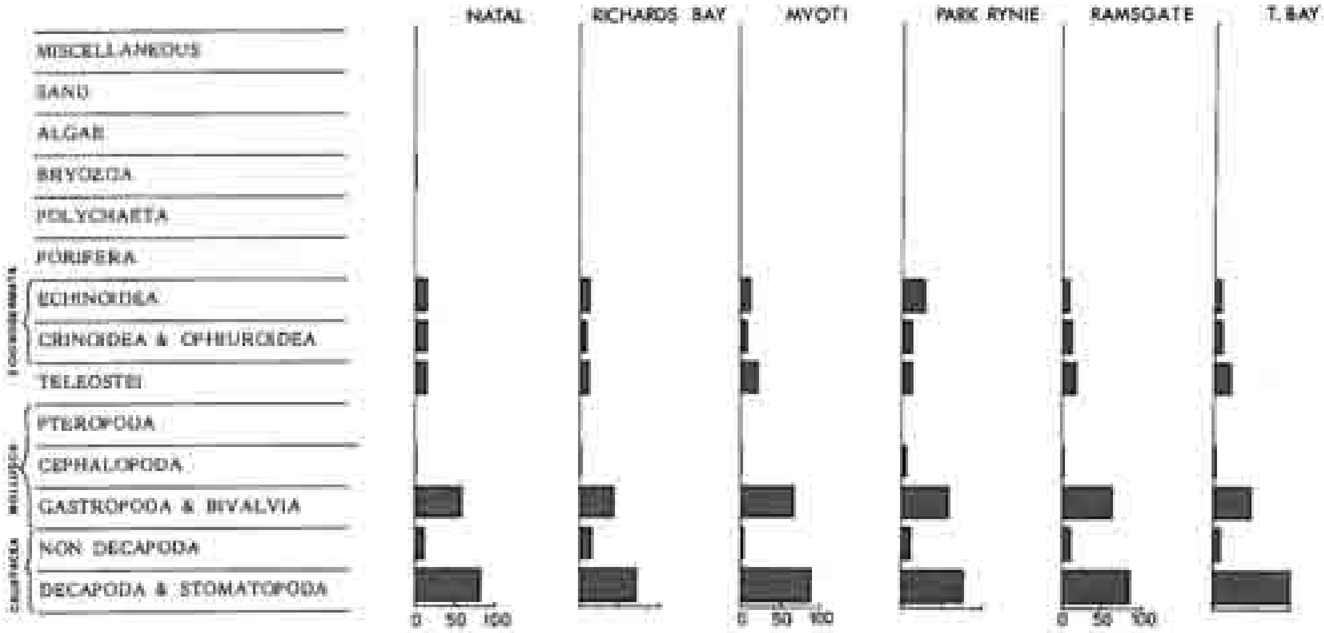

Figure 4. The composition by percentage occurrence, of the diet of *C. puniceus* along the Natal coast and at each sampling station.

The Crustacea 2 group constituted a small and fairly constant proportion of the diet at each station, except at Mvoti, from which fewer fish were found containing these organisms. Teleosts constituted a slightly higher percentage of the overall diet at each station than the Crustacea 2 group. The number of fish containing cephalopods remained low throughout the region. Crinoidea and Ophiuroidea remained fairly constant from one station to another, whereas many more fish at Park Rynie contained Echinoidea than elsewhere along the coast.

Apart from a similar diet during two successive autumns (χ^2 test, with $p > 0.05$), no pattern existed from one season to another or from one year to the next for any food category, the diet being almost as varied seasonally as it was from month to month (Table 2). Separation of the 14 categories of food organisms into two groups, viz. those that are consumed throughout the year and those that occur sporadically in the diet, did not reveal any seasonal trends either.

Food eaten by *C. nufar* (Table 3)

C. nufar is a member of the subfamily Denticinae, which differs from the subfamily Sparinae mainly in dentition. *C. nufar* has caniniform teeth only, whereas *C. puniceus* (subfamily Sparinae) has enlarged front teeth and strong rounded molars. The diets of these species are, therefore, quite different.

Twenty eight species or higher taxa were identified from the alimentary tracts of *C. nufar* during this study.

