Zooplankton-fish interactions in the littoral zone of Nyanza Gulf, Lake Victoria.

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Abstract: The distribution, diversity and abundance of littoral zooplankton, and the relationships between zooplankton and juvenile fishes in the littoral zone (*Lates niloticus* (L.), *Oreochromis niloticus* (L.) and *Rastrineobola argentea* (Pellegrin)) are being studied. Copepoda were tha most abundant zooplankton in most samples followed by Rotifera and Cladocera. Cyclopoid copepods were more abundant than calanoids. Rotifera was the most diverse group with 33 species recorded.

Lates niloticus shifted from a diet of zooplankton to other food items, mainly insects, Caridina nilotica (Roux)and fish as they grew. Juvenile O. niloticus shifted from a zooplankton diet to one of insects, phytoplankton and plant material as they grew. Rastrineobola argentea fed mainly on cladocerans though copepods were also consumed. Changes in feeding preferences were observed spatially and temporally.

Introduction

Interactions between phytoplankton, zooplankton, and secondary consumers such as fish form the basis of the food chains in lakes. The zooplankton community influences nutrient dynamics and occupies a major trophic position in the aquatic food chain. The rich littoral zooplankton community and the benthos combined with omnivory and a higher efficiency in the use of the available animal food (e.g. insects) by juvenile fishes are believed to be critical factors linking fish yields to zooplankton production in tropical fresh waters (Fernando 1994). Predation is considered to be a major factor in shaping zooplankton community (Brooks & Dodson 1965). Larger zooplankters e.g., *Daphnia* spp. are most conspicuous and therefore are most affected by predation and may be locally driven to extinction (Hrbacek *et al.* 1961, Lazzaro 1987). While most fishes begin feeding upon plankton, many pass through a series of ontogenic habitat or diet shifts as they grow (Werner & Gillian 1984) though some remain planktivorous throughout their lifetime.

As an adaptation to the location of the animal food, most tropical fishes are reported to raise their young in shallow littoral situations (Fernando 1994). This area is inaccessible to most predatory fish and thus this strategy reduces predation while bringing the young fish to areas where food is most abundant. Wetzel (1990), in a wide ranging review on metabolic and limnological regulators at the freshwater-land interface, stated that in most freshwaters, much of the organic loading comes from the littoral zone of the lakes, reservoirs and flood plains. To understand the secondary and tertiary production, the interactions between various groups involved must be investigated bearing in mind that both the biotic and biotic factors are important singly and in combination with respect to zooplankton community structure, diversity and density. This study is aimed at establishing the role of zooplankton community as the food base for the littoral fish in Lake Victoria and the influence of predation on some zooplankton community population variables.

Materials and methods

Samples of zooplankton and fish were collected from six sampling stations situated in the Nyanza Gulf (Fig. 1) from June to December 1998. A 3.5 L volume sampler was used to obtain zooplankton samples, which were concentrated through a 76 µm monofilament mesh size strainer. This was supplemented by use of an 80 µm mesh size plankton net, hauled vertically at known depths. Zooplankton samples collected were preserved in 4% formalin. Fish for gut/stomach analyses were obtained through beach seining and preserved in 10% formalin. Identification and enumeration for the zooplankton population densities were done in the laboratory using a plankton counting chamber and a compound microscope. Sub-sampling was done for high density samples and whole counts for low density samples. Densities were calculated from the duplicate sub-sample counts of high density samples and from full counts of the low density samples. While copepods were identified to sub-class level, rotifers and cladocerans were identified to either generic or to species levels. Occurrence, numerical and point methods (Hynes 1950; Frost 1943; Dipper, Bridges & Menz 1977) were used in stomach analysis. The food categories were awarded points proportional to their estimated contribution to stomach volume taking into account differences in stomach fullness. For *Rastrineobola argentea* (Pellegrin), the whole gut was assessed and each food item enumerated and expressed as percentage of the total food items. Prominence values of food items were also calculated to evaluate the most prominent item.

