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THE FEEDING ECOLOGY OF GERREIDAE (TELEOSTEI) IN THE KOSI SYSTEM, WITH SPECIAL REFERENCE TO THEIR SEASONAL DIET

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INTRODUCTION

The biology of the family Gerreidae has not been investigated in any detail and most published information consists of incidental records or notes in general surveys.

Six species of the family, all of the genus *Gerres,* live in the coastal waters of southern Africa (Smith, 1965). They occur in estuaries as far south as the Zwartkops River in the eastern Cape but are uncommon south of the Umtamvuna River in southern Natal. Five species are present in the Kosi system of northern Natal (Fig. 1), where three species are abundant over shallow sandy areas (Blaber, 1978; Cyrus, 1980).

Gerreidae are of economic importance in India and south east Asia particularly in the Pulicat Lake, India (Prabhakara Rao, 1968) and in Africa in the Kosi system (Blaber, 1978; Cyrus, 1980). Wallace *et al.* (1971) classified two of the *Gerres* species from the Kosi system as 'non-angling species of significance as human food'. A study of Gerreidae was undertaken because they are abundant, their role in the estuarine food web was unknown and there was no information on their ecology. The Kosi estuary and lakes were selected as the main study area because Gerreidae are abundant in the system which is in a relatively undamaged state (Begg, 1978). The local economic importance of *Gerres* at Kosi also provided an impetus to research since long-term plans for the management of the local fishery are being drawn up. Detailed biological knowledge of Gerreidae was therefore considered essential as they are one of the commonest groups of fish in the Kosi system. In this paper the food and feeding of Gerreidae in the Kosi system are described with particular reference to the seasonal aspects of diet of the different species. The overall aspects of food and feeding ecology of Gerreidae in the estuaries of Natal, with particular reference to food available in the benthos and the selection of prey, has been published separately (Cyrus & Blaber, 1983a), as has the diet of fry ($<$ 40 mm S.L.) (Cyrus & Blaber, 1983b).

STUDY SITE

The Kosi system consists of four distinct but connected lakes which drain into the sea via a usually permanently open estuary (Fig. 1). The system has a catchment of 500 km^2 with a feeder river length of 30 km. The estuarine area covers some 3500 ha, while the shore line is 53,5 km long (Begg, 1978). The topography and bathymetry of the system and the physics and chemistry of Lakes Nhlange and Mpungwini were studied by Broekhuysen and Taylor (1959), Hill (1969) and Allanson and van Wyk (1969), while Blaber (1978) has given details of the physical characteristics of the system which are important to fish populations. Begg (1978) reviewed all information available on Kosi to assess the present state of knowledge of the system and classed its environmental condition as good.

Due to their distance from the mouth and position in relation to freshwater inflow, each of the lakes is subject to different salinity regimes. Amanzim-