Table 2: Seasonal percentage volume composition of the food of *C. puniceus*

SEASON	CRUSTACEA 1	CRUSTACEA 2	MOLLUSCA 1	MOLLUSCA 2	MOLLUSCA 3	TELEOSTEI	ECHINODERMATA 1	ECHINODERMATA 2	PORIFERA	ANNELIDA	BRYOZOA	ALGAE	SAND	MISCELANEOUS
WINTER 1979 (Aug)	21.0	4.0	9.0	1.5	—	51.0	6.0	—	—	—	0.5	—	1.0	6.0
SPRING 1979 (Sep & Oct)	15.5	3.0	10.5	38.0	—	—	2.0	—	—	—	—	0.5	—	30.5
SUMMER 1980 (Feb)	49.0	4.0	22.0	—	—	11.0	4.0	—	2.0	—	—	2.0	6.0	—
AUTUMN 1980 (Mar — May)	25.7	9.7	10.3	6.0	—	21.3	11.0	1.7	9.7	—	0.3	0.3	2.0	1.0
WINTER 1980 (Jul & Aug)	15.0	2.5	18.5	—	—	35.5	9.5	3.5	13.0	—	—	0.5	—	2.0
SPRING 1980 (Sep — Nov)	35.3	4.0	18.3	0.7	—	—	25.3	4.0	1.3	10.3	—	—	—	0.7
SUMMER 1981 (Dec — Feb)	31.0	10.3	10.7	6.3	10.0	2.0	12.0	2.0	6.7	3.7	0.7	2.0	2.7	—
AUTUMN 1981 (May)	35.0	4.0	14.0	—	—	16.0	9.0	14.0	8.0	—	—	—	—	—
WINTER 1981 (June)	38.0	1.5	37.0	0.5	—	0.5	7.0	4.0	—	—	—	—	—	11.5
WINTER MEAN	24.7	2.7	21.5	1.0	—	29.0	7.5	2.5	4.3	—	0.2	0.2	0.3	6.5
SPRING MEAN	25.2	3.5	14.4	19.4	—	—	13.7	2.0	0.7	5.15	—	0.3	—	15.6
SUMMER MEAN	40.0	7.2	16.4	6.3	5.0	6.5	8.0	1.0	4.9	1.9	0.4	2.0	4.4	—
AUTUMN MEAN	30.4	6.9	12.1	6.0	—	18.7	10.0	7.9	8.9	—	0.2	0.2	1.0	0.5

Teleostei

Analysis of the diet of *C. nufar*, by frequency of occurrence, showed that teleosts were the most important source of food for this species. Thirty nine percent of fish contained teleost remains.

Mollusca — Cephalopoda

Four species of cephalopoda occurred in 11% of fish. Cephalopods represented the second most important food organism consumed by *C. nufar*.

Crustacea

Crustaceans were the third most important group of food organisms. This group was represented almost entirely by two species of Macrura *(Scyllarus* and *Sergestes* sp.) and the mysid *(Gastrosaccus gordonae)*. As a whole they were evident in 10% of the alimentary tracts examined.

Table 3: The composition of the food of *C. nufar*

Type of food		Percentage Occurrence: This study n = 1 072	Coetzee & Baird n = 224	Druzhinin 1975 n = ?
CRUSTACEA:		10.0%	9.6%	22.4%
Macrura	— *Scyllarus* sp.			
	Sergestes sp.			
Stomatopoda	— *Squilla* sp.			
Mysidacea	— *Gastrosaccus gordonae*			
Euphausiacea	— *Euphausia similis*			
Brachyura	— *Portunus* sp.			
MOLLUSCA:		11.0%	31.0%	6.61%
Cephalopoda	— *Sepia* sp.			
	Octopus sp.			
	Abraliopsis sp.			
	Loligo sp.			
TELEOSTEI:		39.0%	59.6%	61.7%
	Sardinops ocellata			
	Scopelopsis multipunctatus			
	Symbolophorus barnardi			
	Lepidotrigla faurei			
	Osopsaron sp.			
	Saurida undosquamis			
	Champsodon sp.			
	Etrumeus sp.			
	Bregmaceros sp.			
	Rhonciscus striatus			
	Scorpenaeidae			
	Callionymidae			
	Sphyraena sp. (juv.)			
	Malacanthus hoedtii			
	Hippocampus sp.			
ECHINODERMATA:				
Crinoidea	— *Tropiometra carinata* ?			
	Gislenometa perplexa			
ELASMOBRANCHII:				
	Dasyatis sp.			

