Zooplankton communities of some tanzanian lake victoria basin water bodies

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Abstract
A survey of the zooplankton communities of some Tanzanian Lake Victoria Basin water bodies was conducted during September/October 2000 and March/April 2001. Plankton nets of mesh sizes 100 µm and 65 µm respectively were used to collect qualitative zooplankton samples from the water bodies on two occasions September/October 2000 and March/April 2001. The samples of zooplankton collected were made up to twenty taxa of rotifers and thirteen crustaceans. The most frequently encountered rotifers were *Asplanchna* spp., *Brachionus angularis, Brachionus caudatus, Brachionus calyciflorus, Brachionus patulus, Keratella cochlearis, Keratella tropica, Keratella quadrata, Lecane bulla*, and *Synchaeta* spp. The most common crustaceans were *Thermocyclops emini, Thermocyclops neglectus* and *Diaphanosoma excisum*. In terms of numerical abundance, Kyarano Dam contributed the highest density. In September/October 2000, when the mean total number was 179,689 m^{-2}. In March/April 2001 the highest density of 479,015 m^{-2} was observed in Lake Ikimba. The structure and composition trends of zooplankton in the surveyed water bodies may be related to both intensity of predation and limitation by environmental factors, which may include the nature of the water bodies, and food quality and quantity.

Key words: Satellite Lakes, Composition, Zooplankton, Diversity, abundance.

Introduction
The zooplankton community in many lakes plays a very important role in the lakes' trophic network as grazers of the rich phytoplankton and as nutrient recycling agents in the lake. When the zooplankton feeds on the phyto and pico-plankton they break down the algal and bacterial cell walls and thus through their feeding habits, defecation, and respiratory products, make available essential growth nutrients of algae (Mavuti and Litterick, 1991). The zooplankton availability is an important factor in determining relative survival of juvenile fishes (Fernando, 1994; Mavuti 1983). Also some species of zooplankton especially amongst the cladocerans and rotifers may be used as indicators of organic and chemical pollution (Mavuti and Litterick 1991). The broad and descriptive community ecology is essential and may demonstrate important species associations and succession, diversity and seasonality. These attributes are useful in elucidating functional mechanisms and ecological interaction of zooplankton and their environment.

Satellite lakes within Lake Victoria catchment area have been discovered to be refuges for the indigenous and endangered fish species of Lake Victora (Katunzi, 2001), some of which are zooplanktivorous fishes, *Haplochromis* spp. Despite the importance of these water bodies very little has been done on zooplankton ecology. Some of the existing information on zooplankton research in East Africa include that of Green (1967, 1971, and 1976) who studied the ecology distribution and production of zooplankton communities in five lakes in western Uganda, and Mavuti (1983; 1991) and Masai (2001 in press) who studied some satellite lakes in Kenya. Only one study of zooplankton ecology has been undertaken in some satellite lakes, a dam and a river within Lake Victoria basin in Tanzania (Waya, 2001).

In contrast to Uganda and Kenya very little is known about the zooplankton ecology in the Tanzania Lake Victoria Basin. A study was thus carried out to determine the pattern or structure of zooplankton community in selected satellite lakes, dams and river.

This paper reports the results of the study including zooplankton species composition, diversity and abundance in these chosen Tanzanian Lake Victoria basin water bodies.

Materials and methods

Study Sites

The study was conducted in Mara, Kagera and Mwanza regions. Zooplankton were collected in eight water bodies from twenty four sampling stations. In Mara region samples were collected at Mara River, Kyarano Dam, Kirumi flood plains and Kubigena Oxbow Lake (1° 36.271' S 34° 08.186' E), in Mwanza region at Malimbe (2° 37.471 S' 32° 53.867' E), in Kagera region at Lake Burigi (2^{o}.05.299'S 31^{0}17.353'E), Lake Katwe (1° 22.500'S, 30° 41.100'E) and Lake Ikimba (1° 27.204'S, 31° 35.208'E).

Methodology

Three stations were sampled from each site; two in the open waters and one taken under the microphytes at the littoral areas using a tube sampler. A plankton net of 100 µm having an opening of 22 cm was used in September/October 2000. In March/April 2001 a net of 65 µm mesh size having an opening of 29 cm was used. The net was lowered as close to the bottom as possible without disturbing the sediment and carefully hauled to allow the water to drip. The net was rigged with a weight to enhance vertical sinking. Three replicate samples were combined to make a composite sample. Fresh samples were preserved in 4% sugar formalin.

In the laboratory each sample was diluted, agitated and sub-sampled with a 5ml syringe. The zooplankton were counted in three sub-samples (two of 2 ml and one of 5 ml). The dominant animals were not counted in the second and third sub samples, when at least 100 animals had been counted. The sub-sample was placed on a modified counting chamber and examined under the microscope at x40 magnification. Taxonomic identification was done using identification keys developed by Ruttner-Kolisko (1974), Korinek, (1984), Boxshall and Braide (1991), Maas (1993) and Korovchinsky (1993), and the species diversity determined. Adult males and females were not separated but identified to species. The development stages of copepods stages one to five were lumped together as a single count category (copepodites). Nauplii stages were also grouped together. Density of zooplankton was computed as follows:

$D = N/V$ ……………………………………………………………………………..1

Where

N =Number of individual samples

= (Number in sub-sample x volume of sample)/sub sample volume

V=Volume of lake water filtered = $\pi r d^2$ where:

r = radius of the mouth of the net

d = depth of the water

Results

Species of zooplankton observed in September/October 2000 and March/April 2001 in the surveyed lakes are shown in table 1 & 2 and the zooplankton mean numerical abundance in the open and the littoral areas is shown in figure 1 & 2.