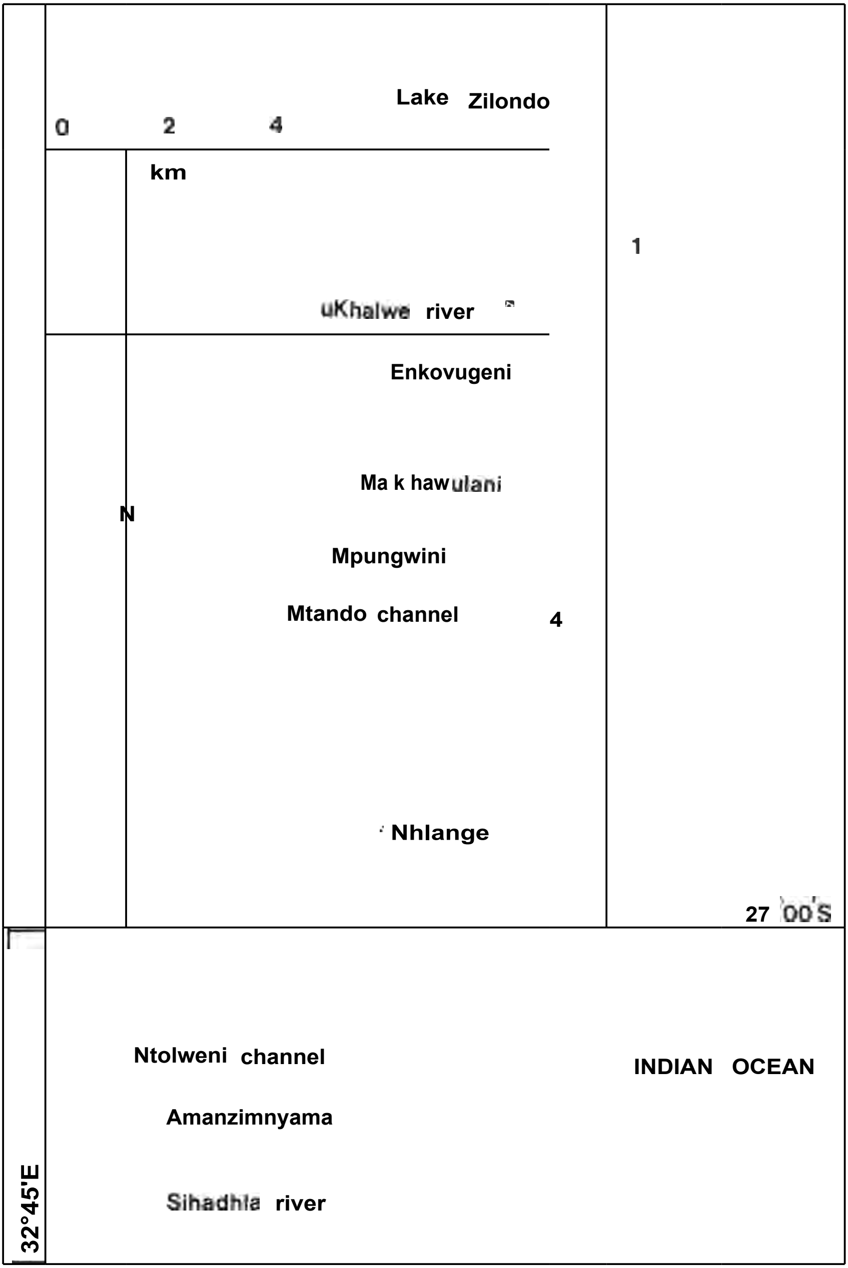

Figure 1. The Kosi system (● = sampling sites; 1 = Estuary; 2 = Water Level Recorder; 3 = Makhawulani; 4 = Mpungwini; 5 = Nhlange).

nyama is always fresh (Blaber, 1978), Nhlange ranges from fresh to 5‰ (Blaber & Cyrus, 1981) and was between 0,5 and 1% during the study period. Mpungwini and Makhawulani show greater variation due to tidal influence, the former ranged from 3 to 6% and the latter from 7 to 14‰ during the study period. At high tides a salt wedge is usually present, extending from the mouth as far as the entrance to Lake Makhawulani, a distance of some 6 km. Temperatures from 17 to 28° C were recorded in this study, these corresponding with the records from the system given by Allanson and van Wyk (1969) and Blaber (1978). The average annual rainfall at the Natal Parks Board station on the north west shore of Lake Nhlange (1965-80) was 1035 mm (n = 16; S.D. = 249), but the study period (October—September, 1978/9 and 1979/80) had slightly less than average (836 and 912 mm). The possible relationship between salinities in Nhlange and annual rainfall are discussed by Blaber and Cyrus (1981). Kosi is an extremely clear water system, particularly when compared with other Natal estuaries. Turbidity measured during 1980 ranged from 0,8 to 4,7 Nephelometric Turbidity Units. There was little variation in turbidity throughout the system.

SUMMARY OF PUBLISHED WORK ON THE SYSTEM

The only botanical work of note at Kosi was that of Breen and Hill (1969) who studied the mass mortality of mangroves caused by the extensive flooding of the system in 1965. The invertebrate fauna has been little studied, although Boltt and Allanson (1975) invistigated the benthic fauna of Lake Nhlange, while Forbes (1979) discussed the distribution and status of the burrowing Sandprawn, *Callianassa kraussi* in the system.

The fish fauna of Kosi has received most attention, but many of the earlier surveys were non-quantitive with limited sampling. These included Campbell and Allanson (1952), Broekhuysen and Taylor (1959), Pike (1967, 1968, 1969 and 1971) and Wallace *et al.* (1971). Recently more detailed work has been carried out by Blaber (1978) and the checklist of recorded species has been revised by Blaber and Cyrus (1981). A number of studies on species and species groups have been undertaken and included work on *Croilia mossambica* (Blaber & Whitfield, 1977a), adult and juvenile mullet (Blaber, 1977; Blaber & Whitfield, 1977b), *Pomadasys commersonni* (Hay & Blaber, In press), *Rhabdosargus sarba* (Blaber, In prep.), *Pranesus pinguis* (Harman *et al.*, 1981), filter feeders (Blaber & Cyrus, 1981) and juvenile gamefish: Carangidae (Blaber & Cyrus, 1983), Sphyraenidae (Blaber, 1982) and Ambassidae (Martin, 1983). Most of the aspects of the biology bf the family Gerreidae in the Kosi system have now also been studied: food and feeding of juveniles and adults (> 40 mm S.L.) (Cyrus & Blaber, 1983a), diet of fry (< 40 mm S.L.) (Cyrus & Blaber, 1983b), reproduction (Cyrus & Blaber, 1984a), predation on *Gerres* (Cyrus & Blaber, 1984b) and species identification and distribution (Cyrus & Blaber, 1982a). Whitfield and Blaber (1979) discussed the penetration of the estuarine environment, particularly at Kosi, by the freshwater teleost *Sarotherodon mossambicus.* Work in progress at present includes a study of *Monodactylus* species. Once this is complete all the important species in the system will have been studied and it should be possible to erect a food web for the fish community.

MATERIALS AND METHODS

Five sites in the Kosi system (Fig. 1) were sampled quarterly from July 1978 to July 1980. Attempts were made to collect a minimum of 30 individuals of each species of *Gerres* from each *site* during each field trip, using 70 m x 2 m x 12 mm bar mesh net. This was however not always possible due to seasonal variation in the numbers of the different species. All specimens were preserved immediately in 10% formalin for analysis in the laboratory. During the summer and autumn trips of 1979 twenty-four hour seining stations were operated at Station 2 the Water Level Recorder (W.L.R.) (Fig. 1), seining every three hours in order to establish the feeding periodicities of the different species.