Results

Estimates of population densities in for various zooplankton groups (Table 1) indicate that the zooplankton community of the lake consists of three major groups, Copepoda, Rotifera and Cladocera. Total zooplankton densities from 63±12.4 ind. L^{-1} to 803±175 ind. L^{-1} were recorded with Kisumu Bay and Homa Bay recording the former and latter densities respectively. Copepods (adults, copepodites and nauplii) were the most dominant zooplankton group in all the sampled stations, and occurred in densities from 53 – 684 ind. L^{-1}. Rotifers were the second abundant group and occurred in densities of up to 2 - 292 ind. L^{-1}. Cladocera were the least abundant group occurring in densities from 2 – 92 ind. L^{-1}. All stations recorded low zooplankton densities in December and June.

Copepods contribute the highest portion of the total zooplankton population (Table 2, Fig. 2), accounting for from 50 – 97%. Cyclopoid copepods occurred in proportions higher than calanoid copepods (Table 3), except for Dunga and Maboko which had higher calanoid copepod values in the months of October and December. There were exceptions, e.g. Homa Bay (June) and Kisumu Bay (November) when rotifers were more abundant than copepods.

Rotifers were the most diverse group (Table 4) contributing the largest number of species (32) followed by Cladocera (8). Rotifers were dominated by the family Brachionidae, with the genera *Brachionus* and *Keratella* having a wide distribution. Different zooplankton species were observed to succeed other species.

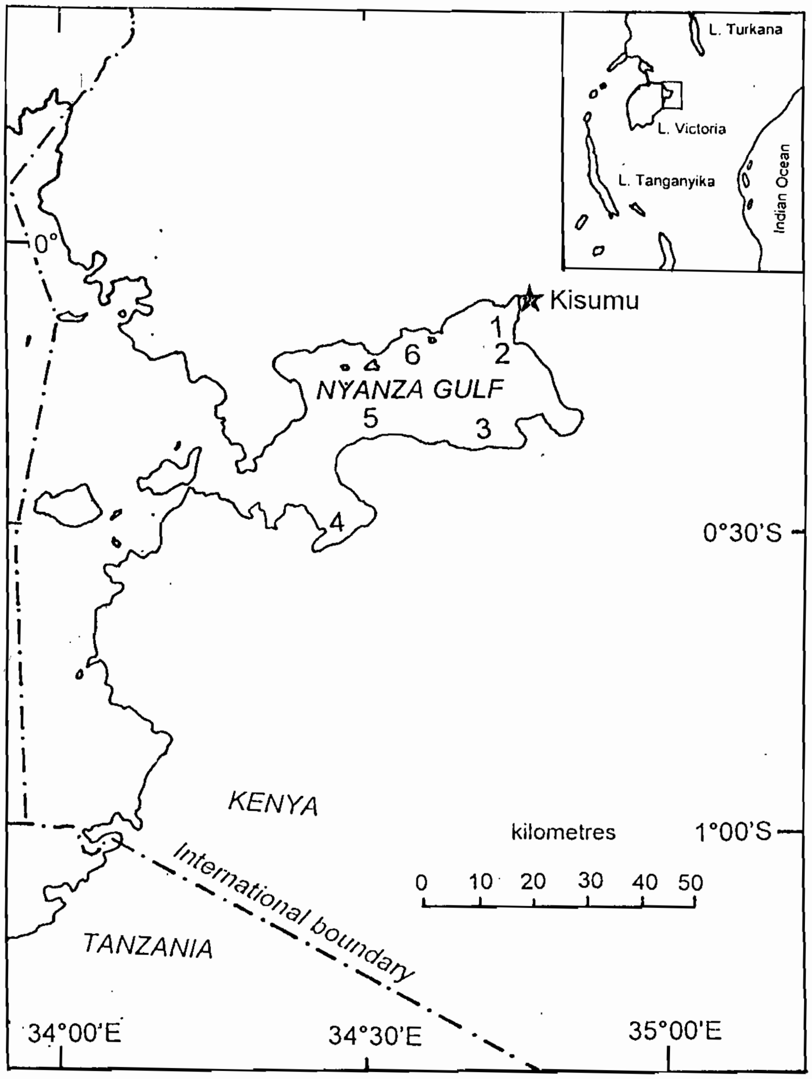

Figure 1. Map of the Nyanza Gulf, Kenya, showing the selected landing sites.

