Benthic Macro-invertebrates of the Tanzania side of Lake Victoria and their role in Fish Production

Mwambungu, J.A.[1], Mhitu, H.A.[2] Chande, A.I.[2]
[1]Tanzania Fisheries Research Institute, P.O.Box 98, Kyela, Tanzania
[2] Tanzania Fisheries Research Institute, P.O.Box 9750, Dar es Salaam

Abstract

Studies on the taxonomic diversity, abundance and distribution of macro-invertebrates and their role in fish production were carried out on sediments of Southeastern Lake Victoria in April, July and December 2000. A total of twenty (20) taxonomic groups were recorded. The macro-invertebrate community was composed of Turbellaria, Hirudinae, Oligochaete, Gastropoda, Bivalvia, Diptera, Ephemeroptera, Tricoptera and Coleoptera (larvae/pupae, nymphs and adults). In most sampling zones molluscs (gastropods and bivalves) were numerically dominant followed by insect larvae and oligochaetes. The oligochaetes (Haplotaxidae), Gastropoda comprising of Viviparidae (*Bellamya* sp) and Thiaridae (*Melanoides s*p) and Bivalvia constituting of Corbiculidae (*Corbicula* sp) and Uionidae (*Caelatura* sp) were widely distributed since they were represented in all sampling zones. Most taxa of macro-invertebrates observed in the sediments were prey items for most commercially important fishes observed in the lake and are therefore important in energy flow and fish production.

Key words: sediments, macro-invertebrates, taxonomic diversity, trophic relationships, fish production

Introduction

Macro-invertebrates are much larger organisms than micro-invertebrates, with body size of up to several centimetres long. In Lake Victoria most of the macro-invertebrate taxa are associated with bottom sediments (macro-benthic invertebrates) whereas some are either associated with vegetation along the lakeshore and littoral zones (macro-littoral invertebrates) or are free swimming in littoral or offshore (macro-pelagic invertebrates).

In the lake most macro-invertebrates form major food sources for fish (Corbert, 1961). Some members of the macro-invertebrates that constitute most of the secondary production are phytoplanktivorous. They convert green plant material into animal protein for use by various fish species and other organisms, which depend on invertebrates as a food source. Prominent invertebrates which serve as food for fish include some members of the molluscs (Gastropoda and Bivalvia) insect (larvae/pupae, nymphs and adults) shrimps (Decapoda – *Caridina nilotica*).

Recently Lake Victoria has suffered major losses in its biodiversity of fish species and changes in its water quality. The introduction of Nile perch and the upsurge in perch production in the late 1970's to early 1980's has contributed to the reduction of indigenous fishes (Witte *et al*., 1992). Nutrient enrichment resulting into eutrophication has occurred in the lake by doubling of nutrient concentrations and algae productivity since 1960 (Mugidde, 1993). The results of this excessive growth of algae is composed of some species which may be toxic to humans and other animals and has deoxygenated the lake's deep water (Hecky *et al*., 1993) and thus decreasing the habitat for bottom dwelling endemic cichlids and other organisms. These changes may affect the availability of food of the fish, which depends on algae, and secondary producers like some macro-invertebrates, which feed on algae. Such changes prompted the need to assess the current situation of the Lakes' ecosystem. Studies of macro-invertebrates in the Tanzania waters of Lake Victoria have not been

comprehensively documented. However limited early investigation on macro-invertebrates confined mainly to Mwanza Gulf (Hoogerhoud, 1986, Witte *et al*., 1992, Goldschimid *et al*., 1993) though largely descriptive with limited sampling area provide a useful basis for comparison with the present investigation.

This paper presents results from selected areas in the South-eastern Lake Victoria sampled in April, July and December 2000. The paper gives the diversity, abundance and distribution of macro-invertebrates observed in the sediment samples. It also presents the trophic interaction between macro-invertebrates and the principal invertebrate eating fish species encountered in the sampling sites as a link in fish production.

