## CHAPTER NINE

## Aquatic invertebrates in Lake Victoria, Uganda portion

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***ABSTRACT**. Copepoda, Cladocera, Rotifera constituted the zooplankton community of Lake Victoria and small basin lakes while several groups of which Diptera and Molluscs are the more distinctive taxa made up the macro-invertebrates. Estimated abundance indicated generally higher densities of organisms and diversity indices around littoral compared to pelagic habitats. These trends can be partly explained by a more productive inshore area that receives nutrients from adjacent hinterlands and to some extent due to groups such as rotifers that show greater diversity and abundance in shallow near-shore area of the lake. Vertical distribution of zooplankton was related to profiles of temperature and dissolved oxygen. In shallow littoral habitats, where there was no development of thermocline and oxycline in the water column, zooplankton densities showed nearly unrestricted distribution from surface water to the bottom. In contrast, the vertical distribution at deeper pelagic stations during thermo-stratification indicated concentration of organisms in mid-to-surface water layers due to development of low dissolved oxygen conditions (<1.0mg $l^{-1}$) in bottom water layers (hypolimnion). The latter situation is tantamount to loss of the hypolimnion as habitable space for zooplankton and other aquatic biota, many of which are sensitive to low dissolved oxygen conditions. Certain categories of invertebrates, however, including chironomids, chaoborids, oligochaetes and Caridina nilotica are physiologically adapted to survive under low dissolved oxygen conditions. The frequent encounter of these organisms in high abundance is a sign to the deteriorating water quality in Lake Victoria. On the other hand, populations of these organisms are capable of utilizing low dissolved oxygen habitats such as the hypolimnion as refugia and are therefore protected from excessive predation by fish and invertebrate predators.*

## INTRODUCTION

Aquatic invertebrates are constituted by two categories that can be distinguished on the basis of body size and the habitats they occupy in a water body. Zooplankton or micro-plankton refers to small-to-minute organisms in the size range of up to 1500µm (1.5mm) body length, which live suspended in the water column. Most of the zooplankton in Lake Victoria belong to two broad taxonomic categories: Crustacea and Rotifera. Crustacean zooplankton comprises several genera and species of copepods and cladocerans (water fleas). Rotifers comprise a large number of genera and species commonly occurring around shallow inshore bays and gulfs.

Macro-invertebrates or macro-benthos refer to a wide range of organisms with body size generally greater than 1.5mm that live on or burrow in bottom sediments. Some of them engage in diurnal vertical migration, ascending into the water column at dusk and retuning to the sediments at dawn. A number of these organisms are also associated with roots of aquatic macrophytes. These include dipteran larvae and pupae, nymphs of aquatic insects, oligochaete worms, ostracods, gastropods and bivalves.

Invertebrates occupy an important position in aquatic food webs. They graze on algae, detrital particles and parts of aquatic macrophytes converting them to animal protein for use further up in the food chain and ultimately for fish production. The grazing activities of zooplankton are known to control algal populations especially in the temperate region where the Spring 'clear water' phase is explained by limitations of phytoplankton growth due to meta-zooplankton (mainly crustaceans) and protozoan grazing impacts and exhaustion of nutrients by the phytoplankton itself (Arndt and Nixford 1991). However, in-situ experiments conducted in Lake Victoria to test effects of nutrients and grazing on phytoplankton by Lehman and Branstrator (1993) indicated minimal impact of zooplankton grazing on algal biomass. Invertebrate feeding activities coupled with high turnover rates are believed to influence the regeneration and recycling of nutrients, which in turn enhance algal production. A number of macro-invertebrates such as some chironomids, some snail species and oligochaete worms can be used as bio-indicators of water quality (Mwebaza-Ndawula *et al.* 2003b). They also provide dependable food sources to fishes (Corbet 1961; Greenwood 1966).

Despite the major roles played by invertebrates in the water quality and trophic ecology of the lake, little research work was undertaken on these organisms before the 1990s (Worthington 1931; Rzoska 1957; Akiyama *et al.* 1977; Hoogenboezem 1985 and Macdonald 1956). A number of substantive studies have however been undertaken since the 1990s to date (Mbahinzireki 1994; Okedi 1990; Mavuti and Litterick 1991; Mwebaza-Ndawula 1994; Mwebaza-Ndawula *et al*. 2003a). Most of these earlier works were limited to shallow inshore areas, but the LVEMP has since the late 1990s provided an opportunity to conduct research activities with a greater spatial coverage of the lake including the open waters up to 70 m depth. Field sampling stations established under LVEMP also cover a variety of habitat types within shallow sheltered bays and gulfs, open deep waters, polluted areas adjacent to urban centers and river mouth areas.

This section presents the field observations on invertebrate taxonomic diversity and spatial-temporal patterns of abundance at field stations in the Ugandan portion of the Lake Victoria based on field collections taken between 2000 and 2003. An attempt is made to relate the observed patterns with key environment parameters including temperature, dissolved oxygen, eutrophic state and polluted areas. An assessment of the status of aquatic invertebrates in conjunction with their ecological functions in the lake and recommendations are made to protect their diversity and abundance.

