# ZOOPLANKTON COMMUNITIES OF SELECTED STATIONS OF LAKE VICTORIA

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**ABSTRACT**

*Species composition and diversity of zooplankton communities of Lake Victoria (Tanzanian waters) were studied. In the shallow waters zooplankton were collected between March and April, and between August and December 2000. In deeper waters zooplankton were collected in August 2001. Overall, 20 genera and 29 species of zooplankton were observed in the shallow waters whereas 12 genera and 20 species of zooplankton were encountered in the deeper waters. The highest abundance was recorded in the deeper waters (2,481,633 $m^{-2}$). In the shallow waters the cyclopoid copepods dominated the zooplankton community, the common species being* Thermocyclops emini *and* Thermocyclops neglectus. *In the deeper waters the calanoid copepod* Thermodiaptomus galeboides *dominated. The abundance of* cladocera *increased with depth, the common species was* Daphnia lumhortzi. *In the shallow waters the cyclopoid contributed much to biomass as opposed to the calanoid in the deeper waters.*

## INTRODUCTION

Crustacean zooplankton provides the basis of fish production, but frequently through additional trophic step (Allison et al. 1996). The quantification of zooplankton production, therefore, assists in the understanding of fisheries production and, perhaps of more importance, of the nature of ecosystem trophic dynamics in the African Great Lakes (Irvine and Waya 1992). In Lake Victoria the obligate zooplanktivorous fishes include *Rastrineobola argentea* (one of the major commercial species) and Haplochromines. Other facultative zooplanktivores include larvae/juvenile fishes and invertebrate predators such as larvae of the fly genus *Chaoborus*, rotifers (*Asplanchna*), mites (Ndawula 1994, Moss 1998) and the cyclopoid copepod *Mesocyclops* (Irvine and Waya 1992). There have been few research works on zooplankton ecology in the southern part of Lake Victoria (Akiyama et al. 1977, Waya 2001). The information on zooplankton in the pelagic area of the Tanzanian waters of Lake Victoria is scanty. The aim of this study was to investigate the zooplankton communities in the shallow nearshore and deep-pelagic waters of the southern part of Lake Victoria with more emphasis on species composition, diversity and standing biomass.

## MATERIALS AND METHOD

### Study Site

In the shallow nearshore areas of Lake Victoria samples were collected between March and April, and between August and December 2000 from four zones namely Emini Pasha Gulf, Speke Gulf, Mara and Mwanza Gulf. In the deep-pelagic waters samples were collected between August and September 2001 at

Ukara Island off Ukara, Lukuba West and Bukasa (Figure 1).

**Methodology**

Zooplankton samples were collected using a plankton net of 65 _m size having an opening of 29 cm diameter and 1 m in length. At each sampling point, three vertical hauls were taken from about 1 m above the bottom sediments to make one composite sample. Fresh samples were preserved in 4% sugar formalin.

