Zooplankton – fish interaction in the littoral zone of Nyanza Gulf, Lake Victoria

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Abstract: *The zooplankton community of the littoral zone of Nyanza Gulf, Lake Victoria was studied between June 1998 and June 1999 to identify and quantify various zooplankton groups, and investigate the interactions that occur between them and the littoral fish through the food chain. Zoopankton samples were collected from five stations using a 83 μm mesh size plankton net hauled vertically through the water column. Fish samples were obtained by beach seine, except at Gingra (May 1999), where trawl samples were used. Gut/stomach analysis was carried out on the three major commercial species,* Lates niloticus *(L.),* Orechromis niloticus *(L.) and* Rastrineobola argentea *(Pellegrin).*

Zooplankton consisted mainly of three groups; Copepoda, Rotifera and Cladocera. Copepods were the most abundant taxonomic group with cladocerans and rotifers occurring in relatively smaller proportions. Zooplankton densities ranged from 4.52 to 803 ind. L^{-1}. *Lates niloticus* fed predominantly on *Caridina nilotica* (Roux), although there was a shift in diet with increasing fish size. Different feeding preferences were observed by the three species between sampling stations. Although copepods were the most abundant group in the water column, *R. argentea* showed a preference for cladocerans. This may explain the low relative abundance of cladocerans in the lake environment

Introduction

The role of zooplankton communities in the functioning and productivity of aquatic systems is vital, particularly to fishery production. This arises from influence of zooplankton on nutrient dynamics and its trophic position in the aquatic food chain. Zooplankton affects phytoplankton populations through grazing, which in turn has profound effects on water quality (Andersson *et al.* 1978). Predation is also considered to be a major factor in shaping zooplankton community (Brooks & Dodson 1965). Larger zooplanktonts, e.g. *Daphnia* species are more conspicuous and therefore most affected by predation, and may be locally driven to extinction (Hrbacek *et al.* 1961; Lazzaro 1987). While most fishes begin feeding on plankton, many pass through a series of ontogenic habitat or diet shifts as they grow (Werner & Gillian 1984), although some remain planktivorous throughout their lifetime. The success of littoral fishes in tropical lakes and floodplains has thus been attributed to their ability to use the zooplankton and benthic invertebrate fauna effectively in their young stages (Fernando 1994), and the survival and recruitment of the young largely depend on zooplankton dynamics.

Knowledge of fish-zooplankton interactions is therefore very important for any meaningful and sustainable exploitation of the fishery resources. Although various aspects of the zooplankton community in Lake Victoria, Kenya, have been examined (Nyamu 1984; Mavuti & Litterick 1991), information on zooplankton-fish interactions has largely come from feeding studies of fish (Mwebaza-Ndawula 1994).

The present study examines the littoral zooplankton community and planktivorous-fish interactions to establish the role of zooplankton as the food base for the littoral fish communities.

Materials and methods

Data were collected from five sampling stations along the Nyanza Gulf of Lake Victoria between June 1998 and June 1999 (Fig. 1). Sampling was not possible during some months because of extensive coverage of water hyacinth, *Eichhornia crassipes* (Mart.) Solms, which hindered access to these areas. Most zooplankton samples were collected using a 83 µm plankton net with a 30-cm diameter mouth, although a few were collected using a water sampler (3.5 L) and concentrated using a monofilament strainer (70 µm mesh size). The net was hauled vertically at known depths and samples were transferred to bottles and preserved in 5% formalin. Identification and enumeration of zooplankton population were done using a plankton counting chamber, compound and dissecting microscopes and various identification keys. Duplicate sub-samples were analysed for each station and the densities calculated from the duplicate sub-sample counts. Copepods were identified to sub-class level, but rotifers and cladocerans were identified to either genus or species levels.

Fish samples were obtained from beach seining, except at Gingra where trawl samples were used. Juvenile Nile perch, *Lates niloticus* (L.) (TL. 2.6-13.5 cm) and adult *Rastrineobola argentea* (Pellegrin) were collected for stomach/gut analysis. Fish were preserved in 10 % formalin for further analysis in the laboratory.