During the four seasons in 1979 two benthic samples, consisting of five grabs each, were collected from each seining site using a Zabolocki type Eckman grab which samples an area of $0,023m^2$ to a maximum depth of 4,5 cm. The five grabs of each sample were taken at distances of 10, 20, 30, 40 and 50 metres from the shore line. After collection larger organisms were separated by washing the sample through a 1mm sieve. A solution of 10% formalin was added to the remainder and the sample stirred into suspension. The formalin causing the live organisms to come to the surface. The formalin was then decanted through a 0,5 mm sieve. This procedure was repeated a minimum of five times; in nearly all cases the number of organisms from the fifth sieving was nil. After each sieving the animals were placed, together with those from the 1mm sieve, into a bottle containing 10% formalin and the vital dye phloxine. The latter facilitated later recognition and sorting of animals. Samples were analysed in the laboratory.

ANALYSES

(a) Laboratory analysis of diet

Stomach contents of individual fish were analysed using four methods:

(i) Frequency of occurrence: the number of stomachs in which each prey item occurred was recorded and expressed as a percentage of the total number of stomachs examined.

(ii) Numerical occurrence: the number of each prey type in all stomachs was expressed as a percentage of the total number recorded.

(iii) Percentage calorific contribution of each prey item: energy values of individual food items were used to establish the percentage energy contribution of each prey type.

(iv) The 'Points' method of Ricker (1968): the percentage fullness of a stomach was assessed, prey items were sorted into species groups and points were then allocated to each group according to the proportion they represented in relation to the other groups present, and the fullness of the stomach. The maximum total points which could be allocated was 100 for a full stomach. This method approximates the volumetric analysis of diet.

Species densities obtained from the benthic analysis were converted to Joules of energy available in the benthos , per species or species group, per m^2 of substrate. From this the percentage energy contribution of the dominant groups at each sampling site could be calculated. The calorific values used for the different groups were obtained from a number of sources and are listed in Cyrus and Blaber (1983a).

(b) Feeding periodicity

Results of the 'points' method of analysis of stomach contents of fish caught during the twenty-four hour seining station at the W.L.R. (Fig. 1) were used to establish the feeding periodicities of the different species.

(c) Benthos

Benthic samples were washed in water causing organic matter to become suspended and enabling it to be poured off through a 0,2 mm sieve. This retained all organic material but not fine substrate particles. The washed samples were then poured into a large petri dish marked with a grid of 42 squares each measuring 2 x 2 cm. Ten squares were then selected using random numbers tables and every animal in each of these was counted. From these counts an estimate of the number of each species per m^2 could be derived.

TABLE 1. Catch per unit effort from seine netting of *Gerres* (>40 mm S.L.) at five sites in the Kosi system during 1979. (S = summer; A = autumn; W = winter; Sp = spring).

	G. *acinaces*				G. *filamentosus*				G. *rappi*				G. *oyena*				G. *oblongus*			
	S	A	W	Sp	S	A	W	Sp	S	A	W	Sp	S	A	W	Sp	S	W	A	Sp
Estuary	13,0	7,5	6,5	4,0	1,8	10,3	15,7	0,2	0,1	0	1,0	0	0	4,1	5,0	0	0,5	1,7	0,8	0,6
Water Level Recorder	5,4	3,7	3,8	9,5	4,8	3,0	0	0	77,7	3,7	0	0	0	0,2	0	0	0	0	0	0
Makhawulani	8,0	7,0	9,1	17,3	22,0	3,8	0,1	0	16,0	4,0	0	0	0	0,1	0	0	0	0	0	0
Mpungwini	8,8	5,6	6,2	14,8	5,6	0,1	0,1	0	6,8	0	0	0	0	0	0	0	0	0	0	0
Nhlange	0,1	0,3	0	0,9	2,9	0,5	0	1,6	22,1	10,8	0	11,6	0	0	0	0	0	0	0	0

RESULTS

1) Abundance and Seasonality

Results from seine netting over four seasons during 1979 are shown in Table 1 in terms of catch per unit effort. This table also shows the seasonal variation of *Gerres* species in the Kosi system. Of the five species recorded during the study *G. oblongus* and *G. oyena* were uncommon and occurred almost exclusively at the estuary. The other three species were found throughout the system being most common during summer and autumn. During the winter and spring only *G. acinaces* was present in any numbers, the other species either leaving the system or moving off the shelf areas of the lakes.

2) Feeding periodicity

Seining every three hours for 24 h periods was undertaken at the W.L.R. site during the summer and autumn The percentage fullness of the stomachs of the three species captured was plotted against time (Fig. 2). The summer sample (Fig. 2a) showed that *Gerres acinaces* fed throughout the day with a peak at 09h00 and a low at 24h00. *G. filamentosus* and *G. rappi* fed mostly during the early evening with *G. rappi* feeding also in the early morning (03h00). Results from autumn (Fig. 2b) revealed a slightly different feeding pattern. All three species fed continuously throughout the day. The lowest percentage fullnesses were recorded between 21h00 and 01h00, as in the summer sample. *G. oblongus* and *G. oyena* occurred only at the estuary and their feeding periodicity was not determined. The movement of large number of *Gerres* into the estuary basin with the rising tide was observed during snorkeling, and seine netting has also shown that fewer fish are present during low tide. Tides may, therefore, affect the feeding periodicity of fish in the estuary area.

3) Diet of Immature and Adult *Gerres* (> 40 mm S.L.)