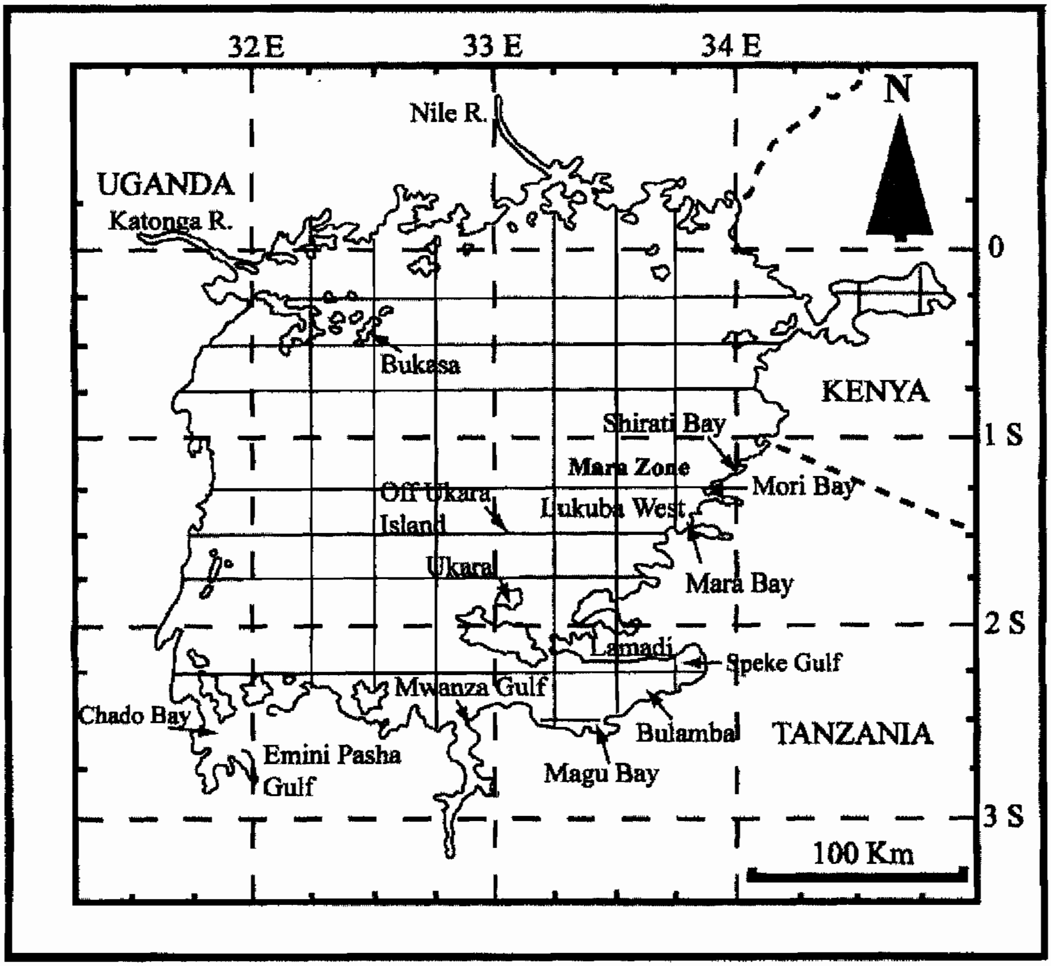


**Figure 1**: A map of Lake Victoria showing sampling sites

In the laboratory each sample was diluted, agitated and sub-sampled with a 5mls syringe. The zooplankton were counted in three sub-samples (two of 2 ml and one of 5 ml). The sub-sample was placed on a counting chamber and examined under the microscope at x40 magnification. Taxonomic identification was done using available identification keys (Ruttner-Kolisko 1974, Korinek

1984, Boxshall et al. 1991, Maas 1993). Adult individuals of both sexes were lumped together and identified to species. The development stages of copepods (C1-C5) were lumped together as a single count category (copepodites). Nauplii stages were also grouped together. The density of zooplankton was calculated from the count data. The species diversity was also determined. For biomass calculation, copepod body length was measured from the top of the head to the tip of the furci-rami. Cladocera and rotifers were measured from the top of the head to the tip of the abdomen excluding the spines and the projections. Their biomass was determined.

Data analysis was done by using instat statistical package. Zooplankton density differences were analyzed by repeated measures ANOVA. The Turkey Kramer multiple comparison test was used to test the difference between sampling stations whereas the Shannon Wiener diversity index (H') (Shannon et al. 1949) was used to calculate species diversity.

## RESULTS

### Zooplankton taxonomic composition

Tables 1 and 2 show the species composition of zooplankton in the shallow nearshore and deep-pelagic waters of the study area. Zooplankton community was composed of rotifers and crustaceans, comprising cyclopoid and calanoid (diaptomid) copepods and cladocerans (water fleas). Other planktonic organism found amongst the zooplankton were the meroplanktonic representatives including larval stages of insects especially chaoboridae and the atyid prawns, the Caridina. In the shallow nearshore areas 20 genera and 29 species of zooplankton were observed (Table 1). In the deep pelagic waters 12 genera and 20 species of zooplankton were encountered; cyclopoid comprised three genera, calanoid comprised one genus and cladocera comprised four genera.

