SPECIES COMPOSITION AND BIOMASS ESTIMATES OF ZOOPLANKTON IN SOME WATER BODIES WITHIN LAKE VICTORIA BASIN

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ABSTRACT

Zooplankton communities were identified and their abundance and biomass estimated in some selected satellite lakes and Mara River in Lake Victoria basin, during wet and dry seasons in 2002. Samples were collected from eight water bodies. Three stations were sampled from each water body using a plankton net (40 µm mesh size) hauled vertically through the water column. The zooplankton community comprised mainly crustacea and rotifers. The results show that the number of species collected during the wet and dry seasons was 31 species and 28 species, respectively. The Shannon wiener diversity indices were not significantly different (Mann-Whitney U Test = 16.000, p = 0.1049). The rotifers were the most dominant during both seasons. The wet season recorded higher biomass in all satellite lakes than during the dry season (t = 2.476, DF = 9, p = 0.0176). On the contrary there was a higher biomass during the dry season than during the wet season in Mara River (Mann-Whitney U Test, = 1.000, p = 0.0150).

INTRODUCTION

Zooplankton play an important role in functioning and productivity of aquatic ecosystems (Mathias 1971, Downing 1984, Wright and O'Brien 1984, Mwebaza-Ndawula 1994). This role can be realized from their influence on nutrient dynamics and trophic position in aquatic food chain (Mwebaza-Ndawula 1994). They are the most important converter of primary to secondary production for carnivorous invertebrates and fishes further up the food chain.

Some findings have revealed a decline in fish biodiversity in Lake Victoria following the introduction of Nile Perch (*Lates niloticus*) (Kaufman 1992, Ogutu Ohwayo 1990, Witte et al, 1992a and 1992b). However, it has been realized that some of the species, which disappeared from Lake Victoria were available in some of the satellite lakes within Lake Victoria basin (Katunzi 2001). This has attracted scientific attention to carry out studies in satellite lakes. Ecological information on zooplankton in satellite lakes and rivers within Lake Victoria basin is still limited to a few studies (Waya 2001a and 2001b). The aim of this study was to determine zooplankton species composition, abundance, biomass and assess its seasonal distribution in River Mara and some selected satellite lakes within Lake Victoria basin so as to have baseline information.

MATERIALS AND METHODS

Study Sites

A total of eight water bodies were sampled covering the three lake zone regions namely; Mara, Kagera and Mwanza. Mara region samples were collected at Mara River, Kyarano Dam, Lake Kirumi and Lake Kubigena. In Kagera region the sites included Lake Burigi, Lake Katwe and Lake Ikimba while in Mwanza region there was only one site i.e. Lake Malimbe. The study was carried out during March/April 2002, which constituted the wet season, and during August/September, which constituted the dry season (Table 1). In each sampling site samples were collected from three stations, which were located using a geographical positioning system (GPS). One station was at the middle of the water body and the rest were located on opposite ends from each other.

Table 1: Monthly total rainfall (mm) for different areas within Lake Victoria Basin during 2002.

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mwanza	140.4	68.0	240.5	206.1	122.6	0.0	0.0	0.0	1.1	61.1	143.0	299.2
Biharamulo	184.5	23.3	205.4	237.6	81.2	0.0	0.0	0.0	29.9	81.2	154.4	109.3
Bukoba	97.5	86.3	440.8	428.3	62.3	23.5	14.2	28.5	92.0	175.0	267.5	174.5
Musoma	64.7	19.4	165.2	167.1	164.6	18.2	17.2	5.5	24.5	49.1	165.3	209.0

Source: Tanzania Meteorological Agency

Methodology

Samples were collected using a plankton net of 40 µm mesh size having an opening of 29 cm diameter and 1 meter in length. The depths of the sampling stations were measured using a portable echo sounder prior to collecting samples. The net was lowered close to the bottom and then slowly hauled to allow the water to be filtered. The net was rigged with weight to enhance vertical sinking. At each sampling station three replicate samples were collected and combined to make a composite sample. The samples were immediately preserved in 4% sugar formalin. During sampling, temperature and water transparency were measured using a Wagtech thermometer and Secchi disc, respectively. Rainfall data were obtained from Tanzania Meteorological Agency.

In the laboratory each sample was diluted, agitated and sub-sampled with a 5 mls pipette. The zooplankton were counted in three sub-samples (two of 2 mls and one of 5 mls). The dominant animals were not counted in the second and third sub samples, when at least 100 animals had already been counted in the first sub-sample.

