Invertebrate communities in northern Lake Victoria, with reference to their potential for fishery production

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Abstract: The zooplankton and macrobenthic communities of Lake Victoria were sampled by lift net and Ponar grab, respectively. The zooplankton comprised copepods and cladocerans, rotifers and aquatic insect larvae. Most taxa exhibited wide distribution in the lake, with the exception of rotifers which were rare in deep offshore waters. The main components in the macro-benthos were chaoborid and chironomid larvae and molluscs. *Caridina nilotica* (Roux) and other groups were rare in the samples.

Zooplankton density ranged from <100 000 to 4 million ind. m^{-2} and increased from the shallow inshore to deep offshore waters. Numerical dominance of cyclopoids and nauplius larvae was a common feature at all stations sampled. Most macrobenthic taxa were also widely distributed, although chaoborid and chironomid larvae and gastropods were the most abundant.

Rastrineobola argentea (Pellegrin) and larval *Lates niloticus* (L.) ate mainly cyclopoid copepods, while cichlids showed a strong preference for adult insects. High ecological stability of the cyclopoids, and the zooplankton community in general, despite radical ecosystem changes in recent years, coupled with what appears to be high predation pressure offers good prospects for the pelagic fishery in the lake.

Introduction

The invertebrate fauna of Lake Victoria falls into two broad categories on the basis of size dimensions and the habitats they occupy. Micro-invertebrates or zooplankton are generally small organisms up to about 2 mm body length. The majority of micro-invertebrates are planktonic, i.e. they live suspended in the water column, and exhibit at most feeble movements of their own. They are therefore mostly dispersed by water movements, i.e. waves, currents etc. Macro-invertebrates are much larger organisms, with body size up to several centimetres long. The majority of taxa are associated with bottom sediments and are therefore described as macrobenthic. Some are associated with vegetation along the lake shore.

Invertebrates occupy the secondary trophic level of production in the lake and, besides phytophagous fishes, are the main consumers of the lake's primary (algal) production. They therefore constitute a major link in energy flow culminating in fish production at the top of the food chain. Relatively little attention has been given to invertebrate studies of the lake in the past despite their great ecological importance, especially with respect to energy flow and fish production. However, some early workers carried out limited but useful preliminary investigations on both macro-invertebrates (EAFFRO Annual Reports 1950-1970; Macdonald 1956) and zooplankton (Daday 1907; Sars 1909; Delachaux 1917).

These early workers provided a useful basis for comparison of the historical findings with those of modern investigations (Mavuti and Litterick 1991; Mbahinzireki 1992, 1993; Mwebaza-Ndawula 1994, 1998; Branstrator, Ndawula & Lehman 1996). Most of the historical invertebrate studies were largely descriptive and characterised by limited sampling range given the huge surface area of Lake Victoria (68 800 km^2). Little or no attempt was made to sample areas beyond shallow sheltered bays, gulfs and channels. Potential variability in both species composition and abundance of invertebrates both in time and space was hardly examined. Although invertebrates are known to constitute an important prey category in most larval, juvenile and adult fishes, only Corbet (1961) has provided detailed information on the fish-invertebrate trophic link.

This paper presents results from field sampling in selected areas in the northern portion of Lake Victoria from 1995 to 1997. The paper presents faunistic lists of aquatic invertebrates encountered in the samples, their distribution and abundance patterns; it compares the recent status of zooplankton communities with the historical situation and highlights the trophic interaction between invertebrates and planktivorous fishes as a vital link in fish production processes in the lake.

Materials and Methods

The area of sampling stretched from the western shores of the lake (approx. 31°40' E) and the northern shores (approx. 0° 30' N) as far east as the Kenya border (approximately 34° E) and southwards to the Tanzanian border (1° S). Sampling stations were matched to fish sampling grids in the three operational zones of the EU (LVFRP) project in the Uganda waters of Lake Victoria..

Zooplankton were sampled using two conical nets of the Nansen type, each of 0.25 m mouth diameter and with 50 and 100 µm mesh sizes. At each sampling point, four vertical hauls were taken from about 1 m above the bottom sediments to make one composite sample. Macrobenthos was sampled with a Ponar grab, of which four grabs constituted a composite sample. Fresh samples were preserved in 4% formalin. Organisms were sub-sampled where necessary, examined, taxonomically identified as far as possible and counted under a binocular stereo-microscope.