The occurrence, numerical and points methods (Hynes 1950; Frost 1943; Dipper *et al.* 1977) were all used in fish stomach analysis. For the points method, the food categories were awarded points proportional to their estimated contribution to stomach volume taking into account differences in stomach fullness. For *R. argentea*, the whole gut was assessed and each food item enumerated and expressed as percentage of the total food items. The prominence value (√ *% occurrence* x *% relative abundance*) of each food item was also calculated to elucidate the most important food items to the diet.

Results

Zooplankton

The zooplankton comprised mainly Copepoda, Cladocera and Rotifera. Rotifers were the most diverse group (32 species; Appendix 1), dominated by the family Brachionidae, with the genera *Brachionus* and *Keratella* having a wide distribution.

Total zooplankton densities ranged from 4.5 ind. L^{-1} in Kisumu Bay in April 1999 to 803 ind. L^{-1} in Homa Bay in August 1998 (Table 1). No seasonal trends in zooplankton density were evident (Table 1; Figs 2, 3 & 4). All stations recorded low zooplankton densities in December 1998, and April and June 1999.

Copepods, their nauplii, and copepodites constituted the largest proportion of the zooplankton communities in the majority of stations throughout the sampling period (Figs 2, 3 & 4).

The highest proportion of copepods was made up of nauplii. Cyclopoid copepods were more abundant than calanoid copepods except at Gingra (50%) and Maboko (53.80%) in March and June 1999, respectively (Fig. 2). Calanoid copepods occurred in very small numbers in Kisumu Bay during March, and were completely absent in April, 1999.

Rotifer density ranged from 0.41 individuals L^{-1} at Maboko to 7.2 ind. L^{-1} at Kisumu Bay (Fig. 3). Rotifers were the most relatively abundant group at Kisumu Bay in April, with the genus *Filinia* constituting over 70% of the total rotifers recorded. *Keratella tropica* occurred in higher densities than any other single rotifera species in all stations over the month of June 1999.

Cladocera were the least abundant group occurring at densities from 0.4-92 individuals L^{-1} (Fig. 4). Nine species of Cladocera were recorded over this period (Appendix 1). They were largely represented by *Daphnia lumholtzi, Ceriodaphnia cornuta, Moina micrura, Bosmina longirostris*, *Diaphanosoma excisum* and lastly, *Daphnia barbata,* which had a limited distribution and was mainly found at Kendu Bay.

Feeding habits

Caridina nilotica (Roux) was the major food item eaten by *L. niloticus* at all stations (Fig. 5), except Kendu Bay, where *Povilla adusta* and corixids were common in the diet during April and June respectively. The importance of *C. nilotica* varied between months and stations (Fig. 5). Nile perch juveniles at Kendu Bay fed more on fish than at other sites, especially in March 1999. These fish were mainly its own young , *R. argentea,* fry of *Oreochromis niloticus* (L.) and haplochromine species. This could have been due to variation in the size of fish examined because larger individuals were examined at Gingra..

Food analysis for *R. argentea* was fragmented and only the results from a few months are given with remarks indicating the food items found (Table 2). Cladocerans were the most frequent and abundant prey eaten by *R. argentea,* especially the larger species *M. micrura, Diaphanosoma exiscum, B. longirostris, D. lumholtzi, D. barbata* and *Ceriodaphnia* species. For example, at Gingra (February), more than 90% of cladocerans in the gut were *B. longirostris*. At Maboko, *R. argentea* fed on *D. lumholtzi* and *M. micrura*, athough copepods (adults and nauplii) predominated in the gut contents in the preceding month.

The diet of *O. niloticus* was dominated by phytoplankton and zooplankton. Cladocera were extremely important in the diet at Dunga but were replaced by copepods at Homa Bay.

Discussion

No obvious temporal or spatial trends in the abundance of zooplankton were found, although the densities found were similar to those recorded previously (Mavuti & Litterick 1991). A few species of rotifers and one Cladocera species (*Daphnia lumholtzi*) were found during the present study which were not recorded by Mavuti and Litterick (1991). The 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 low densities of zooplankton recorded in Kisumu Bay were attributed to the presence of extensive mats of water hyacinth, *E. crassipes,* that rendered the water almost anoxic (0.84 mg L^{-1} oxygen). The higher densities at Kendu Bay over the same period were due to the unusually high presence of the cladoceran *Daphnia barbata.*

The very high zooplankton densities recorded in March were probably due to different sampling equipment used (water sampler, 3.5 L, and a 70 µm mesh size strainer) instead of the 83 µm mesh size net used in other months.