Geographic and seasonal variations in the diet of *C. nufar*

Teleosts were the principal food item of *C. nufar* at all stations (Fig. 5). Cephalopods were evident in the diet at all stations, being most important at Thompsons Bay, least important at Mvoti and represented by similar percentages at the remaining stations. A relatively high percentage of fish containing representatives of the Crustacea 1 group were examined at Richards Bay, a smaller percentage at Mvoti, Park Rynie and Ramsgate and none at Thompsons Bay. The Crustacea 2 group were evident in the diet only at Richards Bay and

Park Rynie, where they were represented almost entirely by the mysid *G. gordonae*. No gastropod or bivalve molluscs were evident in the diet.

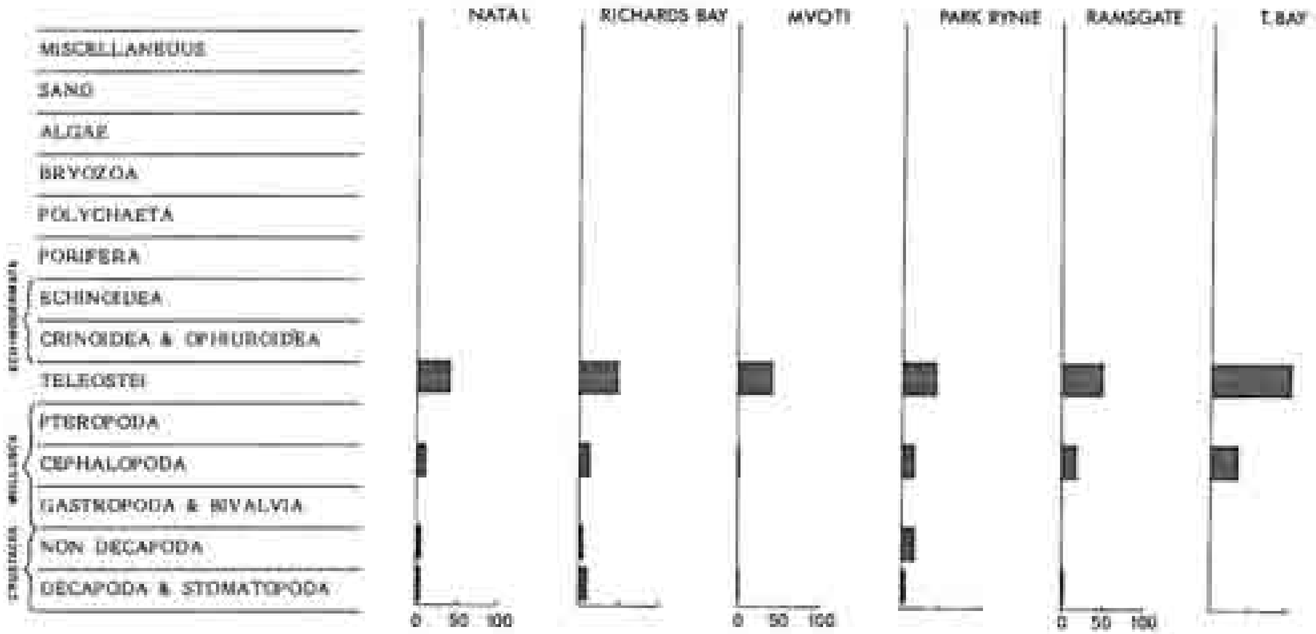

Figure 5. The composition by percentage occurrence, of the diet of *C. nufar* along the Natal coast and at each sampling station.

The analysis of seasonal variation in diet was limited to the 12 month period from July 1980 to June 1981. There was no change in the composition of the diet between seasons, but the frequencies in which food organisms were found changed considerably (Fig. 6).