Materials and methods

Study Area

The area of sampling stretches from the eastern shores of the lake (approx. 31°E) towards the west (approx. 33°E) and the northern shores towards the Kenyan border (approx. 1° 08S) and towards the southern part of the lake (approx.2°30S). Sampling stations were within the four operational zones of the Lake Victoria Environmental Management Project (LVEMP) in the Tanzania waters of Lake Victoria namely sampling zone 1: Mara; sampling zone 2: Speke Gulf; sampling zone 3: Mwanza Gulf and sampling zone 4: Emi-Pasha Gulf (Fig.1)

Sample and Data Collection

Macro-invertebrates were collected from sediments using the Eckman grab. Three samples were collected from each station and analysed separately. Sieves of 500 microns mesh size were used to separate organisms from sediments. The samples were then fixed in 4% formalin. In the laboratory samples were rinsed with water and the organisms were sorted under the stereomicroscope to the lowest taxonomic groupings (due to unavailability of identification keys for macro invertebrates of Lake Victoria), counted and then preserved in 70% alcohol. Data collected was analysed to obtain average number of organisms per m^2 and the percentage of each taxonomic group.

Fish samples were collected using a stern trawler R.V. TAFIRI II with 150 Hp operating a trawl net of 30mm cod-end. The fish samples were sorted into different species, dominant fish species were examined for biological studies which included; *Lates niloticus, Oreochromis niloticus, Clarias gariepinus, Schilbe intermedius Synodontis victorias Brycinus jacksoni* and *Brycinus sadleri.* Each fish was dissected and the gut removed and the gut contents examined for macro-invertebrates.

Both samples of macro-invertebrates and fish were collected from sediments in inshore waters between 4-20 metres in depth at the same time in April, July and December 2000.