Feeding habits of *L. niloticus* juveniles at Kendu Bay were different from other stations within and between months with a variety of food items utilized. Zooplankton plays a major role in the diets of young *L. niloticus* and *R. argentea.* There appears to be a shift from zooplankton to benthic invertebrates/insects and then to fish as the fish get larger, and this will be fully analysed in the future. Younger fish (<5 cm) tended to feed on zooplankton, although *C. nilotica* and insects (corixids) occurred in stomachs of very young fish. Piscivory and cannibalism were the predominant feeding strategies. Insects, *Povilla adusta* and corixids (e.g *Macronecta* spp), were also important food items. Fish at Gingra fed predominantly on *C. nilotica,* (85-99%) within and between months. The increasing importance of *C. nilotica* in the diet of juvenile *L. niloticus* as they grow is a trend observed by previous workers (Hughes 1986; Ogari & Dadzie 1988).

The differences in feeding habits between stations can be explained in terms of food availability and prey selection by the fish, coupled with the size of individuals examined. Gingra (10-12m) is a deeper water station and is likely to have more *C. nilotica* available as food, whilst Kendu Bay is a shallow littoral station which is a nursery habitat for smaller fishes.

The importance of cladocerans in the fish diets shows 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. Rotifers, although present in good numbers, were negligible in the diet. They too may be rejected as food or more likely are easily digested and thus more easily overlooked.

Acknowlegdements

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References

Anderson G.B., Cronberg H.G. & Gerlin C. (1978) Effects of planktivorous and benthic fish on organisms and water chemistry in eutrophic lakes. *Hydrobiologia* **59**, 9-15.

Brooks J.L & Dodson S.I. (1965) Predation and composition of plankton. *Science* **150**, 26–35.

Chimney M.J., Winner R.W. & Seilkop S.K. (1981) Prey utilisation by *Chaoborus punctipennis* Say in small eutrophic reservoirs. *Hydrobiologia* **85**, 193-199.

Dipper F.A. Bridges C.A & Menz A. (1977) Age growth and feeding in the ballan wrasses *Labrus bergylta* Ascanius 1967. *Journal of Fish Biology* **11**, 105-120.

Fernando C.H. (1994) Zooplanton, fish and fisheries in tropical waters: *Hydrobiologia* **272**, 105-123.

Frost W.E. (1943) The natural history of the minnow *Phoxinus phoxinus. Journal of Animal Ecology* **12**, 139-162.

Hrbacek J. (1962) Species composition and amount of the zooplankton in relation to fish stock. *Rozpr CSAV rada matem prir ved* **72**, 1–116.

Hughes N.F. (1986) Changes in the feeding biology of Nile perch *Lates niloticus* (Linn.) (Pisces: Centropomodae), in Lake Victoria, East Africa since its introduction in 1960 and its impact on the native fish community of the Nyanza Gulf. *Journal of Fish Biology* **29**, 541-548.

Hynes H.B.N. (1950) The food of freshwater stickleback (*Gasterosteus aculeatus* and *Pygosteus punqitius*) with a review of methods used in studies of food of fishes. *Journal of Animal Ecology* **19**, 36–58.

Lazzaro, X. (1987) A review of planktivorous fishes, their evolution, feeding behaviours, selectivities and impacts. *Hydrobiologia* **146**, 97-167.

Mavuti K.M. & Litterick M.R. (1991) composition, distribution and ecological role of zooplankton in Lake Victoria Kenya waters. *Verhandlungen der Internationale Vereinigung Fur Theoretische und Angewandte Limnologie* **24**, 1117-1122.

Mwebaza-Ndawula L. (1994) Changes in relative abundance of zooplankton in northern Lake Victoria, East Africa. *Hydrobiologia* **272**, 259-264.

Nyamu M.A, (1984) An assessment of water quality in the Winam Gulf of Lake Victoria. MSc. Thesis, University of Nairobi, 138 pp.