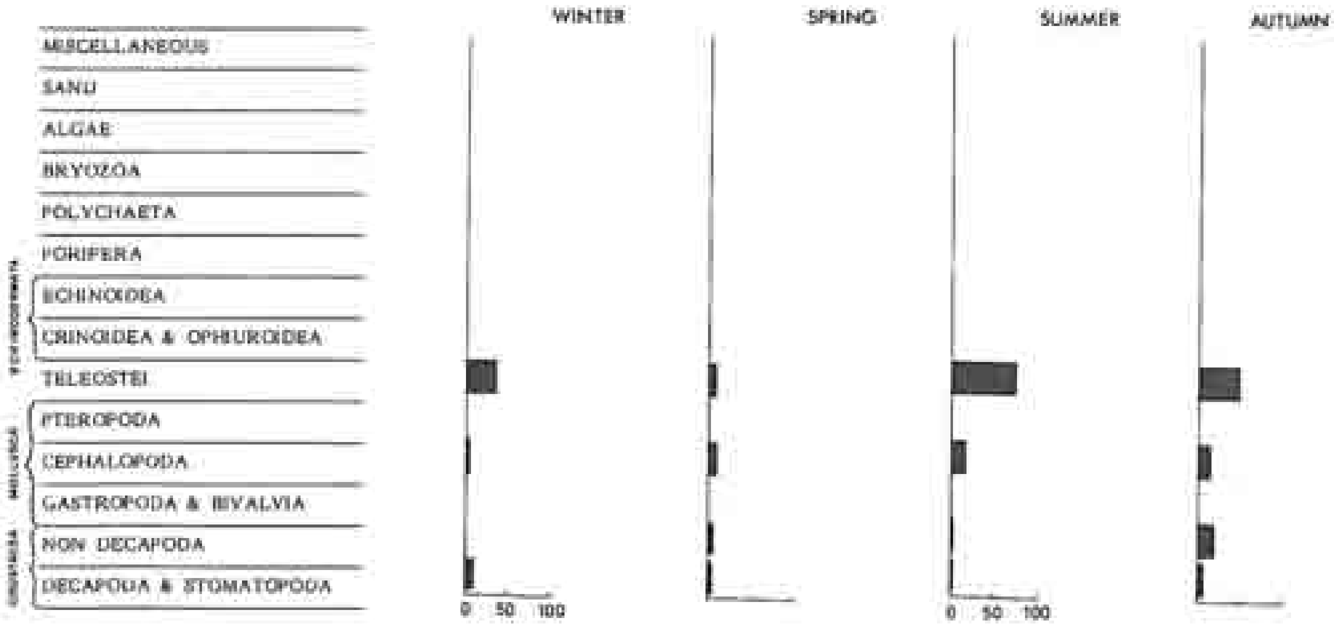

Figure 6. The mean seasonal composition of the diet of *C. nufar* by percentage occurrence.

DISCUSSION

Studies of southern African Sparidae that have dealt with or included aspects of diet have been carried out by Talbot (1955); Ahrens (1964); Hutchings (1968); Mehl (1973); Blaber (1974); Christensen (1976); Hecht (1976); Nepgen (1977); Coetzee (1978); Joubert & Hanekom (1980) and Coetzee & Baird (1981) Buxton & Clarke (1986), Smale (1986). Of these, the study carried out by Ahrens on the seventyfour *Polystegamus undulosus* is the only investigation in which an attempt has been made to assess the food and feeding habits of an offshore reef species in Natal. However, she was unable to provide meaningful data because of regurgitation, stomach eversion and an overwhelming presence of fishermens' bait.

Many methods for studying feeding among fishes have been formulated and have been extensively used by fisheries biologists. These include the frequency of occurrence, numerical, volumetric, gravimetric, points and the dominance methods, and have been reviewed by Hynes (1950), Pillay (1952), Laevastu (1965), Ricker (1971), Baird (1974), Christensen (1976) and Hyslop (1980).

The techniques adopted in this study were limited by the nature of the food organisms consumed, the feeding habits of the fish and the problems of regurgitation and stomach eversion. As most food organisms of *C. puniceus* were badly crushed and fragmented and those of *C. nufar* were mostly soft bodied and in varying stages of decomposition, the most suitable analyses were the occurrence and volumetric methods.

The occurrence method was chosen to assess the feeding habits of both species because of the large numbers of fish examined (Colman 1972), the rapidity with which material had to be assessed (Hyslop 1980), and because it gives a fairly good idea of the relative importance of food items (Pillay 1952). This method probably provides as reliable an indication of diet as numerical methods do, where mastication of food organisms is a problem (Stickney 1976; Crisp *et al.* 1978).