The sub-samples were placed on a modified counting chamber and examined under the microscope at x 40 magnification. Taxonomic identification was done using identification keys as adopted by Ruttner-Kolisko (1974), Korinek (1984), Boxshall and Braide (1991), Korovchinsky (1992, 1993) and Maas (1993). Adult individuals were not separated into sexes. The developmental stages 1 to 5 of Calanoids and Cyclopoids were lumped together as a single count category (copepodites). Nauplii stages were also grouped together. Abundance of the zooplankton was computed from the numbers counted.

For biomass determination, 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. The biomass (B) was determined according to Herzig (1984), as follows:

$B = 4/3\pi ab^2 / 10^6$ µg$*$ x.

Where:

a = 1/2 length

b = 1/2 width

x = Numerical abundance of the taxa

Data analysis was done by using instat statistical package including Mann-Whitney Test and t–test. Shannon Wiener diversity index (Shannon and Weaver, 1949) was calculated to establish the species diversity.

Table 2: Species composition of zooplankton during wet season in selected satellite lakes and Mara River, during 2002 (in %)

Taxa	Mara River	Kyarano	Ikimba	Katwe	Burigi	Malimbe	Kirumi	Kubigena
Cladocera								
Ceriodaphnia cornuta	–	29.3	–	0.1		–	–	–
Chydorid spp.	–		–	–	–		11.7	–
Daphnia barbata	–	0.7	–	–	–	–	–	
Daphnia lumhortzi (helm.)	–	3.2	–	–	–	–	–	22.1
Diaphanosoma excisum	7.0	13.5	–	2.5		27.8	0.7	–
Moina micrura	–	0.1	0.2	0.1	–	4.0	27.2	–
Calanoida								
Thermodiaptomus galeboides	.	1.0		–	–		–	–
Cyclopoida								
Mesocyclops sp.	–	–	1.0	2.6	.	23.9	3.9	7.4
Thermocyclops emini	–	7.6	0.6	5.5	1.8	4.1	0.4	.
Thermocyclops incisus	–	0.2	–	–	3.3		0.3	–
Thermocyclops neglectus	–	–	1.4	25.2	78.4	–	5.3	–
Tropocyclops confinnis	–	–	–	2.6	1.5	4.0	–	–
Tropocyclops tenellus	–	0.1	46.5	0.3	0.9	0.1	0.2	27.8
Rotifera								
Ascomorpha sp.		–	9.2	–	–	–	3.9_	22.1
Asplanchna spp.	11.4	12.4	29.3	7.9	–	4.3	4.8	–
Brachionus angularis	7.6	12.9	1.2	4.2	0.3	4.2	16.0	–
Brachionus calyciflorus	–	–	–	3.9	0.9	6.4	4.1	14.8
Brachionus caudatus	–	0.1	–	1.0	1.5	–	–	
Brachionus falcatus	–	1.7	–	0.2	–	–	0.2	
Brachionus leydig	–	–	–	–	–	0.1	–	
B. quadridentatus	–	–	–	–		–	_3.9	–
Filinia longiseta	4.9		–	0.1	–	–	–	–
Filinia opoliensis	14.4	9.2	–	0.6	–	0.1	0.2	–
Kellicotia spp	18.5	6.1	–	28.5	3.6	1.0	0.4	–
Keratella cochlearis	0.2		–	–	–	0.1	–	2.9
Keratella tropica	–	0.3	–	13.2	8.0	–	0.4	–
Keratella quadrata	–	–	10.6	1.2		0.2	0.5	
Lecane bulla	7.1	–	–	–	–	15.9	16.7	–
Lecane inermas	–	0.1	–	0.2		–	0.3	
Synchaeta spp.	0.1	0.2	–			–	–	–
Trichocerca spp.	28.1	0.6		0.2	–	4.0	4.1	–
Number of species	10	19	9	20	10	16	21	6

RESULTS

Species Composition

Tables 2 and 3 show the occurrence of zooplankton in some selected satellite lakes and Mara River during wet and dry seasons, respectively. The results show that the number of species during the wet and dry seasons was 31 and 28 species, respectively, the difference was not significant. This is clearly shown by Shannon Weiner species diversity indices (Table 4), which were not significantly different between the two seasons (Mann-Whitney U Test, = 16.00, p = 0.1049). However, there were variations in species composition among the sampling sites. For example, during the wet season Lake Kirumi recorded the highest number of species (21 species), followed by lake Katwe

(20 species) and Lake Kyarano (19 species). Lake Kubigena recorded the least (6 species). During the dry season Mara River and Lake Katwe recorded the highest (18 species). The least was recorded at Lake Ikimba (5 species).