The overall aspect of the diet of this group in Natal estuaries has formed a separate paper (Cyrus & Blaber, 1983a). Overall polychaetes were found to be important at the Estuary site, siphon tips (distal ± 5 mm) of the bivalve *Hiatula lunulata* were most commonly taken at the Water Level Recorder, Makhawulani and Mpungwini sites, while chironomid larvae were important in Lake Nhlange. The application of Ivlev's electivity test (Ivlev, 1961) showed that *Gerres* positively selected bivalve siphon tips when searching for food (Cyrus & Blaber, 1983a). Table 2 summarizes the dominant items in their diet.

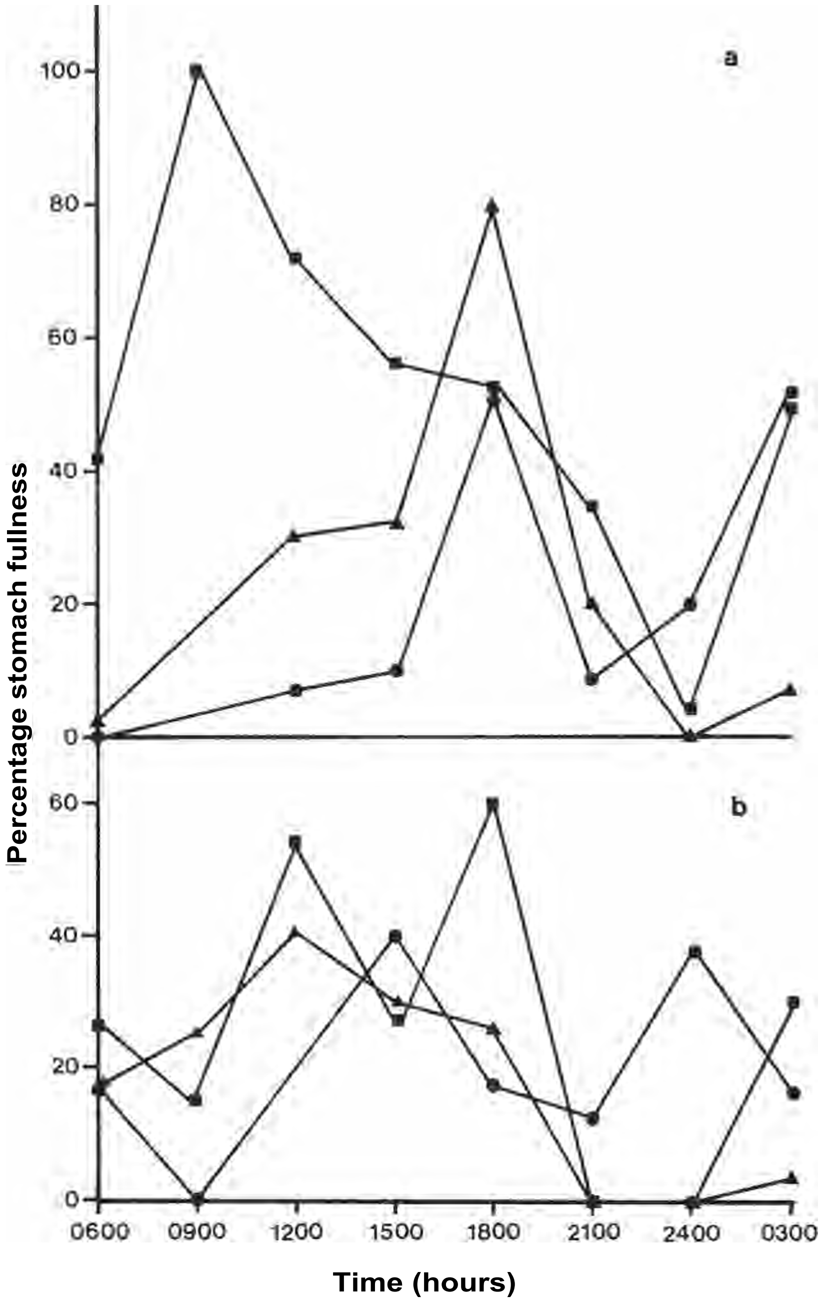

Figure 2. Feeding periodicity of three Gerres species based on the 'points method of stomach analysis. (a = summer 1979; b = autumn 1979; ● = G. rappi;• = G. acinaces; ▲ = G. *filamentosus*).

TABLE 2. Summary of dominant items in the diet of *Gerres* species (40 mm S.L.) in the Kosi system, based on the percentage each food item contributed to the diet in terms of energy (Joules).

Species	*G. acinaces*	*G. oblongus*	*G. oyena*	*G. filamentosus*	*G. rappi*
Musculus virgiliae	–	–	–	–	18
Hiatula lunulata (siphon tips)	64	–	56	59	22
Polychaeta	11	59	32	14	
Copepoda	–	25		–	
Hymenosoma orbiculare	–	–	–	–	17
Chironomidae (larvae)	17	–		21	32
% contribution of dominant items	92	84	88	94	89

The seasonal analysis of the diet of *Gerres* species at each seining site, in terms of energy obtained, is shown in Table 3.