As volumetric techniques probably give the most representative measure of bulk (Hyslop 1980) the percentage volume composition of identifiable food items was used (Bonneau *et al.* 1972) in conjunction with the occurrence method (Windell 1971) to assess the feeding habits of *C. puniceus*.

The main criticisms of the methods employed in this study are that the occurrence method gives little indication of the relative amount or bulk of each food category (Colman 1972), while estimates of the percentage volume composition are difficult to obtain from food items that have been macerated (Hyslop 1980) and are, therefore, subjective (Godfriaux 1970). Hynes (1950) observes, however, that this criticism can be levelled at all methods of food analysis, especially when food organisms are badly crushed and partially digested. Inclusion of the hindgut also introduced a certain amount of bias, resulting in a possible over-estimation of hard bodied animals such as crustaceans and molluscs, and an under-estimation of soft bodied animals such as teleosts and cephalopods, but it was felt that however biased a picture the analysis presented, it would nevertheless yield some understanding of the feeding habits of *C. puniceus* and *C. nufar*. The results have shown that *C. puniceus* is a predator that is opportunistic in its feeding habits and has a very broad diet. This diet consists mainly of benthic organisms with crustaceans and molluscs predominating, but also includes a number of motile pelagic organisms. Similar diets have been recorded for the sparids: red porgy *Pagrus pagrus* of North and South Carolina (Bearden & McKenzie 1969; Manooch 1977), the New Zealand snapper *Chrysophrys auratus* (Godfriaux 1970; Colman 1972; Crossland 1981) and the Florida pinfish *Lagodon rhomboides* (Stoner 1980).

The diet of *C. puniceus* was fairly uniform along the Natal coast. Decapod and stomatopod crustacea were the principal food items at all sampling stations, with gastropod and bivalve molluscs forming the second most important group. Echinoderms were included in the diet at all stations, as were the smaller crustaceans: amphipods, copepods, isopods, mysids, etc. At

Mvoti fewer fish contained these crustaceans, which may be a result of the larger size of fish caught in that area (Garratt 1985) and the fact that there is a marked change in diet with increasing length of this species.

Seasonally, there appeared to be no pattern in the diet of *C. puniceus*. This may indicate that there are no distinct changes in food availability along the coast and that this species feeds on whatever it can whenever it becomes available. However, it is also possible that seasonal changes in diet may have been masked by a combination of broad feeding habits, broad categories to which prey organisms were assigned and the fact that data were collected over a wide area at different times. A more intensive feeding study may reveal seasonal patterns in the diet of *C. puniceus*.

A gastropod worth nothing in the diet of *C. puniceus* is the opisthobranch *Philine asperta* (Linne), family Philinidae. Members of this family are carnivores that burrow through sand and muddy sand searching for infaunal bivalves, polychaete worms, echinoderms and gastropods (Yonge & Thompson 1976). There are very few authenticated reports of any opisthobranchs being taken as food by fish, one of the few reported to do so being the haddock (Yonge & Thompson 1976). The skin of *P. asperta* contains cells that produce and store relatively strong sulphuric acid and it has been established that fish dislike any food that tastes acidic (W. Bateson in Yonge & Thompson 1976). The inclusion of this opisthobranch, albeit in small numbers, in the diet of *C. puniceus* and a closely related sparid *Chrysoblephus anglicus*, and the habits of *P. asperta*, suggests that these fishes disregard this defence mechanism, and ingest *P. asperta* while actively searching for food in sand.

The ingestion of sand has been recorded in the snapper *Chrysophrys auratus* (Godfriaux 1970); the red porgy *Pagrus pagrus*, (Manooch 1977); the panga *Pterogymnus laniarius*, (Hecht 1976) and in a few South African inshore sparids such as the banded galjoen *Coracinus multifasciatus* and the blacktail *Diplodus sargus* (Joubert & Hanekom 1980). None of the above workers could determine whether these particles are swallowed incidentally or whether they are used in the mechanical breakdown of food items in these species. However, the occasional presence of the opisthobranch *P. asperta* in the alimentary tract of *C. puniceus* and the fact that sand was only infrequently ingested by this fish, suggests that *C. puniceus* may at times feed on organisms found on or in sandy substrata and that sand and shell particles are subsequently swallowed incidentally.