Among the major taxa the rotifers contributed the biggest number during both seasons in many lakes. For example, during the wet season Lake Kirumi recorded 13 species followed by Lake Katwe (12 species), Lake Malimbe and Kyarano Dam (10 species). Lake Kubigena recorded the least (3 species). During the dry season the biggest number of rotifers was recorded at Lake Katwe (10 species) followed by Lake Kirumi (9 species), River Mara (8 species). The only exception was observed in Lake Ikimba, where only one species of rotifer was observed (Table 3).

Table 3: Species composition of zooplankton in selected satellite Lakes and River Mara during dry season 2002 (Given in percentage)

Taxa	River Mara	Kyarano	Ikimba	Katwe	Burigi	Malimbe	Kirumi	Kubigena
Cladocera								
Allona spp	9.8	-	-	-	-	-	-	7.7
Ceriodaphnia cornuta	23.4	0.4	-	1.3	0.3	-	0.4	-
Chydorid spp.	7.9	8.1	-	-	-	3.0	-	3.9
Daphnia barbata	-	1.5	-	-	-	-	-	-
Daphnia lumhortzi (helm.)	2.0	8.1	-	-	-	-	-	-
Diaphanosoma excisum	18.9	11.4	-	6.6	2.1	-	0.5	3.9
Moina micrura	2.8	-	-	22.7	-	-	1.8	-
Calanoida								
Thermodiaptomus galeboides	1.6	6.5	-	-	-	-	-	-
Cyclopoida								
Mesocyclops sp.	2.5	8.1	4.8	2.6	-	-	-	-
Thermocyclops emini	7.2	15.6	4.8	2.6	14.9	3.0	2.6	11.6
Thermocyclops incisus	-	0.7	1.8	-	1.7	-	-	-
Thermocyclops neglectus	-	25.7	54.2	2.6	63.6	-	3.3	3.9
Tropocyclops confinnis	-	-	-	9.9	2.4	-	0.2	7.7
Tropocyclops tenellus	1.6	-	-	2.6	4.7	3.0	-	7.7
Rotifera								
Asplanchna spp.	3.9	-	-	18.5	6.6	3.3	17.8	15.5
Brachionus angularis	5.9	0.4	4.2	2.6	-	0.3	10.6	19.3
Brachionus calyciflorus	2.5	-	-	6.0	-	11.9	2.8	7.7
Brachionus caudatus	0.9	-	-	3.7	1.8	-	0.9	7.7
Brachionus falcatus	0.9	-	-	-	0.9	-	45.5	-
Brachionus leydig	0.3	4.5	-	5.9	-	48.9	-	-
Brachionus patulus	-	-	-	2.2	-	7.3	0.2	-
Euclanis sp	-	-	-	-	-	-	-	3.4
Filinia opoliensis	-	-	-	-	-	-	2.3	-
Keratella cochlearis	-	-	-	0.7	0.6	1.3	-	-
Keratella tropica	-	0.9	-	5.4	-	-	4.5	-
Lecane bulla	1.9	2.4	-	1.3	0.4	-	6.6	-
Polyarthra spp.	1.2	4.9	-	2.3	-	-	-	-
Trichocerca spp.	-	0.8	-	-	-	-	-	-
Number of species	18.0	16.0	5	18.0	12.0	9	15.0	12.0

Biomass

Biomass estimates in different sites is presented in Figure 1. The wet season recorded higher values ranging between 54.0 and 1782.7 mg wet weight m^{-2}. During the dry season the values ranged between 43.7 and 1042.6 mg wet weight m^{-2}. Lake Burigi recorded the highest biomass during both seasons. On the contrary there was a higher biomass during the dry season than in the wet season in Mara River (Mann-Whitney U Test, = 1.000, p = 0.0159.

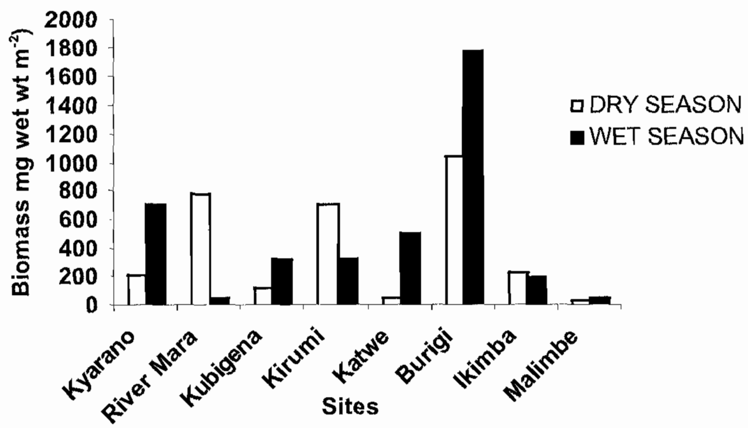

Figure 1: Biomass estimates (mg wet m^{-2}) in different sites wet and dry seasons

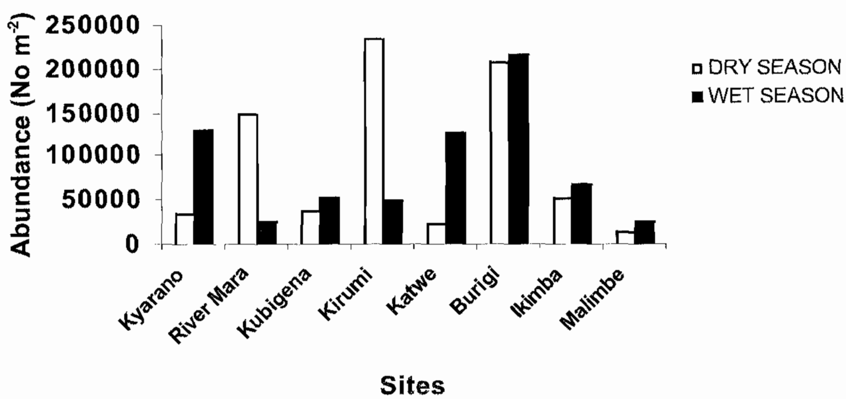

Figure 2: Zooplankton abundance (No m-2) in different sites during wet and dry seasons, 2002

Abundance

The abundance of zooplankton during wet and dry seasons is presented in Figure 2. The results show that on average wet season recorded higher abundance than dry season (t = 2.476, df = 9, p =0.0176). The value for wet season was 25,378 individuals m^{-2} at Mara River and 300,680 individuals m^{-2} at Lake Burigi. During the dry season abundance was 16,328 individuals m^{-2} recorded at Lake Malimbe and 234,618 individuals m^{-2} recorded at Lake Kirumi.

Table 4: Shannon Weiner diversity indices ('H') and number of species for different sites and seasons

Sites	Divrsity indices		Number os species	
	Rainy	Dry	Rainy	Dry
Mara River	0.239	0.204	10	18
Kyarano	0.355	0.221	19	16
Ikimba	0.266	0.166	9	5
Katwe	0.762	0.215	20	18
Burigi	0.184	0.209	10	12
Malimbe	0.263	0.229	16	9
Kirumi	0.289	0.224	21	15
Kubigena	0.248	0.227	6	12

Table 5: Temperature (^{0}C) and water transparency (m) in different water bodies

	Temperature		Water transparency	
	Rainy	Dry	Rainy	Dry
Mara River	26.2	26.2	0.66	0.70
Kyarano			0.20	0.20
Kirumi	27.8	24	0.52	0.30
Ikimba	25.2	25	0.30	0.27
Katwe	24.3	24	0.50	0.80
Burigi	26.5	26.5	0.50	0.85
Malimbe	31.7	19.7	0.30	0.27
Kubigena	24.8	25.6	0.30	0.30

Temperature and water transparency

During the rainy season the highest temperature was recorded at Lake Malimbe (31.7 ^{0}C) while the least was recorded at Lake Katwe (24.3 ^{0}C). Lake Burigi recorded the highest temperature during the dry season (26.5 ^{0}C) and the least was recorded at Lake Malimbe (19.7 ^{0}C) (Table 5). Water transparency during the rainy season ranged between 0.2 m which was recorded at Kyarano Dam and 0.66 m recorded at Mara river. During the dry season the highest was recorded at Lake Burigi (0.85 m) while the least was recorded at Kyarano Dam (0.2 m).

DISCUSSION

Species composition

In general the species composition during the wet and dry seasons was similar. This could imply that the physical and chemical parameters did not vary much to eliminate some of the species. For example, temperature and transparency variation between the two seasons was not significant. Since the water transparency did not vary significantly, probably the level of eutrophication which is a result of chemical pollution was not severe. The pollutants which can kill zooplankton include; chemicals and high quantity of nutrients which cause eutrophication. This phenomenon is common during rainy season when runoff brings nutrients into the water bodies.

The variations in species composition in different water bodies could be attributed to availability of food resources (phytoplankton) for the zooplankton in respective water bodies. The amount of phytoplankton in the water bodies was quite high (Mbonde et al. 2003). Food resources influence growth and reproduction of organisms including zooplankton (Hart et al. 1995). The high species composition of zooplankton in Lakes Kyarano and Kirumi could be a result of low production of fishery resources (Katunzi 2001), which feed on them.

The high contribution of rotifers in many lakes during both wet and dry seasons could mainly be attributed to eutrophic condition of the lakes. The transparency ranged between 0.2 m and 0.85 m. The high turbidity could be a result of the litter dropped by macrophytes associated with the lakes. Rotifers are known to prefer turbid conditions because they are tolerant to pollution and eutrophication (Mavuti and Litterick 1991).

Biomass and Abundance

The higher biomass and abundance of zooplankton species recorded during the wet season could be attributed to the high amount of phytoplankton (Mbonde et al. 2003) which is the food for zooplankton. The high amount of the phytoplankton might have reduced transparency during the wet season (Table 5). Normally rainfall brings nutrients into the water bodies from runoff (Heckey et al. 1987). Rainfall has been reported in other tropical lakes to enhance organic production through episodal nutrient input by either flowing rivers or direct precipitation (Burgis 1974, Mavuti 1990). The abundance and production of zooplankton is normally regulated by temperature, food and predation. Temperature is important mainly because it influences the egg development time, growth rate, brood size and mortality of zooplankton (Herzig 1994, Masundire 1994, Waya 2001b). In this study temperature records did not differ much to cause variations in abundance between the wet and dry seasons. Therefore, food availability seems to have influenced much on the higher zooplankton biomass and abundance during the wet season.

Contrary to what was observed in the satellite lakes, the higher abundance recorded during the dry season than during the wet season in Mara River could be influenced by flushing rate. The flushing rate during the dry season was low which favored the reproductive capacity of the zooplankton species by reducing reproductive output losses (Kim and Joo 2000). The only group, which can tolerate the hush environment, is the rotifer because they have short generation time (Walz and Welker 1998). The rapid growth is necessary to maintain positive net growth, when flushing rate is relatively higher.

CONCLUSION

The results of this study have revealed that the water bodies within Lake Victoria basin consist of a high diversity of zooplankton species mainly of crustacea and rotifers. The high diversity of crustacean zooplankton describes the high productivity of the water bodies within the basin because they provide the basis of fish production (Allison et al. 1996). Moreover, the biomass of zooplankton was higher during the wet season than dry season which confirms that their production depends on the availability of food resources (phytoplankton) which were abundant during the wet season. Since this study gives the baseline information on the status of zooplankton communities in the basin, some more studies are recommended to give their temporal variations on monthly basis for a prolonged period.

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REFERENCES

Allison EH, Irvine K, Thomson AB and Ngatunga BP 1996 The diet and food consumption rates of the offshore fish in Lake Malawi. *Fresh wat. Biol.* **35**: 489-515.

Boxshall GA and Braide EI 1991 The freshwater cyclopoid copepods of Nigeria, with an illustrated key to all species. *Bulletin of British Museum Natural History.* (*Zoology*) **57** (2): 185-212.

Burgis MJ 1974 Revised estimates for the biomass and production of zooplankton in Lake George, Uganda. *Freshwater Biology*, **4**: 535-541.

Downing JA 1984 The assessment of secondary production. In: JA Downing and FH Rigler (eds), *A manual of Methods for the Assessment of Secondary Productivity in Freshwaters.* Blackwell Scientific Publishers, 501pp.

Hart RC Irvine K and Waya R 1995 Experimental studies on food dependency of development times and reproductive effort (fecundity and egg size) of Tropodiaptomus cunningtoni in relation to its natural distribution in Lake Malawi. *Archiv. fur. Hydrobiology.* **133**: 23-47.

Heckey RE and Kling HJ 1987 Phytoplankton ecology of the great lakes in the rift valleys of Central Africa. – *Arch. Hydrobiology. Beih. Ergebn. Limnology.*, **25**:197-228.