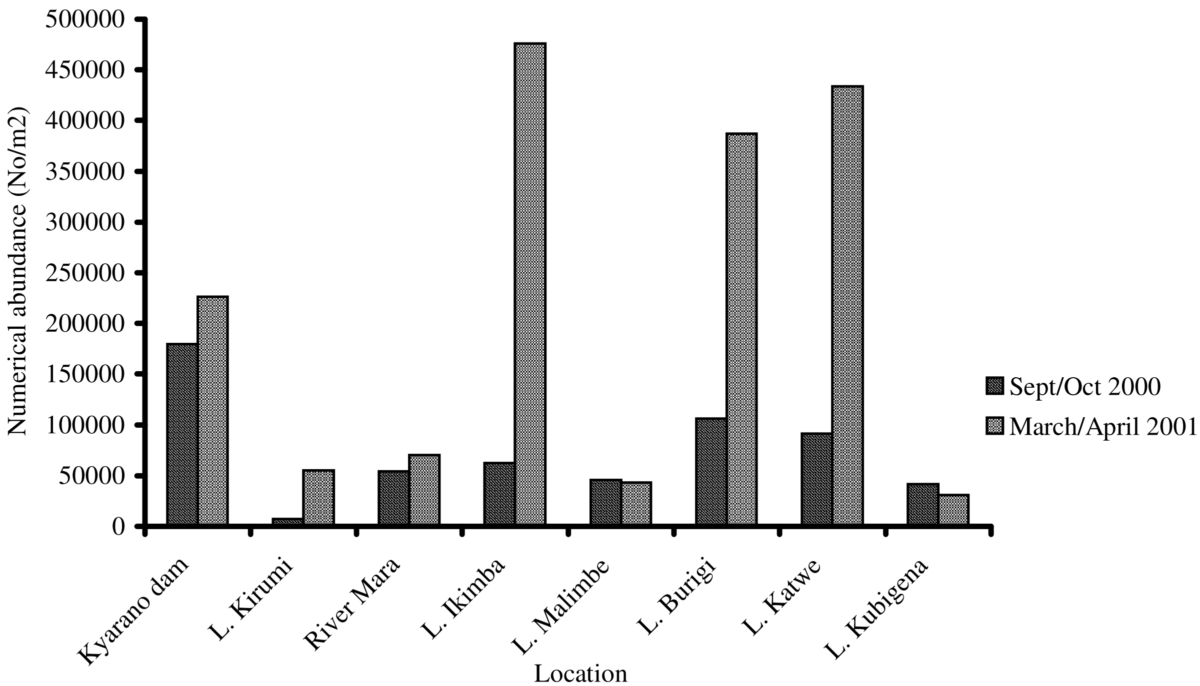

Fig. 1: Zooplankton numerical abundance in the open waters of the satellite lakes

During the period September/October 2000 eleven species were recorded from the samples collected from Kyarano Dam (Table 1). The mean total zooplankton abundance was 179,689 m^{-2}. In March/April 2001, seventeen species were encountered; rotifera contributed the largest number of species (8), followed by copepoda (6) and cladocera (3). The species observed were *Ceriodaphnia cornuta*, *Chydorid* spp., *Diaphanosoma excisum, Themocyclops incisus, Themocyclops emini, Themocyclops neglectus, Tropcyclops confinnis, Tropocyclops tenellus, Thermodiaptomus galeboides, Asplanchna* spp.; *B angularis, B. falcatus, F. opoliensis, K. cochlearis. K. tropica, Synchaeta* spp.,

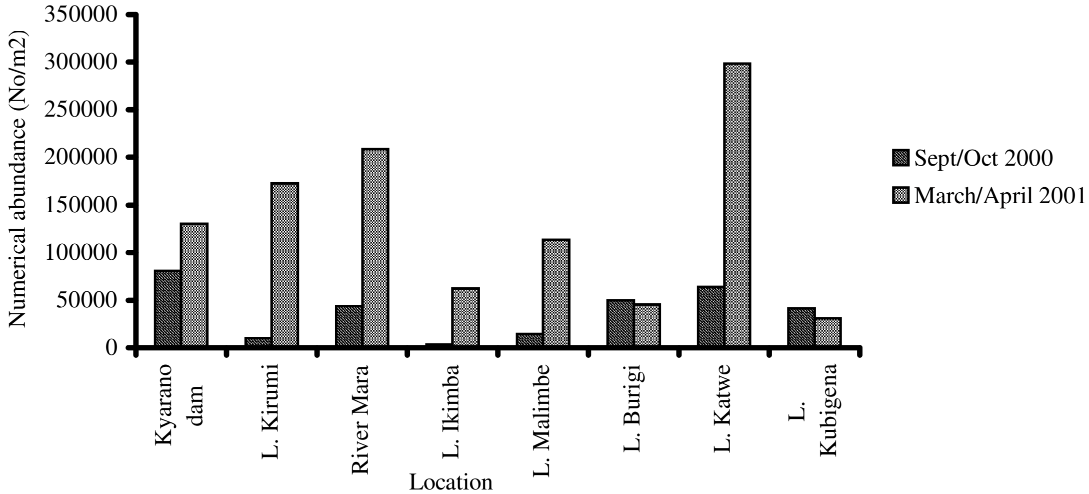

Fig. 2: Zooplankton numerical abundance in the littoral areas of the satellite lakes

and *Lecane bulla* (Table 2). Total zooplankton mean numerical abundance was 226,449 m^{-2}. The copedoda was the most dominant group accounting for 83% of total zooplankton abundance, followed by rotifera (11%) and cladocera (6%) (Table 2)

In Lake Kirumi a total of fifteen species were observed in September/October 2000 (Table 1) and twelve species were observed in March/April 2001 (Table 2). In both studies eight species of rotifera encountered were *Ascomorpha* spp*., Asplanchna* spp*, Brachionus angularis, Brachionus calyciflorus, Lecane bulla*, *Synchaeta* spp., *K. cochlearis* and *K. tropica.* Cladocera contributed six species, *Alona* spp., *Ceriodaphnia cornuta, Chydorid* spp., *Daphnia lumhortzi, Diaphanosoma excisum* and *Moina micrura.* Three species of cyclopoida were observed *T. emini, T. neglectus* and *T. tenellus*. Total zooplankton mean numerical abundance in September/October 2000 was 7,146 m^{-2}. The most important group in terms of numerical abundance was cyclopoida which contributed 39% followed by rotifera 31.8% and cladocera 29%. The mean temperature was 24.1 ^{o}C. In March/April 2001, total zooplankton mean numerical abundance was 54,996 m^{-2}. The cyclopoid were the most common group and contributed 55% of the total zooplankton mean numerical abundance, followed by rotifera (44%). Cladocera were absent in the sample collected at the open waters, but in the littoral area the cladocerans were very common accounting for 44% of the total zooplankton abundance followed by rotifera (39%) and cyclopoids (16%) (Table 1).

In River Mara fifteen species of zooplankton were observed in September/October 2000, Rotifera contributed six species, *Brachionus angularis, Brachionus calyciflorus, Branchionus caudatus, Brachionus falcatus, Synchaeta spp, Keratella tropica.* Copepoda five; Cyclopoida, four species *Thermocyclops emini, Thermocyclops neglectus, Tropocyclops confinnis, Tropocyclops tenellus* and Calanoida one, *Thermodiapomus galeboides* and Cladocera three species *Daphnia lumhortzi, Moina micrura* and

Diaphanosoma excisum (Table 1). In March/April 2001, sixteen species were observed among them ten were rotifera; *Ascomorpha* spp., *Asplanchna* spp., *B. angularis, B. caudatus, B. patulus, Euchlanis* spp., *L. Bulla, Synchaeta* spp., *F. opoliensis* and *Tricocerea* spp. Cladocera spp., *Diaphanosoma excisum* and *Moina micrura*. Only three species of Cyclopoida were observed. *T. emini T. neglectus* and *T. Confinnis* (Table 2). Total zooplankton mean numerical abundance was 53,965 m^{-2} in September/October 2000 and 70,187 m^{-2} in March/April 2001. In River Mara only rotifers were found in the samples collected by net (Table 2). More species of zooplankton were collected in the littoral area by the tube sampler and the total zooplankton mean numerical abundance was higher reaching up to 203,445 m^{-2} (Figure 2). The cyclopoids were very common and contributed 61% of the total zooplankton mean numerical abundance followed by cladocera (27%) and rotifers (12%).

Lake Katwe contributed the highest number of species compared to other lakes in both studies, sixteen species of zooplankton were identified in September/October 2000 and twenty species in March/April 2001. Twelve were rotifers and included *Asplanchna* spp. *B. angularis, B. caudatus, B. Calyciflorus, B. patulus, F. opoliensis, K. cochlearis. K. tropica, K. quadrata, Trichocera* spp., *L. bulla and Synchaceta* spp. Five cyclopoid copepods included *T. emini, T. incisus, T. confinnis, T. neglectus and T. tenellus,* and three cladocerans, *Ceriodaphnia cornuta, chydoridae* spp and *M. micrura*. Total zooplankton mean numerical abundance in September/October 2000 was 90,149 m^{-2} and in March/April 2001 was 434,047 m^{-2}. Cyclopoid copepod contributed 74% of the total zooplankton mean numerical abundance followed by rotifers (23%) and cladocera (3%) (Table 1). More rotifers were encounted in the littoral area with twelve species compared to eight species in the open waters.

In Lake Ikimba seven species were observed during September/October 2000 and seventeen species were encountered in March/April 2001. Rotifera contributed 10 species *Ascomorpha* spp, *Asplanchna* spp*, Brachionus angularis, Brachionus caudatus, Kellikotia* spp., *Keratella cochlearis, Keratella tropica, Keratella quadrata , Lecane bulla* and *Synchaeta* spp., copepod contributed five species: *Thermocyclops emini, Thermocyclops neglectus, Thermocyclops incisus, Tropocyclops confinnis* and *Tropocyclops tenellus.* Only one species of cladocera *Bosmina longirostris* was observed. Total zooplankton mean numerical abundance was 62,359 m^{-2} in September/October 2000 and 476,015 m^{-2} in March/April 2001. Cyclopoid copepod were the most common group and contributed 90% followed by rotifera (10%). No cladocera were observed in the open waters (Table 1). In the littoral area rotifera were the most abundant group accounting for 80% of total zooplankton mean numerical abundance followed by cyclopoid copepod 15% and cladocera (5%)

In Lake Malimbe rotifers showed a higher diversity than other species in September/October 2000. The species encountered were *Asplanchna* spp, *Brachionus angularis Brachionus caudatus, Euchlanis* spp., *Filinia opoliensis, Keratella cochlearis, Keratella tropica, Lecane bulla* and *Synchaeta* spp. Only one cyclopoid copepod was observed *T. emini*, and one species of cladocera *D. excisum*. A total number of eleven species were identified. Total zooplankton mean numerical abundance was 45,730 m^{-2}

and in March/April 2001 43,265 m^{-2}. The cyclopoid copepod (adult, copepodite and nauplius larvae) was the important group in terms of abundance as it contributed 51% of the total zooplankton mean numerical abundance followed by rotifers (49%). No cladocera were observed in the open waters, but in the littoral areas they contributed 9% of the total zooplankton mean numerical abundance.

In Lake Burigi a total of sixteen species of zooplankton were identified, eight rotifers, four cladocerans and nine copepods. The species encounterd were *Brachionus angularis, Brachionus caudatus, Brachionus calyciflorus, Filinia opoliensis, Keratella cochlearis, Keratella tropica, Keratella quadrata, Lecane bulla*, *Thermocyclops emini, Thermocyclops neglectus, Tropocyclops confinnis, Tropocyclops tenellus, C. cornuta, D. lumhortzi, M. micrura* and *D. exisum.* The numerical abundance of cyclopoid was greater (94%) than that of rotifers (5%) and cladocera (2%). Total zooplankton mean numerical abundance in March/April 2001 at the open waters was 386,823 m-^{2}. In the littoral area the rotifers were more abundant accounting for 52% of the total zooplankton mean abundance (Table 1). In September/October 2000 the total zooplankton mean abundance was106,122 m^{-2}.

In March/April 2001 eighteen species of zooplankton were found in Kubigena Oxbow lake, eleven of them were rotifers and included *Asplanchna* species, *B. angularis, B caudatus, B patulus, Euchlanis* species, *F. opoliensis, K. cochleans, B. tropica, L. bulla, Synchaeta* spp. and *Trichocerea* spp. The rotifers contributed notably to the zooplankton structure followed by cladocerans two species, *Bosmina longirostris, Daphnia lumhortzi, Diaphanosoma excisum* and *Moina micrura*. The cyclopoid copepods contributed three species, *T. emini, T. incisus* and *T. neglectus.* Total zooplankton mean numerical abundance in the littoral area was 31,108 m-^{2}. Rotifers were the most numerous accounting for 45% of the total zooplankton abundance followed by cyclopoid copepod (40%) and cladocera (15%) (Table 1). In September/October 2000 Kubigena Oxbow Lake was very shallow with a depth of 0.4m. A total of eleven species were recorded, the total zooplankton abundance being 44,444 m^{-2}.

3.1 Taxonomic Composition

Three major group of zooplankton were observed, copepoda, cladocera and rotifera. Overall twenty one general and thirty three species were identified, of which twenty species were contributed by rotifera. The species encountered were *Ascomorpha* spp, *Asplanchna* spp, *B. angularis, B. caudatus, B. calyciflorus, B. patulus, B. falcatus, B. leydig, B. patulus, Euchlanis* spp., *F. opoliensis, Kellicotia* spp., *K. cochleans, K. tropica, K. quadrata, L. bulla, L. inermas, Synchaeta* spp., *Trichocerca* spp, and *Wolga spinifera.* Copepoda contributed six species *Thermocyclops emini, Thermocyclops neglectus, Thermocyclops incisus, Tropocyclops confinnis* and *Tropocyclops tenellus* and one calanoida *Thermodiaptomus galeboides.* Cladocera contributed 7 species, *Alona* spp., *Bosmina longirostris, Ceriodaphnia cornuta, Cydorid* spp., *Daphnia lumhortzi, Diaphanosoma excisum* and *Moina micrura.*

Table 1: Species of zooplankton observed in the surveyed lakes, Sept/Oct. 2000

Taxa	Kyarano	Kirumi	R. Mara	Katwe	Ikimba	Malimbe	Burigi	Kubigena
Cladocera:								
Bosmina longirostris	–	–	–	–	–	+	–	
Ceriodaphnia cornuta	+	+	–	–	–	+	–	–
Chydorid spp.	–	+	–	–	–	+	–	–
Daphnia lumhortzi (helm.)	+	+	+	–	–	–	–	–
Diaphanosoma excisum	+	+	+	+	–	–	+	–
Moina micrura	–	+	+	+	–	–	–	+
Calanoida	–	–	–	–	–	–	–	+
Thermodiaptomus galeboides	+	–	+	–	–	–	–	–
Cyclopoida								–
Thermocyclops emini	+	+	+	+	+	+	+	
Thermocyclops incisus	–	–	–	+	+	–	+	+
Thermocyclops neglectus	+	+	+	+	+	+	+	+
Tropocyclops confinnis	+	–	+	–	+	+	+	+
Tropocyclops tenellus	+	+	+	+	+	+	+	–
Rotifera:								–
Ascomorpha sp.	–	–	–	+	–	–	+	+
Asplanchna spp.	–	+	+	+	–	+	–	+
Brachionus angularis	–	+	+	+	–	–	–	+
Brachionus calyciflorus	+	+	+	+	–	+	+	
Brachionus caudatus	–	+	+	+	–	+	–	+
Brachionus falcatus	+	–	+	–	–	–	–	
Brachionus forficula	–	–	–	–	–	–	–	
Brachionus patulus								+
Keratella cochlearis	–	+	–	–	–	–	–	–
Keratella tropica	+	+	+	+	–	–	–	
Lecane bulla	–	–	–	+	–	–	–	–
Polyarthra spp.	–	–	–	+	+	–	–	
Synchaeta spp.	–	+	–	–	–	–	–	+
Trichocerca cylindrica	–	–	–	+	+	+	–	–
Trichocerca spp.	–	–	+	+	–	–	–	+
No of species	**11**	**15**	**15**	**16**	**7**	**11**	**8**	**13**

Table 2: Species of zooplankton observed in the open waters of the surveyed lakes, March/April 2001

Taxa	Kyarano	Kirumi	R. Mara	Ikimba	Malimbe	Burigi	Katwe	Kubigena
Cladocera								

Allona spp	–	+	–	–	–	–	–	–
Bosmina longirostris	–	–	+	+	–	–	–	+
Ceriodaphnia cornuta	+	–	+	–	–	+	+	–
Chydorid spp.	+	+	–	–	–	–	+	–
Daphnia lumhortzi (helm.)	–	–	–	–	–	+	–	+
Diaphanosoma excisum	+	+	+	–	+	+	–	+
Moina micrura	–	+	+	–	–	+	+	+
Calanoida								
Thermodiaptomus galeboides	+	–	–	–	–	–	–	–
Thermocyclops emini	+	+	+	+	+	+	+	+
Thermocyclops incisus	–	–	–	+	–	–	+	+
Thermocyclops neglectus	+	–	–	+	–	+	+	+
Tropocyclops confinnis	+	–	+	+	–	+	+	–
Tropocyclops tenellus	+	–	–	+	–	+	+	–
Rotifera								
Ascomorpha sp.	–	+	+	+	–	–	–	
Asplanchna spp.	+	+	+	+	+	–	+	+
Brachionus angularis	+	+	+	+	+	+	+	+
Brachionus calyciflorus	–	+	–	–	+	+	+	–
Brachionus caudatus	–	–	+	+	+	+	+	+
Brachionus falcatus	+	–	–	–	–	–	–	–
Brachionus forficula								
Brachionus leydig					+			
Brachionus patulus	–	–	+	–	–	–	+	+
Euclanis sp	–	–	+	–	+	–	–	+
Filinia longiseta	–	–	–	–	–	–	–	–
Filinia opoliensis	+	–	+	–	+	+	+	+
Kellicotia spp.	–	–	–	+	+	–	–	–
Keratella cochlearis	+	–	–	+	+	+	+	+
Keratella tropica	+	+	–	+	+	+	+	+
Keratella quadrata	–	–	–	+	–	+	+	–
Lecane inermas	–	–	–	–	–	–	–	
Lecane bulla	+	+	+	+	+	+	+	+
Synchaeta spp.	+	+	+	+	+	–	+	–
Trichocerca cylindrica	–	–	–	–	–	–	–	+
Trichocerca spp.	–	–	+	–	–	–	+	+
Wolga spinifera	+	–	–	+	–	–	–	–
No of species	**17**	**12**	**16**	**17**	**14**	**16**	**20**	18

Discussion

The study of September/October 2000 show that the highest species diversity was observed in Lake Katwe where sixteen species were recorded. In this Lake, rotifers contributed ten species, the common ones being *Polyathra* spp, *Tricocerca cylindrical* and *Brachionus caudatus* which contributed 7%, 4% and 2% of the total abundance of zooplankton, respectively Cyclopoida contributed four species but was very important in terms of numerical abundance since it contributed about 70% of the total zooplankton.

The lowest species diversity was shown by the cladocerans, of which two species were recorded and contributing about 10%. Next to Lake Katwe was Kirumi Pond where fifteen species were identified. Among the sampled water bodies, Lake Kirumi showed the highest diversity of cladocera, five species being recorded. The main component was *D. excisum* which contributed 15% of the total zooplankton numerical abundance followed by D. *lumhortzi* (7%) and *C. cornuta (*6%). *Chydrorid* spp. and *M. micrura* contributed 1% each.

The calanoids were not widely distributed. They were found in Kyarano Dam and River Mara only. It is surprising that the calanoids were absent even in Kirumi Pond where some water from the river flows in. In Lake Ikimba the Cladocerans were absent, and the zoolplankton community was dominated by cyclopoid copepod. They comprised more than 95% of the total numerical abundance. Two species of rotifers were also found but in relatively very low numbers. The same was observed in Lake Malimbe, in which the cladocerans were absent in the open waters but two species were encountered in the littoral areas *B. longirostris* and *Chydorid* spp. Rotifera comprised four species and there were no calanoid copepods. There is therefore, a marked scarcity of adult filter feeders in Lake Ikimba and Lake Malimbe. Cyclopoid copepodites are raptorial feeders which grasp their food. They are thus better able than filter feeders to utilize the large particles, which may dominate in the phytoplankton of those lakes.

The cyclopoid *T. tenellus* were the most abundant members of the zooplankton community in Mara River, this pattern being different from other lakes where the *Thermocyclops* were always dominant. *T. tenellus* are the smallest among the Cyclops. This may be to the advantage of their survival, as the predators do not prefer them.

Kubigena Ox-bow Lake was very shallow and turbid. The rotifers were very important in terms of species diversity as well as numerical abundance. The most common species was *Brachionus patulus* which contributed 23% followed by two cladocerans, *M. micrura* (18%) and *D. exisum* (10%) of the total zooplankton numerical abundance.

In terms of abundance Kyarano Dam contributed the highest density. The zooplankton mean abundance reached 179,689 m^{-2}. Copepoda was the most important group and contributed about 56% followed by cladocera (40%) and rotifera (about 4%). The dominant species was *D. excisum*, which contributed 38% of the total zooplankton abundance, followed by *T. emini* (23%). Among the rotifers, *Brachionus* was the common genus. After Kyarano Dam, Lake Burigi had the next highest density, with a zooplankton mean abundance of 106,359 m^{-2}. It was dominated by the copepod, which comprised about 96% of the total zooplankton. The most common species were *T. emini* and *T. neglectus*. *D. excisum* was the only species of Cladocera observed in the lake. Only two species of rotifer were observed in Lake Burigi *Ascomorpha* species and *B. calyciflorus*. This lake is a clear lake without macrophytes. Most rotifers are not planktonic, but are sessile and associated with littoral substrata (Wetzel, 1983). Population numbers are highest in association with submerged macrophytes, especially plants with finely divided leaves (Edmondson, 1944; 1945; 1946). This is probably the reason why only few rotifer species were found in Lake Burigi. The absence of

Cladocera in the lake may be because they are eaten by many young fish, and also by the larvae of the dipteran chaoborus which were also found in the sample. The same findings were observed in Lake George (Burgis *et al*., 1973).

The cyclopoids were the most common species in the lake, the zooplankton population structure showing a tendency of predation pressure caused by fish as well as micro invertebrates most probably the chaoborid larvae and caridina which were found in large numbers comprising 25% of the total zooplankton numerical abundance in the littoral area. Two *Thermocyclops*: *T. emini* and *T. neglectus* were the dominant cyclopoid and contributed 24% and 32% of the total zooplankton numerical abundance. *T. confinnis* were rare. One species of Cladocera *D. excisum* and two species of rotifers *B. calyciflorus* and *Ascomorpha* species were encountered. The structure and composition trends of zooplankton in this lake may be related to both intensity of predation and limitation by environmental factors, which may include food quality and quantity.

In almost all the lakes cyclopoid copepod were the dominant group except in Lake Kubigena and Lake Malimbe, where rotifera were the dominant group. This was probably because of the nature of the lakes. These lakes are shallow about 0.4 m and 2.5 m respectively, a condition which is preferred by rotifers. The cladocera *D. excisum* was widely distributed and presented in all lakes except Lake Ikimba and Lake Malimbe.

During this study zooplankton numerical abundance was higher in Kyarano Dam, Lake Katwe, Ikimba, Malimbe, Buswahili and River Mara. Temperature increase may be the reason for that. During this cruise, the water was warm, about 25^{o}C, compared to that of June 2000 (Waya 2001 in press). This may have an effect on the development times of the copepods and cladoceran eggs as development of these eggs appear to be wholly dependant on temperature (Bottrel *et al.*, 1976; Vijverberg, 1980; Irvine and Waya, 1995). Temperature is important mainly because it influences the egg development time, growth rate, brood size and mortality of zooplankton (Hall, 1964, Herzig, 1994). The egg development rates increase as temperature increases. This may have caused the abundance to be higher in this study.

The study of March/April 2001 was done during and immediately after the rainy season. In almost all water bodies the densities of zooplankton were higher ranging from 31,108 m^{-2} in Kubigena Oxbow Lake to 479,015 m^{-2} in Lake Ikimba. This was probably due to the influent flood waters in the sampling areas which had relatively high nutrient concentration. The nutrents may have resulted in an increase in phytoplankton production. Zooplankton would increase in abundance due to increased food availability (Masundire, 1994). The diversity was also higher than the previous study, as thirty two species were encountered while in the previous study only twenty four species were observed.

The highest species diversity was observed in Lake Katwe, where twenty species were identified. Among them rotifera contributed twelve species, the most common one being *K. tropica* which contributed 17% of the total zooplankton numerical abundance. Next to rotifera was copepoda, the most common one being the cyclopoid copepod *T. neglectus* which was accounted for 16% of the total zooplankton numerical abundance. The nauplii were numerous contributing 39%. The cladocerans were very rare in the sample, the commonest one being *M. micrura*. In the littoral area, rotifers were numerous and contributed 74% of the total zooplankton numerical abundance. *Brachionas* and *Keratella* were the most common genus. The *Brachionids* were *B. angularis* (17%), *B. calyciflorus* (1%) and *B. caudatus* (8%), *Keratela* species were *K. tropica* (26%) and *K. cochlearis* (8%). Another common spicies were *L. bulla* (3%), *F. opoliensis* (4%) and *Asplanchna* spp. (3%). Other species were rare. The small and the transparent cladocera *M. micrura* contributed 8% of the total zooplankton numerical abundance. Next to rotifera was copepoda, the commonest one being the Cyclopoid copepod *T. neglectus* which accounted for 16% of the total zooplankton numerical abundance. The cladocerans were very rare in the sample, the commonest one being *M. micrura*.

Next to Lake Katwe was Kubigena Oxbow Lake. Among the eight species observed, eleven were rotifers. *Brachionus* was the most common genus and it contributed three species; *B. Caudatus, B. angularis* and *B. patulus* which accounted for 9%, 3% and 2% respectively. Other common rotifers were *L bulla* (6%), *Asplanchna* spp. (6%), and *K. cochlearis* (3%). In this lake cladocera were also found, the most common ones being *B. longirostris* and *D. excisum* each of them contributing 5% of the total zooplankton numerical abundance. Together with zooplankton, chaoborid larvae and ostracords were also present in the sample. The copepoda were present in the sample but not many, although the nauplii were numerous. This indicated that the lake condition was not good enough to allow the post-naupliar development stages to be completed. This was the only lake where the copepods were rare.

In Kyarano Dam, seventeen species were encountered Rotifera contributed eight species although they were not many in number. The most common rotifer was *K. cochlearis,* accounting for 7% of the total zooplankton numerical abundance. Copepoda contributed six species. The cyclopoid copepod *T. emini* was the most common species and contributed 12% of the total zooplankton numerical abundance. This is the only lake where the calanoid copepod *T. galeboides* was encountered. *D. excisum* was the most common cladocera and it contributed 5% of the total zooplankton numerical abundance.

In River Mara, 16 species were observed. Zooplankton density was much higher at shallow station than at the deeper stations. Neither cladocera nor copepoda were observed in deeper waters, only rotifers and ostracords, which were present in the sample and contributed 50% of the total zooplankton numerical abundance. The same observation was made in the Sanyati basin of Lake Kariba (Masundire, 1994). He reported that after about five weeks of being 'flooded', the only crustaceans observed were ostracords. In shallow water the density of zooplankton was higher, and rotifera, copepoda and cladocera were all present, the most numerous species being the cyclopoid copepod, *T. emini*, accounting for 24% of the total zooplankton numerical abundance, followed by the cladocera *D. excisum* which contributed 18%. The most common rotifera was *L. bulla* contributing 3.6%. The reason for the higher density at shallow water may be because deeper stations have a large volume of water which will cause greater dilution of nutrients brought up from the bottom at deep stations than at shallow stations. The result will be higher post turn over nutrient concentration at shallow areas, which will cause an increase of food availability of zooplankton.

In Lake Burigi, sixteen species were identified. Rotifera was the most important group in terms of diversity and contributed eight species. In the open waters, the rotifers were not many but in the shallow areas they contributed 52% of the total zooplankton abundance. The most common genus was *Keratela* which contributed 31% of the total zooplankton numerical abundance. The species identified were *K. cochlearis* (5%), *K. tropica* (22%) and *K. quadrata* (4%). Another common species was *F. opoliensis* accounting for 10%. In the open waters the copepoda were very common. *Thermocyclops* were the most common genus accounting for 26% of the total zooplankton abundance. Two species *T. emini* and *T. neglectus,* were the most important species in terms of abundance.

The highest density of zooplankton were observed at Lake Ikimba, where the abundance reached 476,015m^{-2}. It seems that there are no predation pressure on zooplankton, even fishermen were complaining that there are no fish in the lake (Pers. Comm.) Copepoda were most numerous, the mostcommon species being *T. neglectus*. The rotifers contributed the highest number of species, ten species being encountered, and *K. tropica* was the most common species. Cladocera were absent in the open waters, and only *Bosmina longirostris* were observed in the littoral areas.

Lakes Malimbe and Kirumi contributed the lowest number of species, as only twelve species were found in each lake. The zooplankton numerical abundance was also low. In both lakes, no cladocera were observed in the open waters. The only copepod found in these lakes was *T. emini*. In Lake Kirumi the most common rotifer was *Asplanchna* specie*s* which contributed 21% of the total zooplankton numerical abundance, while other common species were *B. angularis, Synchaeta* spp. and *Ascomorpha* spp. which contributed 13%, 5% and 3% respectively. In lake Malimbe the most common rotifer was *B. angularis* which accounted for 18% of the total zooplankton numerical abundance. Other common species were *Asplanchna* spp., *B. Calyciflorus*, *K. Cochlearis* and *K. tropica*. In the littoral areas, high densities were observed in these lakes; in Lake Kirumi, 172,998 m^{-2} and in Lake Malimbe 113,377 m^{-2}. Four cladocerans were encountered in Lake Kirumi and were dominant, contributing 45% of the total zooplankton numerical abundance. Next to *D. excisum* is the *Asplanchna* spp, which contributed 16%. *Synchaeta* spp. was also common. It contributed 14% of the total zooplankton numerical abundance. In Lake Malimbe, the only cladocera was *D. excisum*.