(i) Estuary

At the estuary polychaetes were the dominant food item taken by all species throughout the year, but fewer were eaten in winter and spring (Table 3). During autumn the number of *Gerres* species present in the estuary increased to four with the arrival of *G. oyena*. At this time polychaetes were still the dominant prey of *G. acinaces* and *G. filamentosus,* while *G. oblongus* and *G. oyena* had a more varied diet (Table 3). In winter *G. rappi* arrived in the estuary and the other four species already present showed major changes in their diet. At this time the numbers of polychaetes in the benthos declined (Fig. 3a) and *G. acinaces* and *G. oyena* fed mainly on *Hiatula lunulata* siphon tips, *G. oblongus* took marine calanoid copepods and *G. rappi* fed chiefly on *Musculus virgiliae.* The fifth species *G. filamentosus,* had the most varied diet with the following items making important energy contributions:- *H. lunulata* siphon tips (30%), *Hymenosoma orbiculare* (25%), marine calanoid copepods (24%) and polychaetes (15%). During spring only two species, *G. oyena* and G. acinaces, were present in the estuary and they fed on similar food items, mainly chironomid larvae and polychaetes.

(ii) Water level Recorder

Hiatula lunulata siphon tips were the most important food item taken by all species during the seasons they were present at the W.L.R. *G. rappi* showed the most varied diet (Table 3). *G. acinaces* was the only species present at this site during autumn and winter and although *H. lunulata* siphon tips were still the most important food the diet was more varied. This might be attributed to an increase in the densities of the other food items (Fig. 3b) as well as to a decrease in the number of *H. lunulata,* for example *Hymenosoma orbiculare* which was usually present in insignificant densities, increased to 181 m^{-2} during spring.

(iii) Makhawulani

In Makhawulani *Hiatula lunulata* siphon tips were the most important food item taken by all species throughout the year (Table 3). During summer *H. lunulata* siphon tips and *Musculus virgiliae* were the major items in the diet of *G. rappi,* while the former item and polychaetes were important during autumn. *G. acinaces* was the only species present during winter and spring and as at the previous site they showed greater variation in their diet during

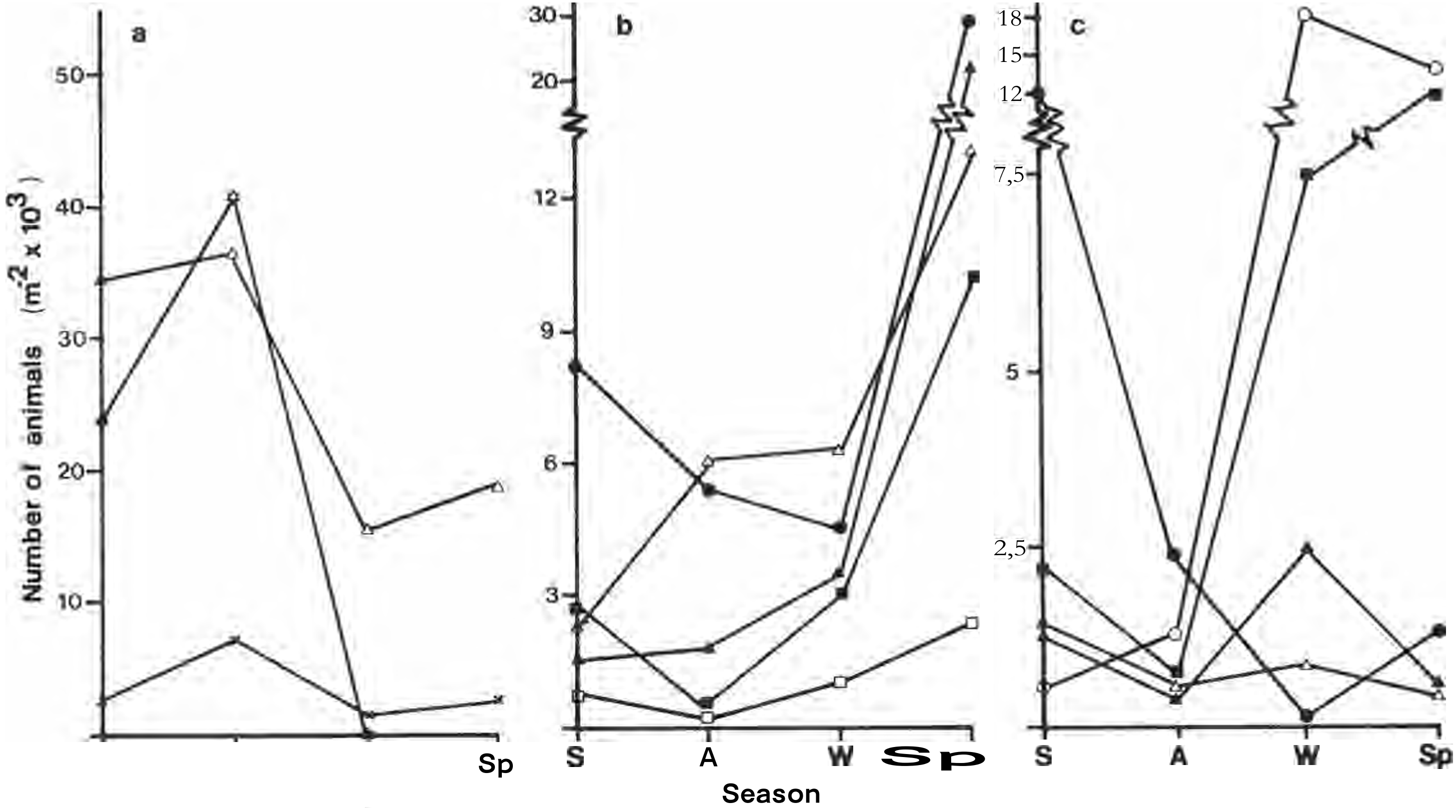

Figure 3. Seasonal variation (density m) of dominant benthic groups at three localities in the Kosi system during 1977. (a = Estuary; b = Water Level Recorder; c = Makhawulani; S = Summer; A = Autumn; W = Winter; Sp = Spring; = Foraminifera; = Polychaeta; x = Nematoda; ● = Oligochaeta; ▲ = Amphipoda; • = Cumacea; □ = Chironomidae larvae; o = Isopoda - Cirolana fluviatilis).