Herzig A 1994 Predator-prey relation ships in the pelagic community of cladocera. *Hydrobiologia*, **275/276**: 81-96.

Herzig A 1984 Fundalmental requirements for zooplankton production studies pp 13 – 14.

Katunzi EF 2001 Satellite lakes, Rivers and dams as refugia for the endangered fish species of Lake Victoria. Paper presented at the National Scientific, Conference held in Mwanza, Tanzania, August, 2001.

Kaufman L 1992 Catastrophic change in species-rich freshwater ecosystems: the lessons of Lake Victoria. *Bioscience* **42**:846 – 858.

Kim HW and Joo GJ 2000 The longitudinal distribution and community dynamics of zooplankton in a regulated large river: a case study of the Nakdong River (Korea). *Hydrobiologia* **438**: 171-184.

Korinek V 1984 Cladocera. *Cercle Hydrobiologique De Bruxelles* pp 5 – 73.

Korovchinsky NM 1992 Sididae and Holopediidae (crustacea. Daphn iiformes). Guides to the identification of the Microinvertabrates of the continental waters of the world, 3 SPB, the Hague, 82 pp.

Korovchinsky N 1993 Introduction to the Cladocera. International Training Course Manuscript, Universiteit Gent, Belgium. 2-36 pp.

Maas S 1993 Introduction to the Copepoda. International Training Course Manuscript, Universiteit Gent, Belgium. 3-204 pp.

Matthias JA 1971 Energy flow and secondary production of amphipods Hyallela azteca and Crangonyx richmondensis accidentalis in Marion Lake. British Columbia. *Journal of Fisheries Research Board Canada,* **28**: 711-721.

Masundire HM 1994 Seasonal trends in zooplankton densities in Sanyati basin, Lake Kariba, multivariate analysis. *Hydrobiologia*, **272**: 211-230.

Mavuti KM 1990 Ecology and role of zooplankton in the fishery of Lake Naivasha. *Hydrobiologia*, **208**: 31-42.

Mavuti KM and Litterick MR 1991 Composition, distribution and ecological role of zooplankton community in Lake Victoria, Kenya waters. *Verh. Intern. Verein. Limnol.* **25**: 846-849.

Mbonde AS, Shayo S, Sekadende BC and Lyimo TJ In press Phytoplankton species diversity and abundance in the near shore waters of Tanzanian side of lake Victoria.

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

Ogutu Ohwayo R 1990 The decline of Native fishes of Lakes Victoria and Kyoga (East Africa) and the impact of introduced species. In: TJ Pitcher and PJB Hart (eds). *The impact of species changes in African lakes*. Chapman and Hall, London, pp. 59-81.

Ruttner-Kolisko A 1974 Plankton rotifers, Biology and Taxonomy. Schweitzerbart'sche, Verlang, 21 pp

Shannon CE and Weaver W 1949 The mathematical theory of communication. Urbana University Illinois press, 117 pp.

Walz N and Welker M 1998 Plankton development in a rapidly flushed lake in the River Spree system (Neuendorfer See, Northeast Germany), *Journal of Plankton Research*. **20**: 2071-2087.

Waya RK 2001a Zooplankton species composition and diversity in Satellite Lakes in comparison with Lake Victoria. Paper presented to Lake Victoria Environment Management Project (LVEMP). National Scientific Conference, Mwanza, Tanzania, August, 2001.

Waya RK 2001b Zooplankton communities of some Tanzanian lake Victoria basin water bodies. Paper presented to a Regional Scientific Conference held in Kisumu-Kenya

Wright DI and O'Brien WJ 1984 Model analysis of the feeding ecology of freshwater planktivorous fish. In: D. G. Meyers & J. R. Strickler (eds), Trophic interactions within Aquatic Ecosystems. A.A. A. selected symposium 85, 472 pp

Witte F, Goldschmidt T, Goodswaard PC, Ligtvoet W, Van Oijen MJP and Wanink JH 1992a Species extinction and concomitant ecological changes in Lake Victoria. *Nether land Journal of Zoology* **42**: 214-232

Witte F, Goldschmidt T, Wanink JH, Van Oijen MJP, Goodswaard PC and Bouton N 1992b The destruction of an endemic species flock, quantitative data on the decline of the haplochromine cichlids of Lake Victoria. *Environmental. Biology. Fisheries*. **34**:1-28