Ogari J. and Dadzie S. (1988) The food of the Nile perch, *Lates niloticus* (L.), after the disappearance of the haplochromine cichlids in the Nyanza Gulf of Lake Victoria (Kenya). *Journal of Fish Biology* 32, 571-577.

Table 1. Total zooplankton density (ind. L^{-1}) June 1998 and June 1999

Month	Kisumu Bay	Kendu Bay	Homa Bay	*Maboko*	Gingra
June	198	91	135	159	302
July	394	115	288	753	185
August	395	378	803	ND	ND
September	471	ND	159	440	475
October	433	698	265	244	265
November	481	ND	345	205	112
December	63	151.4	74	85	240
January	124.5	94.9	87.4	92.2	-
February	115.1	82.4	59.8	128.9	104.2
March	40.9	366.0	248.6	191.4	73.4
April	4.5	103.0	38.4	24.2	60.3
May					
June	106.5	83.3	54.2	8.7	44.2

Table 2. Percentage occurrence, relative abundance by numbers and prominence values of food items eaten by *Rastrineobola argentea*, December 1998 - June 1999

Station and date	*Food item*	% occurrence	Relative abundance (%)	Prominence value	Remarks
Kendu Bay - December	Cladocera	100.0	71.3	712.6	*Moina* spp, *Diaphanosoma* spp
	Copepoda	100.0	28.8	287.5	*B.longirostris*
Gingra – February	Cladocera	100.0	68.8	687.5	Cladocera >90%
	Copepoda	100.0	31.3	312.5	*B.longirostris*
Maboko – February	Cladocera	100.0	54.0	540.4	*D.lumholtzi* and
	Copepoda	76.9	46.0	403.1	*Moina* spp, *Diaphanosoma* spp
Maboko – March	Cladocera	100.0	54.8	547.6	*D.lumholtzi*
	Copepoda	100.0	45.2	452.4	*Moina* spp, Diaphanosoma spp
Gingra – March	Cladocera	100.0	83.5	835.4	*D.lumholtzi, D.barbata,*
	Copepoda	90.9	16.4	156.0	*B. longirostris*
Kendu Bay – April	Cladocera	100.0	98.6	980.0	*D. lumholtzi D.barbata*
	Copepoda	66.2	2.4	19.6	*Moina* spp, *Diaphanosoma* spp
Maboko – April	Cladocera	72.2	84.2	715.8	80% *D. lumholtzi*
	Copepoda	50.0	15.8	111.5	*Moina* spp, *Diaphanosoma* spp
Homa Bay – June	Cladocera	100.0	54.3	542.6	*D. lumholtzi, Moina* spp
	Copepoda	100.0	45.7	457.4	*B. longirostris*
Kendu Bay – June	Cladocera	73.5	14.5	124.2	Cyclopoid copepod & Nauplii
	Copepoda	86.5	85.6	796.0	*Bosmina* spp, *Moina* spp, *Ceriodaphnia* spp
Maboko – June	Cladocera	81.8	66.2	362.8	>90% *D. lumholtzi*
	Copepoda	81.8	37.8	341.7	*Moina* spp, *Diaphanosoma* spp
Gingra – June	Cladocera	100.0	78.4	784.4	
	Copepoda	100.0	20.5	205.4	*D. lumholtzi*
	Rotifera	5.0	1.0	2.3	

Appendix 1. **Checklist of zooplankton species / genera identified in Nyanza gulf (Kenya)**

COPEPODA
Calanoida
Cyclopoida

CLADOCERA
Ceriodaphnia cornuta
Daphnia lumholtzi
D.longispina
D.barbata
Moina micrura
Moina sp.
Bosmina longirostris
Diaphanosoma exiscum
Chydorus parvus

ROTIFERA
Asplanchna siebold
A.prightwelli
Branchionus angularis
Branchionus rubens
Branchionus falcatus
Branchionus quadridentatus
Branchionus caudatus
Branchionus bidentata
Branchionus calyciflorus
Branchionus plicatilis
Keratella tropica
Keratella cochlearis
Platyias patulus
Epiphane clavulata
E.macroura
Epiphane sp.
Euchlanis triquetra
Filinia opolinesis
Filinia longiseta
Filinia terminalis
Hexarthra mira
Lecane bulla
Lecane sp.
Polyarthra vulgaris
Polyarthra remata
Testudinella sp.
Trichocerca longiseta
Lapedella sp.
Ascomorpha sp.
Anuraeopsis sp.
Proales sp.
Dicranophorus sp.
Asplanchnopsis sp.
Cephalodella sp.