TABLE 3. Seasonal analysis of the diet of Gerres species (› 40 mm S.L.) from five sites in the Kosi system measured in terms of the percentage energy contribution (Joules) of each food item. (n = number; - = important items in diet; A = autumn; W = winter; Sp = spring; S = Summer.

Locality	Estuary													
Season	Summer				Autumn				Winter			Spring		
Species	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Musculus virgiliae					-	-	-			-	3	83	-	
Hiatula lunulata (Siphons)	-	4	-	-		22	4	66	-	74	30	-	24	-
Polychaeta	94	80	99	90	60	60	80	17	3	17	E	-	27	30
Oligochaeta	-	-	<1	-	<1	U	8	–	-	-	-	-	-	-
Ostracoda		-	<1	<1	-	-	-	-	-	-	-	<1	4	
Copepoda (calanoid)	5	13		8	13	1	5	6	89	4	24	<1	-	-
Isopoda	-	-	-	-	-	-	-	-	-	4	2	-	-	-
Amphipoda	<1		<1	<1	-	<1	<1	4		<1	<1	2	<1	-
Cumacea						-	-	-	-	-	-	-	-	-
Mysidacea	<1	3	-	1	23	3	2	4	8	-	4	-		-
Hymenosoma orbiculare	-	-	-	-	-	-	-	10		-	25	-	-	-
Chironomidae (larvae)		-	-	-	3	-	4	<1		-	-	14	48	70
%fullness (points)	44	36	26	36	14	48	57	30	12	6	28	7	46	34

Locality	Water Level Recorder							
Season	Summer		Autumn				W	Sp
Species	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Musculus virgiliae	-	5	-	-	-	-	4	4
Hiatula lunulata (Siphons)	98	82	42	97	95	79	74	70
Polychaeta	<1	5	4	7	7	6	5	<1
Oligochaeta	-	-	-	-	-	-	-	-
Ostracoda	<1	<1	<1	-	<1	4	–	4
Copepoda (calanoid)	-	-	-	-	-	-	-	-
Isopoda	-	-	4	4	-	4	<1	3
Amphipoda	<1	<1	1	<1	<1	3	1	1
Cumacea	<1	<1	<1	<1	<1	4	-	<1
Mysidacea	-	-	-	<1	<1	<1	<1	[illegible]
Hymenosoma orbiculare		-	-	-	-	2	2	23
Chironomidae (larvae)	1	7	48	1	4	9	16	2
%fullness (points)	63	32	42	47	30	28	44	35

Locality	Makhawulani							
Season	Summer		Autumn				W	Sp
Species	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Musculus virgiliae	4	-	44	-		1	4	2
Hiatula lunulata (Siphons)	99	99	47	99	99	48	81	69
Polychaeta	<1	<1	2	<1	-	38	5	<1
Oligochaeta	-	-	-	-	-	-	-	-
Ostracoda	4	4	<1	-	-	<1	-	<1
Copepoda (calanoid)	-	-	-	-	-	4	-	<1
Isopoda	<1	-	5	<1	<1	1	5	24
Amphipoda	<1	4	4	<1	<1	<1	<1	.
Cumacea	<1	<1	<1	-	<1	<1	<1	<1
Mysidacea	<1	[illegible]	-	4	–	-	-	<1
Hymenosoma orbiculare	-	-	-	-	<1	-	2	2
Chironomidae (larvae)	<1	<1	<1	<1	<1	11	6	1
%fullness (points)	78	28	6	71	43	46	44	25

Locality	Mpungwini					
Season	Summer		A	W		Sp
Species	[illegible]	[illegible]	G. [illegible]	[illegible]	[illegible]	[illegible]
Musculus virgiliae	<1	7	-	<1	12	4
Hiatula lunulata (Siphons)	33	88	3	98	80	93
Polychaeta	7	<1	3	<1	<1	<1
Oligochaeta	-	4	<1	-	<1	-
Ostracoda	<1	<1	<1	-	-	-
Copepoda (calanoid)	4	<1	-	-	<1	<1
Isopoda	2	4	-	<1	<1	<1
Amphipoda	<1	<1	<1	<1	1	<1
Cumacea	<1	<1	<1	-	<1	<1
Mysidacea	<1	-	-	-	4	–
Hymenosoma orbiculare	61	3	82	1	5	<1
Chironomidae (larvae)	3	<1	11	4	<1	-
%fullness (points)	56	36	8	79	58	49

Locality	Nhlange				
Season	Summer		A	Spring	
Species	[illegible]	[illegible]	[illegible]	G. filamentosus (n = [illegible])	G. rappi (n = 35)
Musculus virgiliae	-	-	-	-	
Hiatula lunulata (Siphons)	-	-	-	-	6
Polychaeta	<1	<1	<1	-	-
Oligochaeta	-	-	-	-	-
Ostracoda	<1	-	-	-	<1
Copepoda (calanoid)	<1	<1	-	-	76
Isopoda	-	<1	<1	<1	-
Amphipoda		<1	<1	-	<1
Cumacea	-	-	-	<1	-
Mysidacea	-	-			
Hymenosoma orbiculare	-	-	-	-	-
Chironomidae (larvae)	99	99	99	99	17
%fullness (points)	49	23	53	27	29

these seasons; in spring the isopod *Cirolana fluviatilis* contributed 24% of their diet. This coincided with an increase in densities of *C. fluviatilis* (Fig. 3c).