Fish were sampled with a small mid-water trawl net, having a 1 m^2 mouth opening, 5-mm mesh size and towed behind a canoe with a 25 HP outboard motor. Samples were taken at Napoleon Gulf and off Bugaia Island, representing inshore and offshore waters respectively. Fish were preserved in 10% formalin. For each fish, total length (mm) was measured, the fish was dissected, the gut was carefully removed, and the contents examined under a microscope. Prey organisms were identified to broad taxonomic groups and counted. Prey biomass was computed from existing length-weight regressions (Botrell 1976). Historical zooplankton and fish samples were obtained from J. Talling (Freshwater Biological Association, UK) and the Fisheries Research Institute (FIRI) Museum in Jinja respectively.

Results

Zooplankton taxonomic composition

The zooplankton community of Lake Victoria was composed of crustaceans, comprising cyclopoid and calanoid (diaptomid) copepods and cladocerans (water fleas). Rotifers, aquatic insect larvae and pupae, arachnid mites and a few minor elements were also commonly found (Table 1). Cyclopoids comprised three genera, namely *Thermocyclops*, containing four species, *Mesocyclops* with two species and *Tropocyclops* also with two species. Calanoida comprised two genera: *Thermodiaptomus* and *Tropodiaptomus* with one species each. Cladocera comprised seven genera, each with one species, except *Daphnia* which had two species. Among non-crustaceans, Rotifera was the most important group especially around the shallow inshore areas, and consisted of several genera and species. Rotifers were rare in samples from offshore waters and nearly absent from the historical sample. Other zooplankton taxa occurred in most sampling stations.

Zooplankton relative abundance

Relative abundance of the various taxonomic groups was compared between inshore (NG) and offshore (BG) areas of the lake and with a historical sample (off Dagusi Island, 1961) (Fig. 1). Numerical dominance of cyclopoid copepods (adults and copepodite instars) and larval copepods (nauplii) was a common feature in all four data sets. Comparison of the historical (1961) and recent samples (1995/1996) indicated a substantial increase in the proportion of cyclopoids, and a decline in diaptomids and Cladocera. The long term changes in cyclopoid, diaptomid and cladoceran relative abundance is confirmed by biomass data (Fig. 2).

The horizontal distribution of zooplankton increased from <100 000 ind. m^2 in the shallow inshore areas of the lake to 4 million ind. m^2 in the deeper open waters (Fig. 3). This pattern of abundance contrasts with that of fish in general (Kudhongania & Cordone 1974; Okaronon, Muhoozi & Bassa 1999), and in particular with that of zooplanktivorous fishes which decrease along an inshore-offshore gradient (Mwebaza-Ndawula 1998).

Macro-invertebrate occurrence and densities

The macrobenthic community comprised chaoborid and chironomid larvae (lakefly instars), Oligochaetae (aquatic earthworms). Nematoda (roundworms), Gastropoda (aquatic snails), *Caridina nilotica* (Roux) (freshwater prawns) and other aquatic insect nymphs i.e. Trichoptera (caddis flies) and Ephemeroptera (Mayflies) (Table 2).

All macro-invertebrates encountered during the surveys were widely distributed in the lake (Table 2). Densities increased from inshore to offshore. Based on frequency of occurrence and density, chaoborid larvae, chironomid larvae and gastropods were the most important taxa. This observation corroborates the 'thick clouds' of lakeflies regularly seen over the lake surface as chaoborid and chironomid adults emerge *en masse*. Oligochaetes, chaoborid and chironomid pupae, *C. nilotica*, Trichoptera, Ephemeroptera, bivalves, and nematodes were absent in several stations sampled and their abundance was relatively low.

Zooplankton in the diet of Rastrineobola argentea

The frequency of different zooplankton taxa in the diet of *R. argentea* from inshore and offshore waters and from the historical sample (1966) showed cyclopoid copepods to be the main prey item (Fig. 4). In the offshore sample, nearly 100% cyclopoid consumption was found. However, a higher consumption of both Cladocera and diaptomid copepods was found in the historical *R. argentea* sample compared to recent data reflecting the greater abundance of both prey taxa in the historical zooplankton community (see Figs 1 & 2).