According to Shannon Weiner species diversity indices (H') there were no significant difference of species diversity between the shallow nearshore waters and deep-pelagic waters ($t = 0.5977$, $df = 6$, $P = 0.5719$).

### Zooplankton abundance

Mean zooplankton abundance in the shallow nearshore and deep-pelagic waters is shown in Figures 2 and 3. In the shallow areas, the highest number of zooplankton was recorded in December 2000. The number of zooplankton reached 745,867 $m^2$ and few zooplankton were recorded between March and April, the abundance was 40,072 $m^{-2}$. The zooplankton community of Lake Victoria is dominated by the copepods, which comprised 90% of the total zooplankton abundance between March and April 2000, 91% in August 2000, and 89% in December 2000. Among the copepods, cyclopoid copepods (Adults, copepodites and nauplius larvae) were the most common group throughout the study period. The average percent composition by number between March and April 2001 was as follows: cyclopoid copepods (44%), calanoid copepods (7%), nauplius larvae (40%), cladocerans (3%) and rotifers (7%). In August the average percent composition was as follows: cyclopoid (60%), calanoid copepod (20%), nauplius larvae (10%), cladocerans (4%) and rotifers (6%). In December the average percent composition was as follows: cyclopoid (37%), calanoid copepods (3%), nauplius larvae (50%), cladocerans (1%) and rotifers (8%).

**Table 1:** Zooplankton species composition (mean no/m$^2$) at different zones in the littoral aeas of Lake Victoria, March/April, August & December 2000