## MATERIALS AND METHODS

Littoral (UL) and pelagic (UP) stations (Figure 1) were sampled monthly and quarterly respectively. Zooplankton samples were taken using a five-litre Schindler trap from 0.5 m, at secchi depth, at 1% depth of incident light, at the thermocline, and at 10-metre intervals to the bottom.

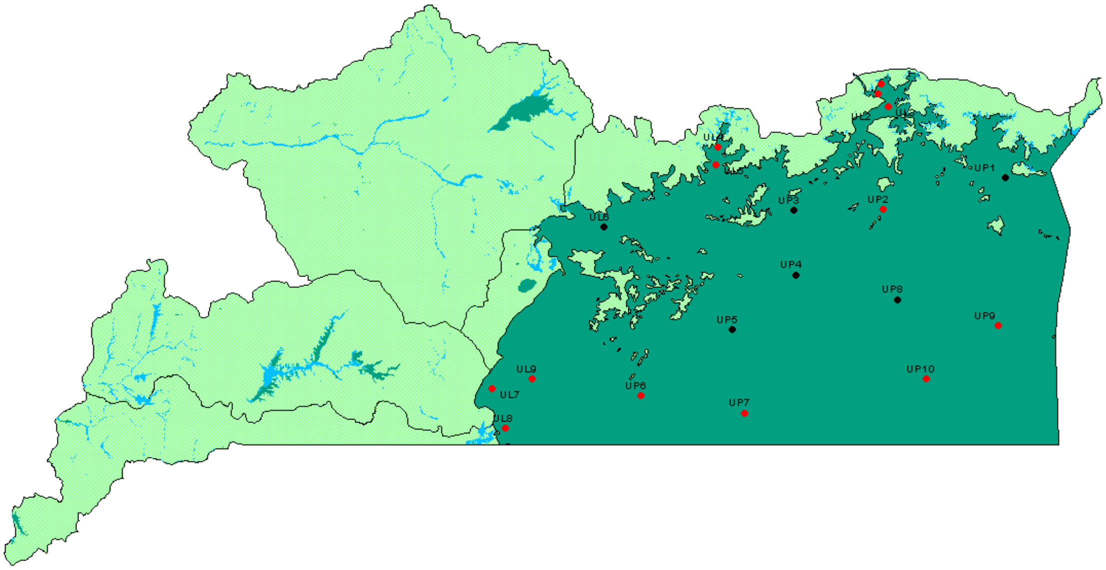


*FIG. 1. Map of Lake Victoria showing sampled stations (UL and UP).*

Samples were preserved with 4% sugar-formalin solution in labeled bottles. In the laboratory, preserved samples were rinsed in tap water using a 50 µm sieve. Concentrated samples were diluted to 20mls and sub-samples of 2 and 5mls were taken using a bulb pipette and examined under an inverted microscope (Hund Weltzar) at x40 (for enumeration of individuals) and x100 (for taxonomic identification) magnification. Taxonomic keys by Boxshall and Braide 1991; Lindberg 1957; Rutner-Kolisko 1974; Korovchinsky 1992; Koste 1978; and Korinek 1999 were used for identification of zooplankton to species level.

Macro-invertebrates were sampled by taking sediment hauls with a Ponar Grab (Petitte Ponar, Model No: 1728 G32). The sediments were sieved through a 400-µm nitex mesh bag and the organisms sorted and preserved with 70% Ethanol. Each sample was examined under a binocular dissecting microscope (Wild M3B, Model No: 445302) at x25 magnification; organisms were taxonomically identified as far as possible using various taxonomic keys (Epler 1995; Merrit and Cummins 1984; Mandall Barth 1954; Pennak 1953) and enumerated to generate composition and abundance data.

Taxonomic composition and abundance data was analysed using Microsoft Excel computer program. Appropriate data tables and graphs were developed to track variations in distribution and abundance patterns of organisms in spatial-temporal perspectives. A Shannon-Weaver Index of Diversity was calculated for the zooplankton data

## RESULTS

### Species Composition and Diversity

The zooplankton community was made up of copepods, cladocerans, rotifers and other minor organisms. Rotifera was the most diverse group containing several genera and numerous species (Table 1). Copepods and cladocerans also had several genera but with generally fewer species per genus compared to rotifers. Copepod species found include *Thermocyclops emini, T. neglectus, Tropocyclops confinnis, T. tenellus* and *Thermodiaptomus galeboides*. The cladoceran species found were *Diaphanosoma excisum* and *Moina micrura.* The rotiferan species found were *Keratella tropica, K. cochlearis, Synchaeta* sp. *Filinia longiseta*, *Brachionus anguralis* and *Trichocerca cylindrica* constituted a group of zooplankton that were most encountered in both littoral and pelagic habitats. The frequent encounter with these was in contrast to very rare species such as *Macrothrix* sp., *Chydorus* sp., *Eucyclops* sp., *Tropodiaptomus stuhlmanni*, *Synchaeta pectinata* and Harpacticoid copepods. Distribution of computed diversity indices indicated generally lower diversity at pelagic (UP series) compared to littoral (UL series) stations (Figure 2).