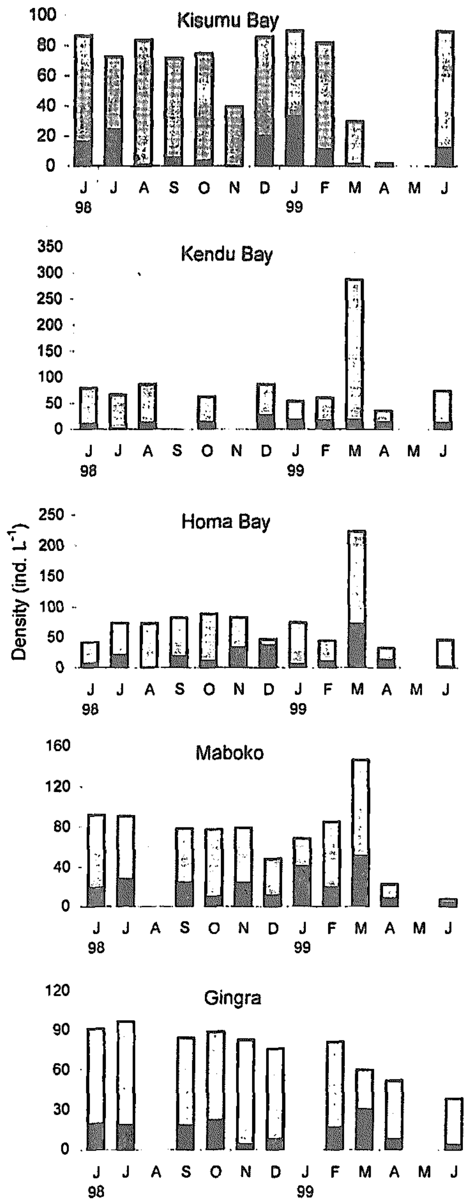

Fig. 2. Densities of Copepoda at five stations in Lake Victoria, Kenya between June 1998 and June 1999 (solid - Copepoida; shaded - Calanoida).