| Taxa | Mara region No/m$^2$ | % | Mwanza gulf No/m$^2$ | % | Emini pasha gulf No/m$^2$ | % | Speke gulf No/m$^2$ | % |
|---|---|---|---|---|---|---|---|---|
| **Cladocera** | | | | | | | | |
| *Bosmina longirostris* | 145 | 0.1 | 157 | 0.0 | 170 | 0.0 | 778 | 0.1 |
| *Ceriodaphnia cornuta* | 2721 | 1.0 | 38 | 0.0 | 907 | 0.2 | 1361 | 0.2 |
| *Daphnia lumhortzi* (helm.) | 1171 | 0.4 | 2154 | 0.5 | 0 | 0.0 | 3311 | 0.4 |
| *Diaphanosoma excisum* | 1607 | 0.6 | 2683 | 0.6 | 1602 | 0.4 | 10899 | 1.5 |
| *Moina micrura* | 1660 | 0.6 | 6122 | 1.4 | 0 | 0.0 | 2166 | 0.3 |
| **Calanoida** | | | | | | | | |
| Calanoid copepodites | 14034 | 5.4 | 24666 | 5.6 | 10320 | 2.5 | 33996 | 4.6 |
| *Thermodiaptomus galeboides* | 11163 | 4.3 | 19501 | 4.5 | 7823 | 1.9 | 23196 | 3.1 |
| **Cyclopoida** | | | | | | | | |
| Cyclopoid copepodite | 51595 | 19.7 | 65558 | 15.0 | 118781 | 28.8 | 168394 | 22.7 |
| *Eucyclops spp.* | 0 | 0.0 | 113 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| *Mesocyclops sp.* | 265 | 0.1 | 9410 | 2.1 | 6485 | 1.6 | 6378 | 0.9 |
| *Thermocyclops emini* | 20094 | 7.7 | 20005 | 4.6 | 32653 | 7.9 | 23280 | 3.1 |
| *Thermocyclops incisus* | 1663 | 0.6 | 19 | 0.0 | 8027 | 1.9 | 11134 | 1.5 |
| *Thermocyclops neglectus* | 11144 | 4.3 | 12320 | 2.8 | 23278 | 5.6 | 24683 | 3.3 |
| *Tropocyclops confinnis* | 11722 | 4.5 | 12270 | 2.8 | 6165 | 1.5 | 20286 | 2.7 |
| *Tropocyclops tenellus* | 11909 | 4.5 | 21857 | 5.0 | 17221 | 4.2 | 41831 | 5.6 |
| **Nauplius larvae** | 96163 | 36.7 | 114223 | 26.1 | 163731 | 39.7 | 289263 | 39.0 |
| **Rotifera** | | | | | | | | |
| *Ascomorpha sp.* | 340 | 0.1 | 0 | 0.0 | 0 | 0.0 | 642 | 0.1 |
| *Asplanchna spp.* | 1185 | 0.5 | 6878 | 1.6 | 986 | 0.2 | 1704 | 0.2 |
| *Brachionus angularis* | 2338 | 0.9 | 58957 | 13.5 | 915 | 0.2 | 1419 | 0.2 |
| *Brachionus calyciflorus* | 725 | 0.3 | 3798 | 0.9 | 786 | 0.2 | 21655 | 2.9 |
| *Brachionus caudatus* | 3118 | 1.2 | 29025 | 6.6 | 1493 | 0.4 | 2362 | 0.3 |
| *Brachionus falcatus* | 165 | 0.1 | 239 | 0.1 | 302 | 0.1 | 265 | 0.0 |
| *Filinia longiseta* | 197 | 0.1 | 0 | 0.0 | 0 | 0.0 | 2774 | 0.4 |
| *Filinia opoliensis* | 238 | 0.1 | 19 | 0.0 | 0 | 0.0 | 635 | 0.1 |
| *Filinia longiseta* | 227 | 0.1 | 0 | 0.0 | 0 | 0.0 | 1088 | 0.1 |
| *Keratella cochlearis* | 6009 | 2.3 | 1361 | 0.3 | 1512 | 0.4 | 6259 | 0.8 |
| *Keratella tropica* | 2154 | 0.8 | 5480 | 1.3 | 1141 | 0.3 | 26594 | 3.6 |
| *Keratella quadrata* | 1854 | 0.7 | 12094 | 2.8 | 1429 | 0.3 | 12094 | 1.6 |
| *Synchaeta spp.* | 599 | 0.2 | 2910 | 0.7 | 3598 | 0.9 | 1209 | 0.2 |
| *Polyarthra spp.* | 420 | 0.2 | 472 | 0.1 | 605 | 0.1 | 454 | 0.1 |
| *Trichocerca spp.* | 813 | 0.3 | 1852 | 0.4 | 1436 | 0.3 | 272 | 0.0 |
| *Trichocerca cylindrica* | 454 | 0.2 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| *Lecane bulla* | 0 | 0.0 | 2721 | 0.6 | 314 | 0.1 | 877 | 0.1 |
| **Chaobrid larvae** | 1995 | 0.8 | 454 | 0.1 | 0 | 0.0 | 231 | 0.0 |
| **Ostracods** | 454 | 0.2 | 0 | 0.0 | 847 | 0.2 | 0 | 0.0 |
| **Caridina** | 385 | 0.1 | 340 | 0.1 | 0 | 0.0 | 0 | 0.0 |
| **Snail** | 0 | 0.0 | 340 | 0.1 | 0 | 0.0 | 0 | 0.0 |
| **Ordonata** | 1011 | 0.4 | 0 | 0.0 | 0 | 0.0 | 283 | 0.0 |
| **Total no m$^{-2}$** | **261739** | | **438039** | | **412527** | | **741771** | |

**Table 2:** Zooplankton species composition (Mean no/m2) in the offshore waters of the southern part of Lake Victoria, August/September 2001.