The macro-invertebrate community was made up of several broad taxonomic groups including Diptera, Anisoptera, Ephemeroptera, Gastropoda, Bivalvia, Oligochaeta and other minor organisms. Gastropoda and Bivalves were the most diverse groups each containing several genera (Table 2). The genera, *Corbicula* sp. (Bivalves), *Melanoides* sp. (Gastropoda), *Chaoborus* sp. and *Chironomus* sp. (Diptera), were the most encountered taxa occurring in both littoral and pelagic habitats. The high frequency of these was in contrast to very rare taxa such as Anisoptera, Ceratopogonids (Diptera), *Caenis* sp. (Ephemeroptera) and Nematoda.

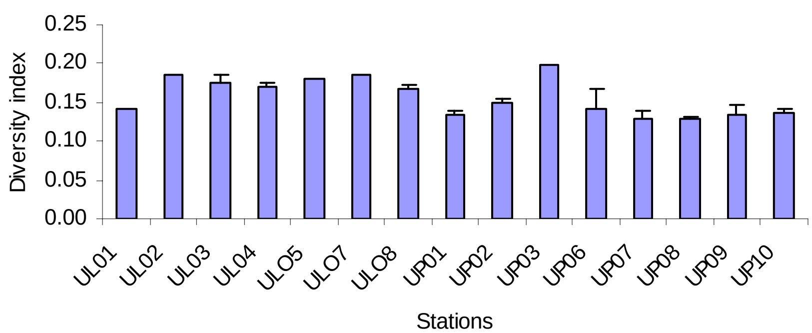


*FIG. 2. Diversity index of zooplankton at littoral (UL) and pelagic (UP) stations.*

*TABLE 1. Checklist of zooplankton species at littoral (UL) and pelagic (UP) stations.*

| | UL01 | UL02 | UL03 | UL04 | UL05 | UL07 | UL08 | UL09 | UP01 | UP02 | UP03 | UP06 | UP07 | UP08 | UP09 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cladocera:** | | | | | | | | | | | | | | | |
| *Bosmina longirostris* | | | | + | ++ | | ++ | | | | + | ++ | + | ++ | + |
| *Ceriodaphnia cornuta* | | | + | | | | | | + | ++ | +++ | ++ | + | + | + |
| *Daphnia longispina* | | | + | | | | | | | + | ++ | ++ | + | | |
| *Daphnia lumholtzi* | | | | | | | | | | + | ++ | ++ | + | | + |
| *D. lumholtzi (helmeted)* | | | | + | + | | | + | | | | | | | |
| *Diaphanosoma excisum* | ++ | ++ | ++ | ++ | ++ | | ++ | + | + | ++ | ++ | ++ | ++ | ++ | ++ |
| *Macrothrix* sp. | | + | | | | | | | | | | | | | + |
| *Moina micrura* | | | + | ++ | ++ | ++ | ++ | + | + | + | + | | + | ++ | |
| *Chydorid* sp. | | + | + | | | | | | | + | | | | | |
| **Copepoda:** | | | | | | | | | | | | | | | |
| *Eucyclops* sp. | | | | | | | + | | | | | | | | |
| Harpacticoida | | | | + | | | | | | | | | | | |
| *Mesocyclops* sp. | + | + | | + | | | | | | + | | + | | | |
| *Thermocyclops decipiens* | | | | | | | | | | | | | | | |
| *T. emini* | +++ | ++ | ++ | ++ | +++ | ++ | ++ | ++ | ++ | ++ | ++ | +++ | ++ | ++ | +++ |
| *T. incisus* | | | + | + | + | | + | | | + | | | | | |
| *T. neglectus* | +++ | +++ | +++ | +++ | ++ | ++ | +++ | +++ | ++ | +++ | +++ | +++ | +++ | +++ | +++ |
| *T. oblongatus* | | | | | | | ++ | | | + | | | | | ++ |
| *Tropocyclops confinnis* | +++ | +++ | ++ | +++ | ++ | ++ | ++ | + | ++ | ++ | ++ | ++ | + | ++ | + |
| *T. tenellus* | +++ | +++ | +++ | +++ | +++ | +++ | ++ | +++ | + | ++ | +++ | +++ | + | ++ | + |
| *Tropodiaptomus stuhlmanni* | | | + | | | | | | | | | | | | + |
| *Thermodiaptomus galeboides* | ++ | ++ | ++ | ++ | ++ | | +++ | +++ | ++ | +++ | +++ | +++ | ++ | +++ | +++ |
| **Rotifera:** | | | | | | | | | | | | | | | |
| *Asplanchna* sp. | | | + | | | +++ | ++ | | | | + | | + | + | |
| *Brachionus angularis* | ++ | ++ | ++ | +++ | +++ | +++ | ++ | | ++ | + | + | + | + | | + |
| *B. bidentatus* | | | | | | | | | | | | | | | |
| *B. calyciflorus* | ++ | + | + | + | + | ++ | ++ | | + | + | | | | | |
| *B. caudatus* | | | | | | | | | | | + | | | | |
| *B. falcatus* | | | + | + | + | ++ | + | | + | | | | + | | |
| *B. forficula* | | ++ | + | + | | | | | + | + | + | + | + | + | + |
| *B. patulus* | | | + | | | ++ | | + | | | + | | | | |
| *Euclanis* sp. | | + | ++ | + | ++ | +++ | ++ | | | + | | + | + | | |
| *Filinia longiseta* | ++ | ++ | + | ++ | ++ | ++ | | + | + | + | + | + | + | | + |
| *F. opoliensis* | | +++ | ++ | ++ | ++ | | + | + | | + | | + | + | + | + |
| *Hexathra* sp. | | + | + | + | + | | | | + | | | | + | | |
| *Keratella cochlearis* | ++ | ++ | ++ | ++ | ++ | +++ | ++ | ++ | ++ | ++ | +++ | ++ | ++ | ++ | ++ |
| *K. tropica* | +++ | +++ | +++ | +++ | +++ | +++ | ++ | ++ | +++ | +++ | +++ | ++ | ++ | +++ | ++ |
| *Lecane bulla* | | | + | | | | | + | + | + | ++ | | | | |
| *Polyarthra* sp. | + | + | | + | + | | | | | + | +++ | | | | |
| *Polyarthra vulgaris.* | | ++ | + | + | | ++ | + | | + | + | + | | + | | |
| *Synchaeta pectinata* | | | + | | | | | | | | | | | | |
| *Synchaeta* sp. | ++ | +++ | ++ | ++ | ++ | +++ | +++ | +++ | ++ | +++ | ++ | +++ | ++ | +++ | +++ |
| *Trichocerca cylindrica* | ++ | ++ | +++ | +++ | ++ | +++ | ++ | ++ | + | ++ | ++ | + | + | + | |