(iv) Mpungwini

During the autumn, winter and spring *G. acinaces* was the only species present in Mpungwini and *Hiatula lunulata* siphon tips were the main items of diet. In summer, however, the diet of the three species of *Gerres* present differed (Table 3) as follows:- *G. acinaces* and *G. rappi* both had *Hymenosoma orbiculare* as their most important food items with *Hiatula lunulata* siphon tips and chironomid larvae being of secondary importance to each species respectively. *G. filamentosus,* however, fed almost exclusively on *H. lunulata* siphon tips. Mpungwini was the only locality where *Hymenosoma orbiculare* was of any significance in *Gerres* diet, it was also here that it was present in significant number in the benthos, with highest densities being recorded during summer. The dominant species in the benthos fluctuated greatly over the seasons (Fig. 4a).

(v)Nhlange

In Nhlange chironomid larvae were the single most important food item taken at all seasons (Table 3) by all species (> 90%), except when they were at their lowest densities (137 m^{-2}) in spring (Fig. 4b). During this season *G. rappi* switched to the copepod *Pseudodiaptomus stuhlmanni* with chironomid larvae only making up 17% of the diet. In summer *Gerres* fed predominantly on chironomid larvae (99%) when they were at their greatest densities (5995 m^{-2}). *G. filmentosus* also took small numbers of Odonata larvae for which no energy value was available. Seasonal analyses of the diet of *G. acinaces* were not possible as they were present in only small numbers, (catch per unit effort – $\bar{x}$ of four seasons = 0,3) at this site.

4) Benthic Analysis

The density of animals in the substrate and their overall percentage contribution to the diet of *Gerres* in the Kosi system has been described by Cyrus and Blaber (1983a). Table 4 summarises the percentage energy contribution of the dominant groups to the benthos of the five sampling sites. The seasonal variation of the dominant benthic groups at each of the sites are illustrated in Figs. 3 and 4. Although most groups were commonest during spring and summer, seasonal variation in the densities of dominant groups did occur. *Cirolana fluviatilis* and oligochaetes showed highest densities during winter at Makhawulani and Nhlange respectively.

TABLE 4. Percentage energy contribution of dominant items in the benthos at five sampling sites in the Kosi system.

	Estuary	Water Level	Makhawulani	Mpungwini	Nlange
Polychaeta	98	45		41	24
Cirolana fluviatius		24	90	16	
Hymenosoma orbiculare	–	15		26	–
Chironomidae (Larvae)	–			–	59
Hiatula lunulata			–	10	
% contribution of dominant items	98	84	90	93	83