| Taxa | 28 m Lukuba West No/m$^2$ | % | 58 m Ukara No/m$^2$ | % | 70 m Off Ukara No/m$^2$ | % |
|---|---|---|---|---|---|---|
| **Cladocera** | | | | | | |
| *Bosmina longirostris* | 2721 | 0.4 | 0 | 0.0 | 0 | 0 |
| *Daphnia lumhortzi* (helm.) | 0 | 0.0 | 119728 | 4.8 | 8163 | 1.8 |
| *Diaphanosoma excisum* | 10884 | 1.4 | 10884 | 0.4 | 0 | 0.0 |
| *Moina micrura* | 0 | 0.0 | 21769 | 0.9 | 2041 | 0.4 |
| **Calanoida** | | | | | | |
| Calanoid copepodites | 46259 | 6.1 | 228571 | 9.2 | 79592 | 17.1 |
| *Thermodiaptomus galeboides* | 35374 | 4.7 | 565986 | 22.8 | 234694 | 50.4 |
| **Cyclopoida** | | | | | | |
| Cyclopoid copepodite | 136054 | 17.9 | 582313 | 23.5 | 30612 | 6.6 |
| *Mesocyclops sp.* | 0 | 0.0 | 81633 | 3.3 | 2041 | 0.4 |
| *Thermocyclops emini* | 21769 | 2.9 | 310204 | 12.5 | 20408 | 4.4 |
| *Thermocyclops incisus* | 0 | 0.0 | 16327 | 0.7 | 2041 | 0.4 |
| *Thermocyclops neglectus* | 10884 | 1.4 | 272109 | 11.0 | 24490 | 5.3 |
| *Tropocyclops confinnis* | 0 | 0.0 | 5442 | 0.2 | 6122 | 1.3 |
| *Tropocyclops tenellus* | 21769 | 2.9 | 70748 | 2.9 | 4082 | 0.9 |
| **Nauplius larvae** | 446259 | 58.8 | 174150 | 7.0 | 38776 | 8.3 |
| **Rotifera** | | | | | | |
| *Ascomorpha sp.* | 2721 | 0.4 | 0 | 0.0 | 0 | 0 |
| *Asplanchna spp.* | 0 | 0.0 | 5442 | 0.2 | 4082 | 0.9 |
| *Brachionus angularis* | 2721 | 0.4 | 5442 | 0.2 | 2041 | 0.4 |
| *Brachionus calyciflorus* | 0 | 0.0 | 0 | 0.0 | 4082 | 0.9 |
| *Brachionus leydig* | 0 | 0.0 | 0 | 0.0 | 2041 | 0.4 |
| *Brachionus patulus* | 2721 | 0.4 | 0 | 0.0 | 0 | 0.0 |
| *Keratella cochlearis* | 13605 | 1.8 | 0 | 0.0 | 0 | 0.0 |
| *Keratella tropica* | 2721 | 0.4 | 5442 | 0.2 | 0 | 0.0 |
| *Keratella quadrata* | 2721 | 0.4 | 0 | 0.0 | 0 | 0.0 |
| **Chaobrid larvae** | 0 | 0.0 | 5442 | 0.2 | 0 | 0.0 |
| **Caridina** | 0 | 0.0 | 0 | 0.0 | 2041 | 0.4 |
| **Total no/m2** | **759,184** | | **2,481,633** | | **465,306** | |

The highest density of zooplankton (741,771 m$^{-2}$) was recorded in Speke gulf (Table 2). Mwanza Gulf was next (438,039 m$^{-2}$), followed by Emini Pasha Gulf (412,527 m$^{-2}$) and Mara Region (262,062 m$^{-2}$). The density difference between zones was significant (Repeated Measures Analysis of Variance, F = 3.498, P = 0.0177). The Tukey Kramer Multiple comparisons showed a significant difference between Mara Region and Speke Gulf (P<0.05). In the deep-pelagic waters the highest density of zooplankton was recorded around Ukara; the density was 2,481,633 m$^{-2}$ (Figure 3). Generally the density difference among the stations was very significant (Repeated Measure Analysis of Variance F = 5.677, P = 0.0015). According to Tukey Kramer multiple comparisons test there was a significant difference between Lukuba West and Ukara (P<0.05), Bukasa and Ukara (P<0.01) and between Ukara and off Ukara (P<0.01). Calanoid copepod contributed much to the total zooplankton abundance. Off Ukara the calanoids contributed 67% of the total zooplankton mean abundance.