Fish gut/stomach analysis

Percentage frequency of occurrence, percentage numerical abundance and prominence values of different food items are provided (Fig. 3, Tables 5 6, 7 & 8). Zooplankton was important in the diet of juveniles of *Oreochromis niloticus* (L.), *Lates niloticus* (L.) and *R. argentea*. In 62 *L. niloticus*, *72 O.niloticus* and 62 *R. argentea* stomachs/guts analyzed, zooplankton had percentage frequency occurrence of from 9.3-100%. *Caridina nilotica* (Roux) progressively became the prominent food for *L. niloticus* with increasing length.

In most juvenile fishes, cladocerans especially the genera *Moina* and *Daphnia,* were the main zooplankton food item. Although copepods were the major zooplankton group in the plankton samples, they were not well represented in the fish diets, though *O. niloticus* juveniles and, to a lesser extent, *R. argentea* fed on them.

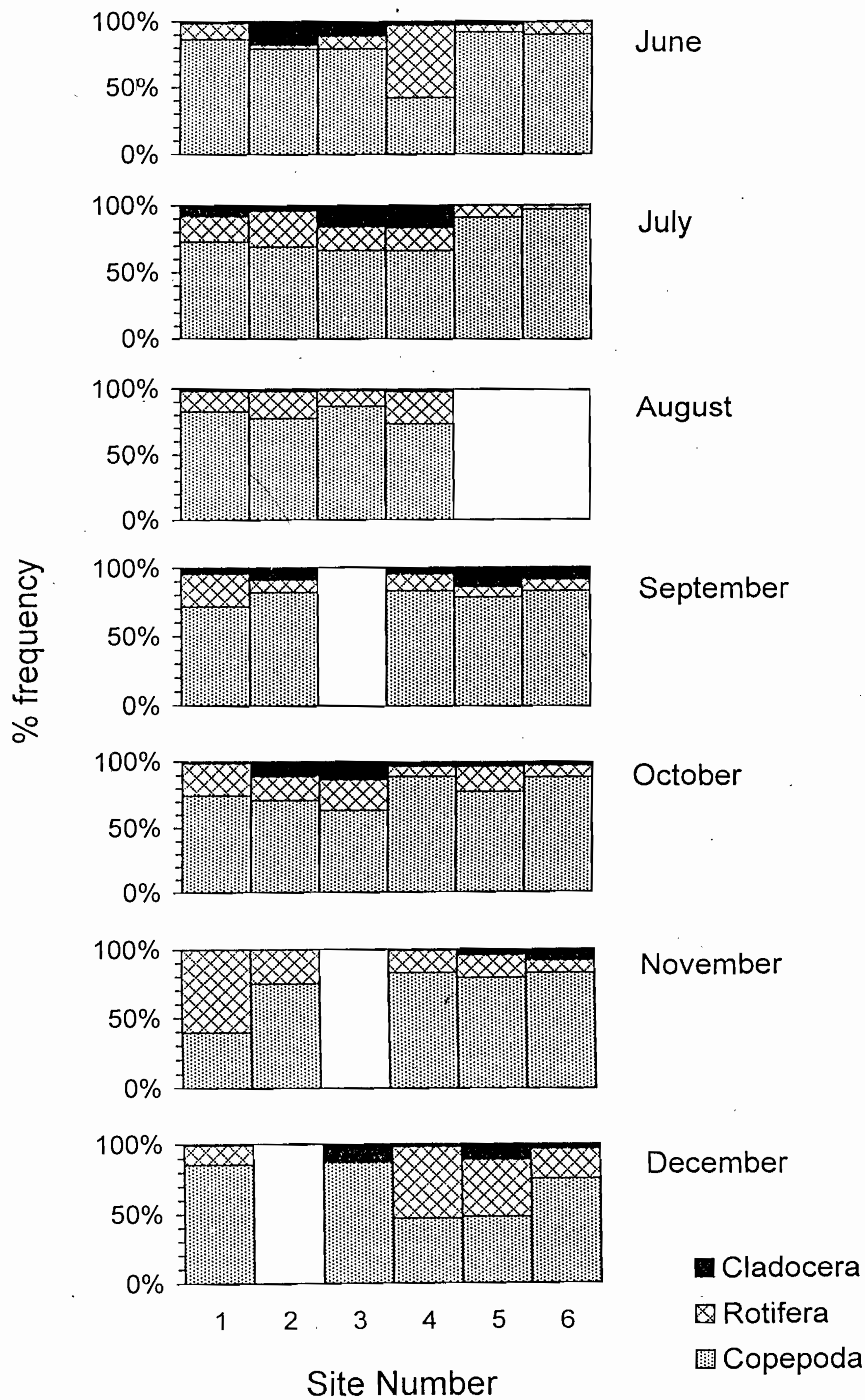

Figure 2. Percentage composition of the three main zooplankton groups at the six sampling sites in the Nyanza Gulf between June and December 1998.

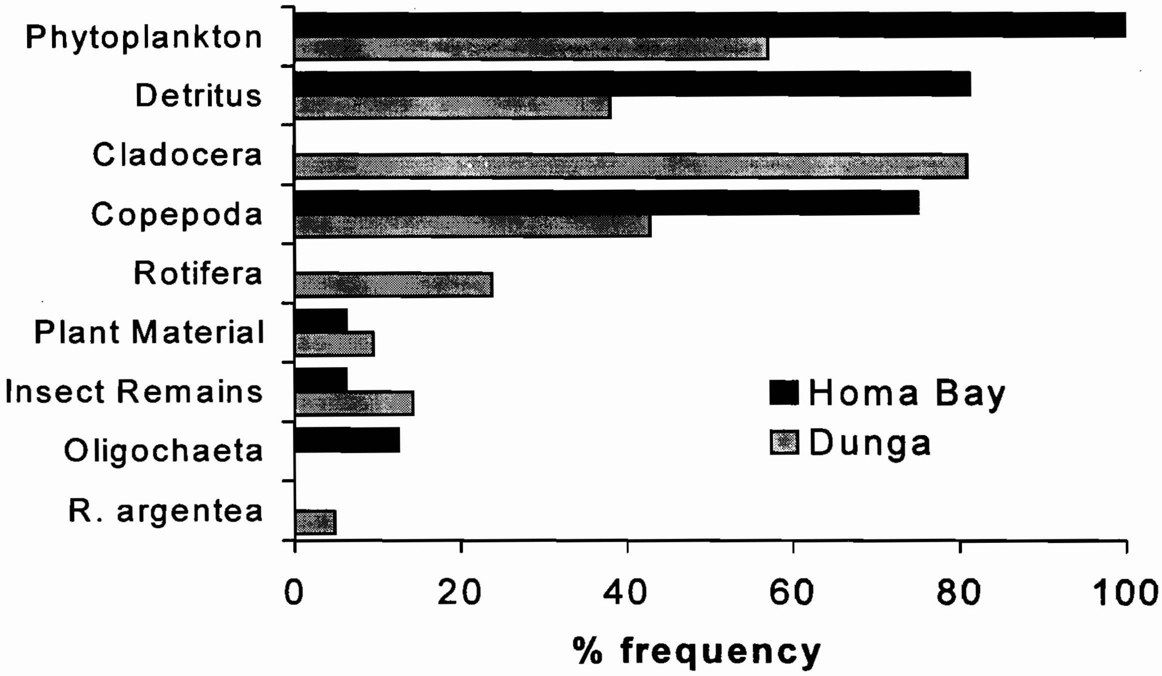

Figure 3. Percentage frequency of occurrence of food items found in stomachs of O. niloticus at Homa Bay and Dunga.

Discussion

No clear trend was seen in terms of zooplankton densities by stations, although the range of values recorded was not significantly different from those recorded by Mavuti and Litterick (1991). A few species of rotifers and one Cladocera species (*Daphnia lumholtzi*) were recorded during the present study though they were not recorded by Mavuti and Litterick. High Rotifera diversity may be attributed to the high eutrophication levels in some of the stations as was reported by Mavuti and Litterick (1991).