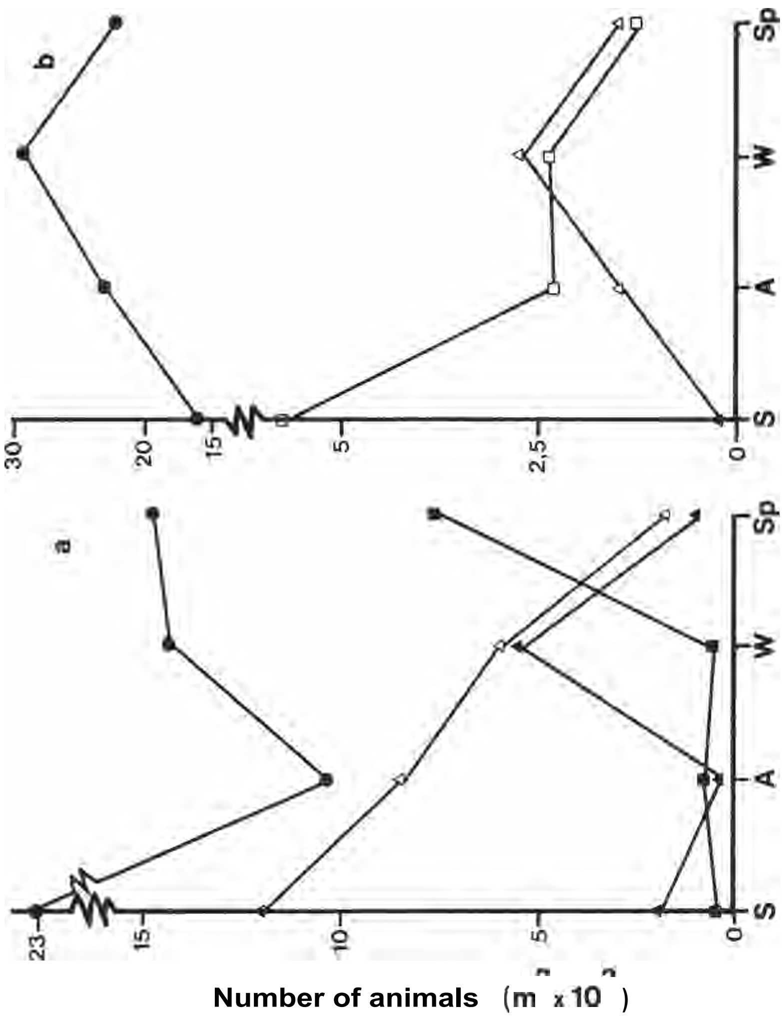

Figure 4. Seasonal variation (density m) of dominant benthic groups at two localities in the Kosi system during 1979. (a = Mpungwini; b = Nhlange; S = Summer; A = Autumn; W = Winter; Sp = Spring; ● = Oligochaeta; = Polychaeta; • = Cumacea; ▲ = Amphipoda; E = Chironomidae larvae).

DISCUSSION

Little seasonal variation occurred in the diet of the different species (> 40 mm S.L.) at the various localities (Table 3). Instead, the number of *Gerres* species present at the different sites declined during winter and spring with the exception of the Estuary and Nhlange.

The occurrence of at least three species at each of the sites during summer and autumn may be related to the availability of food, since the greatest densities of benthic animals occurred at these seasons. Different feeding periodicities may reduce interspecific competition.

The summer twenty-four hour sampling at the W.L.R. (Fig. 2a) showed that each of the three species present had feeding peaks at somewhat different

times. However, the autumn twenty-four hour station (Fig. 2b) indicated that all three species continued feeding throughout the period. It is possible that a superabundance of food may permit *Gerres* species to coexist in one area. The observed habit of 'loose association' shoaling by *Gerres* (Cyrus & Blaber, 1984b) during feeding might reduce intraspecific competition because a fixed 'nearest neighbour' distance appears to be enforced.

At the estuary the seasonal variation of polychaetes in the benthos (Fig. 3a) was reflected in the contribution that they made to the *Gerres* diet during each season (Table 3). Here variation in the numbers and diversity of benthos was greatest (Cyrus & Blaber, 1983), this is probably related to the daily tidal movements of water, the continual movement of the course substrate and variations in the volume of water flowing out of the lake system. A similar continual movement of coarse sands was noted by Brown (1959) in the Orange river estuary on the west coast of southern Africa. The benthos of this area was almost devoid of life. As the west coast estuaries appear to have rather impoverished faunas compared to those of the east coast, one might assume that it is not only the coarse sands which are causing low species diversity. However, Hill (1966) described a similar situation at the mouth of the Mlalazi estuary on the east coast, where water currents are strong, causing continual changes in the position of the sand banks and channels of the mouth area. The fauna in this part of the estuary was not rich and consisted of animals that could move around and cope with the changing conditions. The situation at the mouth of the Kosi estuary is thus not an unusual one, but rather, typical of estuarine areas where coarse mobile sands occur.

Snorkel observations and seine netting showed that large numbers of *Gerres* moved into the Kosi tidal basin at high tide when the littoral areas have a greater depth of water. Stomach analysis of *Gerres* from the Estuary site, although indicating that the greater percentage of food taken came from the Estuary basin, also showed that the fish were feeding in other areas at low tide. This is indicated by the presence of oligochaetes, *Hiatula lunulata* siphon tips, juvenile *Solen corneus* and terebellid tentacles in the stomachs, none of which were found in the grab samples collected from the estuary site and which occur in areas upstream from the Estuary basin. The other sampling sites in the Kosi system are more stable in nature. Most food items consumed by *Gerres* at these sites were found in the grab samples with the exception of Odonata larvae and *H. lunulata* in Nhlange. It is of interest that neither of these were recorded in the benthic surveys of this lake by Boltt and Allanson (1975). The feeding habits of *Gerres* (> 40 mm S.L.) in Natal estuaries have been compared with results from work in other parts of the world (Cyrus & Blaber, 1983). It appears that polychaetes are the single most important food item taken by the family. While no mention is made in other works of *Gerres* feeding on bivalve siphon tips, whole bivalves are important in the diet of *Gerres* species.

Five *Gerres* species are able to exist sympatrically in different parts of the Kosi system and resource segregation may occur as a result of some differences in diet, differences in feeding periodicity as well as a superabundance of food (Cyrus & Blaber, 1983). During winter when food may be limiting, most *Gerres* species leave the shelf area of the system, with only *G. acinaces* remaining in large numbers.

SUMMARY

The food and feeding ecology of five species of *Gerres*, occurring sympatrically in the Kosi system, was investigated from 1978 to 1981. Sampling was carried out at the Estuary mouth and the narrows as well as in

the three main lakes of the system. *Gerres oyena* and *G. oblongus* were found only at the estuary mouth in small numbers. *Gerres rappi* were dominant in Lake Nhlange, *G. filamentosus* at the estuary mouth and *G. acinaces* in Lakes Makhawulani and Mpungwini.

Variation in seasonal diet of adults and juveniles (> 40 mm S L.) was found to be limited. However there was a decline in the number of species present during winter and spring at three of the five sites sampled. Resource segregation appears to occur as a result of some differences in diet, differences in feeding periodicity and a superabundance of food *(Hiatula lunulata* siphon tips) during summer and autumn. During winter and spring when food may be limiting most *Gerres* leave the shelf areas of the system, with only *G. acinaces* remaining in large numbers.

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