## Littoral-Pelagic Distribution and Abundance

Numerically, the zooplankton community of the lake in both littoral and pelagic zones was characterized by domination of copepods compared to Cladocera, Rotifera and the minor groups (Figure 3). The estimated volumetric abundance indicated generally higher densities of organisms in the littoral compared to pelagic zones, although this distribution pattern was not clearly defined for cladocerans and rotifers. Cladocerans occurred at generally low abundance (mean value: 0.25-1.5 indiv. $\ell^{-1}$) except at UL04, UL05 and UP06 where relatively higher density estimates (mean value range: 2.5-3.5 indiv. $\ell^{-1}$) were obtained. Rotiferan high abundance (mean value range: 16.8-26.9 indiv. $\ell^{-1}$) occurred at UL04, UL07, UP02 and UP3.

*TABLE 2. Checklist and frequency of occurrence of macro-invertebrate taxa from littoral (UL) and Pelagic (UP) stations.*

| | UL01 | UL02 | UL03 | UL04 | UL05 | UL08 | UL09 | UP02 | UP06 | UP07 | UP10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Anisoptera | + | | | ++ | ++ | | | | | | |
| **Bivalves:** | | | | | | | | | | | |
| *Byssanodo* | | ++ | | ++ | | ++ | ++ | ++ | +++ | | |
| *Caelatura* | + | | | | | +++ | +++ | | | | |
| *Corbicula* | +++ | +++ | ++ | +++ | ++ | +++ | +++ | ++ | ++ | + | |
| *Sphaerium* | | | | | | +++ | +++ | | ++ | | |
| Conchostraca | | ++ | ++ | | ++ | | | | | | |
| **Decapoda:** | | | | | | | | | | | |
| *Caridina* | | ++ | ++ | +++ | ++ | | | ++ | | | |
| **Diptera:** | | | | | | | | | | | |
| Ceratopogonidae | + | | | | | + | | | | | |
| *Chaoborus* | ++ | +++ | +++ | ++ | ++ | ++ | ++ | +++ | +++ | ++ | ++ |
| Chironomid | +++ | ++ | +++ | +++ | ++ | +++ | +++ | | +++ | ++ | +++ |
| **Ephemeroptera:** | | | | | | | | | | | |
| *Caenis* sp. | | | | | | ++ | | | | | |
| *Povilla* | | | + | | | +++ | ++ | | | | |
| **Gastropoda:** | | | | | | | | | | | |
| *Bellamya* | +++ | +++ | | +++ | | | | | ++ | | |
| *Biomphalaria* | | | | ++ | | | | | | | |
| *Bulinus sp.* | + | ++ | | ++ | | | | | | | |
| *Gabbia sp.* | +++ | ++ | | ++ | | | | | | | |
| *Melanoides* | +++ | ++ | | +++ | ++ | +++ | +++ | | ++ | | |
| **Hirudinea** | | | | | | ++ | | | | | |
| **Nematods** | | | | | | | ++ | | | | |
| **Oligochaetes** | ++ | ++ | + | ++ | ++ | ++ | +++ | | ++ | | |
| **Ostracods** | ++ | + | ++ | ++ | ++ | ++ | | | | | |

The macro-invertebrate community of the lake was numerically, dominated by dipteran larvae (chaoborids and chironomids) and mollusks, which comprised gastropods and bivalves. Density estimates indicated that most benthic macro-invertebrates were mostly associated with littoral zone, being rare and at times absent in most pelagic or offshore stations (Figure 4). Mayfly (Ephemeroptera) nymphs appeared to exhibit rather restricted distribution being recovered in relatively high abundance only at UL07 (380.9 indiv.$m^{-2}$), UL08 (129.2 indiv.$m^{-2}$ and UL09 (138.3 indiv.$m^{-2}$) and nearly none at all from other UL and UP stations.