Among the cladocerans, *Ceriodaphnia cornuta, D. excisum* and *M. micrura* were wide spread in the water bodies surveyed. They were found in at least four locations. These species were also found in most tropical fresh waters (Dumont, 1994; Korovchinsky, 1992; Austin *et al*., 1994). *Moina micrura* have the advantage of being small and transparent, therefore they are relatively immune to fish predation, although they may suffer substantial losses due to invertebrate predators (Dumont, 1994). That is why their occurrence in Lake Katwe, River Mara, Lake Kirumi and Kubigena Oxbow Lake was not low. *B. Longirostris, Chydorid* spp., *D. Lumhortzi* and *Alona* spp. were rare species.

Alona species were found in Lake Kirumi only. In tropical lakes and flood plains, the littoral offers a year round site for higher densities of micro and meso-plankton (Fernando, 1994). This has been true in Lakes Kirumi and Malimbe, and in River Mara, the densities of zooplankton being much higher in the littoral than in the open waters. The numerical abundance of zooplankton was relatively higher in this study because of the high densities of nauplii and rotifers. This may be because of the amount of nutrients available as well as the type of gear used. The mesh size of the net was 65 µm, and this was able to collect early copepodites, nauplii and rotifers. Also the predation of fish does not affect them much because normally fish select larger prey that they can catch and digest. The larger the prey, the greater the chance of being caught. The visual predators must see their prey to catch it, so objects smaller than about 1mm are not really seen, and thus the rotifers, small cladocera such as *Bosmina*, nauplii and early copepodites will escape (Moss, 1998).

The copepoda were widely distributed and were the most common group in almost all the lakes, while the cladocera were very rare, especially the large cladocera which are most vulnerable. They move slowly and probably do not have sensory mechanisms capable of detecting the shock wave of an approaching fish. In contrast, the copepods have sensory hairs on their antennae. With a flick of their abdomens, they can move away with great speed from the line of attack by the fish (Lynch, 1979). This can explain their success in the lakes surveyed.

It seems that there is no competition among grazers in the surveyed lakes. Large Daphnia species, which could compete with small rotifers, were absent in almost all lakes. Smaller cladocerans such as *Bosmina* may co-exist with rotifers because they are not powerful feeders. Small cladocerans may also be more vulnerable to invetebrate predation which prevents rises in populations to a competitive level (Moss 1998).

This pattern of zooplankton structure and composition in some Tanzanian Lake Victoria Basin water bodies is similar to that in some of the Ugandan satellite lakes, (Ndawula and Kiggundu, unpublished report), in Kyoga satellite lakes (Kawi, Lemwa, Nyaguo, Nakua, Agu, Gigate and Nawampasa), Lake Wamala, Lakes Nabugabo and the satellite lakes of Kayugi and Kayanja, and River Nile and that of Kenyan satellite lakes (Masai 2001 in press). Rotifers supported higher species diversity just as has been observed in this study. In most of the Ugandan satellite lakes, the most common rotifers were *Keratella tropica, Brachionus caudatus, and Tricocerca,* which were also common in this study. One species *Macrothrix laticornis* was observed in Lakes Agu and Nawampasa but was not found in the surveyed water bodies. *Thermocyclops neglectus* was the most common copepod in Tanzania and Uganda, but *Thermocyclops emini,* and *Diaphanosoma excisum* were not common crustaceans in Ugandan satellite lakes. *Diaphanosoma excisum* were common crustaceans in Tanzanian and Kenyan satellite lakes. No calanoids were observed in dams in Kenya (Masai, 2001) but in Tanzania calanoids were found in Kyarano dam and River Mara (Waya, 2001).

CONCLUSION

This study revealed that three major groups of zooplankton exist in the satellite lakes i.e. copepoda, cladocera and rotifera; overall 21 genera and 33 species were identified. The dominance of the cyclopoid copepod was a common trend in all water bodies surveyed except Kubigena Ox-bow Lake and Lake Malimbe where the rotifers dominated. Rotifers were always important in terms of species diversity. Lake Katwe is species rich, and contributed the highest number of species compared to other lakes in both studies. In terms of numerical abundance, Kyarano Dam contributed the highest density in September/October 2000, the mean total number being 179,689 m^{-2} . In March/April 2001 the highest density of 479,015 m^{-2} was observed in Lake Ikimba. Generally the density of zooplankton was higher in September/October 2000 than in March/April 2001.

RECOMMENDATIONS

i. Studies on the population dynamics and production of zooplankton are useful because the quantification of zooplankton production assists in the understanding of fisheries production and perhaps of more importance, of the nature of ecosystem trophic dynamics in aquatic ecosystems.
ii. Also there are no identification keys for the Lake Victoria invertebrates. It is therefore recommended that this be worked on, especially for copepods which are a very complicated group.

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