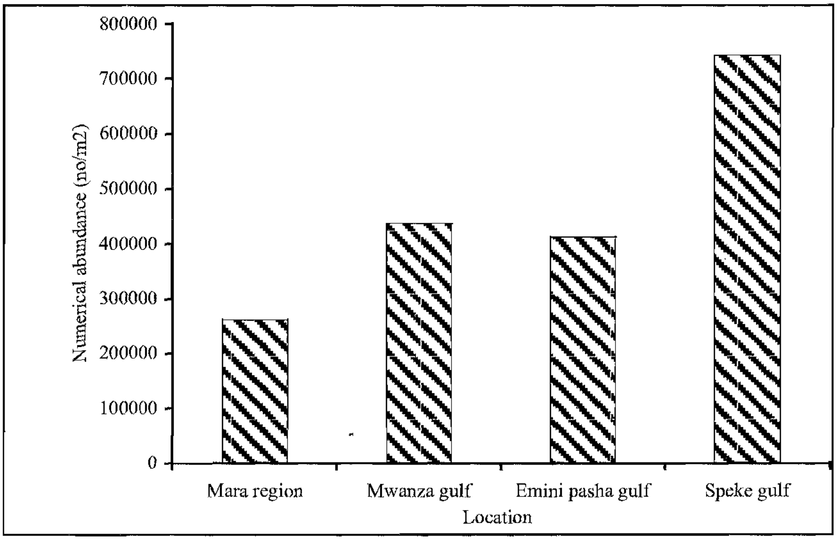


**Figure 2:** Zooplankton mean abundance (no/m2) in the near shore waters of Lake Victoria, March/April. August & December

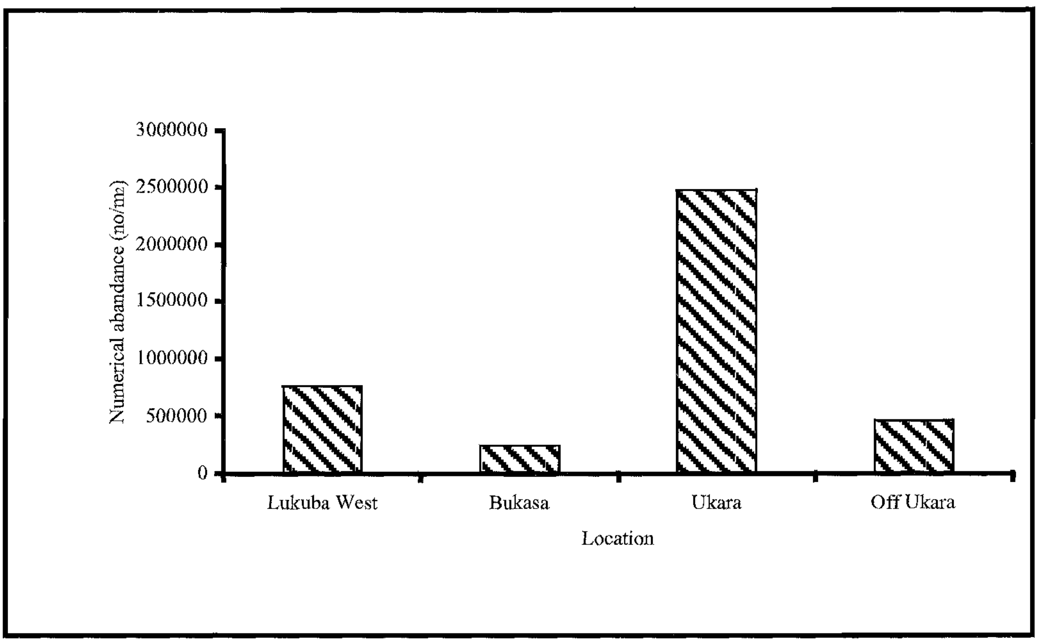


**Figure 3:** Zooplankton mean abundance (no/$m^2$) in the deep pelagic waters of lake Victoria

**Biomass estimates**

Estimates of biomass of the major zooplankton groups in the shallow nearshore and deep-pelagic waters of Lake Victoria are shown in Figure 4. In the shallow nearshore waters the mean total biomass was 2,281 mg wet wt $m^{-2}$. The highest biomass was observed in December 2000 at Emini Pasha Gulf contributed mostly by the cyclopoids (55% of the total biomass) followed by calanoids (30%), cladocerans (5%) and rotifers (3%). In the deep-pelagic waters the highest biomass was contributed by zooplankton in deeper stations between, 48.4 m and 70 m. The overall mean biomass was 12,078 mg wet wt $m^{-2}$. Biomass was dominated by the calanoid copepod *Themodiaptomus galeboides* which comprised 62% of the total crustacean biomass followed by the cyclopoid copepod (30%), Rotifers and Cladocerans contributed relatively little to total biomass (1% and 6% respectively).

## DISCUSSION

Lake Victoria is given special attention as a lake that has exhibited changes in limnological condition during the present century, which seem to be driven primarily by changes in nutrient input and regional climate (Lehman 1996). However, the zooplankton community structure in the lake is in agreement with studies on other East African Great Lakes. One striking enigma of the African Great Lakes, however, is the contrast between levels of biodiversity in their littoral and benthic habitats with those of the lake pelagia. Most of the species richness in these lakes is confined to nearshore regions, and biological communities in the pelagic areas may be species poor in comparison with some temperate great lakes ecosystems (Lehman 1996).

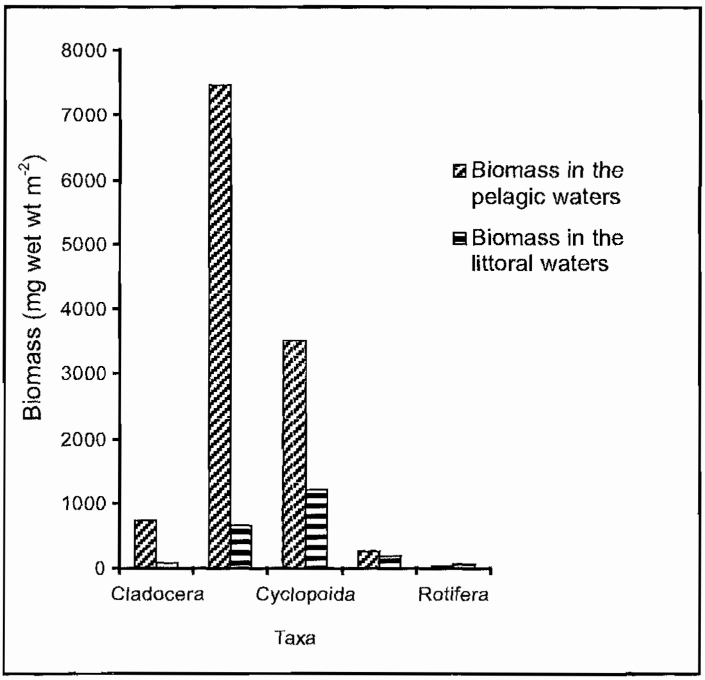


**Figure 4**: Biomass estimates (mg wet wt $m^{-2}$) in Lake Victoria

In common with the other East African Great lakes the offshore region of Lake Victoria comprised fewer zooplankton species than nearshore regions. 20 species of zooplankton were encountered offshore while 29 species were identified in the nearshore. The zooplankton of the nearshore and offshore stations are similar in that, copepods are always most abundant with fewer cladocera and still fewer rotifers. The cyclopoids were dominant in all stations except at 48.4 m and 70 m where calanoids (copepodites and adults) were dominant. The abundance of cladocera increased with depth. This result agreed with that of Branstrator et al. (1996) who suggested that the large bodied cladocerans *Daphnia longispina* and *D. lumholtzi* var. *monacha* are more successful at the offshore of Ugandan waters. Another study on the distribution of cladocerans in East African lakes was described by Green (1971) as a nearshore-offshore gradient in species distributions, particularly for *D. lumholtzi* in Lakes Albert and Edward. He found that larger *Daphnids* were more successful in offshore regions and, that the smaller forms tended to dominate nearshore regions of the large lakes. The findings of Green (1971) agree with the current study where the large cladocerans *D. lumholtzi* were found at 57.9 m and 70 m. A similar pattern was followed by the large calanoid copepods. The distributional pattern of daphnids observed in Ugandan waters is consistent with a gradient in fish planktivory that declines from nearshore to offshore. Probably this may be the reason why the daphnids and calanoids were more abundant in offshore than nearshore.