## Vertical Distribution and Abundance of Zooplankton

Total water depth for littoral stations varied between 4 and 25 metres and between 45 and 70 metres for pelagic stations. Zooplankton vertical distribution patterns in the shallow littoral areas exhibited continuous occurrence over the entire water column for the period January to November 2001 although local concentrations at some depths could be discerned probably due to influence of local prevailing conditions such as light intensity (Figure 5).

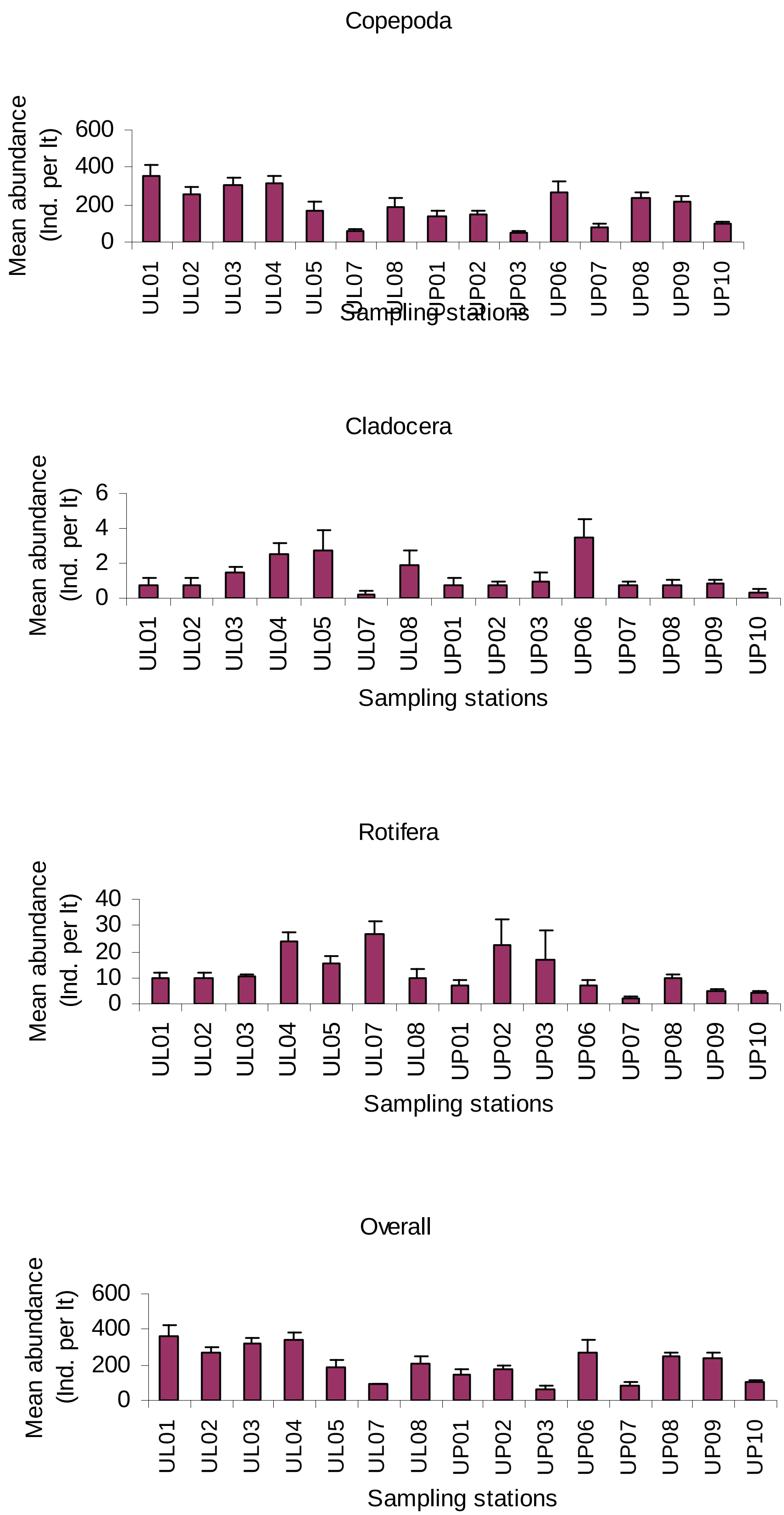


*FIG. 3. Mean abundance estimates of zooplankton broad taxonomic groups.*