The importance of cladocerans in the fish diets show that the fish and particularly the juveniles select specific foods. The preference of cladocerans as the main food items by juvenile fish and adult planktivores could explain their low abundance in the water column.

The increasing importance of *C. nilotica* in the diet of juvenile *L. niloticus* as they grow is a trend observed by previous workers (Hughes1986; Ogari & Dadzie 1988).

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Table 1. Estimates of population density (mean ind. L^{-1}) of major zooplankton groups at stations in Nyanza Gulf. ND – no data, not sampled due to presence of water hyacinth.

	Kisumu Bay	Dunga	Kendu Bay	Homa Bay	Maboko	Gingra
COPEPODA						
June	187	151	72	57	146	272
July	286	246	76	212	684	178
August	326	80	328	588	ND	ND
September	336	65	ND	131	343	400
October	323	281	442	237	189	235
November	189	307	ND	285	162	102
December	53	ND	131	69	41	182
ROTIFERA						
June	8	6	49	74	8	28
July	74	96	20	55	67	6
August	62	21	45	198	-	-
September	113	7.0	ND	19	32	30
October	104	72	164	19	46	23
November	292	105	ND	57	34	4
December	8.5	ND	0	94	35	50
CLADOCERA						
June	3	34	10	4	5	2
July	33	16	19	21	3	1
August	7	2	5	17	ND	ND
September	22	7	-	8	65	45
October	6	42	92	9	9	7
November	-		1	3	9	6
December	2	-	20	3	9	8
TOTAL DENSITY						
June	198	191	91	135	159	302
July	394	351	115	288	753	185
August	395	103	378	803	ND	ND
September	471	79	ND	159	440	475
October	433	395	698	265	244	265
November	481	412	ND	345	205	112
December	63	ND	151.4	74	85	240

Table 2. Percentage composition of zooplankton groups at stations sampled between June and December8. Co = copepods, Ro = rotifers and Cl = cladocerans.

	JUNE			JULY			AUGUST			SEPTEMBER			OCTOBER			)VEMBER		DECEMBER		
	Co	Ro	Cl	Co	Ro	Cl	Co	Ro	Cl	Co	Ro	Cl	Co	Ro	Cl	Ro	Cl	Co	Ro	Cl
STATION																				
Kisumu Bay	86.39	12.02	1.69	72.45	18.84	8.33	83.34	15.78	1.87	71.34	24.00	4.67	74.51	24.01	1.39	60.65	0.00	85.39	13.69	0.91
Dunga	79.04	2.99	17.96	69.00	26.81	4.34	77.15	20.69	2.08	81.49	9.25	9.25	71.28	18.18	10.91	25.36	0.00			
Kendu Bay	79.18	9.46	11.36	66.25	17.60	16.13	86.72	11.90	1.36				63.22	23.53	13.24			86.79	0.00	13.20
Homa Bay	42.04	54.78	3.18	73.65	18.92	18.92	73.19	24.72	2.06	82.58	12.21	5.21	89.15	7.34	3.50	16.54	0.97	47.05	50.90	2.05
Maboko	91.79	5.22	2.99	90.79	8.87	0.34				78.04	7.28	14.75	77.65	18.82	3.54	16.67	4.59	48.15	40.74	11.11
Gingra	90.07	9.27	0.66	96.58	3.10	0.31				84.07	8.37	9.55	88.68	8.73	2.59	9.09	8.48	75.69	20.72	3.60

Table 3. Percentage composition of calanoid (Cal) and cyclopoid (Cyc) copepods.

	JUNE		JULY		AUGUST		SEPTEMBER		OCTOBER		NOVER		DECEMBER	
	Cal	Cyc	Cal	Cyc	Cal	Cyc	Cal	Cyc	Cal	Cyc	Cal	Cyc	Cal	Cyc
STATION														
Kisumu Bay	18.62	81.33	33.33	66.60	0.64	99.36	7.50	92.50	4.89	95.60	0.0	100.00	23.36	76.60
Dunga	23.36	76.64	16.66	83.33	1.03	98.97	12.60	87.40	69.36	30.65	0.0	100.00	37.50	62.50
Kendu Bay	12.94	82.05	-	-	14.28	85.70	-	-	21.43	78.57		-	31.58	68.42
Homa Bay	15.38	84.6	26.87	75.12	-	-	21.87	78.13	12.50	87.50	39.6	60.35	77.42	22.58
Maboko	20.51	79.49	30.53	69.47	-	-	30.95	69.05	12.73	87.20	30.5	69.46	22.60	75.40
Gingra	21.28	78.72	18.81	81.82	0.00	100.00	21.48	78.54	24.70	75.30	4.7	95.20	10.42	89.60

Table 4. Checklist of zooplankton species identified in Nyanza Gulf.

COPEPODA	*B.calyciflorus*
	B.plicatilis
Calanoida	*Keratella tropica*
Cyclopoida	*K.cochlearis*
	Platyias patulus
CLADOCERA	*Epiphane clavulata*
	E.macroura
Ceriodaphnia cornuta	*Epiphane* sp.
Daphnia lumhotzi	*Euchlanis triquetra*
D.longispina	*Filinia opolinesis*
D.barbata	*F.longiseta*
Moina macroura	*F.terminalis*
Moina sp.	*Hexarthra mira*
Bosmina longirostris	*Lecane bulla*
Diaphanosoma exiscum	*Lecane* sp.
Chydorus parvus	*Polyarthra vulgaris*
	Polyarthra remata
ROTIFERA	*Testudinella* sp.
	Trichocerca longiseta
Asplanchna sieboldi	*Lapedella* sp.
A..brightwelli	*Ascomorpha* sp.
Branchionus angularis	*Anuraeopsis* sp.
B.rubens	*Proales* sp.
B.falcatus	*Dicranophorus* sp.
B.quadridentatus	*Asplanchnopsis* sp.
B.caudatus	*Cephalodella* sp.
B.bidentata	

Table 5. Relative numerical abundance, percentage frequency of occurrence and prominence values of food items found in stomachs of *Oreochromis niloticus* (TL 1.5 – 9.8 cm, mean = 3.8 cm) at Homa Bay, n = 76.

Food item	Relative abundance	% occurrence	Prominence value
Phytoplankton	66.8	100.0	668.0
Detritus	23.8	81.3	214.2
Copepoda	9.3	75.0	80.4
Plant Material	30.0	6.3	75.0
Oligochaeta	12.0	12.5	42.4
Insect Remains	9.0	6.3	22.5

Table 6. Relative numerical abundance, percentage frequency of occurrence and prominence values of food items found in stomachs of *Oreochromis niloticus* (TL 1.5 - 14.4 cm, mean = 3.28) at Dunga. September 1998, n = 51.

Food Item	Relative abundance	% occurrence	Prominence value
Cladocera	43.3	81.0	389.9
Phytoplankton	29.0	57.1	219.1
Copepoda	11.5	42.9	75.4
Insecta	6.6	14.3	24.8
Detritus	4.1	38.1	25.0
Vegetative Material	3.2	9.5	9.8
R. argentea	6.8	4.8	14.9
Rotifera	2.3	23.8	11.4

Table 7. Percentage frequency of occurrence of food items in stomachs of *Lates niloticus* (TL 3.5 – 30 cm), n = 62.

Food item	% Frequency of occurrence	Numerical abundance	Prominence value
Caradina nilotica	84.4	82.4	756.0
Insect remains	28.1	10.3	57.5
R. argentea	18.8	4.3	18.5
Zooplankton	18.8	2.6	11.0

Table 8. Percentage frequency of occurrence of values of food items found in stomachs of *Rastrineobola argentea* (Kisumu Bay & Homa Bay) in September 1998.

Food Item	% Frequency of occurrence	% Numerical abundance	Prominence value
Kisumu Bay (n = 32)			
Cladocera	100.0	70.9	709.0
Copepoda	100.0	27.6	276.4
Rotifera	10.0	1.5	4.6
Homa Bay (n = 30)			
Cladocera	100.0	78.2	782.1
Copepoda	100.0	21.8	217.9