Sponges have been recorded in the diets of other offshore species (Godfriaux 1970, Manooch 1977), but the amount ingested by them has been insignificant and thus regarded as material incidentally ingested with associated food. The occurence of a single species (*Tethya* sp.) in the diet of *C. puniceus* was also originally regarded as incidental, but the sponge not only occurred frequently in the alimentary tract but also constituted as much as 26% of the total diet during April and August of 1980. As it has been found that some sponges have calorific values higher than crustaceans and molluscs (Cummins 1967, Cummins & Wuycheck 1971), it would appear that *C. puniceus* includes this single species of sponge as part of its diet.

Cheimerius nufar is a more specialised feeder than *C. puniceus*. It is primarily a piscivore, but also feeds on cephalopods and crustaceans. Twenty eight species or higher taxa were identified in the diet of *C. nufar* in this study, 16 in the study conducted by Coetzee & Baird (1981) in the eastern Cape, and 15 in that of Druzhinin (1975) in the Gulf of Aden region. Coetzee and Baird (1981) were able to carry out an in-depth quantitative study on the feeding habits of *C. nufar* in the region of St Croix Island, Algoa Bay, using a modified points method and the occurrence method. In their study the contents of the stomach and intestinal tracts were investigated, and although regurgitation and stomach eversion occurred in a large percentage of their specimens (41.8% having empty stomachs), the number of stomachs containing food items was far greater than that in the present study. This is possibly due to the relatively shallow depths from which the samples were acquired (18-30 m).

Use of the occurrence method in this study, and the work by Druzhinin (1975) and Coetzee and Baird (1981), allowed comparisons to be made of the feeding habits of *C. nufar* from three regions that differ considerably in abiotic and biotic conditions, viz. The Gulf of Aden, Natal and the eastern Cape.

Teleostei constituted the most important source of food in each of the three regions (Table 4). However, the species composition of the diet varied from one region to another. Ten species of teleosts were identified by Druzhinin, 15 in this study and only five by Coetzee and Baird. Considering that the 15 species identified in this study were from a mere 4-5% of the total number of fish sampled, it is probable that *C. nufar* preys upon a wider variety of teleosts in Natal than in the Eastern Cape; and that the number of fish examined by Druzhinin were not sufficient to reveal the variety of teleosts preyed upon in that region.

Table 4: The percentage occurrence of the three main food categories of *C. nufar* in the Gulf of Aden, Natal, and the eastern Cape.

Region	Teleostei	Cephalopoda	Crustacea
Gulf of Aden	61.70%	6.61%	22.40%
Natal	39.00%	11.00%	10.00%
Eastern Cape	59.60%	31.00%	9.60%

Cephalopods constituted the second most important food organism in Natal and the eastern Cape, but in the Gulf of Aden region cephalopods took third place with crustacea occupying second. The high percentage of *C. nufar* containg cephalopods in the eastern Cape may indicate that cephalopods are a more important source of food in that region than in either of the other regions. Similarly, it would appear that crustaceans are more important in the diet of *C. nufar* in the Gulf of Aden region than in Natal or the eastern Cape.

Although changes in frequency, and hence the importance of food organisms, occur between the above three regions in which investigations have taken place, this study has shown that the diet of *C. nufar* from different regions is very similar. It has also shown that, whilst there are geographic and seasonal fluctuations along the Natal coast, the type of food preyed upon remains fairly constant.

Finally, the occurrence of the termite *Hodotermes mossambicus* in the diet of *C. puniceus* requires some explanation. The alate forms of *H. mossambicus* emerged from their nests in their thousands on the evening prior to sampling the boats on the lower south coast of Natal during October 1979. This emergence coincided with heavy downpours of rain in the region. The following day *C. puniceus* caught in approximately 40 m of water were found to have stomachs that were so full of the termite and so distended that the fish had difficulty regurgitating their stomach contents. The termites found in the stomachs of these fish had retained their wings, and as this insect floats on water (due to the high fat content of the abdomen and surface tension on the wings), it must be assumed that shoals of *C. puniceus* rose from the depths to the surface to feed on them. As there is no other logical explanation as to how these fish received the 'message' that food was available on the surface, it must be assumed that *C. puniceus,* on occasion, frequents the upper layers of the water column during darkness.

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