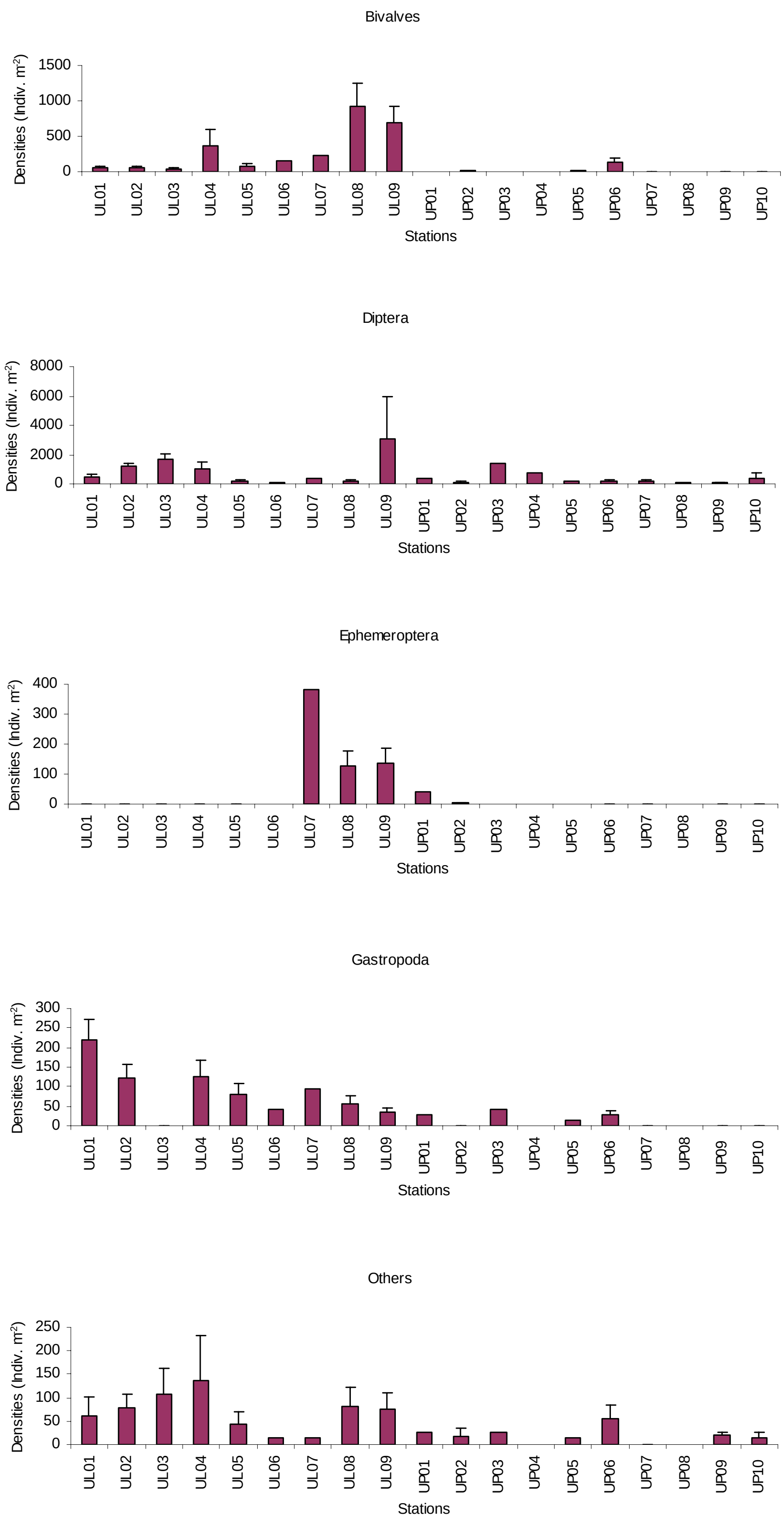


*FIG. 4. Mean density estimates of macro-invertebrates at littoral (UL) and Pelagic (UP) stations.*

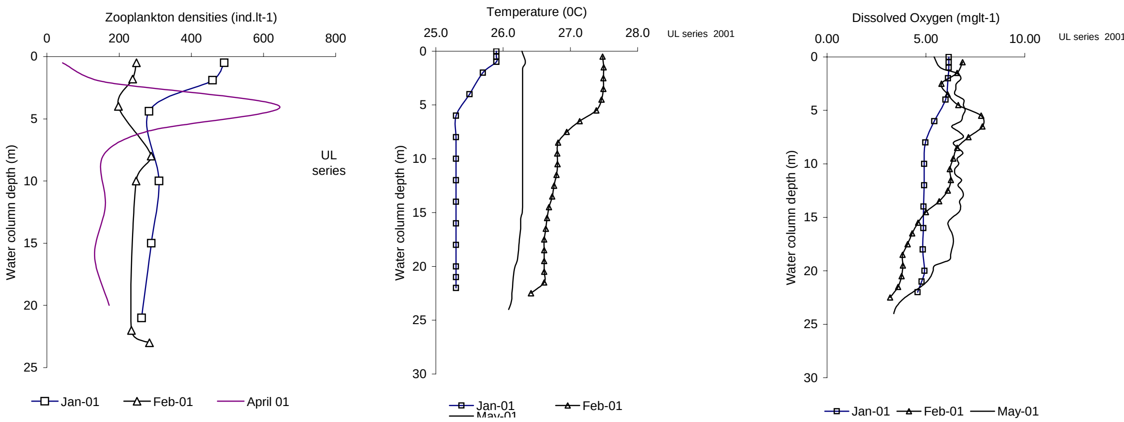


*FIG. 5. Vertical profiles of zooplankton densities, temperature and dissolved oxygen at selected littoral sites, Lake Victoria 2001.*

The corresponding environmental profiles indicated largely even distribution of temperature and dissolved oxygen probably due to continuous mixing in these shallow water areas. The vertical distribution in the UP stations with deeper water columns over the same period showed concentration of organisms in mid- to- surface waters (Figure 6).