Invertebrates in the diet of other commercial fish species

Nile perch larvae ingested mostly cyclopoids (70%) and cladocerans (17%), whilst cichlid larvae and adult *Yssichromis laparogramma* (Greenwood and Gee) preferred *Chaoborus* larvae (48%) followed by adult insects (20%) and cyclopoid copepods (18%) (Fig. 5). Supplementary prey for *L. niloticus* included calanoids, nauplii and other minor items, while adult insects, cyclopoid copepods and cladocerans supplemented the diet of cichlids.

Discussion

Comparison of recent (1990s) and historical (1961) zooplankton samples showed no recognisable changes in species composition despite radical changes in the lake's physico-chemical character and fish fauna since the 1960s. Nonetheless changes in relative abundance have been reported with respect to cyclopoid and calanoid copepods and cladocerans (Mwebaza–Ndawula 1994). Such shifts in abundance may be associated with eutrophication processes in the lake and concomitant changes in algal species composition. Decline in abundance of Cladocera which are known to be vunerable to fish predation may also suggest substantial increase in predation levels resulting from fish community changes in the lake following the establishment of the introduced Nile perch. The large-sized Cladocera, *Daphnia lumholtzi* seem to be confined to the deep offshore waters (Branstator *et al.* 1996) where planktivorous fish stock densities were much lower than in the shallow inshore areas of the lake (Mwebaza-Ndawula 1998).

The decapod prawns, *C. nilotica*, and chaoborid larvae, although common among zooplankton collections are, only partially planktonic; being associated with bottom sediments or the oxycline during day time but ascending into the water column by night, presumably to feed on small planktonic organisms. The abundance of *C. nilotica* in Lake Victoria has increased tremendously over the past three decades (Lehman, Mbahinzireki & Ndawula 1994) although the present results (Table 2) show very low densities of the prawn at all stations sampled. The timing and frequency of sampling operations and the type of gear used (Ponar grab) may have, to some extent, biased the estimates. The absence of rotifers in the historical zooplankton collection (Table 1) was probably due to the sample being taken with a large mesh net.

Most taxa of zooplankton and macro-invertebrates found (Tables 1 & 2) are prey items of either *R. argentea* (Figs. 4 and 5) or other fishes in the lake (Corbet 1961) and are therefore important in the energy flow and fishery production.

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Table 1. Occurrence of zooplankton taxa at inshore (Napoleon Gulf) and offshore (off Bugaia Island) areas of Lake Victoria (1993-95) compared to a historical sample.

Taxa	No. of species	Occurrence		
		Inshore	Offshore	Historical
Rotifera				
Branchionus	7	P	P	
Filinia	2	P	A	
Keratella	2	P	P	
Polyarthra	1	P	A	
Lecane spp	++	P	A	
Asplanchna	1	P	P	
Trichocerca	1?	P	A	
Aneuropsis	1	P	A	
Euclanis	1	P	A	
Hexathra	1	P	A	
Pompholyx	1?	P	A	
Crustacea				
Cylopoida				
Thermocyclops	4	P	P	P
Mesocylops	2	P	P	P
Tropocylops	2	P	P	P
Calanoida				
Thermodiaptomus	1	P	P	P
Tropodiaptomus	1	P	P	P
Cladocera				
Daphnia	2	P	P	P
Ceriodaphnia	1	P	P	P
Diaphanosoma	1	P	P	P
Bosmina	1	P	A	P
Chydorus	1	P	A	P
Alona	1	P	A	P
Moina	1	P	A	P
Decapoda				
Caridina	1	P	P	
Insecta				
Chaoborus (larvae/pupae)	1	P	P	
Arachnida				
Acarid mites	?	P	A	A

Table 2. Occurrence and density (no. m^{-2}) of macro-invertebrate taxa in different sampling stations in Lake Victoria November 1995 – October 1997