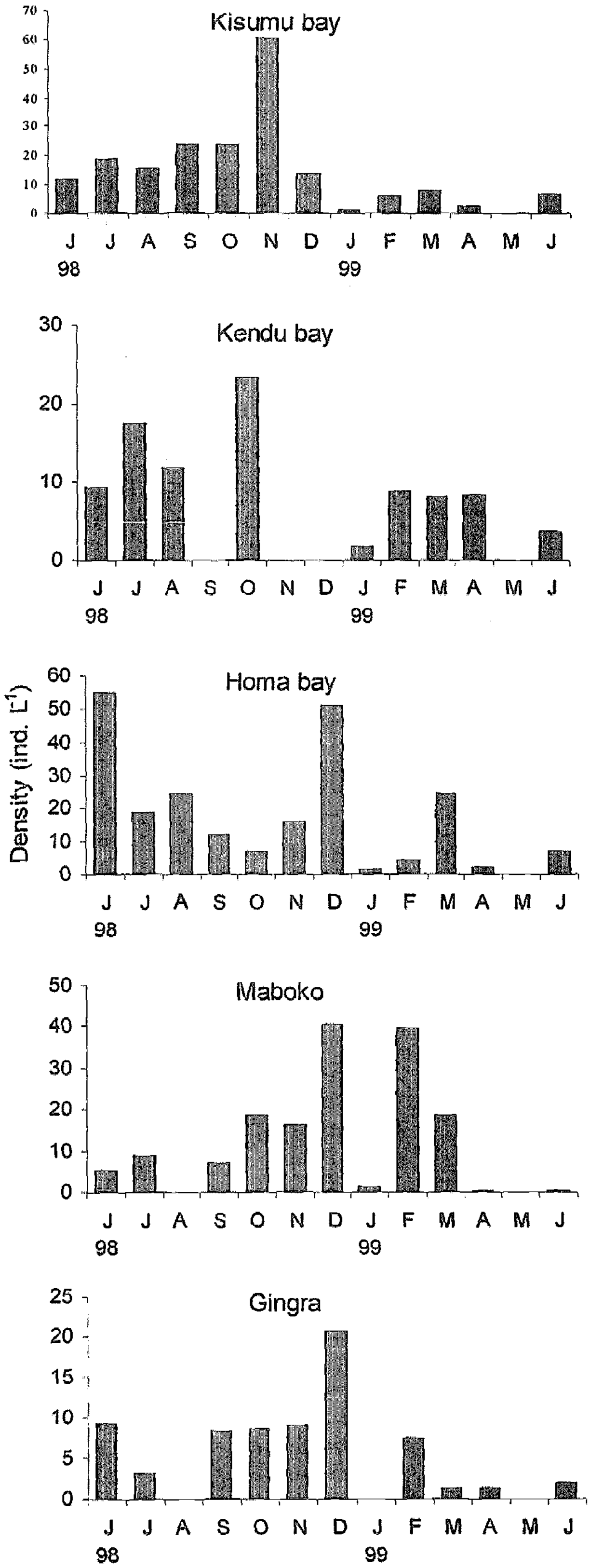

Fig. 3. Densities of rotifers at five stations in Lake Victoria, Kenya between June 1998 and June 1999.

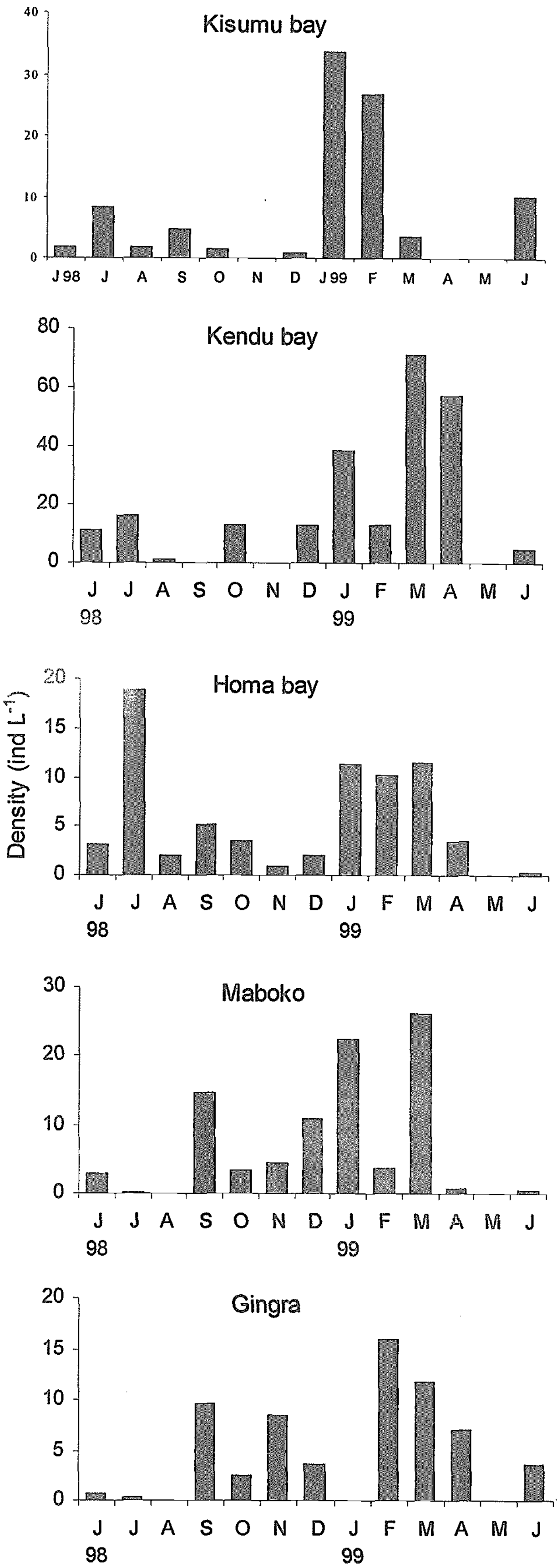

Fig. 4. Densities of Cladocera at five stations in Lake Victoria, Kenya between June 1998 and June 1999.