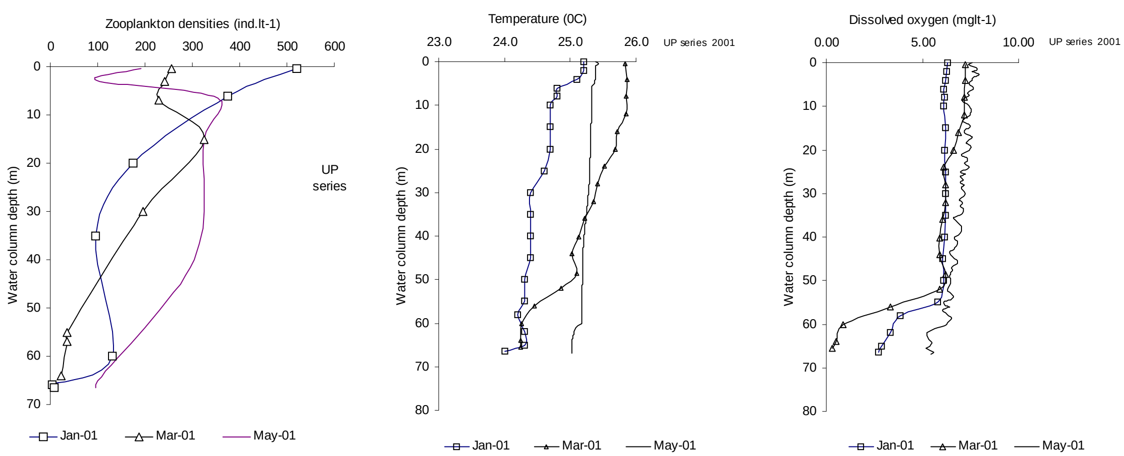


*FIG. 6. Vertical profiles of zooplankton densities, temperature and dissolved oxygen at selected pelagic sites, Lake Victoria 2001.*

Zooplankton density generally decreased progressively from mid-waters to the bottom where in some instances (UP2, UP7 and UP10) only few or no organisms were recovered. Corresponding environmental profiles indicated pronounced development of thermocline and oxycline between 40 and 70 m depths accompanied by occurrence of very low dissolved oxygen conditions in the deepest part of the water column (Table 3).

*TABLE 3. Low dissolved oxygen levels in the hypolimnion during thermal stratification.*

| Date | Station | Depth range (m) | DO range (mg l$^{-1}$) |
|---|---|---|---|
| February 2001 | UP09 | 40-65 | 0.18-0.45 |
| March 2001 | UP10 | 50-70 | 0.42-1.25 |
| May 2001 | UP10 | 55-68 | 0.20-0.25 |
| May 2001 | UP07 | 57-60 | 0.35-0.68 |


| Date | Station | Depth range (m) | DO range (mg L$^{-1}$) |
|---|---|---|---|
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| May 2001 | UP10 | 55-68 | 0.20-0.25 |
| May 2001 | UP07 | 57-60 | 0.35-0.68 |


## DISCUSSIONS

Zooplankton species composition did not vary markedly between stations both within and between UL and UP series (Table 1). Lower diversity indices seen at most pelagic stations (Figure 2) may be due to restricted distribution of some groups like rotifers that are known to be more diverse and abundant in the more eutrophic shallow inshore areas and rare in less eutrophic offshore areas of the lake (Mwebaza-Ndawula *et al.* 2003a).

Numerical abundance of zooplankton appeared to be driven by the superabundant cyclopoid copepods, which also exhibited a ubiquitous distribution in both littoral and pelagic zones (Figure 3). Observed high volumetric abundance around shallow inshore areas (UL stations) is likely to be an indicative of the more productive littoral zone that receives nutrient loading from adjacent hinterlands and stream inflows. The ecological significance of the high abundance of cyclopoid copepods lies in its function as a food base for commercially important fishes in the lake especially *Rastrineobola argentea* or Mukene (Mwebaza-Ndawula and Schiemer, 1997; Mwebaza-Ndawula, 1998). Equally important is the wide distribution and often high abundance of dipteran larvae, mollusks and the atyid prawn, *Caridina nilotica* among macro-invertebrates (Figure 4). These and other macro-invertebrates are key forage items for a number of fishes (Corbet 1961; Greenwood 1966; Ogutu-Ohwayo 1990; Ogari and Dadzie 1988) and are believed to be a key factor in the recovery of some haplochromine and other species observed in Lake Victoria in recent field collections.