Station	Date	Depth (m)	Chaoborid larvae	Chironomid larvae	Oligochaeta	Gastropoda	Others
Sari-kasuri	Oct. 95	13	82	143	41	1286	143
Mweza-kasayi	Feb. 96	15	82	20	367	102	61
South Banga point	Feb. 96	29	306	367	286	163	367
Sigulu	Apr. 96	17	265	0	41	265	122
Sigulu	Sep. 97	17	775	388	0	0	41
White Stony	Mar. 97	22	408	163	48	490	82
Itome Bay	Aug. 97	19	2285	143	82	20	224
Itome Bay	Apr. 97	29	2836	1857	20	41	0
Dagusi	Aug. 97	16	347	122	0	102	20
Mvuja	Aug. 97	18	551	1387	0	265	20
Mvuja	Oct. 97	39	1388	82	0	41	40
Frequence of occurrence			11	10	7	10	

Note: 'Others' include: Chaoborid pupae, Chironomid pupae. *Caridina*, Trichoptera, Ephemeroptera, Bivalves and Nematoda

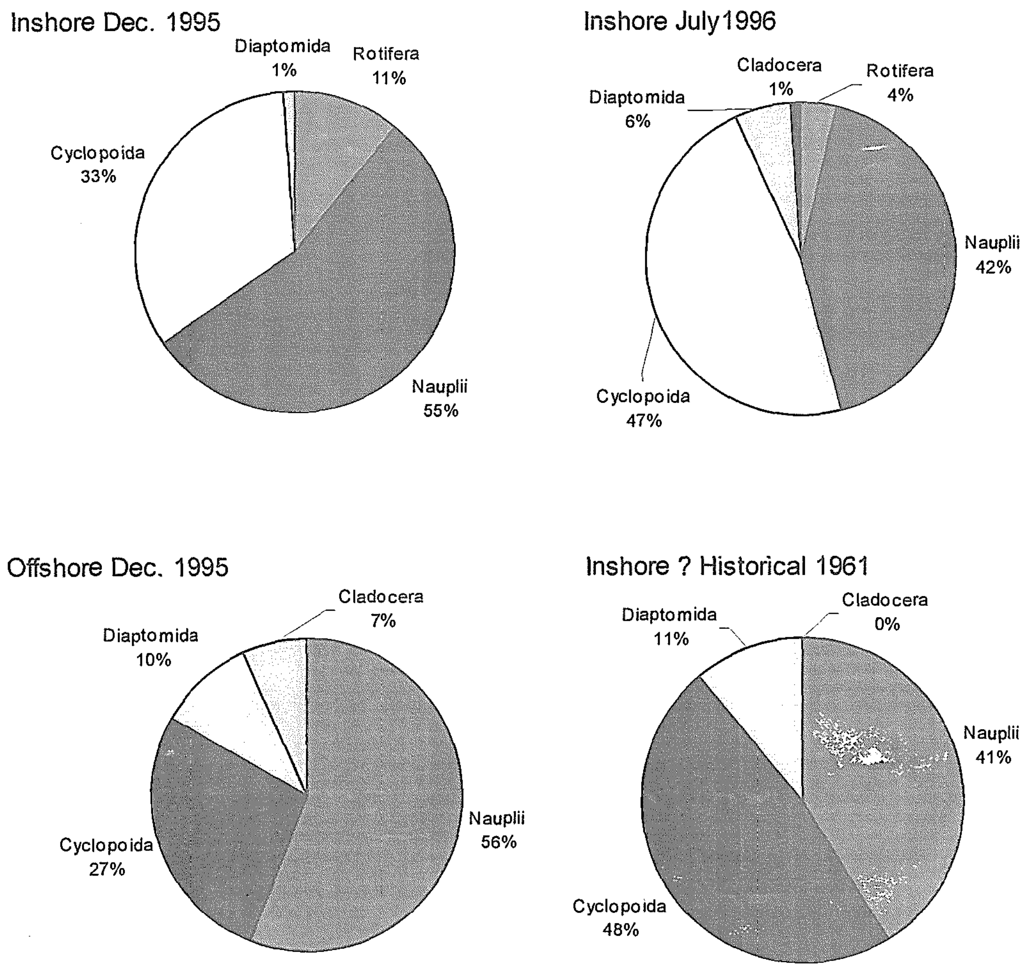


Fig. 1. Relative abundance (numbers) of zooplanktonic groups between inshore and offshore waters

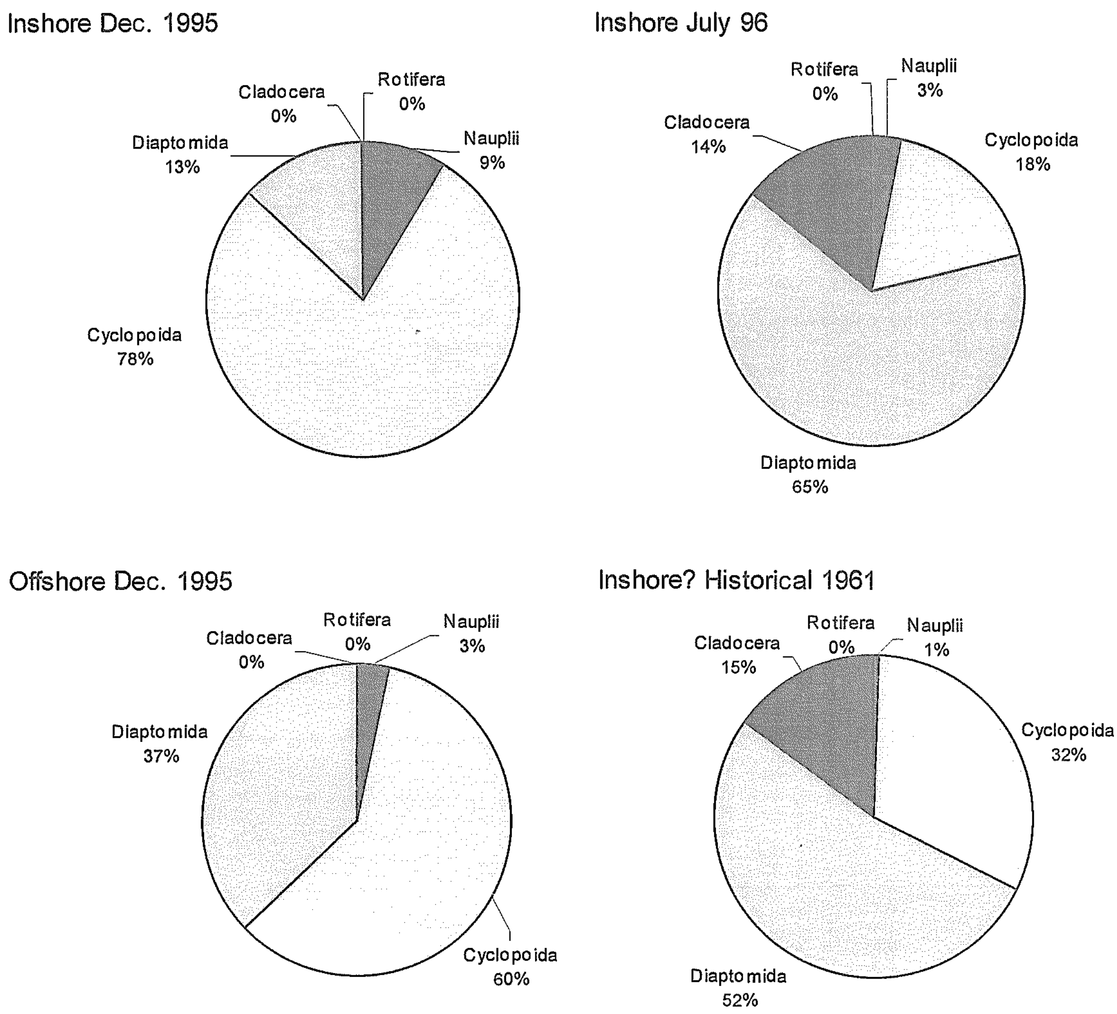


Fig. 2. Relative abundance (biomass) of zooplanktonic groups between inshore and offshore waters

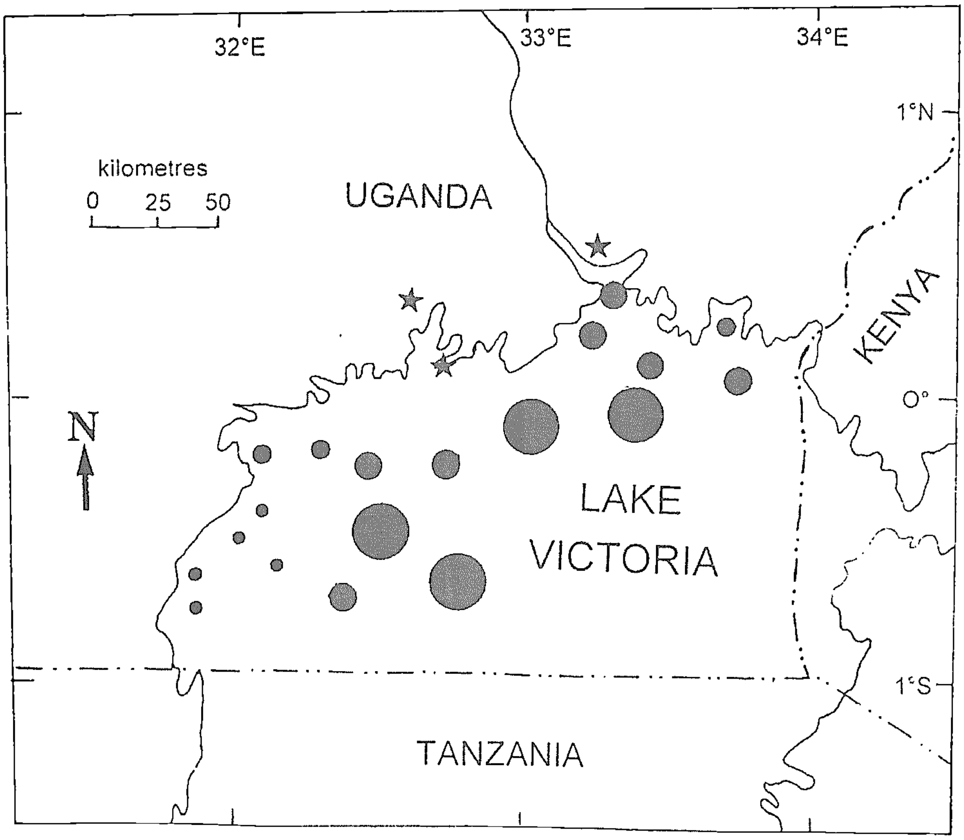


Fig. 3. Map of the Ugandan waters of Lake Victoria showing concentrations of zooplankton, represented by (●) at the sampling sites, with relative abundance indicated by the size of the circles.

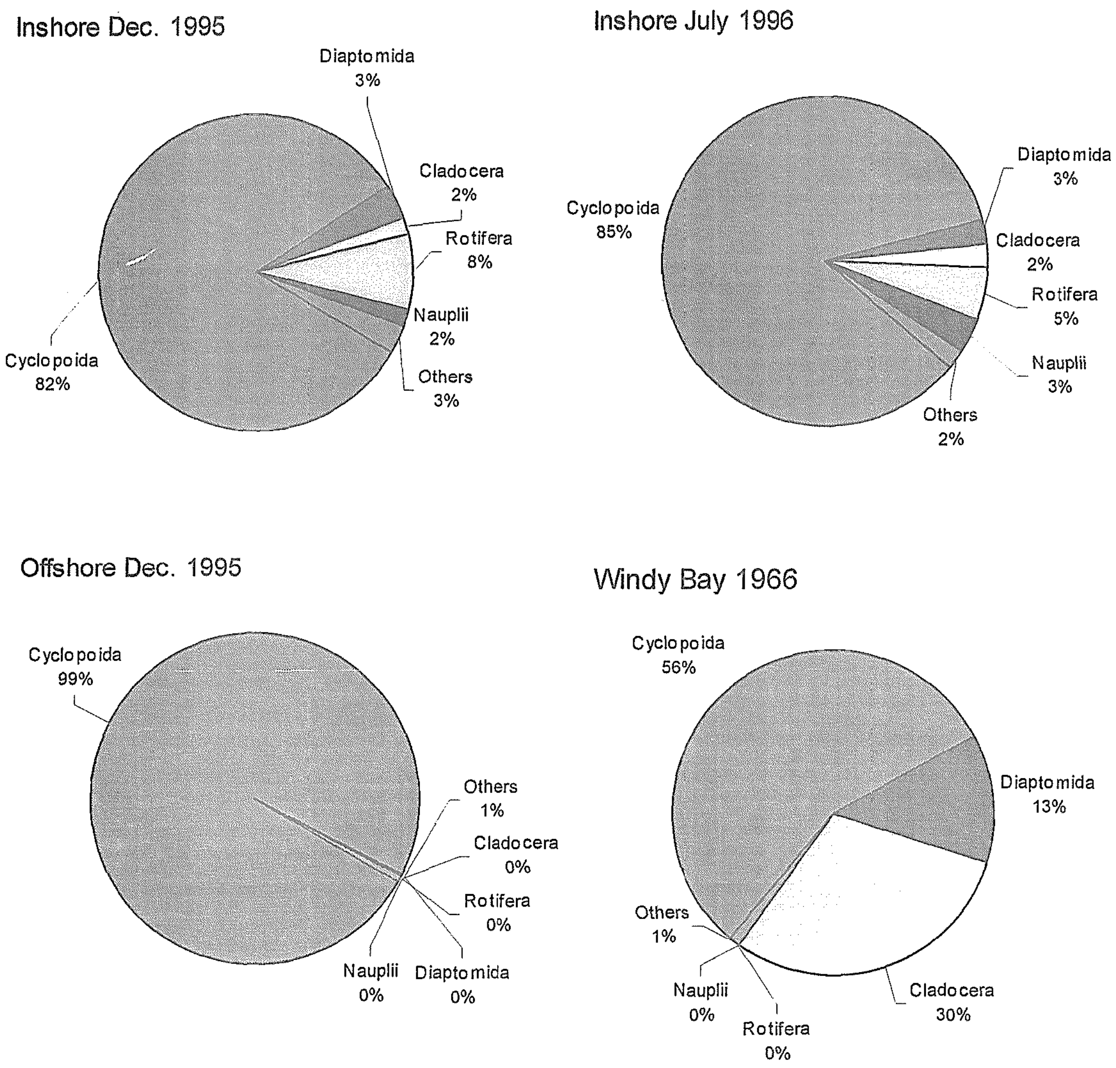
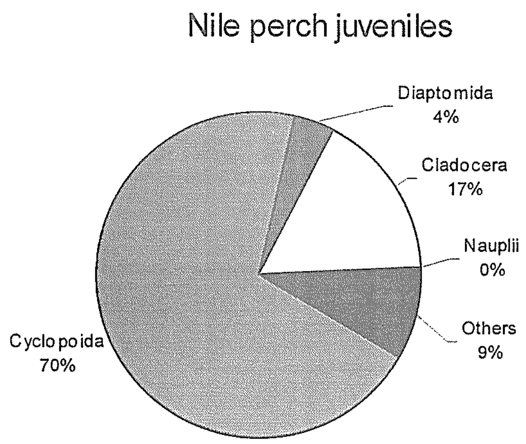


Fig. 4. Relative composition of different zooplankton taxa in the food of *R. argentea* from inshore, offshore and historical samples.



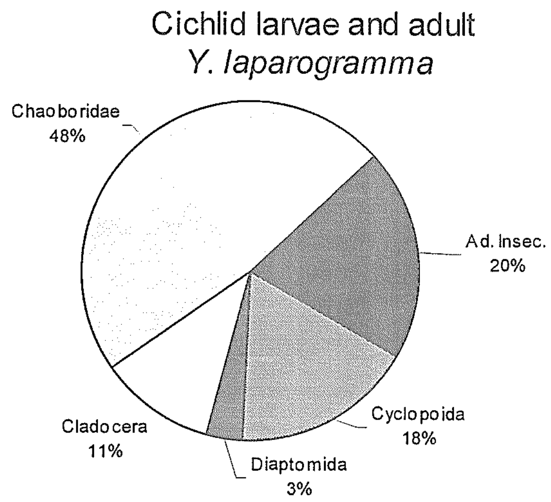


Fig. 5. Relative composition of prey taxa in juvenile *Lates*, cichlids and adult *Yssichromis laparogramma*.