In the current study rotifers were not many in the offshore waters. According to Lehman et al. (1993) "a reverse gradient in the intensity of invertebrate predation may exist from the nearshore to offshore regions of these large lakes as this would account for the paucity of small bodied zooplankton prey, particularly rotifers, observed in the offshore regions. This may explain why more rotifers were observed in the nearshore waters.

In this study the highest number of zooplankton were in the offshore waters at 57.9 m, where the density reached 2,481,633 $m^{-2}$. This may be because the area is more productive. Also it may suggest that there is more predation in the nearshore water. According to Greenwood (1966), *Rastrineobola argentea* are mainly found from the surface of nearshore waters although sometimes the species are obtained from surface waters over great depth (69 m). Also the nearshore zones may be a refuge for otherwise open-water organisms or provide food at particular stages in their life histories. Plants and their detritus are used by many species of fish to lay their eggs so the newly hatched fish after utilizing the remains of the yolk sac feed on organism of a size appropriate to their mouth gape such as algae and rotifers. The biomass was high in the offshore waters compared to the nearshore waters, this may be because the zooplankton community in the offshore is dominated by the large calanoid copepods.

During March and April and August and December 2000, the highest number of zooplankton species was recorded from Speke Gulf (26 species) followed by Mara region (24 species) and the least from Emini Pasha Gulf and Mwanza gulf (19 species each). The group Rotifera contributed the largest number of species (17) and was widely distributed and dominated by Brachionids. The highest number of rotifera was also reported by Mavuti et al. (1991) in Kenyan waters. It was observed that both *Branchionid caudatus* and *B. calyciflorus* were the common occurrence but in the present study the common species was *B. caudatus.* The higher diversity of rotifers in Lake Victoria may reflect eutrophication in the lake. Similar results were observed in Winam Gulf in Kenyan waters by Mavuti et al. (1991) who noted that the increased eutrophication of the Winam Gulf is reflected by the reduced species diversity of cladocera and increased diversity of rotifer species.

Cladocera were dorminated by three species, *D. excisum, Bosmina* longirostris and *Moina micrura. Diaphanosoma* was widely distributed in all zones surveyed. *B. longirostris* and *M. micrura* were encountered in 3 zones, Mwanza Gulf, Speke Gulf and Mara Region. The daphnids were very scarce. They seem to prefer the open water areas (Mavuti et al. 1991). Copepoda was the most dominant zooplankton in Speke Gulf, Emini Pasha Gulf and Mara Region. *Tropocyclops tenellus* was the dominant species in Speke Gulf. This may be attributed to higher fish species diversity and catches in Speke Gulf.

Normally the zooplankton community is often shaped by predation and vertebrate effects seem to be more extensive than those of invertebrate predators (Moss 1998, Hrbacek et al. 1961). If predation is high the zooplankton community tends to change from large zooplankton like *Daphnia* and *Mesocyclops* to smaller zooplankton such as *Ceriodaphnia, Tropocyclops* and *Bosmina.* This may explain the dominance of *Tropocyclops tenellus* in Speke Gulf. In Emini Pasha Gulf two species of *Thermocyclops* were dominant, *T. emini* and *T. neglectus.* In Mara Region, Mori bay, Shirati bay and Baumann Gulf the dominant species were *T. emini* but in Mara Bay the calanoid *Thermodiaptomus galeboides* was the common species and *T. neglectus* was the dominant copepoda in Mwanza Gulf.

In Kenyan waters (Mavuti et al. 1991), reported *T. neglectus* and *T. emini* to be the most dominate copepods. This was not the case in Speke Gulf and Mara Bay confirming that the zooplankton distribution is not uniform (Waya 1995). The post naupliar copepodite and nauplius larvae were the most numerous. This observation is similar to that in the Ugandan waters (Mwebaza – Ndawula 1994).

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