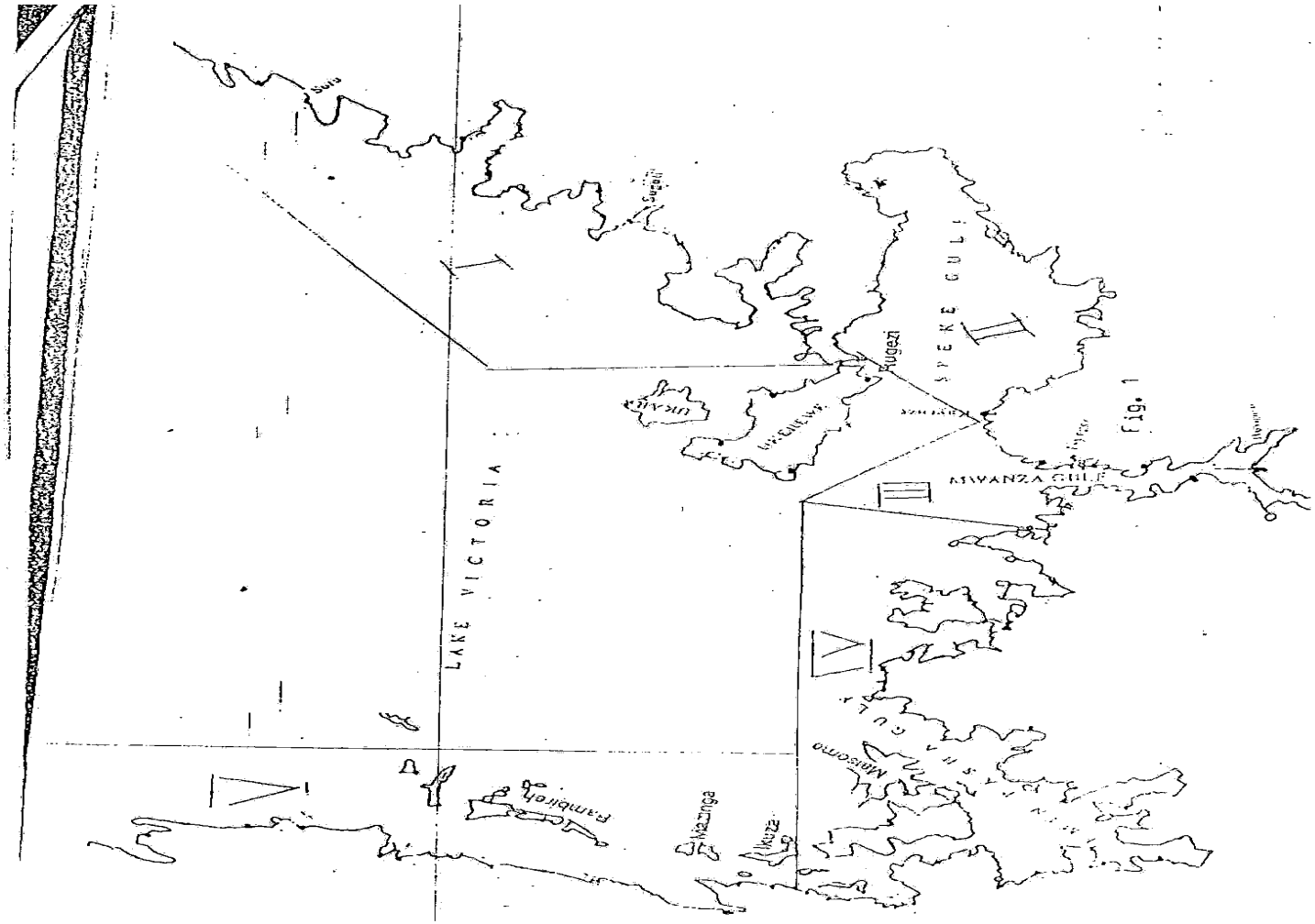

Fig. 1: The map of Lake Victoria (Tanzania) showing the sampling zones or strata

Results

Macro-Invertebrate Taxonomic Diversity

Table1shows the macro-invertebrate community which is composed of Turbelaria, Hirudinae, Oligochaetes (Haplotaxidae and Lubriculidae, Gastropods comprising of Viviparidae (*Bellamya unicolor*) , Birthynidae (*Gabbiella humerosa*). Thiaridae (*Melanoides tuberculata*) and Planorbidae (Planorbinae-*Biomphalaria pfeifferi* and Bulininae-*Bulinus globosus*). Bivalvia comprising of Unionidae (*Caelatura hauttecoeuri*), Mutelidae (*Mutela bourguigati)*, Sphaeriidae (*Sphaerium stuhlmanni* and *Byssanodonta parasitica*) and Corbiculidae (*Corbicula africana*) were also common. Others included Crustacea (Decapoda-*Caridina nilotica*), Ephemeroptera (Ephemerellidae-*Povilla adusta*), Tricoptera (Polycentropodidae), Coleoptera (Distiscidae) and Diptera (Chironomidae-Tanypodinae and Chironominae and Chioboridae-*Chaoborus* sp).

A total of twenty taxonomic groups were recorded in the four sampling zones. Mara Region had eighteen taxa (18), Speke Gulf registered seventeen taxa (17) while Mwanza and Emin Pasha Gulf registered twelve (12) and eight (8) taxonomic groups respectively. The taxonomic diversity shows the increase in number of taxa from south (Emin Pasha Gulf) towards the north (Mara Region).

Macro-Invertebrate Relative Abundance

Relative abundance of macro-invertebrate taxa in the four sampling zones show the numerical dominance of Molluscs (Gastropods and Bivalves) from Mara Region, Speke Gulf and Mwanza Gulf, followed by Insect larvae comprising mainly of Diptera, Ephemeroptera and Coleoptera. Oligochaeta contributed the least to the total catch. Molluscs were generally rare in sampling zone 4. In this zone Insect larvae mainly Diptera (Chaoboridae and Chironomidae) dominated the catch.

Macro-Invertebrate Densities and Distribution

Table 2 shows the density and distribution of different sampling zones of Lake Victoria from sediments.

Molluscs (Gastropods and Bivalves) were represented in all zones. Gastropods had highest density of organisms in Speke Gulf while Bivalves were higher in Mara Region. Both taxa had the lowest densities in Emin Pasha Gulf. *Bellamya sp* and *Melanoides sp* were the only two gastropods represented in all sampling zones. *Corbicula sp* and *Caelatura sp* were the common bivalves and were presented in all four zones. *Sphaerium sp* and *Byssanodonta sp* were missing from Emin Pasha Gulf, while *Mutela sp* was confined to Mara Region. A crustacean (*Caridina nilotica*) with a low density was represented in Mara Region and Speke Gulf . Oligochaetes were the only worms represented in all four zones. Turbellaria were recorded from Mara Region and Mwanza Gulf while Hirudinae was represented in Speke Gulf only. Two taxonomic groups of Diptera *Chaoborus sp* and Chironomids were represented in the four sampling zones. Ephemeroptera (*Povilla adusta*) were represented in Mara Region while Tricoptera (Polycentropodidae) was represented in Mara Region and Coleoptera from Speke Gulf.

Table 1: Taxonomic diversity (present "P" or absent "A") of macro-invertebrates from sediments sampled from South Eastern Lake Victoria in 2000.

Taxon/Zone	Zone 1: (Mara Region)	Zone 2:(Speke Gulf)	Zone 3:(Mwanza Gulf)	Zone 4:(Emin-Pasha Gulf)
Turbellaria	P	A	A	
Oligochaeta				
Haplotaxidae	P	P	P	P
Lumbriculidae	P	P	A	A
Hirudinae	A	P	A	A
Gastrapoda				
Viviparidae (*Bellamya* sp)	P	P	P	P
Bithynidae (*Gabbiella* sp)	P	P	P	A
Thiaridae (*Melanoides* sp)	P	P	P	P
Planorbidae				
Planorbinae (*Biomphalaria* sp)	P	P	A	A
Bulininae (*Bulinus* sp)	P	P	P	A
Bivalvia				
Unionidae (*Caelatura* sp)	P	P	P	P
Mutelidae (*mutela* sp)	P	A	A	A
Corbiculidae (*Corbicula* sp*)*	P	P	P	P
Sphaeriidae (S*phaerium* sp, *Byssanodonta* sp)	P	P	P	A
Crustacea				
Decopoda (*caridina* sp)	P	P	A	A
Ephemeroptera				
Ephemerellidae (*Povilla* sp)	P	P	P	A
Tricoptera				
Polycentropodidae	P	A	A	A
Coleoptera				
Disticidae	A	P	A	A
Diptera				
Chironomidae				

Tanypodinae	P	P	P	P
Chrinominae (*Chironomou*s sp)	P	P	P	P
Chaoboridae (C*haoborus* sp)	P	P	P	P
Number of taxa	18	17	12	8

Legend: P = Present; A = Absent

Trophic Relations of Macro-Invertebrates to Fish Species

Macro-invertebrate prey items found in the stomachs of the dominant fish species included insect larvael pupae nymph and adults (ingested by *Lates niloticus*, *Oreochromis niloticus, Clarias gariepinus, Schilbe intermedius, Synodontis victoriae* and *Brycinus jacksonii*); Molluscs (ingested by *L. niloticus, C. gariepinus, S. victoriae, B. jacksonii* and *B. sadleri*); Decapoda – *Caridina nilotica* (ingested by *L.niloticus, O. niloticus, C. gariepinus* and *S. intermedius*) and Annelids (ingested by *L. niloticus, O. niloticus, S. intermedius* and *B. sadleri*).

Trophic relationship of macro-invertebrates to fish species in Lake Victoria is shown in Fig. 2. Most members of the macro-invertebrate community which constitute the secondary production are either phytoplanktivorous (insect larvae, *Caridina*, gastropods and bivalves) which convert green plant material into animal protein for use by other organisms including fish or regenerate soluble nutrients from the bottom like the prawn, the *Caridina nilotica* and some insects when they feed on detritus. Therefore from phytoplanktivores/detritus energy flows either via *Caridina*, molluscs or insect larvae to various fish taxa (Haplochromines, *Schilbe, Brycinus, Synodontis, Clarias*, *Protopterus Burbus*) culminating into adult Nile perch (Ligtvoet and Witte, 1991).

Discussion

Occurrence of two Gastropods *Bellamya* sp and *Melanoides* sp and a bivalve *Corbicula* sp widely distributed agree with earlier studies (Corbert, 1961; Mothersil *et al*., 1980; Hoogerhoud, 1986). *Caelatura* sp have been previously observed to be important genera from sediments in Murchison Bay (Okedi, 1990). In the present survey the bivalve was common in all four zones. Working in Mwanza Gulf Hoogerhoud (1986) observed that *Sphaerium* sp was the most important of the smaller bivalves. In this study *Sphaerlum* sp was important in Mwanza zone Speke Gulf and Mara zone.

The annelid Oligochaetes was the most important taxa in the sediment than Hirudinae while nematodes were not represented at all in the samples. The present results also indicate low densities of *Caridina nilotica* at all sampled stations although previous reports indicate large quantities of the prawn over the past three decades (Witte *et al*., 1992; Goldschinmidt *et al*., 1993; Lehman *et al*., 1994). This study has found major aquatic benthic insects larval stages from Lake Victoria to include Diptera (Chaoboridae and Chironomidae), Ephemeroptera (*Povilla* sp), Tricoptera (Polycentropodidae) and Coleoptera (Disticidae). Studies carried out by Okedi (1990) in Ekumu Bay (near Kampala) in 1987/88 show that Chironomid larvae ranked first and *Povilla* nymphs ranked second. These results agree with the present findings whereby Diptera (Chironomidae and Chaoboridae) rank first followed by *Povilla nymphs.*

Table 2: Density (No/m²) and distribution of macro-invertebrate taxa from sediments sampled from South- eastern Lake Victoria in April, July and December 2000

Zone	Zone 1: (Mara Region)			Zone 2: (Speke Gulf)			Zone 3: (Mwanza Gulf)			Zone 4:(Emin Gulf)		Pasha
	April	July	Dec.	April	July	Dec.	April	July	Dec.	April	July	Dec.
Turbellaria			2						9			
Hirudinae				4		36						
Oligochaetes	130	96	39	37	100	3	20	17	61	2	26	
Gastropoda	468	448	483	431	507	644	147	217	339	83	54	6
Bivalvia	754	616	336	336	619	197	132	182	329	26	23	3
Decapoda *(Caridina*)	2	17		2								
Ephemeroptera	9			7								
Tricoptera	4											
Coleoptera				2								
Diptera (chaoboridae)	26	52	182	59	-	237	102	17	17	387	9	23
Diptera (chironomidae)	312	144	56	26	13	20	30	52	43	140	40	44
TOTALS	**1705**	**1373**	**1098**	**904**	**1239**	**1137**	**431**	**485**	**798**	**638**	**152**	**76**

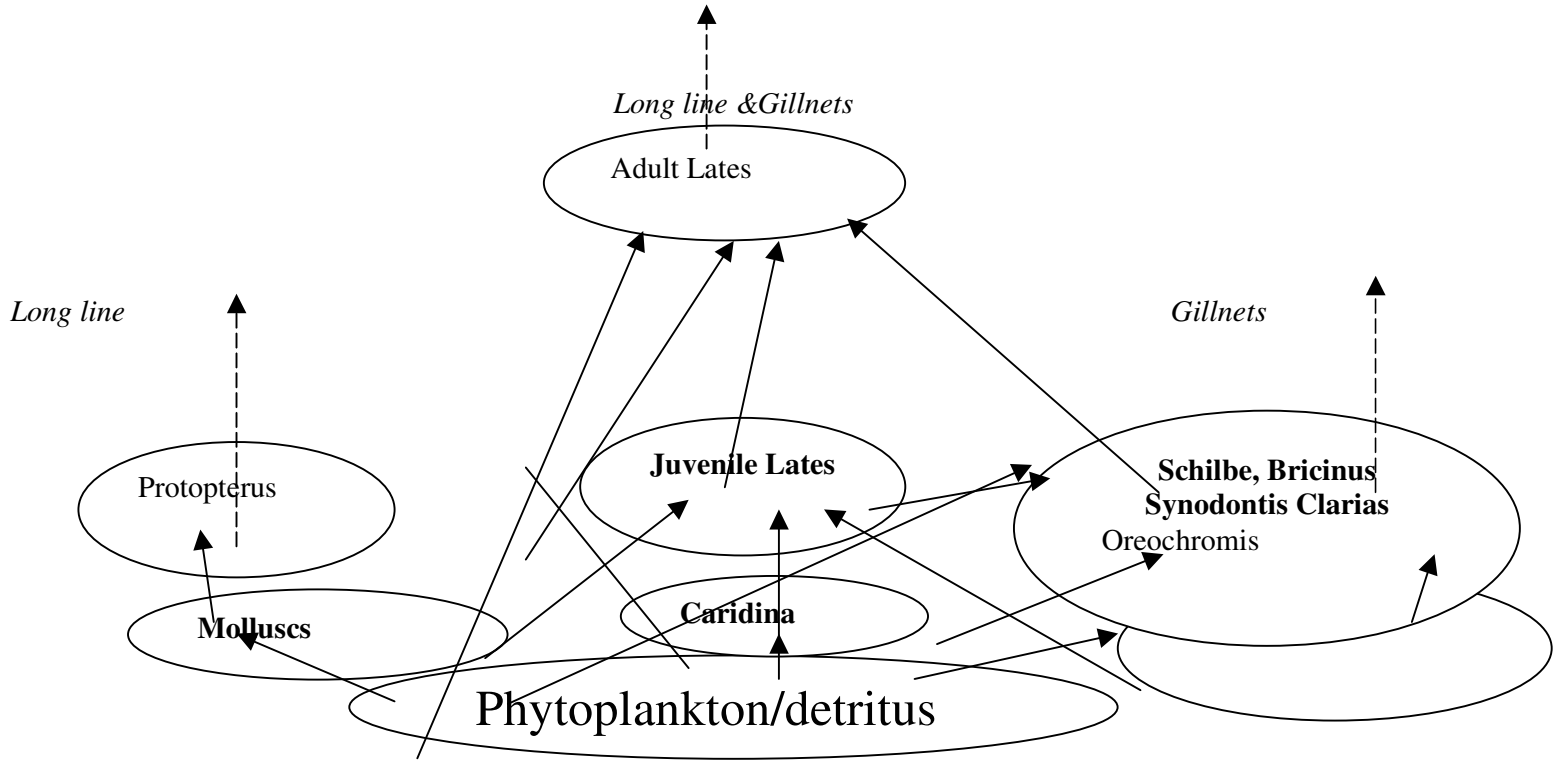

Fig.2: Trophic relationship of macro-invertebrtaes and fish species

Various studies on food and feeding habits in Lake Victoria show that Macro-invertebrates are a source of food items for many fishes. For example, Gastropods and Bivalves are a source of food for *Protopterus aethopicus, Synodontis victoriae, Barbus altianalis* and for Haplochromine molluscivores (Corbert, 1961; Greenwood, 1981; Katunzi, 1983; Balirwa, 1984; Hoogerhould, 1986; Mosile, 1988). The decapod prawn *Caridina nilotica* is known to be a prey to most haplochromines and tilapines and has been observed as a food item in the diet of many species of *Bagrus, Clarias, Schilbe, Barbus* and in Mormyrids (Corbert, 1961). Annelid worms (Oligochaetes and leeches) are also reported to be important invertebrate fish food items. Fish species of *Gnathonemus and Synodontis* are known to feed on Oligochaetes while leeches are mainly exploited by Haplochromine cichlids (Corbert, 1961). It is reported that insects form by far the most important food for many fish in the Lake Victoria basin (Corbert, 1961; Hoogerhould *et al*., 1983; Goldschimidt *et al*., 1990; Witte and Van Oijen, 1990; Witte *et al*., 1995). