Aquatic biodiversity of Lake Victoria basin

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ABSTRACT

Lake Victoria is the largest lake in Africa, with the largest freshwater fishery in the world. There are nine main affluent river basins (Sio, Nzoia, Yala, Nyando, Sondu-Miriu, Awach, Kuja, Mara, and Kagera), and one surface outlet, the River Nile. The basin has extensive wetlands and small water bodies, which have (or had) a hydrological connection with Lake Victoria and therefore constitute potential "refugia" for biotic and genetic diversity from the main lake. The biological diversity in these waters is known to be exceptional both in number of species and in their endemism. While the ecosystem changes have been documented, causes of these changes remain uncertain due to lack of basic data on the abundance and diversity of the biota. Through the Lake Victoria Environmental Management Project (LVEMP), the three riparian states of Kenya, Uganda and Tanzania, with assistance from the Global Environmental Facility (GEF) and the International Development Agency (IDA) have collectively responded to the issues of ecosystem and resources degradation in the lake basin. Areas of concern which constituted specific components of the project were declining fisheries, proliferation of the water hyacinth, extreme sediment and pollution loads in the river and lake waters, reduced vegetation and forest cover in the catchment, wanton clearance and draining of wetlands and poor land use practices in and around the basin. One of the critical components of LVEMP therefore concerned Fish Biology and the Conservation of Aquatic Biodiversity. This document provides information on the pertaining situation of the basic biodiversity in the Lake Victoria basin. The composition, diversity, distribution as well as the ecological and socio-economic importance of the various species have been presented. The communities discussed include macroinverterbrates, phytoplankton, macrophytes, invertebrates, and vertebrate. The need for more studies to ensure sustainability as a result of the ongoing exploitation is emphasised.

Key words: *Lake Victoria basin, Biodiversity, Macroinverterbrates, Aquatic ecosystems, satellite water bodies, Algal Communities, Phytoplankton, Macrophytes, Invertebrates, Vertebrates*

INTRODUCTION

Lake Victoria experienced dramatic changes in the past century. These changes occurred in the drainage basin involving the vegetation, industrialization, agricultural developments, introduction and invasion of alien species and intensive non-selective fishing. These, among other factors, have led to destruction of native and endemic components of the Lake Victoria basin. Lake Victoria lost about 60% of its cichlid taxa in the last decade and faced deterioration in water quality from over exploitation of the fishes and human impacts on the ecosystem (Witte and others 1992a,b; Kudhongania & Chitamwebwa 1995; Gophen and others 1995; Ogutu-Ohwayo and others 1997). Other components of the aquatic system that changed included algae, macrophytes, invertebrates, birds, amphibians and reptiles that are important parts of the ecosystem. There has been progressive build-up of physical and chemical changes in Lake Victoria. Increased chlorophyll "a" concentration and primary production, a decrease in silica and sulphur concentrations compared to values measured 30 years ago was noted (Hecky 1993). Other ecological shifts include the dominance of blue-green algae and leading to increased algal blooms.

A number of endemic species of fish and birds in Lake Victoria basin face various threats from a variety of human activities. In 1988, about one hundred native fish species endemic to Lake Victoria were entered in the World Conservation Union's Red Book of endangered species. A number of studies report remarkable post perch structural changes directly impacting on the niche composition at all levels of biodiversity (Mbahinzireki 1994; Mugidde 1992; Gichuki & Odhiambo 1994; Seehausen & Witte 1995; Seehausen 1995; Chapman and others 1995). The wetland ecosystems in Lake Victoria basin are rich with vertebrates. Other than fish most of these are not well studied. It is reported that Kingfisher (*Ceryle rudis*) diet changed from haplochromines to dagaa (Omena) following the explosion in Nile perch population (Goudswaard & Wanink 1994). The ecosystems are quite diverse and provide different ecological niches or habitats for different species. The rivers and their associated wetlands provide *refugia* for fish species endangered from Nile perch and other predators (Chapman and others 1996). Some species, thought to have disappeared following the perch introduction in the lake, have been found in satellite lakes and other *refugia*. Some of these species or populations could recover under effective ecosystem management.

The lake basin is estimated to have a population of 30 million people which is growing at > 3% per annum. The lake supports one of the most productive freshwater fisheries in the world with annual fish yields in excess of 500,000 tonnes annually. Other economic activities in the lake basin include agriculture, mining, hydropower generation and transport. Three major cities (Kampala, Kisumu and Mwanza) with a combined population of at least six million people depend on the lake for domestic and municipal water supply and waste disposal. The challenge on Lake Victoria is to sustain the lucrative fishery that emerged out of the Nile perch introductions, and at the same time restore and conserve the lost fish diversity.

Diversity of Aquatic ecosystems in the Lake Victoria basin

Lake Victoria, the largest tropical lake in the world, is shared by the three East African states: Kenya, Tanzania, and Uganda. Lying at an altitude of 1134 m above sea level with a surface area of 68,800 km^2 and a shallow depth (92m max. depth), the lake is almost a square saucer (with max. length and width of about 400 km and 320 km respectively) dipping out into the White Nile. Much of the lake is shallow (≤ 40 m). The catchment area is about 194,200 km^2. Located between latitudes 0° 20' N, 3° 0' S and longitudes 31° 39' E, 34° 53' E, the lake is truly equatorial. The bottom has a thick carpet of soft organic mud, broken only in isolated patches of hard substrate, sand or rock. It has a highly indented coastline with many bays and gulfs. The Kagera and Nzoia Rivers are the major inflows while the major out flow is via River Nile.

Lake Victoria and its small satellite water bodies (SWB) in Kenya

About 6% of the total lake area lies in Kenya, most of this being the Nyanza (Kavirondo or Winam) Gulf (Figure 1). The Gulf joins the main lake through the Rusinga channel. The causeway that links Rusinga Island to the mainland blocked Mbita Channel, severing the only other connection with the main lake. The blocked current flow and exchange of water between the gulf and the open lake severely affect the water quality in the gulf. The catchment of the Kenya portion of Lake Victoria covers approximately 47,709 km^2 and has numerous rivers, small lakes, dams and streams (Figure 1) collectively referred to as Satellite Water Bodies (SWBs). Notable among the SWBs are lakes Kanyaboli, Sare, Simbi and Namboyo; and rivers Sio, Kibos, Nzoia, Yala, Nyando, Sondu-Miriu, Awach, and Kuja. Other smaller lakes are Tinga Migowa (34°46'S, 34° 32' 03 E), Achoro (0° 30' 48 S, 34° 32'00 E), Aimo (0° 32' 23 S, 34° 36'56 E), Uranga (0° 05' 32.4 N, 34° 16' 33.2 E), Mauna (0° 12' 31 6 N, 34° 09' 26,3 E), Ulanda (0° 05' 57 N, 34° 09' 53 E), Mwer (0° 07 12' N, 34° 10' 19.8 E), Ugege (0° 13' 3.2 N, 34° 12' 34.6 E) and Ufinya.

Most of these SWBs are surrounded by extensive papyrus swamps save for the steep sided Lake Simbi, which lies in a crater with hot springs that do not support papyrus growth. Lake Kanyaboli with a surface area of about 10.5 km^2 is located at 0°05' 32.3 N, 34° 16' 33 2 E. It receives its waters from River Yala. The lake has no direct outlet but discharges its water to Lake Victoria through underground seepage. Most of the dams were sunk in the 1940s and 1950s to provide water for domestic and livestock uses. Fish endemic to Lake Victoria were introduced into some of these dams and lakes to supplement fish yields and resource value. The SWBs are the remaining refuge to those endemic species, now feared to have disappeared from the main Lake. The stocks in these SWBs are well established and contribute immensely to the biological diversity.

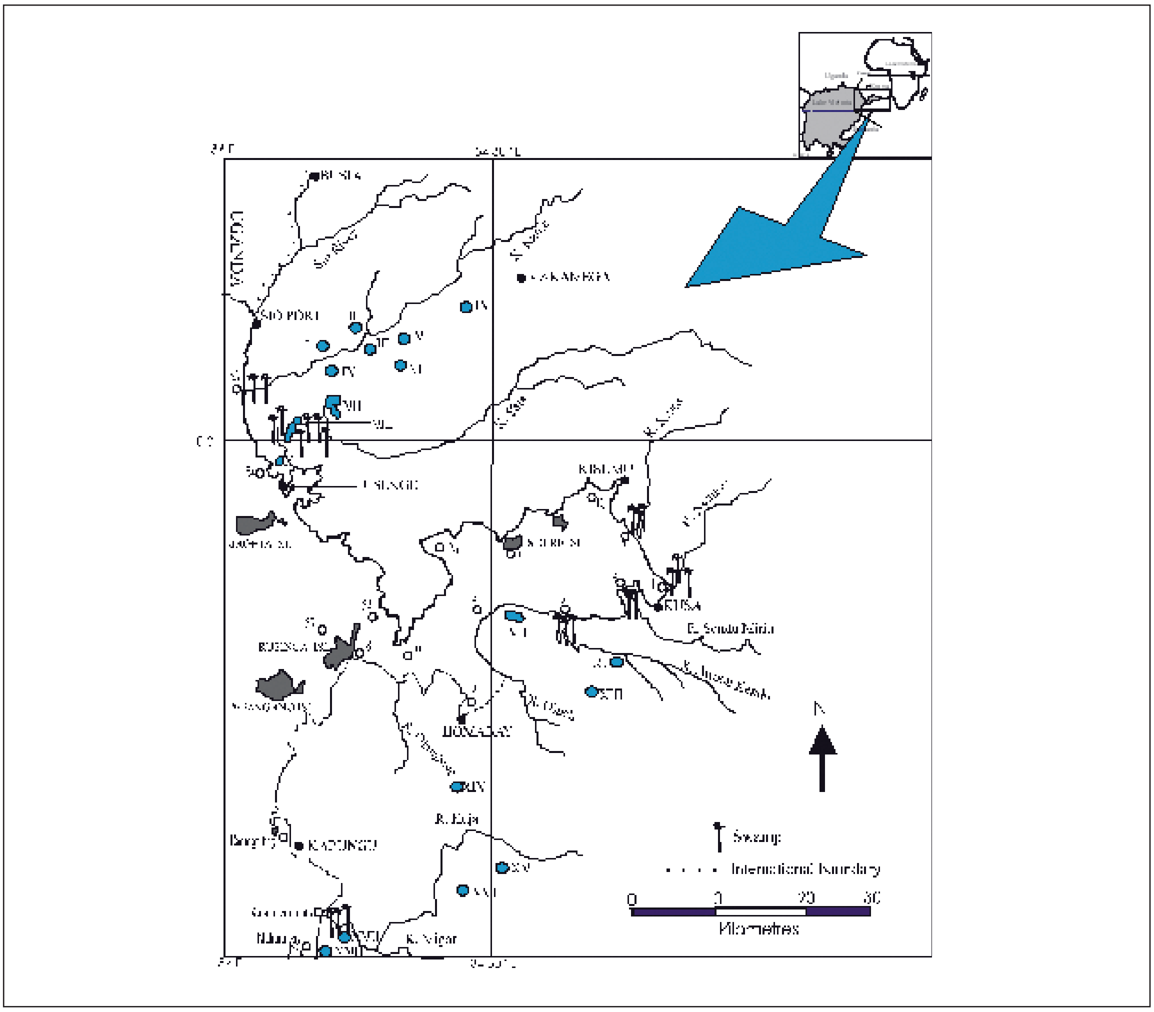

Figure 1: Map of Lake Victoria showing the study sites in the main lake and the location of the SWBs. The SWBs are; I: Mauna, II: Ugege, III: Kalenyjuok, IV: Mwer, V: Ufinya, VI: Ulanda, VII: L. Kanyaboli, VIII: L. Namboyo, IX: Uranga, X: L. Sare, XI: Kosiga, XII: Ulanda, XIV: Mugowa, XV: Stella, XVI: Uriri, XVII: Kokech, XVIII: Olasi (Source Gichuki and others 2004).

Lake Victoria and the small water bodies in Uganda

Approximately 43% of the total lake area lies in Uganda. Major lake systems associated with Ugandan portion of Lake Victoria basin are the Kyoga, Nabugabo and Kooki (Figure 2). Many of these lakes are eutrophic and are relatively shallow compared to Lake Victoria. Lakes Victoria and Kyoga share a common evolutionary history and have similar native fish faunas (Worthington 1929). Both lakes are ichthyo-geographically similar and received Nile perch (*Lates niloticus*) and Nile Tilapia (*Oreochromis niloticus*) introductions in the 1950s. Satellite lakes surrounding Lake Victoria include: Wamala, Kachera, Mburo, Nabugabo, Kayanja and Kayugi. Those constituting the Kyoga system are lakes Nawampasa, Nyaguo, Agu, Gigate, Lemwa and Kawi (Figure 2). Lakes Kachera, Mburo, Kijanebalola and Nakivali are referred to as the Kooki lakes. The Kooki lakes are located in an extensive swamp fed by River Ruizi, and exited by River Kibali, which discharges into Sango Bay, Lake Victoria. Most satellite lakes are isolated from each other and from their main lakes by swamps. Many of the satellite lakes, especially, those associated with Lake Kyoga harbour stocks of endemic fish species, which are rare or extinct from Lake Victoria.

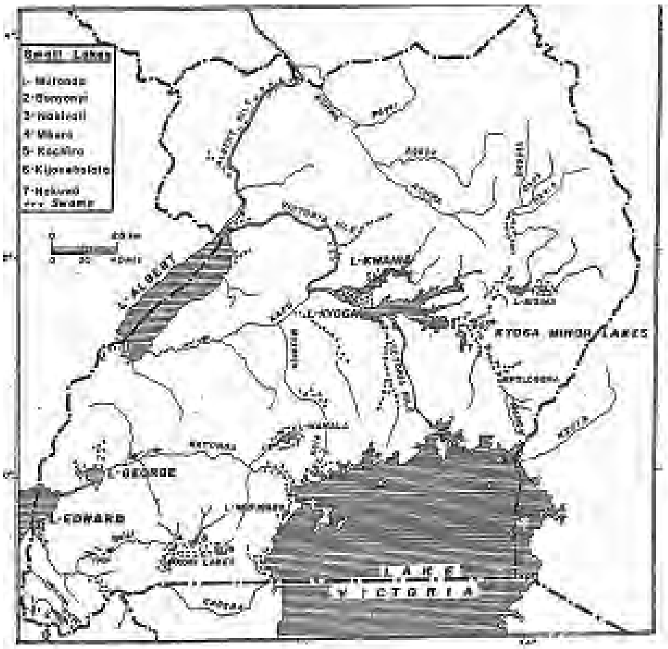

Figure 2: Map showing Lake Victoria and associated satellite lakes in Uganda (Source Gichuki and others 2004)

Lake Victoria and its small satellite water bodies (SWB) in Tanzania

The Lake Victoria drainage basin on the Tanzanian part covers an area of 115,380 km^2, which is about 51 % of the total lake area. The Kagera region in the West, Mwanza and part of Shinyanga regions in the South and Mara region in the East are part of the lake's catchment (Figure 3). Small satellite water bodies in this portion of the Lake Victoria basin include lakes Burigi, Ikimba and Malimbe and rivers Kagera, Mara, Simiyu, Rubana, Suguti and Mori (Figure 3). The lakes and wetlands systems comprise those of the lower Kagera complex (lakes Rusha, Kalenge, Katwe, Ikimba, Bugiri, Rwakajunju and Ngoma), the Masirori swamp (Lake Kubigena), and the Kirumi ponds. Major rivers draining into Lake Victoria are Mara, Mori, Suguti, Grumet, Simiyu, Rubana, Suguti, Ngono, Magogo, Mbalageti, Moame and Kagera. Kagera and Mara rivers originate from Rwanda and Kenya respectively.

The Tanzanian SWBs are shallow with maximum depth in the range 1.8 m to 8 m. One commonality of these lakes is the presence of extensive macrophytes mostly *papyrus* along their shorelines. Lake Burigi is 7,000 ha in area and is linked to river Kagera and Lake Victoria through an extensive wetland drained by River Mwisa. Half of the lake area falls within the National Park, and this has strongly influenced sustainability of fish diversity. Lake Ikimba has a surface area of 12,500 ha., and is also connected with Lake Victoria through river Mwisa. Together with Lake Malimbe, these lakes (Burigi, Ikimba and Malimbe) contain high fish diversity. The lakes are important refugia to the endangered fish species of Lake Victoria. They share the floral and faunal composition with Lake Victoria. The dense cover of macrophytes surrounding these lakes makes it difficult to access.

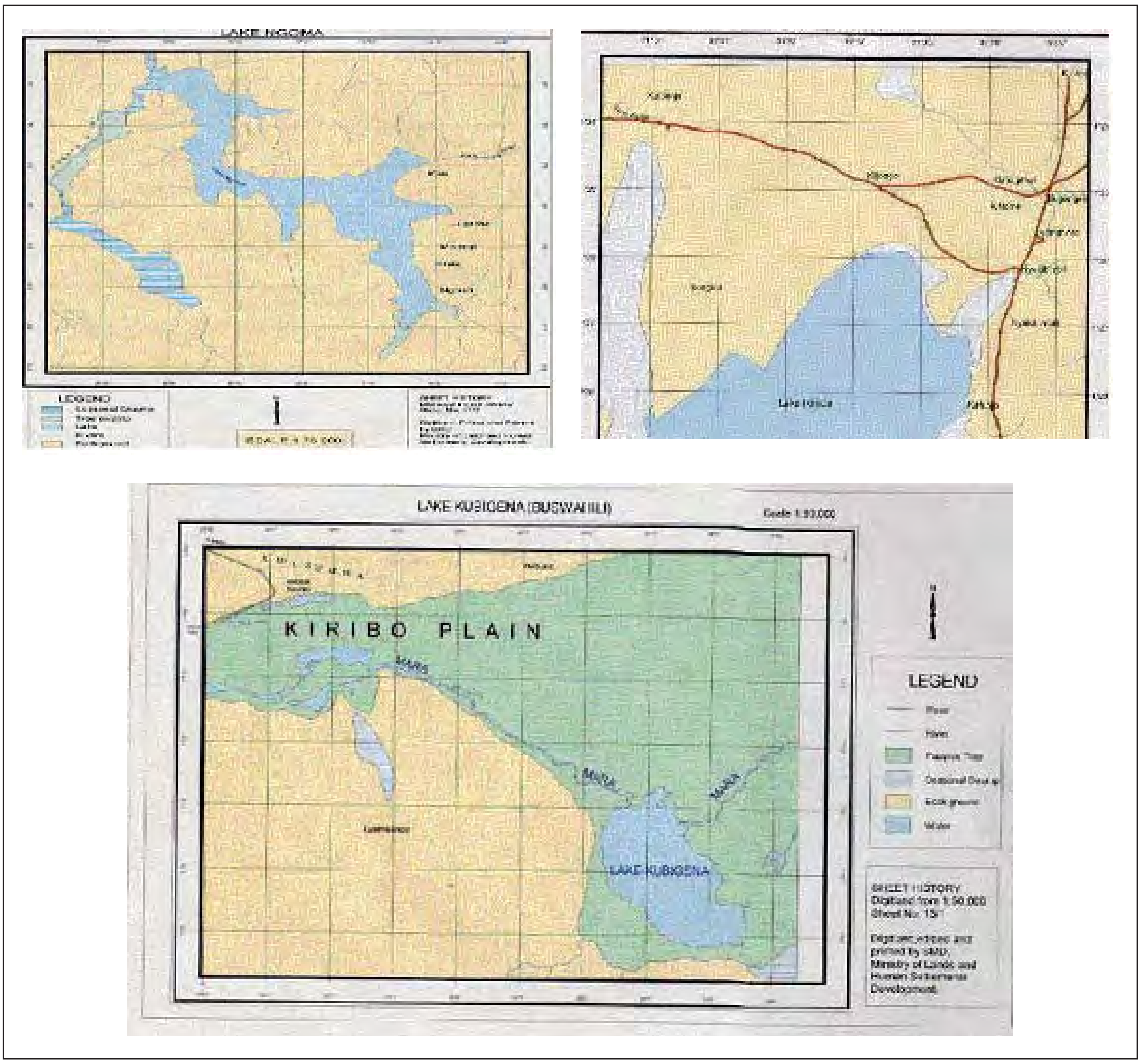

Figure 3: Map showing small water bodies in the Tanzanian part of the Lake Victoria basin (Source Gichuki and others 2004).

Algal Communities in the Lake Victoria basin

General floristic survey of African lakes begun at the turn of the nineteenth century (Schmidle 1898, 1902; West 1907; Woloszynska 1914), and initial phytoplankton samples from Lake Victoria were collected by Stuhlmann in 1892 (Crul 1995). Different African lakes have thus received variable attention since the 1940s and up to the present day. Detailed classical records of algal species are those of Evans (1962a 1962b) and Talling (1965 1966), while those for algal primary productivity are Talling (1957a, 1957b) and Talling & Talling (1965). These records are a benchmark for rating changes in algal composition and productivity over the time. Later studies on this flora were stimulated by interests on pollution, conservation of biodiversity and the drastic loss of fish species in Lake Victoria (Talling 1987; Ochumba & Kibaara 1989; Hecky 1993; Hecky and others 1994; Mugidde 1993; Komarec & Kling 1991; Lehman & Branstrator 1993; Lehman 1998). About five hundred infrageneric taxa in over one hundred genera of algae have been described for the African great lakes (Cocquyt and others 1993; Cocquyt & Vyverman 1994). Diatoms are of especial paleo-ecological significance (Richardson and others 1978; Kilham & Kilham 1989) in these lakes.

The combined effects of chemical, physical and hydrological factors largely determine the algal communities in aquatic systems. Consequently, the ecological integrity of several of the East African lakes has been altered as a result of simultaneous changes in their physical, chemical and biological properties. These changes have had impacts on the quality and quantity of algae, especially in Lake Victoria (Akiyama and others 1977; Hecky 1993; Hecky and others 1996; Lehman and others 1998; Lung'ayia and others 2000; Kling and others 2001; Mugidde 2001). Diatom community is now dominated by *Nitzschia spp* as opposed to *Aulacoseira* (*Melosira*) and *Cyclostephanos* that made up to 70%-99% of the biomass of the 1960s (Talling 1957a 1957b; Evans 1962a, 1962b; Kling and others 2001). A wide variety of cyanobacteria (blue-green algae) that were consistently low in the 1960s now appear more frequently and filamentous heterocystous cyanobacteria such as *Cylindospermopsis* make up a large fraction of the algal community of the lake. Green algae also occur in very low abundance with some taxa, e.g., Desmids having disappeared. Larger chlorophytes such as *Pediastrum* are rare. Phytoplankton biomass (chlorophyll *a*) has increased 6-fold since the 1960s (Talling 1966, 1987; Mugidde 1992, 1993; Kling and others 2001) following the general increases in phosphorus (P) and nitrogen (N) loading in the lake (Hecky 1993; Lipiatou and others 1996; Ogutu-Ohwayo 1992; Lehman and others 1998). Global warming, climate change, and species introductions are believed to be the driving forces behind the phytoplankton blooms and driving domination by cyanobacteria. Fish species introductions enhanced changes in algal species composition through the trophic cascading. Note that following the introductions (of Nile Perch *Lates niloticus* and Nile Tilapia *Oreochromis niloticus*), the endemic detritivorous and phytoplanktivorous haplochromine and tilapiine cichlids (*Oreochromis variabilis, O. esculentus* and *O. leucostictus*) got displaced and disappeared from the lake (Goldschmidt and others 1993; Ogutu-Ohwayo 1992).

Algae and fisheries

Algae play an important role in the productivity of Lake Victoria and the small water bodies in the lake basin. They form the main part of phytoplankton in the open waters, whereas, in the littoral zone, algae are important in the benthos. Algae and macrophytes (*Azolla*, papyrus, and water hyacinth) are the major primary producers and the source of food in the Lake Victoria ecosystems. Several microalgae species such as *Oscillatoria, Microcystis, Aulacoseira*, *Nitszchia, Melosira* and *Pediastrum* are frequently encountered in the food items of detritivorous and phytoplanktivorous cichlids in Lake Victoria.

Excessive algal proliferation (algal blooms) may cause death to a number of aquatic animals either from lack of oxygen (at night) or from toxins (Boney 1975). Reports exist on massive fish kills in Lake Victoria. For example, in the 1990s, massive fish kills were observed in the Nyanza Gulf and attributed to the effects of the then cyanobacteria blooms (Ochumba 1990). Cyanobacteria, especially *Microcystis* occur in high abundances in Lake Victoria and some of the SWBs.

Phytoplankton groups

There are 344 species in 140 genera and 8 phyla of phytoplankton in Lake Victoria and SWBs (Table 1). The eight phyla are Cyanophyta, Chlorophyta, Bacillariophyta, Dinophyta, Euglenophyta, Pyrrophyta, Chrysophyta and Cryptophyta. Bacillariophyta (diatoms) are the most diverse with 111 species on the Kenya side of the lake (Table 1). Cyanophyta (cyanobacteria or blue-green algae) are well represented in the SWBs. They often constitute between 60 to 97% of individuals (cells or filaments) in the main Lake Victoria and the SWBs. The most abundant planktonic genus found in most water bodies is *Microcystis*. *Cylindrospermopsis* is a common cyanobacterium that occurs almost throughout the year.

Microcystis aeruginosa, M. flos-aquae, Anabaena circinalis and *A. circularis* are the most abundant cyanophytes in the inshore waters of Lake Victoria (especially in Nyanza, Mwanza and Napoleon Gulfs, and in the bays). Filamentous cyanobacteria are often abundant in the littoral zone and on rocky shores where they form an important part of the biomass. Solitary filamentous cyanobacteria, e.g., *Planktolyngbya*, *Anabaena, Pseudoanabaena*, and *Anabaenopsis* species are also common in the plankton. Non-mucilaginous green algae: *Scenedesmus*, *Ankistrodesmus, Coelastrum* and *Cosmarium* spp are associated with shallow nutrient-rich waters and are among the most common green algae in all the lakes. The diatom, *Nitzschia,* especially *N. acicularis,* dominates the phytoplankton in the open waters of Lake Victoria though are often overtaken by cyanobacteria during non-mixing periods. *Nitzschia* is also common in most of the SWBs. Members of Euglenophyta such as *Euglena*, *Phacus* and *Trichelomonas* are well distributed in many of the shallower SWBs.

Table 1: Numbers of algal species belonging to different phyla in the various water bodies (Source: Lungáyia and others 2004).

Taxa/ Water body	Victoria-Uganda	Victoria-Kenya	Victoria-Tanzania	Kachera	Mburo	Kayanja	Kayugi	Nabugabo	Gigati	Kawi	Agu	Nyaguo	Lemwa	Nakuwa	Nawambasa	Wamala	Victoria Nile	Ulanda	Mauna	Ufinya	Kalenjuok	Nyamboyo	Uranga	Ugege	Mwer	Sare	Kanyaboli	Kosiga	Kokech	Oyombe	Migowa	Olasi	Uriri	Stella	Simbi	Katwe	Mara	Kirumi	Malimbe	Burigi/Butiama	Ikimba	Buswahili	Kyarano
Cynophyta	29	31	20	17	26	10	9	9	27	28	14	39	32	23	19	24	26	3	5	5	3	3	1	4	3	3	4	2	5	5	1	3	2	2	5	20	9	11	17	11	12	2	3
Chlorophyta	25	21	26	19	23	11	11	20	15	15	14	20	23	12	4	18	22	4	1	2	3	6	6	3	3	0	3	1	4	3	3	1	2	1	5	23	7	14	20	15	10	4	7
Bacillariophyta	9	111	15	5	5	2	2	1	7	7	2	4	8	4	3	8	14	5	2	4	1	0	3	3	2	1	3	5	2	0	0	0	3	2	0	9	8	8	3	7	4	10	7
Dinophyta	0	1	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	1	0	1	0	0	0	0	0	1	0	1	0	1	0	0	0	0	1
Euglenophyta	2	5	2	3	1	2	1	3	1	2	0	2	2	1	1	5	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	2	2	1	1	2	1
Pyrrophyta	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chrysophyta	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	1	0	0
Cryptophyta	1	0	0	1	1	1	1	1	1	1	0	0	0	1	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
Total number of taxa	**67**	**169**	**72**	**47**	**56**	**26**	**24**	**34**	**51**	**53**	**30**	**65**	**65**	**41**	**27**	**58**	**69**	**13**	**9**	**11**	**7**	**9**	**10**	**12**	**8**	**5**	**10**	**9**	**11**	**8**	**4**	**4**	**7**	**6**	**10**	**55**	**26**	**37**	**43**	**35**	**28**	**18**	**19**

Abbreviations used are given in brackets: Lake Victoria - Uganda (Victoria-Uganda, Vic-U), Lake Victoria - Kenya (Victoria-Kenya, Vic-K), Lake Victoria - Tanzania (Victoria-Tanzania, Vic-T), Kachera (Kra), Mburo (Mbr), Kayanja (Kja), Kayugi (Kgi), Nabugabo (Nbo), Gigati (Ggt), Kawi (Kwi), Agu (Agu), Nyaguo (Ngo), Lemwa (Lmw), Nakuwa (Nwa), Nawambasa (Nsa), Wamala (Wla), Victoria Nile (V.le), Ulanda (Ula), Mauna (Mau), Ufinya (Ufi), Kalenjuok (Kal), Nyamboyo (Nya), Uranga (Ura), Ugege (Uge), Mwer (Mwe), Sare (Sar), Kanyaboli (Kan), Kosiga (Kos), Kokech (Kos), Kokech (Kok), Oyombe (Oyo), Migowa (Mig), Olasi (Ola), Uriri (Uri), Stella (Ste), Simbi (Sim), Katwe (Kat), Mara (Mar), Kirumi (Kir), Malimbe (Mal), Burigi/Butiama (Bur), Ikimba (Iki), Buswahili (Bus), Kyarano (Kya).

The algal species composition of Lake Victoria is comparable to that in the SWBs. Many of the species are widely distributed in the different water bodies (Tables 1,2) although a few are rare and are reported in only one or a few water bodies. Some species were found in some of the SWBs but were not recorded in the main lake during the surveys and vice versa.

Table 2: The most widely distributed phytoplankton species in Lake Victoria and its satellite small water bodies. (Source: Lungáyia and others 2004).

Species	Number of water bodies where present	Species	Number of water bodies where present
Anabaena circinalis	15	Anksitrodesmus falcatus	20
Anabaena flos-aque	13	*Cosmarium* sp.	23
Anabaenopsis sp.	19	Pediastrum simplex	17
Aphanocapsa sp.	23	Pediastrum tetras	14
Chroococcus sp.	19	Scenedesmus acuminatus	19
Cylindrospermopsis africana	13	Scenedesmus arcuatus	21
Merismopedia elagans	12	Scenedesmus quadricauda	26
Merismopedia tenuissima	27	*Scenedesmus* sp.	15
Microcystis aeruginosa	31	*Stuarastrum* sp.	15
Microcystis flos-aquae	17	Tetraedron trigonum	18
Microcystis sp.	13	*Cyclotella* sp.	19
Planktolyngbya circumcreta	22	*Fragilaria* sp.	15
Planktolyngbya contorta	14	*Nitzschia* sp.	15
Planktolyngbya sp.	22	*Phacus* sp.	13

Macrophytes Communities in the Lake Victoria basin

Macrophytes are higher plants that grow in aquatic ecosystems and whose processes and characteristics are largely controlled by water. They can be subdivided into four major groups on the basis of their water requirements, life forms and habitats:

- Submerged macrophytes are completely covered under water and rooted in the substrate. These macrophytes have thin finely dissected leaves adapted for rapid exchange of nutrients with water. Examples include *Ceratophyllum demersum* and *Najas horrida*.
- Floating leafed macrophytes are rooted but have their leaves floating on the water surface. *Nymphaea lotus* and *Trapa natans* are good examples of floating leafed macrophytes.
- Free-floating macrophytes are a group of water plants that float on the water surface. Such plants have buoyancy and are adapted to drift on the water surface. Under this category are found *Eichornia crassipes* and *Pistia stratioptes*.
- Emergent macrophytes. These are rooted plants with their principal photosynthetic surfaces projecting above the water. Notable examples include *Phragmites australis* and *Typha domingensis*.

Establishment, distribution and diversity of macrophytes

It is believed that haplochromines used to protect the inshore areas of the lake from the establishment of macrophytes by constantly disturbing the substrate (Witte and others 1992a). The heavy rains of 1961-1964 caused a 2m rise in lake levels and destroyed most aquatic plants especially floating leafed and submerged macrophytes in the littorals. Deforestation of the catchment and the resultant elevated soil erosion and heavy siltation of river mouths and shores of the lake, have lately contributed to extensive macrophyte establishment. Macrophytes in Lake Victoria occur mainly in the vicinity of river mouths. As riverbeds widen, the water current is reduced and begin to deposit silt. These are easily colonised by emergent macrophytes and form swamps.

Factors that influence the establishment and distribution of macrophytes include: depth, topography, type of substrate, and exposure to currents/winds and water turbidity. The distribution of macrophytes is also often related to their method of attachment (Sculthorpe 1976). Macrophytes may be dispersed through river currents. Birds also play a role in dispersal of seeds, spores and asexual propagules. Man is responsible for macrophyte dispersal through fishing nets. In the Lake Victoria basin, areas with muddy substrates, especially river mouths, have higher densities and diversity of macrophytes compared to rocky and sandy substrates.

The two free-floating macrophytes on Lake Victoria: *Pistia stratiotes* (the water cabbage) and *Eichornia crassipes* (the water hyacinth) are exotic. The latter is believed to have originated from Rwanda and Burundi through River Kagera. The weed was first spotted in Lake Victoria in the late 1980s. The only free floating plants in the lake before the invasion by water hyacinth were *Pistia stratiotes, Azolla pinnata* and *A. nilotica.* On the establishment of water hyacinth, in mid 1990s, the weed smothered and pushed *Pistia stratiotes* and the *Azolla* spp out of the water. The increased debris in proximity to land due to the dense water hyacinth mats encouraged proliferation of *Vossia cuspidata* and *Echinochloa haploclada* communities, leading to total displacement of *Pistia stratiotes* and the *Azolla* spp. The latter has since disappeared from the Kenyan portion of the lake.

Other communities that were decimated by water hyacinth included *Nymphaea lotus*, *Ceratophyllum demersum*, *Najas horrida* and *Trapa natans*. The successful control and subsequent successions have however resulted in the re-emergence of some of the endemic flora. This cycle is expected to continue so long as the biological control agents continue to suppress proliferations of water hyacinth in the lake. Small water bodies in Lake Victoria basin are refuge to some unique macrophytes not found in the main lake. Such plants include *Ottelia ulvifolia* and *Nymphoides brevipedicellata* while those unique to the lake are *Vallisneria spiralis* and *Trapa natans*.

Zonation pattern of macrophytes

Macrophytes normally establish in succession of zones between the dry land and water, each zone being dominated by specific plant species. Jensen (1977) demonstrated that lakes can be characterized by the type of vegetation observed along transects for those areas not influenced by in-flowing or out-flowing rivers, as these tend to have luxuriant vegetation. Variation in zonation pattern depend on hydrology and may also be affected by ecological succession where a plant community alters environmental conditions in a way that makes the habitat less favourable for its own survival but more favourable for the development of another community. In a typical macrophyte zonation in Lake Victoria, free-floating plants normally occupy the lake ward open water zone (Figure 4). During some seasons, this zone may also be occupied by floating islands consisting mainly of the emergents *Cyperus papyrus* and *Vossia cuspidate.* These however, eventually sink to the bottom or drift out to the shores. Behind the open water zone follows floating leafed and submerged macrophytes. Emergent macrophytes occupy the zone next to land. In this zone are *Vossia cuspidata*, *C. papyrus*, *Hibiscus* spp and many climbers like *Ipomoea aquatica* and *I. rubens*. Behind the shoreline zone are usually water tolerant grasses, sedges, shrubs and trees. The latter, of which *Acacia elaphroxylon* is an example, is more common around the main lake while the small water bodies are dominated by other *Acacia* spp.

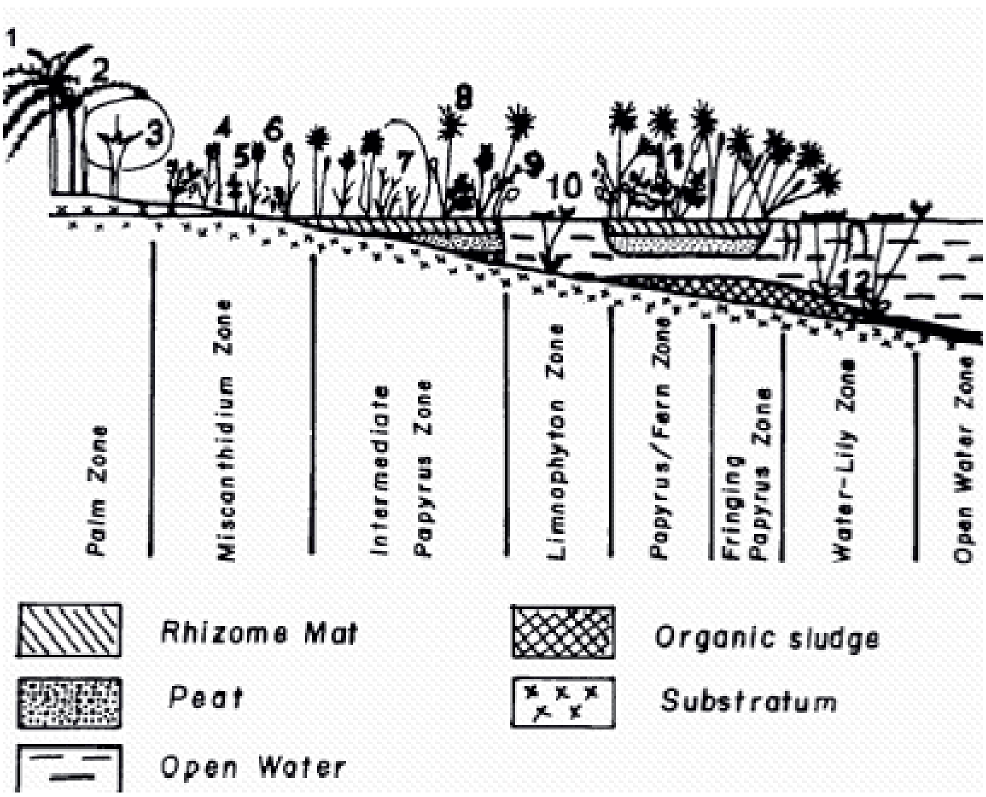

Figure 4: Typical zonation of macrophytes in the Lake Victoria basin. The species represented are: (1) *Phoenix reclinata* (2) *Raphia monbuttorum* (3) *Mitragyna stipulosa*. (4) *Sphagnum* spp. (5) *Dissotis brazzei* and *Leersia hexandra*. (6) *Miscanthidium Violaceum*. (7) *Ficus verruculosa*. (8) *Cyperus papyrus.* (9) *Limnophyton obtusifolium*. (10) *Trapa natans*. (11) *Dryopteris striata*. (12) *Ceratophyllum demersum, Utricularia i*nflexa and *Potamogeton* schweinfurthii (From Thompson 1976 cited in Lyaruu, and others 2004).

Ecological importance of macrophytes

Ecologically, macrophytes constitute one of the most important plant communities found in Lake Victoria. Macrophytes are regarded as the most productive plant communities in the world (Penfound 1956; Reddy 1984; Westlake 1963). They are also known to be the cradles of biological diversity, providing water and primary productivity upon which countless species of plants and animals depend for survival (Chapman and others 2001). Besides forming the base of the varied type of food chains, food webs, energy flow patterns and energy pyramids, the aquatic vegetation exerts a much more profound influence upon the ecosystem of which it is a part, than does the terrestrial vegetation. They act as the physical substrate for periphyton and insects thus providing a positive benefit to the ecosystem, facilitating overall food chain production as well as contributing to primary production. Macrophytes provide surfaces for egg incubation and *refugia* for juvenile fish (Kaul and others 1971). Recent studies have shown that the encroachment of the shores and beaches by water hyacinth has resulted in the re-appearance and subsequent increase of some fish species that were reportedly on the decline or threatened with extinction (Odongkara 1997; Njiru and others 2002). Wide coverage of water hyacinth provided protection of the breeding and nursery grounds that were vulnerable to poor and destructive fishing methods. Macrophytes are known to support a wide array of fish diversity and form important breeding grounds of both fish and avifauna.

Macrophytes act as efficient filters of excessive nutrients from the catchments, which could otherwise lead to eutrophication in the lake. Although the absorption may not in itself ensure the removal as the plants might re-release them on decomposition, the wet, low oxygen soils favour denitrification by bacteria leading to loss of nutrients (Gaudet 1976). In some cases, species of macrophytes such as

Eichornia crassipes are known to have the capability of absorbing high amounts of heavy metals that result from industrial effluents and domestic sewage. Macrophytes, especially emergents, form buffers around water bodies where they intercept silt and protect the shorelines from wave action. These plants also help in conservation of the water bodies by controlling indiscriminate utilization.

Socio-economic importance of macrophytes

The communities around the lake have utilized macrophytes from the basin for various purposes (Table 3).

Table 3: Economic importance of some macrophytes in Lake Victoria basin (Source: Lyaruu, and others 2004).

Scientific name	Local names	Uses
Cyperus papyrus	Matende, Togo	Construction, medicinal
Nymphaea capensis	Malenda, Yunga	Medicinal
Phragmites mauritianus	Matete, Odundu	Construction
Pistia stratiotes	Vinete, Anyuongi	Medicinal, mulching
Sesbania sesban	Marugume, Osaosao	Construction, firewood and fodder
Vossia cuspidata	Etezi, Saka,	Fodder
Luffa cylindrica	Dodoki, Spanj	Medicinal
Thelypteris totta	Ebingara	Animal food, soil binder
Aeschynomene elaphroxylon	Mizira, Ambach, Orindi	Construction
Eichornia crassipes	Gugu maji	Fodder, manure, ornamental
Cyperus digitatus	Ndago, saka	Fodder
Ceratophyllum dermesum	Marwenge	Medicinal
Trapa natans	Sikio la tembo, Ndaali	Medicinal
Echinochloa scabra	Saka, Nasakagazi	Fodder
Commelina benghalensis	Odielo	Fodder
Vernonia glabra	Olusia	Medicinal
Typha capensis	Mahuhi, Odhong'	Construction
Ipomoea cairica	Selele	Fodder

Problems associated with macrophytes

Less than 20 of the 700 species of macrophytes are considered weeds (Triest 1993). As a consequence of their prolific growth and production, macrophytes often interfere with human utilization of water bodies in a number of ways. Recent findings indicate that apart from interfering with fishing and navigation, free-floating mats of macrophytes are a threat to biological diversity affecting fish and other fauna, plant diversity, and food chains (Garry and others 1997).

In Lake Victoria, water hyacinth proliferation interferes with navigation and fishing activities. Small boats are not able to penetrate through the mats, while their engines get clogged with submerged macrophytes. Fishing gear, especially gill nets, are frequently destroyed by the floating islands. The latter also destroy spawning and nursery grounds by scraping the substrate in the shallow areas. Macrophytes in Lake Victoria basin also play host to a number of disease vectors including snails and mosquitoes (for Bilharzias and Malaria, respectively).

Zooplankton communities in the Lake Victoria basin

Zooplankton communities in the Victoria basin are mostly crustaceans, of which the key groups are copepods and cladocerans or water fleas (Plate 1). Non-crustacean zooplankton includes rotifers and the semi-benthonic insect larvae of *Chaoborus* spp.

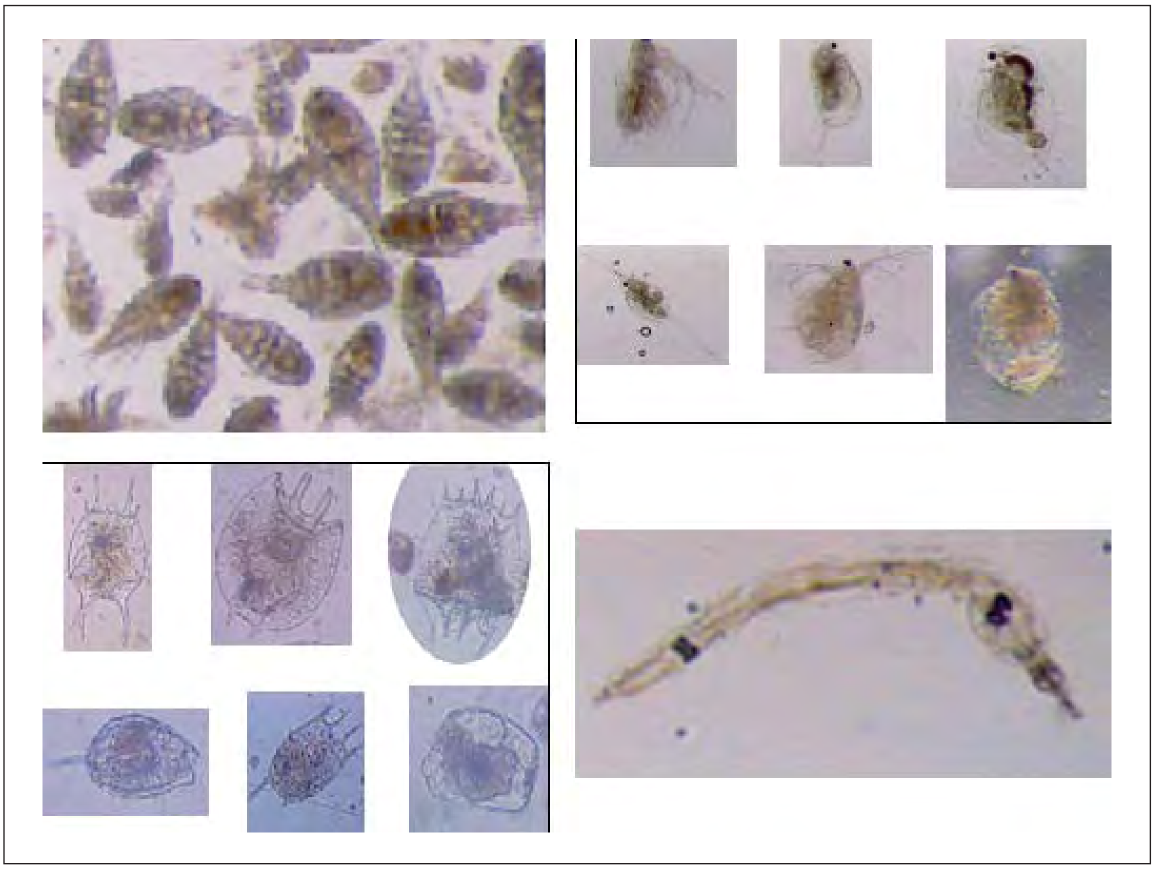

Plate 1: Top left: Copepoda; Top right: Cladocera; Bottom left: Rotifera; Bottom right: *Chaoborus* larva (Source: Mwebaza-Ndawula and others 2004).

The chaoborids stay in or near bottom sediments during daytime but ascend into the water column by night. Also the semi-benthonic freshwater prawns, *Caridina nilotica* Roux are commonly encountered in the plankton of Lake Victoria especially in samples taken at night owing to diurnal migratory behaviour similar to that of chaoborid larvae. Occasionally, water mites (Hydracarina) and ostracods also occur in the plankton. Pioneer studies on zooplankton communities in Lake Victoria were carried out through the expeditions of the early twentieth century (Daday 1907; Sars 1909; Delachaux 1917; Worthington 1931). These studies were largely descriptive and restricted to the shallow sheltered bays, gulfs and channels of the lake, and they provide a basis for tracking community changes by comparison with present-day investigations (Akiyama and others 1977; Mavuti & Litterick 1991; Mwebaza-Ndawula 1994 1998; Branstrator and others 1996).

Zooplankton community of Lake Victoria

The zooplankton community of Lake Victoria is made up of three broad taxonomic groupings: Copepoda, Cladocera and Rotifera. Other groups of minor importance are: the dipteran larvae and the acarid mites. The Zooplankton species composition is almost uniform over the lake (Table 4). Among cyclopoid copepods for example, 6 of the 8 species are common to the three portions of the lake (Kenya, Tanzania, and Uganda). The only two exceptions are: *Thermocyclops oblongatus* Sars, missing from Tanzania waters, and *Thermocyclops decipiens* Kiefer not encountered in Ugandan and Tanzanian waters. The two-calanoid species (*T. galeboides* Sars and *T. stuhlmanni* Mrazek) are widely distributed over the lake. Seven of the 10 Cladocera species occur in all three portions, as *Daphnia barbata* is only found in the Kenya portion, while *Chydorus sphaericus O.F.M.* and *Alona* sp. are not encountered in the Tanzania waters. A total of 16 rotiferan species out of 24 are distributed lake wide. The remaining 8 species are missing in the southern portion of the lake (except *Platyias patulus*, which is also not encountered in the Ugandan records).

Table 4: A Checklist of zooplankton species composition in the Kenyan, Ugandan and southern portion of Lake Victoria (P = present; A= not encountered). (Source: Mwebaza-Ndawula and others 2004).

Taxa	Kenya	Southern portion	Uganda	Taxa	Kenya	Southern portion	Uganda
Crustaceans				*B. calyciflorus* Gosse	P	P	P
Cyclopoida				*B. caudatus* Ahstrom	P	P	P
Thermocyclops neglectus Sars	P	P	P	*B. patulus* Muller	A	A	P
T.emini Mrazek	P	P	P	*B. falcatus* O.F. Muller	P	P	P
T. incisus Kiefer	P	P	P	*Filinia longiseta* Zacharias	P	P	P
T. oblongatus Sars	P	A	P	*F. opliensis* Zacharias	P	P	P
T. decipiens Kiefer	P	A	A	*Keratella cochlearis* Gosse	P	P	P
Mesocyclops spp.	P	P	P	K.quadrata	P	P	P
Tropocyclops confinnis Kiefer	P	P	P	*K. tropica* Apstein	P	P	P
T. tenellus Sars	P	P	P	*Polyarthra vulgaris* Carlin	P	P	P
Calanoida				Sychaeta sp.	P	P	P
Thermodiaptomus galeboides Sars	P	P	P	Lecane spp.	P	P	P
Tropodiaptomus stuhlmanni Mrazek	P	P	P	Monostyla sp.	P	A	P
Cladocera				Collotheca sp.	P	A	P
Daphnia lumholtzi Sars (hemeted)	P	P	P	*Asplanchna brightwelli* Gosse	P	P	P
D. lumholtzi var.monacha	P	P	P	*Ascomorpha* sp.	P	P	P
D. longispina Leydg	P	P	P	*Trichocerca cylindrica* Imhof	P	P	P
D. barbata	P	A	A	Aneuropsis sp.	P	A	P
***Ceriodaphnia cornuta* Sars**	P	P	P	Epiphanes	P	A	P
Diaphanosoma excisum Sars	P	P	P	Euclanis sp.	P	P	P
Bosmina longirostris O.F.M.	P	P	P	Hexathra mira	P	A	P
Chydorus sphaericum O.F.M	P	A	P	Platyias patulus	P	A	A
Alona sp.	P	A	P	Pompholyx sp.	P	A	P
Moina micrura Kurtz	P	P	P	Insecta			
Decapoda				*Chaoborus* larvae/pupae	P	P	P
Caridina nilotica Roux	P	P	P	Arachnida			
Non-crustaceans: Rotifera				Acarid mites	A	A	P
Brachionus angularis Gosse	P	P	P				

Copepods, represented by Cyclopoida and Calanoida (adults and their life cycle instars: copepodites and nauplius larvae) dominate the zooplankton community of Lake Victoria. Field investigations carried out over the period 2000-2002 in Kenya, Uganda and the southern portion of the lake showed that over 80% of the community is constituted by cyclopoid copepods (Fig. 5). Cyclopoida were abundant at both shallow inshore waters as well as deep open areas. On the other hand calanoid copepods contributed much smaller numerical proportions except in the offshore areas of the southern waters where a relatively high level of abundance (39.5%) was encountered. Rotifers, which were common and abundant at inshore sites, diminished to very small proportions in offshore waters of the lake. Cladocera highest numerical abundance occurred in the Kenya section with 7-8% compared to 1-3% in the southern portion and Uganda sections of the lake. Corresponding biomass data for shallow inshore areas and deep offshore waters in Uganda portion of the lake confirm the dominance of cyclopoid copepods (Figure 5) in the zooplankton community.

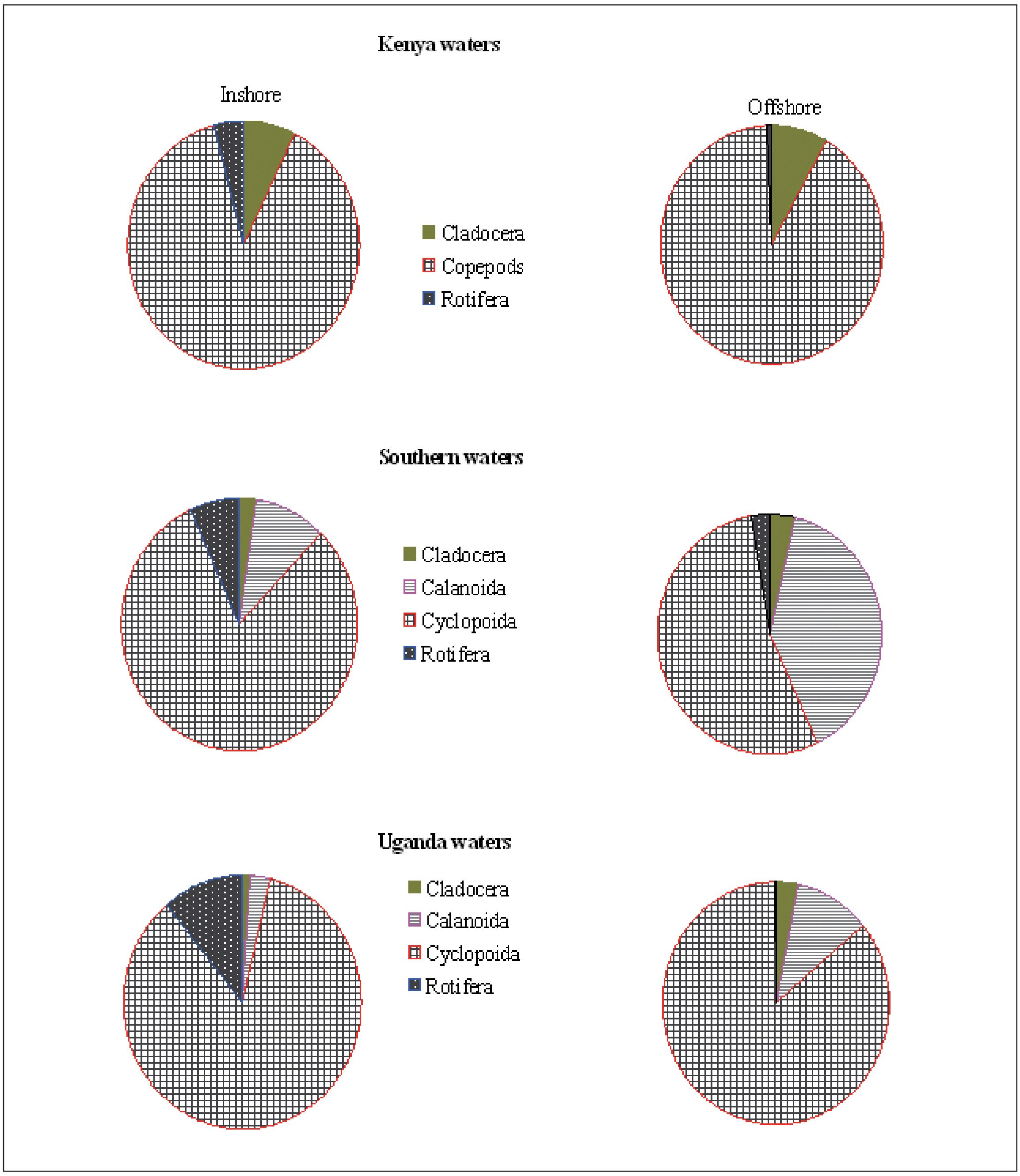

Figure 5: Relative abundance of different zooplankton taxa at selected locations in the Kenya, Uganda and southern portion of Lake Victoria 2000-2002. (Source: Mwebaza-Ndawula and others 2004).

Zooplankton communities of small water bodies in the Victoria basin

The zooplankton communities of the small water bodies in the Kenyan, Ugandan and southern sections of the Victoria basin are similar in that they are composed of the same crustacean taxa i.e. Cladocera and Copepoda; and non-crustacean Rotifera (Tables 5, 6, & 7). At species level, *Diaphanosoma excisum* and *Chydorus* sp. have global distribution in the basin. Data in the tables below present some of the observable regional and local differences in distribution of Zooplankton species. Zooplankton species richness varied widely between water bodies in the Victoria basin area. Kenya basin small water bodies gave an extreme example where only 2 species were recorded in Mwer dam compared to 14 in Lake Kanyaboli. In the Ugandan and southern basin area species richness was much higher (range: 17-32 and 17-23 respectively) and inter-lake variation in species richness was much lower compared to the Kenya section (Tables 5, 6 & 7).

Ecological and economic role of zooplankton communities

The ecological role of the zooplankton community in Lake Victoria has been presented and discussed by Mavuti & Litterick (1991). As one of the major primary consumers, zooplankton converts algal production into animal material for use by fish and other organisms further up in the food chain. In Lake Victoria, zooplankton is an important food source for all fish larvae. As a result, the survival of fish larvae and eventual recruitment of fish into the fishery is largely dependent on zooplankton availability. Trophic relationships between zooplankton and fishes have shown the importance of certain taxa as key forage items for commercially valuable fishes such as *R. argentea*, *O. niloticus* and larval *Lates niloticus*. *R. argentea* derives over 70% of its food requirements from copepods (particularly cyclopoid copepods), which constitute the commonest and most abundant group in Lake Victoria (Mwebaza-Ndawula 1998). Fish larvae prefer the small-bodied rotifers, which are abundant around shallow inshore areas of the lake.

Juveniles of the commercially important Nile perch, *Lates niloticus* Linne feed largely on the semi-planktonic freshwater prawn, *Caridina nilotica* (Ogutu-Ohwayo 1990; Ogari & Dadzie 1988). Adult Nile perch is indirectly dependent on zooplankton through feeding on the zooplanktivorous *Rastrineobola argentea* Pellegrin and pelagic haplochromines. Zooplankton also constitutes important forage for carnivorous invertebrates such as *Mesocyclops* spp. (cyclopoid copepod) and *Chaoborus* sp. (midge larva), which are in turn important food for fish (Irvine & Waya 1995). Zooplankton community is therefore a major link in energy flow integrating carnivorous invertebrates and pelagic fishes for production of major commercial fishes such as the Nile perch. Worldwide, zooplankton is known to affect phytoplankton populations through grazing, which in turn influence water quality and fish production. In the tropical Lake Victoria however, Lehman & Branstrator (1994) found no significant impact of zooplankton grazing on algae.

Table 5: Occurrence and distribution of zooplankton species/taxa in small water bodies in the Kenyan portion of the Victoria basin (Source: Mwebaza-Ndawula and others 2004).

	Water body							
Taxa	Uranga dam	Ugege dam	Ulanda dam	Mwer dam	Mauna dam	Ufinya dam	Lake Sare	Lake Kanyaboli
CLADOCERA								
Diaphanosoma excisum	A	P	P	A	P	P	A	A
Daphnia *lumholtzi*	A	A	A	A	A	A	P	P
Chydorus sp.	A	A	A	A	P	A	A	A
Alona karua	A	A	A	A		P	A	A
Macrothrix sp.	A	A	A	A	A	P	A	A
COPEPODA								
Cyclopoida	P	P	P	P	P	P	P	P
Calanoida	A	A	A	A	A	A	P	P
ROTIFERA								
Keratela tropica	P	P	P	P	P	A	P	P
Brachionus angularis	A	A	P	A	A	A	P	P
B. plicatilis	P	A	A	A	A	A	A	A
B. caudatus	P	A	A	A	A	A	A	A
Aneuropsis spp	A	A	A	A	A	A	A	P
Epiphanes spp.	A	A	A	A	A	A	A	P
Asplanchna	P	A	A	A	A	A	A	P
Trichorcerca	P	A	A	A	A	A	A	P
Proales spp.	A	A	A	A	A	A	A	P
Synchaeta sp.	A	A	A	A	A	A	A	P
Polyarthra spp	P	A	A	A	A	A	A	P
Total number of species/taxa	**7**	**3**	**4**	**2**	**4**	**4**	**5**	**14**

Table 6: Occurrence and distribution of zooplankton species/taxa in small water bodies in the southern portion of the Victoria basin,. P = present, A = not encountered, helm = helmeted (Source: Mwebaza-Ndawula and others 2004).

Taxa	Water body							
	Lake Kyaramo	Lake Kubigena	Kirumi Pond	River Mara	Lake Katwe	Lake Ikimba	Lake Malimbe	Lake Burigi
CLADOCERA								
Bosmina longirostris	A	P	A	A	A	P	A	A
Ceriodaphnia cornuta	P	A	P	A	P	A	A	P
Daphnia lumholtzi (helm.)	P	P	P	P	A	A	A	P
Diaphanosoma excisum	P	P	P	P	A	A	A	P
Moina micrura	A	P	P	P	P	A	P	P
Chydoruss sp.	P	A	A	A	P	A	A	A
Alona sp.	A	A	P	A	P	A	A	A
COPEPODA								
Calanoida								
Thermodiaptomus galeboides	P	A	A	A		A	A	A
Cyclopoida								
Thermocyclops emini	P	P	P	P	P	P	P	P
Thermocyclops incisus	P	P	A	A	P	P	A	A
Thermocyclops neglectus	P	P	P	P	P	P	P	P
Tropocyclops confinnis	A	A	A	P	P	P	P	P
Tropocyclops tenellus	P	A	P	P	P	P	P	P
ROTIFERA								
Ascomorpha sp.	A	A	P	P	P	P	A	P
Asplanchna spp.	P	P	P	P	P	P	P	A
Brachionus angularis	P	P	P	P	P	P	P	P
Brachionus calyciflorus	P	A	P	P	P	A	P	P
Brachionus caudatus	A	P	P	P	A	P	P	P
Brachionus falcatus	P	A	A	P	A	A	A	A
B. patulus	A	A	A	P	P	A	A	A
Kellicotia sp.	A	A	A	A	A	P	A	A
Euclanis sp	A	P	A	P	A	A	P	A
Filinia longiseta	A	A	A	A	A	A	P	A
Filinia opoliensis	P	P	A	P	P	A	P	P
Keratella cochlearis	P	P	P	A	P	P	P	P
Keratella tropica	P	P	P	P	P	P	A	P
Keratella quadrata	A	A	A	A	P	P	A	P
Lecane spp	P	P	A	P	P	P	P	P
Polyarthra vulgaris.	A	A	A	A	P	P	A	A
Synchaeta spp.	P	P	P	P	P	P	P	A
Trichocerca cylindrical	A	A	A	A	P	P	P	A
Trichocerca spp.	P	P	A	P	P	A	A	A
Total number of species/taxa	**19**	**17**	**16**	**20**	**23**	**18**	**16**	**17**

Table 7: Occurrence and distribution of zooplankton taxa in small water bodies in the Ugandan portion of the Victoria basin. P = present, A = not encountered. (Source: Mwebaza-Ndawula and others 2004).

Taxa	Water body						
	Lake Kayanja	Lake Kayugi	Lake Nabugabo	Lake Kachera	Lake Mburo	Lake Wamala	Kabaka's lake
CLADOCERA							
Bosmina longirostris	A	A	P	A	A	P	A
Ceriodaphnia cornuta	A	A	P	P	A	P	A
Chydorus spp.	A	A	A	A	A	P	A
Diaphanosoma excisum	A	P	P	A	A	P	P
Moina micrura	P	P	P	P	P	P	P
Macrothrix sp.	P	A	P	A	P	P	P
COPEPODA							
Harpacticoida	A	A	P	A	A	A	A
Cyclopoida							
Eucyclops spp.	A	A	P	P	A	A	A
Mesocyclops spp.	P		P	P	P	P	
Thermocyclops emini	A	A	A	A	P	P	A
T.incisus	P			P		P	P
T.neglectus	P	P	P	P		P	P
T.decipiens	A	A	A	A	A	P	A
T . tenellus	A	A	P	A	A	A	A
ROTIFERA							
Ascomorpha spp.	A	A	A	A	A	P	A
Asplanchna spp.	P	P	P	P	A	P	P
Brachionus angularis	P	P	P	P	P	P	P
B.bidentatus	A	A	P	P	A	P	A
B.budapestinensis	A	A	P	P	P	P	P
B.quadridentatus	A	A	A	A	A	P	A
B.calyciflorus	P	P	P	P	P	P	P
B.falcatus	P	P	P	P	P	P	P
B.patulus	A	A	A	P	A	A	A
Brachionus spp.	A	A	A	A	P	A	A
Euclanis spp.	A	A	A	A	P	P	A
Filinia longiseta	P	P	P	P	P	P	P
F.opoliensis	P	P	P	P	P	P	P
Hexathra spp.	P	P	P	P	P	P	A
Keratella cochlearis	P	P	P	A	A	P	P
K.tropica	P	P	P	P	P	P	P
Lecane bulla	P	P	P	P	P	P	A
Polyarthra spp.	A	P	P		P	P	A
Polyarthra vulgaris.	P	P	P	P	P	P	P
Synchaeta pectinata	A	A	P	P	A	P	P
Synchaeta spp.	P	P	P	P	P	P	P
Trichocerca cylindrical	P	P	P	P	P	P	P
Trichocerca spp.	A	A	P	A	P	P	P
Total number of species	**18**	**17**	**28**	**22**	**20**	**32**	**19**

Macroinvertebrates communities of the Lake Victoria basin

Aquatic macroinvertebrates are macroscopic fauna without a backbone (vertebra), visible to unaided eye, and retained by a standard sieve of mesh size 0.5-0.6 mm (APHA 1985; Reddy & Rao 1991; Wiederholm 1980). The group is distinguished from Meiofauna whose size range is 0.25 to 0.4 mm; and from zooplankton, which are free-floating in open or pelagic waters. Also commonly referred to as Macrofauna and/or Macrobenthos, they include flatworms, roundworms, annelids, molluscs, echinoderms and macrocrustaceans. They are mostly found attached to the substratum under water. Since they are almost always close to, on, or in the bottom substrate, they also are collectively referred to as benthos. Those living close to or in association with water plants are also described as phytofauna. None the less, though macrofauna live at particular environment within a water body (on rock surfaces, in gravel, on sand, on roots, on stems or on leaves; as the case may be), it does not mean that they are restricted to this environment. Most of them migrate from one habitat to another. Their descriptive names are therefore not fixed for any group, but on the basis of where they were located at the time of sampling. For example, *Chaoborus spp* and *Caridina nilotica* Roux undergo diel vertical migration within the water column. Some macroinvertebrates live in both aquatic and terrestrial environments depending on the stage of development in their life history. Lepidoptera (moth), Ephemeroptera (Mayfly), Odonata (dragonfly) and Plecoptera (stonefly) during larval and nymphs stage live in aquatic environment but live on land as adults. Some species have even more complex life cycles. Insect groups for example, Coleoptera (adults and larvae) and Hemiptera (instars and adults) contribute to the diversity in aquatic environments (Muli 2003).

Communities of macro-invertebrates are under threat in many water bodies from environment degradation, especially eutrophication and pollution. These threats may cause alterations in species composition, distribution and abundance patterns and ultimately community structure, which affect their ecological functions. In their different forms of existence, these organisms contribute to the well being of their habitats either as prey or predator. It is therefore important to study the status of aquatic macroinvertebrates as a basis to understanding their ecological values including contribution to fishery production.

Economic importance of aquatic macroinvertebrates in the Lake Victoria basin

Aquatic macroinvertebrates have manifold benefits. The water beetles of the family Curculionidae, *Neochetina Eichorniae* Warner and *Neochetina bruchi* Hustache have been successfully used to control the noxious Water hyacinth (*Eichornia crassipes* (Mart.) Solms.) worldwide. The swamp worm *Alma emini* (Michaelsen) is harvested for fish bait around Lake Victoria (Muli & Mavuti 2001). Some communities in Lake Victoria basin consume Lakeflies (Macdonald 1953). *Caridina nilotica* and mollusc shells are commercially exploited in some parts of Lake Victoria, processed and incorporated into domestic animal feeds.

Benthos are cheaper and better indicators for assessing and monitoring water quality in lakes and rivers. The biotic indices such the Belgian Biotic Index (BBI), Biological Monitoring Working Party-score (BMWP) and Trent Biotic Index (TBI) are some examples of the biological assessment methods in use in Europe (Premazzi & Chiaudani 1992). Because they have long life, are a constant presence, sedentary, comparatively large sized, and they endure external stress, benthos can integrate changes in the habitat over time, which can be used to interpret characteristic changes in the sediment and the water column (Wielderholm 1980; Reddy & Rao 1991).

Though most other species do not have direct economic uses, their contribution to the functioning of the ecosystem cannot be underestimated. A number of mollusc species found in the lake basin are vectors of diseases of man, livestock and wildlife such as Schistosomiasis, Fascioliasis and Paramphistomiasis. Mollusc vectors commonly occurring in Lake Victoria basin include species of the genera *Lymnaea, Bulinus* and *Biomphalaria*. Other benthos that are vectors of human diseases are mosquito larvae (*Anopheles, Aedes* and *Culex* genera) known to transmit Malaria, Yellow fever and Filariasis among others (Muli and others 2000). Ceratopogonidae (biting midges) suck blood and can be a pest locally (Rzóska & Lewis 1976). Lakeflies (again) do not carry disease but can be a nuisance. Leeches and argulids are parasitic on other aquatic organisms, e.g. fish (Mbahinzireki 1977). The mayfly *Povilla adusta* Navás (Ephemeroptera) is a well-known woodborer and its larvae can cause serious damage to wooden structures beneath the waterline (Corbet 1957).

Ecological role of macroinverterbrates in the ecosystem

Macroinvertebrates promote primary production and nutrient recycling. According to Mwebaza-Ndawula (1990), the role of detritus feeding organisms including benthos and *Caridina nilotica* Roux is of particular importance in the regeneration of soluble nutrients from the bottom sediments in Lake Victoria. *Caridina* promotes photosynthetic production of submerged plants through detritus consumption and subsequent exposure of their leaf surfaces to light. Molluscs secrete sulphuric acid in their digestive process and this is an essential nutrient to the water promoting primary productivity (Fish 1956).

Macroinverterbrates play a crucial role in conversion of plant material into animal protein for use by other organisms including various fish species, which depend on invertebrates for food. Gastropods and bivalves, for example, are important prey for the lungfish *Protopterus aethiopicus* (Heckel) (Mosile 1988); chironomid and chaoborid larvae are important in the diet of most demersal (bottom-dwelling) fishes such as the *Ningu* (*Labeo victorianus* (Boulenger) and elephant snout fish, *Mormyrus kannume* (Forsskal). The freshwater prawn, *Caridina nilotica*, Mayfly (Ephemeroptera) and Dragonfly (Odonata) nymphs constitute the food for juvenile Nile perch, *Lates niloticus* (Ogutu-Ohwayo 1984). Macro-invertebrates therefore play an important role in aquatic food chains, bridging between algal primary production and the higher trophic levels. Many phytoplanktivorous insect larvae and molluscs (gastropods and bivalves) form the basis of secondary production in the lake (Macdonald 1956; Corbet 1961; Greenwood 1966; Witte and others 1995a,b).

Diversity and distribution of macroinvertebrates in Lake Victoria basin

The benthic fauna of Lake Victoria is dominated by molluscs (ca. 44%), insect larvae and nymphs (ca. 41%). Oligochaetes, leeches, nematodes, ostracods and other crustaceans are also present though in minor proportions (Figure 6). A total of 66 benthic macroinvertebrate species have been recorded in Lake Victoria (Tables 8a and 8b). These include 28 species of molluscs, 26 species of insects, 5 species of crustaceans and 5 species of oligochaetes. The Kenya portion of Lake Victoria has the highest number of taxa (62) compared to 26 and 22 for the Uganda and Tanzania portions of the lake respectively.

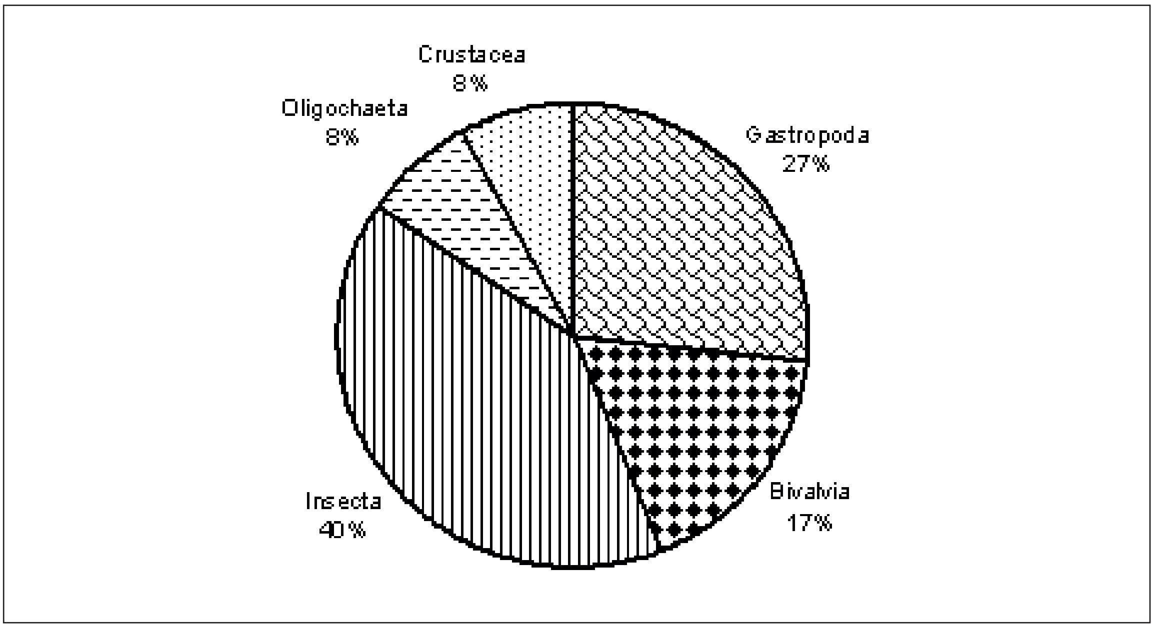

Figure 6: Composition of major benthic macroinvertebrates groups in Lake Victoria (1990-2003).

(Source: Muli and others 2004).

Table 8a: List of benthic mollusca and Annelida taxa recorded in Lake Victoria (P-present). Adapted with modification from Okedi (1990), Mbahinzireki (1994), Muli and Mavuti (2001) and Mwambungu (2003).

(Source: Muli and others 2004).

Taxa	Kenya	Tanzania	Uganda	Taxa	Kenya	Tanzania	Uganda
GASTROPODA				Sphaerium victoriae	P		
Viviparidae				Eupera ferruginea	P	P	
Bellamya unicolor	P	P	P	Mutelidae			
Bellamya constricta		P		Mutela bourguiguati	P	P	P
Pila ovata gordon (Smith)	P	P		Mutela dubia	P		
Pila ovata nyanzae (Smith)	P	P		*Aspatharia* spp.	P	P	
Thiridae				Unionidae			
Melanoides tuberculata	P	P	P	*Cafferia caffra* (Krauss)	P		
Cleopatra guillemei Bourguignat	P	P		Caelatura hauttecouri	P	P	P
Cleopatra bulimoidae		P		Caelatura monceti	P	P	
Bithyniidae				Caelatura alluandi		P	
Gabbiela humerosa (Martens)	P	P	P	Corbiculidae			
Planorbidae				Corbicula fluminalis africana	P	P	P
Biomphalaria spp.	P	P		**OLIGOCHAETA**			P
Biomphalaria choanomphala (Martens)	P	P		Tubificidae			
Bulinus spp. Müller	P			Branchiura sowerbyii	P		
Bulinus globosus (Morelet)	P	P	P	*Limnodrilus* spp. Claparède	P		
Bulinus ugandae				*Tubifex* spp.	P		
Bulinus truncatus trigonus (Martens)	P	P		Haplotaxidae	P	P	
Ancylidae				Lumbriculus variegates		P	
Ferrissia clessiana Jickeli	P			Glossoscoleidae			
Ferrissia kavirondica Mandahl-Barth	P			Alma emini	P	P	
BIVALVIA				**HIRUDINEA**	P	P	P
Sphaeriidae							
Sphaerium nyanzae	P	P					
Sphaerium stuhlmauni	P	P					

Table 8b: List of benthic non-mollusca taxa recorded in Lake Victoria (P-present). Adapted with modification from Okedi (1990), Mbahinzireki (1994), Muli and Mavuti (2001) and Mwambungu (2003). (Source: Muli and others 2004)

Species	Kenya	Tanzania	Uganda	Species	Kenya	Tanzania	Uganda
INSECTA				Baetidae			
HEMIPTERA				*Baetis* spp. Leach	P	P	P
Corixidae		P	P	ODONATA			
Micronecta spp. Leach	P			Libellulidae	P	P	P
Stenocorixa spp.	P			*Pantala* spp.	P		
Sigara spp.	P	P		*Somatochlora* spp. Selys	P		
Notonectidae		P	P	Macromiidae			
Anisops spp.	P			*Macromia* spp. Rambur	P		
Plea spp.	P			*Didymops* spp. Rambur	P		
Notonecta spp.	P			Gomphidae		P	P
Belostomatidae				*Aphylla* spp.	P		
Lethocerus niloticus	P			TRICHOPTERA			P
Hydrocyrius spp.	P			Polycentropodidae	P	P	
DIPTERA				Leptoceridae	P		
Chaoborus spp.	P	P	P	Pschomyiidae	P		

Chironomus formasipennis	P	P		CRUSTACEA			
Chironomidae	P	P	P	Potamonidae	P		
Tanyodinae	P	P	P	Potamonautes spp.	P		
Heleidae	P			Atyidae	P		
Procladius brevipetiolatus	P			*Caridina nilotica* Roux	P	P	P
Tanypus gullatipennis	P			Chydoridae	P		
EPHEMEROPTERA				*Chydorus* spp. Leach	P		
Polymitarcidae				Ostracoda	P		P
Povilla adusta	P	P	P	Conchostraca			P
Caenidae							
Caenis spp. Stephens	P	P	P				

Molluscs are globally distributed in most major habitats of lake. For example, the group constituted 50 – 94 % in abundance of macroinvertebrates at the Mara, Yala, and Sondu river mouths; and in Mwanza gulf, Speke gulf, Asembo bay, and Kisumu bay. Gastropoda of the families Viviparidae and Planorbidae, and particularly the two species: *Melanoides tuberculata* (Müller) and *Bellamya unicolor* (Olivier) are the most represented and abundant of the molluscs. These two gastropods are widely distributed over the major habitats of the lake. For example, the densities of *M. tuberculata* are highest in the Winam gulf and the mouth of River Yala compared to the open waters. On the other hand, *Bellamya unicolor* is most abundant at the Mara mouth, in Speke gulf and Mwanza gulf. Though rare, the ancylids *Ferrissia clessiniana* (Jickeli) and *Ferrissia kavirondica* Mandahl-Barth, are found in appreciable quantities in the Winam gulf between the Yacht Club and Dunga (Brown 1994; Muli & Mavuti 2001). The Schistosomiasis vectors: *Bulinus globosus* (Morelet), *Bulinus ugandae* and *Biomphalaria choanomphala* (Martens) are also rare.

The most speciose Bivalvia families in the lake are Sphaeriidae, Mutelidae and Unionidae (Table 8a). In Kenya waters, Bivalvia is dominated in abundance by three species, *Caelatura hauttecouri, Mutela* spp., *Corbicula fluminalis africana* and *Sphaerium nyanzae* Smith in that order of increasing dominance in both the Winam gulf and main lake. Oligochaetes are ubiquitous in occurrence in most habitats of the lake where in most cases their abundance is less than 6% of the total benthic abundance. In some areas such as Entebbe and Namirembe bays the abundance is slightly elevated ranging between 13 and 28 %. Areas near the mouths of rivers Kasat, Kibos and Nzoia and in open deep waters (ca. 40 m), off the Nyanza Gulf had very high densities of this group dominated by tubificids *Limnodrilus* spp. Claparède, *Tubifex* spp. *Branchiura sowerbyii* Beddard and *Alma emini* (Michaelsen).

Insecta consists mainly of hemipterans and dipterans. Other major taxa in order of decreasing species richness were Odonata, Ephemeroptera and Trichoptera. Insects tend to dominate (> 75%) in abundance in areas where mollusks and oligochaetes are scarce such as northern Lake Victoria in Uganda and the Kagera region in Tanzania. The abundant species are the larvae and nymph of aquatic insects belonging to the families Chironomidae and Orders Ephemeroptera, Odonata and Trichoptera. The dominant species are *Chaoborus* spp. Lichtenstein, *Chironomus formasipennis, Procladius brevipetiolatus, Tanypus gullatipennis* (Chironomidae), *Povilla adusta* Navás (Ephemeroptera) and *Libellula* spp. Linné (Odonata). The other insect species are very rare. The swimming insects include hemipteran imagoes and nymphs of *Micronecta* spp., *Sigara* spp. Fabricius (Corixidae), *Anisops* spp. (Notonectidae) and *Lethocerus niloticus* (Belostomatidae). Larvae of Chironomidae and Chaoboridae are represented in all major habitats of the lake. They are the most abundant benthic fauna in northern Lake Victoria, Uganda (Mbahinzireki 1994) and in Kagera region in Tanzania. The other orders are confined to particular habitats of the lake. For example, ephemeropterans are confined to mouths of Rivers Sondu/Miriu and Yala. Larvae and pupae of Trichoptera are confined in Winam gulf and Namirembe bay.

Caridina nilotica Roux is widely distributed in the lake and constitutes a major by-catch in *Rastrineobola argentea* (Pellegrin) fishery. Ostracods are common in northern Lake Victoria (Uganda) but are rare in Kenyan waters. They have not been reported in Tanzania waters. Crabs (*Potamonautes* spp.) are also rare though frequently encountered in gillnet fish catches from rocky shores all round the lake. For example, they occur in fishing grounds around Lwanda Gembe in Suba district.

Pelagic macroinvertebrates of Lake Victoria

The common macroinvertebrates in the water column of Lake Victoria are the fresh water prawn *Caridina nilotica* Roux, larval and pupae stages of chaoborids, chironomids and corixids and water mites (Mavuti & Litterick 1991). These macrofauna are not restricted to the water column, but do migrate to different regions within lake. They occur in both littoral and pelagic regions as well as the profundal.

Benthos of satellite lakes and dams in the catchment of Lake Victoria

Satellite lakes of Lake Victoria are considered important because they are natural museums of Lake Victoria. Lakes Kanyaboli, Sare and Namboyo have been described as the "Lake Victoria of the 1950s"; because some endemic fish species, which are known to have disappeared from Lake Victoria, occur abundantly in these lakes. These lakes have in fact been proposed as national parks to preserve their rich biota (Muli 1998). A number of studies have been documented benthos on these lakes, e.g., Abila (1995) on Lake Kanyaboli; Muli (2001) on Lakes Sare, Kanyaboli and Simbi and in various dams such as: Mauna, Migowa, Ugege, Uranga, Kaleny juok, Mwer, Ulanda, Oyombe, Migowa, Kosiga, Kwambai (Ratanga), Gogo falls, Stella, Kokech and Kobodo; and Mwambungu (2003) on Lakes Katwe, Kirumi, Buringi, Ikimba, Kyarano dam and Mara River. Lakes Mburo, Nabugabo, Kayanja and Kayugi in Uganda, have been studied more extensively since mid 1960's compared to other satellite lakes. Reports by Corbet (1961) and Greenwood (1966) provide valuable information on fish-macro-invertebrate trophic relationships and therefore their contribution to fishery production in Lake Victoria and other water bodies in the basin. Other studied satellite lakes include Wamala, Lemwa, Kawi, Gigati, Nyaguo, Agu, Bisina, Kachera, Kyoga, Nawampasa and Nakuwa.

The species composition of benthos in satellite lakes and dams is not different from that of Lake Victoria. However, the satellite lakes are characterized by very low species richness and abundance of benthos compared to the Lake Victoria. Differences in the substratum could account for differences in diversity. Lake Victoria has an heterogeneous substratum while satellite lakes and dams have a comparatively homogenous substrata (Muli 2001). Besides this, and especially so in Lake Simbi, high water salinity is also responsible for the low species richness (Brown 1994) as does high predation in other SWBs. This low benthic species richness and abundance implies that the amount of food available to fish is low. It is therefore likely that fish production in these SWBs is relatively low.

Fish Communities of the Lake Victoria basin

Before the introduction and the subsequent establishment of the Nile perch and the Nile tilapia, Lake Victoria had a multi-species fishery dominated by haplochromine cichlids (Kudhongania and Cordone 1974). The lake had a variety of habitats that harboured different fish species adapted to life in those specific habitats. Close to 70 non-haplochromines and over 200 haplochromines had been identified and described from the basin (Greenwood 1966; Greenwood 1981). Through predation, environmental degradation and possibly competition for space, many of these species have been displaced from the lake. It is estimated that over 60% of the haplochromine species have greatly diminished in numbers or been completely eliminated. This loss of diversity has ecological repercussions to the whole lake ecosystem. The food web structure has changed with a number of food resources either not used or are underutilized leading to ecological wastage. Other factors thought to be responsible for ecological changes are the lake morphometry and hydrology. Occasional violent storms for example may cause abrupt mixing of the water column leading to massive fish kills (Ochumba 1990). Although many native non-haplochromine fish species have had their numbers diminished in the main lake, none is extinct from the basin. Likewise, new haplochromine species are being identified from areas that were previously not been exhaustively explored, e.g., the rocky habitats and marginal vegetative areas, probably providing refugia to these species.

Fish Species Diversity

Historical Trends in Fish species Diversity

Before the introduction of Nile Perch and the exotic cichlids in the 1950's, Lake Victoria beamed with a diverse fish population whose main components were: tilapiines, *Oreochromis esculentus* (Graham 1929) and *Oreochromis variabilis* (Boulenger 1906); the lungfish *Protopterus aethiopicus* (Herkell 1851); catfish, *Bagrus docmak* (Forskal 1775) and *Clarias gariepinus* (Burchell 1822); and the cyprinid, *Labeo victorianus* (Boulenger 1901). Haplochromines were the most abundant group constituting about 80% of the demersal fish biomass (Kudhongania & Cordone 1974). There were over 300 haplochromine species, majority of them (more than 99%) endemic to the lake (van Oijen and others 1981; Witte and others 1992). This group occupied all trophic levels and played an important role in the flow of organic matter in the ecosystem. Up to 11 trophic groups of haplochromine cichlids were identified from Mwanza Gulf alone (Witte & van Oijen 1990).

The Lake Victoria fish stocks and the fisheries have undergone remarkable changes over the past 20 years. Signs of overfishing were reported as early as 1970 when catch rates of tilapia dropped from 100 fish per 50m long net (127 mm stretched mesh) to less than 5 fish (Ssentongo 1972). As the stocks of Nile perch increased, the diversity of haplochromines decreased rapidly. The contribution of haplochromines to fish biomass in the lake decreased from 80% to less than 1% within a decade of the 1970s and 1980s (Kudhongania & Cordone 1974; Okaronon and others 1985). Following these drastic shifts in species composition and stocks depletion (Othina & Odera 1996), a number of management measures have been instituted on the lake. Notably among these measures are: the ban on the use beach seine nets and under-sized mesh nets (<127 mm stretched mesh) of 1994, the ban on trawlers in 1996, and the introduction of slot size of 50 – 84 cmTL for Nile perch (of 2002).

Various reasons have been advanced for the loss of fish species in Lake Victoria. Haplochromines, for example, were decimated by the introduced perch, overfishing, and environmental changes (Acere 1988; Ogutu-Ohwayo 1988). The native tilapiines i.e. *Oreochromis esculentus* and *O. variabilis* were displaced through inter-specific species competition for food, space, and mates by the introduced superior breeds of *O. niloticus, Tilapia zillii* (Gervais 1848) *T. rendallii* (Boulenger 1896) and *O. leucostictus* (Trewavas 1933) (Balirwa 1990). Deforestation as a result of fuelwood collection to process Nile perch increased sediment run-off into the lake, which also increased nutrient levels. The nutrients have induced eutrophication and led to proliferation of water hyacinth. The decomposition of the algae and water hyacinth results into depletion of dissolved oxygen thus making much of the water column uninhabitable by cichlid and other aqualife. Eutrophication has also disturbed traditional mating systems, which has also contributed to the decline of cichlid species (Goudswaard & Witte 1985). Extensive cover of the inshore waters with water hyacinth and other macrophytes protected the settling off sediments and decaying plant material from currents wash off, thus encroaching on the nesting grounds for the cichlids.

Current status of Fish Diversity in Lake Victoria basin

Recent surveys have shown some resurgence of species, which were thought to have disappeared. Apart from *Lates niloticus, Oreochromis niloticus* and *Rastrineobola argentea*, which for some time constituted the entire fishery on Lake Victoria, more other species, notably: *Labeo victorianus*, *Schilbe intermedius, Clarias gariepinus, Synodontis victoriae, S. afrofischeri* and a number of *Haplochromines* (Nsinda & Mrosso 1999; Chande & Mhitu 2003) have lately been recovered in appreciable quantities, though in localised catches. The main occupants in satellite lakes are *O. esculentus, O. niloticus, Protopterus aethiopicus* and *C. gariepinus*, while the diversity in the rivers is dominated by *S. intermedius, Lake Victorianus, Synodontis* spp. and *Brycinus* spp. These riverine stocks were highly impacted by pollution, habitat destruction, and over fishing at the river mouths. Included among the important environmental factors that contributed to species losses were: competition for food, space and mate; food availability; habitat choice; predation; parasitism; and symbiosis.

Competition affects fish species diversity through niche overlaps where several species exploit a common guild. This type of competition is readily recognised among the tilapiines and is responsible for the disappearance of the endemic stocks as *O. niloticus* got established in the lake. The rise in lake levels too, flooded the nesting areas of *O. esculentus* compromising the competitive ability of this population in the lake (Welcomme 1967). Nevertheless, the introduced *O. niloticus* was more robust and superior and therefore readily out competed the rest. *O. niloticus* was originally an herbivore but shifted its food interests to grazing on zooplanktons, and eventually, ended up eating fish larvae (Balirwa 1990; Njiru 2002). The species is presently the dominant tilapiine on the lake.

The young of Nile perch and adult *Rastrineobola argentea* feed on zooplankton resources of the lake. The share the pelagic zone where they graze on the free-swimming zooplankton. *Barbus altianalis*, which mainly feed on gastropod molluscs, has been pushed out of the Nyanza Gulf into the Nyando River where it is restricted to the upper reaches.

Fish Habitat Diversity

Vegetated littoral habitats

Littoral areas of the lake are defined as areas with waters less than 6 metres deep (Witte & van Densen 1995). Shallow inshore habitats with fringing macrophytes are known to provide important refugia to stocks of the native species in lakes Victoria and Kyoga. These areas have higher abundance and greater species richness than the open waters (Brazner 1997). Aquatic vegetation supports numerous epiphytic organisms that comprise food for young tilapia and other herbivorous fish species (Welcomme 1964) making these environment important nursery areas. Papyrus (*Cyperus papyrus)* swamps fringing most of the shores of Lake Victoria provide a special refuge against predation by Nile perch. In Lake Victoria *Oreochromis variabilis* still occurs in inshore habitats with fringing papyrus reeds, *Cyperus papyrus.* Nile perch is sensitive to low-oxygen which delimit their distribution and interaction in these hypoxic habitats (Fish 1956).

Some of the cichlids in Lake Victoria can tolerate extreme low oxygen levels, which permit them to use the structural inshore habitats as refugia. In lakes Nabugabo and Nakuwa where Nile perch was also introduced, most of the haplochromine cichlids live among submerged macrophytes especially water lilies where they are protected from predation by Nile perch. Lake Nawampasa is separated from L. Kyoga by dense macrophytes, which have provided a barrier to Nile perch from this lake. These habitats are however under threat from invasive weeds and drainage of surrounding wetlands for agriculture. Weed mats destroy rooted and floating macrophytes leading to destruction of breeding and nursery grounds. Hyacinth mats also cause localised deoxygenation that has resulted in periodic fish kills. Decaying sunken water hyacinth releases poisonous gases like ammonia and hydrogen sulphide. Drainage and clearance of marginal wetlands for agriculture also destroys these breeding and nursery grounds.

Rocky habitats

Rocky shores and islands are currently the most important refugia for indigenous fishes in lake Victoria. They harbour the highest densities and diversity of the cichlids. These habitats are a dominant feature of the shallow waters in the lake. Their complex spatial structure provides a large number of ecological niches and allows complex food webs to thrive. They also provide protection against predation, for example in Mwanza Gulf the rock-dwelling fish species are reportedly the least affected by Nile perch predation (Witte and others 1992a,b). A number of species critically low in numbers or originally believed to be eliminated from Lake Victoria have been recovered from these habitats. Some examples are: *Paralabidochromis victoriae*, *Xystichromis phytophagus* and *Pyxichromis para-orthostoma* among other haplochromines; and *Oreochromis variabilis* and *Labeo victorianus*.

A completely new group of haplochromines, the rock dwelling Mbipi species have been identified and also many species described (Seehausen 1996; Seehausen and others 1998). More than 170 haplochromine species have been recorded from rocky substrates in the southeastern region of Lake Victoria (Seehausen 1996), while 180 have been recorded from rocky habitats in the northern portion. Some non-cichlids also rely on these habitats. Recent research findings have shown that *Lates niloticus* is a frequent member of the rock-dwelling fish communities. While the juveniles of perch may live together with other rock dwelling fishes, the adults are often found hovering near these rocky habitats in search of prey.

Pelagic habitat

Due to reduced oxygen concentrations down the water column during periods of stratification, some fish species, better able to withstand the low oxygen levels close to the oxycline than the predator, use this zone as refuge from the predator. Such fish species commonly referred to as “the small pelagics”, include *Rastrineobola argentea*, and the zooplanktivorous haplochromines *Yssichromis laparogramma* and *Y. fusiformis*. Also in the pelagic zone may be found juveniles of the Nile tilapia *Oreochromis esculentus* and the Nile perch *Lates niloticus*. Recent trends in the population of pelagic fishes indicate an overall increase in their stocks lake-wide. Populations of *R. argentea* are believed to have increased tenfold between 1970 and 1990 (Ogutu-Ohwayo 1990; Seehausen and others 1997). Of late, catches of zooplanktivorous haplochromines are matching that of *R. argentea*. The fish species composition listed by locality are presented in Tables 9a – 9d).

Satellite Lakes

Satellite lakes and dams have played an important role in conserving endangered fish species of the Lake Victoria region. They have been referred to as “living museums” of East African ecological history (Mwanja and others 2001). The structural heterogeneity of macrophytes surrounding these lakes has made it difficult to access by fishers and to apply certain fishing methods. This has kept much of the biodiversity intact. Many fish species especially the haplochromines considered to have been eliminated from or whose numbers are dangerously low in the main Lake Victoria are still found in these satellite lakes.

The predatory Nile perch has failed to gain access to many of these lakes. Because of the physical and chemical conditions in some of the lakes, the predator could not survive even when directly introduced by man. Due to the dense underwater macrophytes cover for example in Lake Nawampasa (a lake satellite to Lake Kyoga), oxygen concentrations are too low to support the Nile perch at night although the water is supersaturated with oxygen during the day. Fish communities of most of the satellite lakes are composed of fishes native to Lake Victoria. Among the tilapiines, significant populations of the two native species: *O. variabilis* and *O. esculentus* remain in satellite lakes though completely displaced from the main lake. *O. esculentus* has disappeared from lakes Victoria and Kyoga, but has survived both as native and introduced populations in satellite lakes within the Victoria and Kyoga basins.

Table 9a: Main Satellite Lakes of the Lake Victoria basin and their species of biodiversity importance. (Source: Wandera and others 2004).

Country	Drainage System	Lake	Species of Biodiversity importance
Kenya	Yala System	Kanyaboli	*Oreochromis esculentus* and haplochromines
		Sare	*O. esculentus*, Haplochromines
		Namboyo	*O. esculentus*, Haplochromines
		Mauna Dam	*Oreochromis variabilis*
Tanzania	Mara System	Kubigena	*O. leucostictus, Clarias garepinus, Protopterus*
		Kirumi	Haplochromines, *O. esculentus, O. niloticus, O. variabilis*
	Dam	Kyarano	*Labeo victorianus, O. niloticus*
	Kagera System	Katwe	*O. niloticus, Clarias gariepinus, O. leucostictus*
		Kalenge	Haplochromines, *O. esculentus*
		Rushwa	O. esculentus, haplochromines
		Mitoma	*O. esculentus, Haplochromis*
		Lwakajunju	*O. niloticus, Clarias,* Haplochromines
		Ngoma	*O. niloticus, O. esculentus, O. variabilis,* Haplochromines
	Other systems	Burigi	*O. esculentus, O. niloticus, O. variabilis*
		Ikimba	*O. esculentus, O. niloticus*
Uganda	Koki Lakes	Nakivali	O. esculentus
		Mburo	*O. esculentus*
		Kachera	*O. esculentus*
		Kijanebalola	*O. esculentus*
	Nabugabo System	Nabugabo	*Schilbe intermedius, mormyrids, haplochromines*
		Manywa	*O. esculentus*, haplochromines
		Kayugi	*O. esculentus*, haplochromines
		Kayanja	*O. esculentus*, haplochromines
	Kyoga system	Nawampasa	*O. variabilis, O. esculentus* Haplochromines
		Nakuwa	*Schilbe intermedius & Synodontis victoriae*
		Gigati	*O variabilis*, Haplochromines
		Lemwa	*O. esculentus,* haplochromines
		Kawi	*O. esculentus, O. variabilis,* Haplochromines
		Nyaguo	*O. esculentus*, Haplochromines, *Mormyrus macrocephala*
		Agu	Haplochromines
		Bisina	Haplochromines O. variabilis
		Opeta	*O. variabilis,* Haplochromines

Table 9b: Native non- cichlid fish species in Lake Victoria, Kenya (Source: Wandera and others 2004).

	Sampling station																				
TAXA	Nyando R. mouth	Miriu R. mouth	Awach R. mouth	Gingra rock	Oluch river mouth	Gull shoal	Mbita East	Homa Bay	Kibos R. mouth	17A	Asembo Bay	Maboko Island	Ndere Island	Kopiata	36A	Sikri point	M. Mbili	Kuja	Sio River mouth	Nzoia R. mouth	Yala R. mouth
CLARIIDAE																					
Clarias gariepinus			P		P			P		P	P	P		P	P	P	P				
PROPTERIDAE																					
Protopterus aethiopicus							P	P		P		P	P								
CYPRINIDAE																					
Barbus profundus		P																		P	
Barbus kersteni		P																		P	
Barbus trispilopleura			P					P													
Barbus jacksonii			P					P													
Barbus altianalis					P			P													
Barbus neumayeri					P											P					
Barbus apleurogramma					P															P	
Barbus cercops			P	P	P		P													P	
CHARACIDAE																					
Brycinus sadleri	P	P		P	P			P			P	P	P			P					
B. jacksonii	P	P									P	P									
MORMYRIDAE																					
Mormyrus kannume			P																	P	
Gnathonemus longibarbis			P																	P	
Marcusenius victoriae			P																	P	
BAGRIDAE																					
Bagrus docmac						P															
MASTACEMBELIDAE																					
Afromastacembelus frenatus																	P				

Table 9c: Native non- cichlid fishes in the Tanzanian waters of Lake Victoria (Source: Wandera and others 2004)

Species name	Bulamba	Ramadi	Magu Bay	Bunda hills	Mara Bay	Mori Bay	Bauman Gulf	Luchiri	Chatu Bay	Namirembe	Lubafu Bay	Mwanza Gulf
Clarias gariepinus	P	P	P		P	P	P		P	P		P
Labeo victorianus	P	P									P	P
Proptopterus aethiopicus	P					P	P	P				P
Schilbe intermedius	P	P	P	P		P		P				P
Synodontis afrofischeri								P	P		P	P
Synodontis victoriae									P			P
Brycinus jacksonii												P
Brycinus sadleri	P		P	P	P	P				P		P
Caecomastacembelus frenatus										P		
Mormyrus kannume			P									
Marcusenius victoriae			P									

Table 9d: Native non cichlid fishes recorded from Lake Victoria (Uganda), and Lake Kyoga (Source: Wandera and others 2004).

	Koki lakes		Nabugabo lakes			Kyoga lakes				Lake Victoria		
Fish species	Kachera	Mburo	Kayugi	Kayanja	Nabugabo	Nawampasa	Nakuwa	Bisina	Kyoga	Napoleon	Thruston	Hannington
Afromastacembelus frenatus	-	-	-	-	-	P	-	-	P	P	P	P
Barbus altianalis	-	-	-	-	-	-	-	-	P	-	-	-
Bagrus docmak	-	-	-	-	-	-	-	P	-	-	-	-
Brycinus jacksonii	-	-	-	-	-	-	-	-	-	P	P	P
Barbus kerstenii	-	-	P	P	P	-	-	-	-	-	-	-
Brycinus sadleri	-	-	-	-	P	P	-	P	P	P	P	P
Barbus trispidopluera	-	-	-	-	-	P	-	P	-	-	-	-
Clarias alluaudi	-	-	-	P	-	P	-	P	-	P	P	-
Clarias carsonii	-	-	P	-	-	P	-	-	-	P	-	-
Clarias gariepinus	P	P	-	P	-	P	P	P	P	P	-	-
Clarias liocephalus	P	P	-	-	-	-	-	-	-	-	-	-
Gnathonemus victoriae	-	-	P	P	-	-	P	P	-	-	-	-
Mercusenius grahami	-	-	-	-	-	-	-	-	P	-	-	-
Mormyrus kannume	-	-	-	-	-	-	-	-	-	P	P	-
Mormyrus macrocephalus	-	-	-	-	-	-	P	-	P	-	-	-
Mercusenius macrolepidotus	-	-	-	-	-	-	P	-	P	-	-	-
Protopterus aethiopicus	P	P	-	P	P	P	P	P	P	P	P	P
Petrocephalus catostoma	-	-	P	P	-	-	-	P	-	-	-	-
Synodontis afrofischeri	-	-	-	-	P	P	P	P	P	P	P	-
Schilbe intermedius	-	-	-	-	P	-	P	P	P	-	-	-
Synodontis victorianus	-	-	-	-	-	P	P	P	P	P	P	-

Streams, Rivers and River mouths

Streams and rivers affluent to Lake Victoria contribute about 20% of the water into the lake (NEJLV 2002). Because they flow through farmlands, towns and cities, they transport much of the common pollutants produced from these areas of human activities, loading the lake with heavy metals, agricultural chemicals and silt. They therefore influence physico-chemical characteristics of the lake. At the points of entry into the lake (river mouths) they present a water environment different from the rest of the lake. The river mouths therefore constitute a different habitat type with its constituent assembly of fish species.

Rivers act as breeding grounds for anadromous fish species. Long macrophytes that cover banks of the rivers and streams also avail refuge to many species against their predators. Thus rivers and streams have continued to contain fish species that are otherwise in danger of extinction in the main lake. Drainage into Lake Victoria can be grouped into the Eastern and Western drainage systems. There is no major river system save for the numerous seasonal streams draining into the lake from the southern portion while the Northern section has the outlet through the River Nile. The western drainage forming the largest watershed drains the mountains of Rwanda and Burundi through River Kagera. River Katonga and Rwizi/Kibali in Uganda also constitute part of this system. The Eastern system has rivers originating from the Kenyan highlands. Surveys have shown these rivers and their associated streams as containing a number of native fish species that are of conservation value in the main lake.

Waterfowls of the Lake Victoria basin

Lake Victoria basin is endowed with a variety of wetlands ranging from permanent swamps to highly seasonal (some, very temporal) swamps around open water bodies and along rivers. As transition ecosystems between land and water, wetlands are characterized by high diversity of flora and fauna including waterfowls. Throughout the world, birds are a dominant, conspicuous and diverse component in wetland ecosystems. Out of 1,060 species of birds found in Kenya, 255 (44 families) are reportedly associated with water and aquatic vegetation. Thus the wetlands support approximately 25 % of Kenya's avifauna (Gichuki & Gichuki 1992). A total of 170 bird species have been recorded in association with water and wetlands vegetation within the Lake Victoria basin. In Uganda, Omoding and others (1996) reported 159 bird species in 38 families from 82 wetlands. This number is highest (1113 species) on the Tanzania side. This diversity of water birds reflects the fundamental importance, productivity and wider ecological influence of waters in all biomes (Ormerod & Tyler 1993).

Importance of Water Fowl in the Lake Victoria basin

On a global scale, birds are probably better researched and monitored than any other group of animals or plants, and are thus well placed to indicate the overall health of our environment (Furness and others 1993; Greenwood and others 1995). Status of birds can warn habitat loss and modification and can indicate the likely environmental changes on other organisms. The Marabou storks, Leptoptilos *crumeniferus* were generally confined to the national parks and fish landing sites in the past, but lately, they are common even in major towns. The Yellow-billed Oxpecker *Buphagus africanus* and Red-billed Oxpecker *Buphagus erythrorhyncus* are hardly seen on livestock though are common and quite abundant on wildlife in national parks. The Marabou is attracted to the towns by the refuse indicating poor refuse management in towns while Oxypecker was probably thrown out of business by the acaricides. Birds have thus gained important use as 'flagship' species in conservation efforts.

In the fresh water ecosystems, waterfowls are some of the top predators. An important characteristic of birds is their high mobility (Seys and others 1995). The abundance and distribution of birds usually reflects the status of the lower trophic levels and thus giving an indication of the associated biodiversity. For example, fishers use gulls and terns behaviour to locate productive fishing sites (Seys and others 1995). Lesser flamingos respond to unfavourable food conditions related to changes in availability of water and its chemistry by moving from one saline lake to another thereby acting as biological indicators of environmental change (Gichuki & Gichuki 1992). Birds are also important biological elements of the Lake Victoria ecosystem, by returning nutrients through deposition of their *guano*, a nutrient rich form of urea into the herbivorous food chain and are an important food source for other higher vertebrates.

The list of avifauna in the Lake Victoria basin is presented in Table 10, and the conservation status in Table 11.

Table 10: Species Composition birds sited in the Lake basin. (Source: Boera and others 2004).

		Wetlands of Lake Victoria basin	
Common names	**Species**	**TANZANIA**	**KENYA**
Reed cormorant	*Pharacrocorax africanus*		+
Long tailed cormorant	*Pharacrocorax africanus*		+
White breasted cormorant	*Pharacrocorax carbo*		+
African Darter	*Anhinga melanogaster*		+
Little egret	*Egretta garzetta*	+	+
Great-white egret	*Egretta alba*	+	+
Yellow-billed egret	*Egretta intermedia*	+	+
Cattle egret	*Bubulcus ibis*	+	+
Squacco heron	*Ardea ralloides*	+	+
Goliath heron	*Ardea goliath*		+
Grey heron	*Ardea cinerea*	+	+
Black-headed heron	*Ardea melanocephala*	+	+
White stock	*Ciconia ciconia*		
Abdim's Stork	*Ciconia abdimii*		+
Marabou	*Leptoptilos crumineferus*		
Hamerkop	*Scopus umbretta*		+
Yellow-billed stork	*Mycteria ibis*	+	+
African open-billed stork	*Anastomus lamelligerus*	+	+
Saddle-billed stork	*Ephippiorhynchus senegalensis*		
Hadada ibis	*Bostrychia hagedash*	+	+
Sacred ibis	*Threskiornis aethiopica*	+	+
Glossy ibis	*Plegadis falcinellus*	+	+
African spoonbill	*Platalea alba*	+	+
Egyptian goose	*Alopochen aegypticus*		+
Spur-winged goose	*Plectropterus gambensis*		+
Fulvous tailed whistling ducks	*Dendrocygna bicolour*		+
White-faced whistling duck	*Dendocyna viduata*	+	+
African fish-eagle	*Haliaeetus vocifer*	+	+
African marsh-harrier	*Circus ranivorus*	+	+
Black kite	*Milvus migrans*	+	+
Augur buzzard	*Buteo auguralis*	+	
Black-crake	*Amaurornis flavirostris*	+	+
Common moorhen	*Gallinula chloropus*	+	+
Purple gallinule	*Porphyrio porphyrio*	+	+
Crested crane			+
Grey-crowned crane	*Balearica regulorum*	+	
African Jacana	*Actophilornis Africana*	+	+
Common stilt	*Himantopus himantopus*	+	+
Common pratincole	*Glareola pratincola*	+	+
Ringed plover	*Charadrius hiaticula*	+	+
African wattled lapwing	*Vanellus senegallus*	+	
Long-toed lapwing	*Vanellus crassirostris*	+	

		Wetlands of Lake Victoria basin	
Common names	**Species**	**TANZANIA**	**KENYA**
Spur-winged lapwing	*Vanellus spinosus*	+	
Crowned plover	*Vanellus coronatus*	+	
Little stint	*Caladris minuta*	+	+
Pectoral sandpiper	*Caladris melanotos*	+	
Ruff	*Philomachus pugnax*	+	
Redshank	*Tringa tetanus*	+M	
Green shank	*Tringa nebularia*	+M	+
Wood sandpiper	*Tringa glareola*	+M	+
Common sandpiper	*Actitis hypoleucos*	+M	+
Grey-headed gull	*Larus ridibundus*	+M	+
Herring gull	*Larus argentatus*	+M	+
Hemprich gull	*Gelochelidon nilotica*		+
White winged black terns	*Chlidonias leucopterus*		+
Little tern	*Sterna albifrons*		+
Gull-billed tern	*Gelochelidon nilotica*	+M	+
Namaqua dove	*Oena capensis*	+R	+
African mourning dove	*Streptopelia decipiens*	+R	+
Fischer's lovebird	*Agopornis fischeri*	+R	
Speckled mousebird	*Colius striatus*	+R	+
Grey-headed kingfisher	*Halcyon leucocephala*	+R	
Malachite kingfisher	*Corythornis cristata*	+R	+
Pied kingfisher	*Ceryle rudis*	+R	+
Larks		+R	
Common bulbul	*Pycnonotus barbatus*	+R	+
Cistocals		+R	+
Sunbirds		+R	+
Long-tailed fiscal	*Lanius cabanisi*	+R	+
White-helmet shrike	*Prionops plumata*	+R	+
Pied crow	*Corvus splendens*	+R	+
African drongo	*Dicrurus adsimilis*	+R	+
Superb starling	*Spreo superbus*	+R	
Wattled starling	*Creatophora cinerea*	+R	
Ashy starling	*Cosmopsarus unicolor*	+R	
House sparrow	*Passer domesticus*	+R	+
Chestnut sparrow	*Passer eminibey*	+R	
Black-headed weaver	*Ploceus cucullatus*	+R	+
Viellot's black weaver	*Ploceus nigerrimus*		+
Yellow-backed weaver	*Ploceus melanocephalus*	+R	+
Golden backed weaver	*Ploceus jacksonii*	+R	+
Northern masked weaver	*Ploceus taeniopterus*	+R	
Little weaver	*Ploceus luteolus*	+R	
Cardinal quelea	*Quelea cardinalis*	+R	
Red-billed quelea	*Quelea quelea*	+R	
Zanzibar red bishop	*Ueplectes nigroventris*	+R	
Black-winged red bishop	*Euplectes afer*	+R	
Blue cheeked cordon-bleu	*Uraeginthis angolensis*	+R	

		Wetlands of Lake Victoria basin	
Common names	**Species**	**TANZANIA**	**KENYA**
Common waxbill	*Estrida astrid*	+R	
Pin-tailed whyadah	*Vidua macrroura*	+R	+
Bronze Mannikin	*Lonchura fringilloides*	+R	

Key to abbreviations: R = Resident; M = Migratory

Table 11: The Conservation status of wetland birds of the various wetlands in Kenya and of Mwanza Gulf Tanzania (Source: Boera and others 2004).

				TANZANIA	KENYA
Common names	Species	Habitat	Behaviour	Resident conservation status	Conservation status (IUCN)
Long tailed commorant	*Pharacrocorax africanus*	Swamp	feeding	Rare	abundant
Reed commorant	*Phalacrocorax africanus*	Swamp, estuary	feeding	Rare	abundant
White breasted cormorant	*Pharacrocorax carbo*	Swamp	Feeding, nesting roosting	Common,	abundant
African darter	*Anhinga melanogaster*	Swamp	feeding	Rare	
Cattle egret	*Bulbulcus ibis*	Open beaches and shores	Feeding, breeding	Abundant	
Little egret	*Egretta garzetta*	Open beaches and shores	Feeding, breeding	Abundant	
Yellow- billed egret	Egret *Egretta intermedia*	Open beaches and shores	feeding		
Great egret	*Egretta alba*	floodplain	feeding	Common	
Grey heron	*Ardea melanocephala*	floodplain	feeding		
Black-headed heron	*Ardea melanocephala*	Open beaches and shores	Feeding, breeding, nesting	Anundant	
Goliath heron	*Ardea goliath*	Swamps	feeding	Rare	Vulnerable
Hamerkop	*Scorpus umbretta*	Open beaches and shores	Feeding, breeding,nesting	Common	
Open- billed stork	*Anastomus lamelligerus*	floodplain	feeding	Common	
Abdim's stork	*Ciconia abdimii*	Estuary, floodplain	feeding	Common	
Marabou stork	*Leptoptilos crumineferus*	Open beaches and shores	feeding	Common	
Glossy ibis	*Plegadis falcinelus*	floodplain	feeding	Rare	
Hadada ibis	*Bostrychia hagedash*	floodplain	feeding	Rare	
Sacred ibis	*Threskiornis aethiopicus*	Estuary,floodplain	feeding	Abundant	
Crowned crane	*Balearica regulorum*	Swamp, floodplain	feeding	Common	
Augur buzzard	*Buteo rufofuscus*	Open beaches and shores	feeding	Rare	
Grey kestrel	*Falco ardosiaceus*	Open beaches and shores	feeding	Rare	
Black kite	*Milvus migrans*	Open beaches and shores	Feeding, nesting	Abundant	
African fish eagle	*Haliaeetus vocifer*	Swamp	feeding	Rare	
African jacana	*Actopholornis africanus*	Swamp	Feeding	Common	
Spotted bone curlew	*Burhinus copensis*	Swamp	Roosting	Rare	
Pied kingfishers	*Ceryle rudis*	Open beaches and shores	Nesting and feeding	Abundant	
Malachite kingfisher	*Alcedo cristata*	Estuaries	feeding	Common	
Blue breasted kingfisher	*Halcyon malimbicus*	Estuaries	feeding	Rare	
Brown hooded kingfisher	*Halcyon albiventris*	Estuaries	feeding	Rare	

Conservation needs of birds in aquatic ecosystems

Survival of aquatic birds relies in conservation of feeding, breeding, roosting, loafing, and over-wintering sites. Most water birds forage in the wetlands, which include inshore or littoral areas of the lake, swamps, flooded areas (draw-down zones or floodplains), pools and rivers. Wetland macrophytes (papyrus, reeds, trees, etc) are preferred by many species as nesting, roosting and loafing sites. Therefore proper management measures need to focus on wetland ecosystems. Since some sites in the Lake Victoria basin aquatic systems fulfil the requirement criteria for the establishment of the Ramsar sites, efforts should be put in place to initiate the establishment of more such sites for effective management of the waterfowl biodiversity.

Other higher vertebrates associated with water and wetlands in the Lake Victoria basin

The Lake Victoria basin is home to several species of amphibians, mammals, and reptiles. Each taxon differs in the extent of dependence on aquatic ecosystems. Some species are specialists and require aquatic ecosystems for most of the basic needs during the course of their life. This group usually comes into contact with water for relatively longer periods year round, either for breeding, feeding, or refuge purposes. Other species are generalists or visitors and use aquatic ecosystems occasionally for getting certain basic needs. They use the vegetation part of the aquatic ecosystem for shelter, feeding, or breeding. They also utilise water mainly for drinking, swimming across from one end to another or for leisure.

Factors influencing diversity of higher vertebrates

Size and extension of the littoral zone, macro and microhabitats available for the different aquatic fauna and the extension of wetlands are the main determinants of amphibian, reptilian and mammalian habitation. Most amphibians, for example, are not completely independent of aquatic environments because they must at one time (during breeding and early stages of growth) return to water.

Species richness of higher vertebrates in the Lake Victoria basin

A total of 31 amphibians, 28 reptilian and 44 mammalian species have been recorded from various sites in Lake Victoria basin. Members of the genus *Xenopus* are the only purely aquatic amphibians. They only move from one wetland or water body to another following prolonged rains when the soils become water logged. This group prefers living in slow flowing vegetated streams or ponds with permanent water. Most other species can be said to be semi-aquatic.

The inshore waters and fringing wetlands support several species of reptiles, the commonest of which are the Nile crocodile (*Crocodylus niloticus* Laurent 1768), monitor lizard (*Varanus niloticus* Linnaeus 1766), and snakes such as the African rock python (*Python sebae* Gmelin 1789), mambas, and cobras (Pitman 1974; Chisara and others 2001).

The majority of mammals recorded in the basin are generalists and visit non-aquatic habitats (e.g. forests, shrubs, reeds, sedges) of wetlands for foraging or shelter. Flooding patterns of the aquatic ecosystems controls their presence. Many mammals leave for relatively drier areas during heavy rains. Few species are well adapted to aquatic environment for feeding and breeding purposes. Mammals that largely depend on aquatic environment in their life include Hippos (*Hippopotamus amphibius*) and Spotted-Necked Otter (*Lutra maculicollis*). The Sitatunga (*Tragelaphus spekei*) is a wetland endemic species, which is highly adapted to wading on wetland vegetation and swimming in water.

Specific diversity on selected study sites of the Lake Victoria basin in Uganda

Six major diversity sites, namely LakeVictoria, Kooki lakes - Mburo and Kachera, Lake Wamala, Lake Nabugabo and River Nile are reported. A total of 27 amphibian, 18 reptilian and 40 mammalian species have been recorded in the sites. Lake Nabugabo was the most species rich site for amphibians with 25 species followed by L. Wamala (12) and Lake Victoria sites (11), while L. Mburo (7) and L. Kachera (8) were the poorest (Table 12).

Table 12: Amphibian fauna of the Lake Victoria basin, Uganda

(Source: Behangana and others 2004).

Species	Common name	L. Victoria	L. Mburo	L. Kachera	L. Wamala	L. Nabugabo	R. Nile
Afrana angolensis	Angola Frog	x			x	x	
Afrixalus fulvovittatus	Banded Banana Frog					x	
Amnirana albolabris	White-lipped Frog	x			x	x	
Amnirana galamensis	Marble-legged Frog					x	
Bufo gutturalis	Guttural Toad	x	x	x	x	x	x
Bufo steindachneri	Steindachner's Toad					x	
Bufo vitattus	Banded Toad	x			x	x	x
Hoplobatrachus occipitalis	Groove-crowned Bullfrog	x			x	x	x
Hyperolius acuticeps	Sharp-nosed Reed Frog			x	x	x	
Hyperolius cinnamomeoventris	Cinnamon-bellied Reed Frog	x				x	
Hyperolius kivuensis bituberculatus						x	
Hyperolius kivuensis kivuensis	Kivu Reed Frog	x	x	x	x		x
Hyperolius viridiflavus bayoni		x	x	x	x	x	x
Hyperolius viridiflavus variabilis	Variable Reed Frog					x	
Hyperolius viridiflavus viridiflavus	Common Reed Frog				x		x
Kassina senegalensis	Bubbling Kassina		x			x	
Leptopelis bocagii	Bocage's Tree Frog		x			x	
Phrynobatrachus acridoides	East African Puddle Frog					x	
Phrynobatrachus dendrobates	Medje River Frog					x	
Phrynobatrachus graueri	Rugege River Frog					x	
Phrynobatrachus natalensis	Natal River Frog			x	x	x	x
Ptychadena anchiatae	Benguella Grassland Frog					x	
Ptychadena chrysogaster	Yellow-bellied Ridged Frog					x	
Ptychadena mascareniensis	Mascarene Grassland Frog	x	x	x	x	x	x
Ptychadena oxyrhynchus	Kaffirland Grasslan	x		x		x	
Ptychadena porissisima	Ethiopia Grassland Frog	x	x	x	x	x	x
Xenopus laevis victorianus	African Clawed Frog					x	
Total		**11**	**7**	**8**	**12**	**25**	**9**

For reptiles, Lake Nabugabo had the highest richness with 15 species followed by Lake Victoria sites (12). Lake Wamala (4) and R. Nile (5) are ranked as the poorest (Table 13).

Table 13: Reptilian fauna of the Lake Victoria basin sites, Uganda (Source: Behangana and others 2004).

Species /Sites	Common Name	Lake Victoria	L. Mburo	L. Kachera	L. Wamala	L. Nabugabo	R. Nile
Adolphus jacksonii	Jackson's Forest Lizard		X				
Agama atricollis	Common Tree Agama		X	x	x	x	x
Atractaspis irregularis	Burrowing Viper	X				x	
Chamaeleo gracilis	Graceful Chameleon					x	
Chamaeleo laevigatus	Smooth Chameleon	X					
Cocodylus niloticus	Nile Crocodile	X	X	x			x
Crotaphopeltis degeni	Yellow-flanked Snake					x	
Dromophis sp.		X				x	
Mabuya maculilabris	Speckle-lipped Skink	X	X	x	x	x	X
Mabuya striata	Common Striped Skink		X	x		x	
Meheleya capensis	File Snake	X				x	
Naja melanoleuca	Water Cobra	X	X	x	x	x	X
Naja nigricollis	Spitting Cobra		X			x	
Natriciteres olivaceous	Olive Marsh Snake	X				x	
Pelomedusa subrufa		X				x	
Psammophis sibilans	Sand Snake	X				x	
Python sebae	Rock Python	X	X	x	x	x	
Varanus niloticus	Monitor Lizard	X	X	x		x	X
Total		**12**	**9**	**7**	**4**	**15**	**5**

As for mammals, Lake Nabugabo again has the richest diversity with 35 species followed by Lake Victoria (19), while L. Kachera (5), Lake Wamala (6) and the R. Nile (6) are the poorest (Table 14). Lake Mburo had 181 hippos making it the richest site for hippos in the Lake Victoria basin.

Table 14: Mammalian fauna of the Lake Victoria basin sites, Uganda (Source: Behangana and others 2004).

Species	Common Name	Lake Victoria	L. Mburo	L. Kachera	L. Wamala	L. Nabugabo	R. Nile
Aethomys kaiseri	Kaiser's Bush Rat					x	
Arvicanthis niloticus	Nile Grass Rat						x
Atilax paludinosus	Marsh Mongoose	X		x	x		
Cercopithecus aethiops	Vervet Monkey	X	X		x	x	
Cercopithecus ascanius	Red-tailed Monkey	X				x	
Chaerophon major	Lappet-eared Free-tailed Bat					x	
Chaerophon pumila	Little Free-tailed Bat					x	
Colobus guereza	Black and White Colobus Monkey	X				x	
Crocidura fuscomurina	Tiny Musk Shrew					x	
Crocidura infinetismus	Least Dwarf Shrew				x		
Crocidura littoralis	Butiaba Musk Shrew					x	
Crocidura luna	Greater Grey-brown Musk Shrew					x	
Crocidura mourisca	Northern Swamp Musk Shrew	x			x	x	
Crocidura olivieri	Northern Giant Musk Shrew	x	x			x	x
Crocidura turba	Southern Woodland Musk Shrew	x	x			x	

Dasymys incomtus	Shaggy Marsh Rat					x	
Epomophorus labiatus	Little Epauletted Fruit Bat					x	
Epomops franquenti	Franquet's Fruit Bat					x	
Geneta servelina	Serveline Genet	x	x			x	
Gramnomys dolichurus	Common Thicket Rat	x				x	
Hippopotamus amphibius	Hippopotamus	x	x	x			
Lemiscomys striatus	Common Striped Grass Rat						x
Lepus victoriae	Savanna Hare	x				x	
Lophuromys flavopunctatus	Eastern Brush-furred Rat					x	x
Lophuromys sikapusi	Common Brush-furred Bat	x		x		x	x
Lutra maculicollis	Spot-necked Otter	x	x	x	x	x	
Mastomys hildebrandtii	Multimammate Rat	x				x	x
Mus minutoides	Pygmy mouse					x	
Oenomys hypoxanthus	Rusty-nosed Rat	x				x	
Otomys tropicalis	Tropical Groove-toothed Rat					x	
Paraxerus alexandri	Alexander's Dwarf (Bush) Squirrel					x	
Pelomys hopkinsi	Papyrus Rat	x				x	
Praomys jacksoni	Jackson's Soft-furred Rat			x		x	
Rousettus aegyptiacus	Egyptian Fruit Bat					x	
Rousettus angolensis	Bocage's Fruit Bat					x	
Sylvicapra grimmia	Common (Bush) Duiker	x	x			x	
Sylvisorex megalura	Climbing Forest Squirrel					x	
Thryonomys gregorianus	Lesser Cane Rat					x	
Tragelaphus scriptus	Bushbuck	x				x	
Tragelaphus spekii	Sitatunga	x			x	x	
Total		**19**	**7**	**5**	**6**	**35**	**6**

Specific diversity on selected study sites of the Lake Victoria basin in Kenya

The Yala swamp complex consists of two rivers (Yala and Nzoia) and covers mainly the northern shores of Lake Victoria including the satellite lakes Sare, Kanyaboli, and Namboyo. Six amphibian species are reported in this swamp (Table 15). The African Clawed Frog (*Xenopus laevis*) is the most dominant species encountered in all satellite lakes.

Table 15: Amphibian fauna of the Lake Victoria basin, Kenya. (Source: Behangana and others 2004).

Species	Common Name	L. Sare	L. Kanyaboli	L. Nyamboyo	R. Yala	R. Nzoia	Yala swamp
Afrana angolensis	Angola Frog	x	X				x
Bufo maculates	Flat-backed Toad						x
Kassina senegalensis	Bubbling Kassina						x
Phrynobatrachus natalensis	Natal River Frog						x
Ptychadena chrysogaster	Yellow-bellied Ridged Frog				x	x	
Xenopus laevis	African Clawed Frog	x	X	x	x	x	
Total		**2**	**2**	**1**	**2**	**2**	**4**

Among the 13 species of reptiles recorded in the swamp, the commonest were *Grayia smithii* Leach 1818 and *Grayia tholloni* Mocquard 1897 (Table 16). The species richness adds up to 19 with opportunistic records outside the sampled sites but within the basin. The most specious sites are the macrophyte zones in the wetland with 7 species, while River Nzoia was poorest (3 species).

Table 16: Reptilian fauna of the Lake Victoria basin, Kenya. (Source: Behangana and others 2004).

Species	L. Sare	L. Kanyaboli	L. Namboyo	R. Yala	R. Nzoia	Yala swamp (macrophyte zone)
Adolfus jacksoni						
Cansus lichtensteinii				X		
Crocodilus niloticus						
Crotopholpeltis degeni	x	x	x			
Grayia smythii	x	x	x	X	X	
Grayia tholloni	x	x	x	X	X	
Hemidactylus mabouia						
Latastia longicaudata						
Leptotyphlops conjuctus						X
Lygodactylus marini						
Naja melanoleuca				X	X	
Naja nigricollis						X
Philothamnus carinatus						X
Philothamnus heterolepridotus				X		X
Philothamnus niticlus	x	x	x			X
Philothamnus semivariegatus	x	x	x			
Psammophis mossambicus						X
Python sebae				X		X
Varanus niloticus						
Total	**5**	**5**	**5**	**6**	**3**	**7**

Eight species of mammals were recorded from the Yala swamp (Table 17), the Hippopotamus (*Hippopotamus amphibius*) being the commonest. The list excludes small mammals, which are generally very difficult to locate.

Table 17: Mammalian fauna of the Lake Victoria basin, Kenya. (Source: Behangana and others 2004).

Species	Common name	L. Namboyo	L. Kanyaboli	L. Sare	R. Yala	R. Nzoia	Yala swamp
Cercopithecus aethiops	Vervet Monkey						x
Epomophorus wahlbergi	Wahlberg's Epauletted Fruit Bat						x
Hippopotamus amphibius	Hippopotamus	X		x			x
Kobus ellipsiprymnus	Defassa Waterbuck						x
Phacochoerus aethiopicus	Common Warthog						x
Redunca redunca	Bohor Reedbuck						x
Tragelephus scriptus	Bushbuck						x
Tragelophis spekii	Sitatunga						x
Total		**1**	**0**	**1**	**0**	**0**	**8**

Specific diversity on selected study sites of the Lake Victoria basin in Tanzania

Published information on species diversity of amphibians that occur in the Lake Victoria basin - Tanzanian side is very scanty. Frogs and toads are, however, believed to utilise a wide range of habitats, including palustrine swamps, marshes, ponds, streams, irrigated paddy fields, inundated floodplains, and reservoirs. Of the 10 species recorded in the lake basin, *Ptychadena* spp were the most widely spread in vegetated streams, springs, and rice fields.

Table 18: Amphibian fauna of the Lake Victoria basin, Tanzania.

(Source: Behangana and others 2004)

Species	Common name
Afrixalus brachycnemis	Short-legged Spiny Reed Frog
Afrixalus fulvovitattus	Banded Banana Frog
Amnirana galamensis	Marble-legged Frog
Bufo kerinyagae	Kenya Highlands Toad
Hoplobatrachus occipitalis	Groove-crowned Bullfrog
Hyperolius viridiflavus	Painted Reed Frog
Kassina senegalensis	Bubbling Kassina
Ptychadena mascareniensis	Mascarene Grass Frog
Xenopus laevis	African Clawed Frog
Xenopus muelleri	Muller's Clawed Frog

Studies conducted around Lake Victoria on the Tanzanian side showed that inshore waters and the fringing wetlands support many species of reptiles, including the Nile Crocodile (*Crocodylus niloticus*), Monitor Lizards (*Varanus niloticus*) and snakes such as the African Rock Python (*Python sebae*) (Chisara and others 2001). No specific accounts exist on reptiles and mammals, but based on information drawn from local knowledge, citations from Rubana and Simuyu ecosystems given vernacular names are listed below with assigned scientific names (Table 19 and 20).

Table 19: Common reptilian fauna of the Lake Victoria basin, Tanzania. (Source: Behangana and others 2004).

Local name	Swahili name	Scientific Name	Common Name	Rubana	Simiyu
	Mamba	*Crocodylus niloticus*	Crocodile	X	x
Mbulu-kenge,	Kenge	*Varanus niloticus*	Monitor lizard	X	x
	kasa,	*Pelomedusa subrufa*	Tortoise	X	
	Kobe				x
Chatu, satu, ebhasoti		Naja melanoleuca	Water Cobra		x
Ibambahili					x
Ibiheke				X	
Indugi				X	
Kifutu				X	x
Kinyarunyasi				X	
Kiwira				X	
Koboko				X	x
Mbubi, njubi, mbubi wa majini				X	x
Ndelema		*Python sebae*	Python	X	x
Nghimbeji					x
Ngoboko					x
Nyakehacha				X	
Nzoka ya rudutu				X	x
Nzubi					x

Local name	Swahili name	Scientific Name	Common Name	Rubana	Simiyu
Sawadi					x
Shana				X	x
Shilwe					x
Swila				X	x
Swila wa majini					x
Wange					x
Chura,			Frogs	X	
Total				**16**	**19**

Table 20: Common mammals recorded at Rubana and Simiyu wetlands, Tanzania. (Source: Behangana and others 2004)

Scientific name	Common Name	Rubana	Simiyu
Hippopotamus amphibius	Hippopotamus	X	X
Lutra maculicolis	Spot Necked Otter	X	X
	Wildebeest	X	
Cercopithecus aethiops	Velvet monkey	X	X
Potamoceros porcus	Bushpig	X	X
Tragelpus spekii	Sitatunga	X	X
Crocutta crocuttq	Spotted hyaena	X	X
Felis pardus	Leopard	X	
Thyronomys gregorianus	Cane Rat		X
Madoqua guentheri	Dik dik		X
Histrix cristata	Crested Porcupine		X
Lepus victoriae	Savvana Hare		X
Papio anubis	Olive Baboon	X	X
Total		**9**	**11**

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