The near-even vertical distribution of zooplankton observed at most littoral stations (Figure 5) probably relates to the continuous mixing characteristic of short water column depths that are common in shallow inshore areas of the lake. Such patterns of mixing dispel development of thermal stratification (in which the water column is layered due to differences in temperature and hence water density) that is common in deepwater areas such as in UP stations. When this thermal layering develops, low dissolved oxygen levels characterize the colder and denser water mass below the thermocline. Under eutrophic conditions, hypolimnetic oxygen deficit is exacerbated by consumption of the little available oxygen as a result of the decomposition process of unutilized algal biomass. Oxygen levels may thus get so low (generally <1.0mg/l; see Table 3) that the hypoxic water mass becomes unsuitable for habitation by most aquatic life and is thus tantamount to loss of habitable space. In this case organisms may be either laterally displaced to shallower well-oxygenated water or vertically displaced to mid- and surface waters. This scenario may partly explain the observed progressive decrease in zooplankton densities with increasing water column depth during periods of thermal stratification at the deeper pelagic (UP) stations (Figure 6).

An emerging environmental factor likely to impinge on the stability of invertebrates and other aquatic biota is the threat of pollution especially in some bay areas close to major urban centers such as the Murchison bay, which receive effluents from Kampala City via the Nakivubo channel. Aquatic organisms are vulnerable to different levels of pollution loads, which in many instances may translate into biodiversity reduction or loss. Recent field studies by Sekiranda (2005) at three bays associated with different land uses of adjacent catchments indicate progressive impoverishment of fish and macro-invertebrate (benthic) communities from Hannington bay (rural and largely unpolluted) through Fielding bay (semi-urban with indications of nascent pollution) to Murchison bay (urban and highly polluted) in Lake Victoria. Calamari *et al.* (1995) provides an account of pollution types and sources in the Kisumu bay, Kenya waters and potential impacts to aquatic life.

Certain categories of dipteran larvae such as the 'blood worms' carry a red (haemoglobin) pigment that enables them to survive in low-oxygen habitats such as the hypolimnion during thermal stratification and deoxygenated organic mud sediments. The relatively high abundance of these organisms in the littoral stations (Figure 5) is therefore an indication of deteriorating water quality due to pollution and eutrophication of these near-shore areas. Oligochaetes have also been reported to commonly occur in polluted areas where most other organisms have been eliminated (Matagi 1996). The detritivorous freshwater prawns, *C. nilotica* have been shown to withstand low dissolved oxygen conditions (Branstrator and Mwebaza-Ndawula 1998) and can take refuge from Nile perch predation in the hypoxic hypolimnion. In addition, the epi-benthic position ensures them ample detrital material food supply.

## Conclusions

Zooplankton community composition in Lake Victoria is dominated by cyclopoid copepods, which exhibit ubiquitous distribution and occurs in relatively high volumetric abundance in both littoral and pelagic areas. This has implications to the production and sustainability of fishes (i.e. *R. argentea, some* haplochromines and larval fishes) that utilize these organisms as a food source.

Macro-invertebrate composition is dominated by dipteran larvae and mollusks, which occur in relatively high abundance around littoral areas. This too has implications to the production of fishes (i.e. juvenile fishes and the lungfish, *Protopterus aethiopicus*) that use these organisms as a food source.

Vertical dispersion of zooplankton is inhibited by oxygen depletion in the deepest part of the water column during spells of thermal stratification at most pelagic stations. Such displacement is tantamount to habitat loss and the resulting concentration of zooplankton in mid- to-surface waters may lead to unlimited consumption by pelagic planktivores (fishes and invertebrate predators), with implications to the sustainability of pelagic fisheries.

Macro-invertebrates that have high tolerance to low-oxygen conditions such as some dipteran larvae (chironomid bloodworms, chaoborids) and *Caridina nilotica* utilize the low-oxygen hypolimnion water mass as a refugia against excessive consumption by fish predators including the Nile perch.

The occurrence of relatively high abundance of low-oxygen taxa at littoral stations is an indication of deteriorating water quality conditions due to eutrophication and pollution processes especially around near-shore areas of the lake.

## Recommendations

In light of the current threats and concerns to invertebrate communities and other biota in the lake, management interventions are necessary. These include:

Determination of optimum nutrient levels for aquatic production (at different trophic levels) and taking decisive steps to enforce existing laws and regulations to avert excessive loading of nutrients and pollutants into Lake Victoria. These include proper treatment of industrial and domestic wastes, control of burning of organic materials in the lake catchment that load nutrients into the atmosphere, control of deforestation in the catchment that results in increased loading of nutrients and pollutants into the lake and guiding wise use of riparian ecotone zones).

Identification, mapping and demarcation of biodiversity hotspots including riparian wetlands and river mouths and instituting legislation to protect them from encroachment.

Identification and mapping of sources of pollutants and instituting control measures (i.e. provision and enforcement of chemical/nutrient standards of effluents to waterways and the lake) in order to avert further pollution of the lake waters and thereby protect the valuable living resources of Lake Victoria.

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