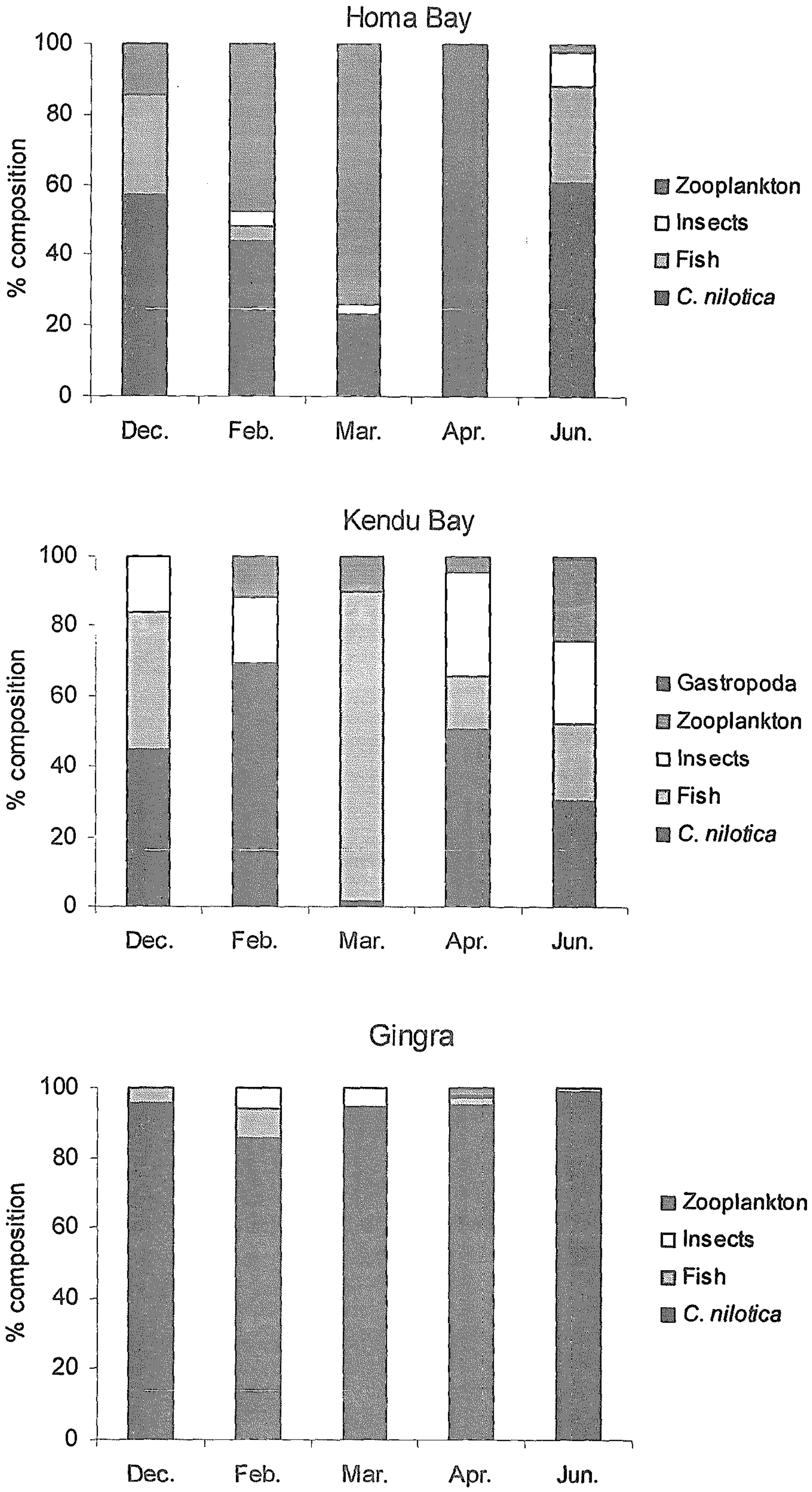

Fig. 5. Dietary composition of juvenile *Lates niloticus* in three locations of Lake Victoria in Kenya.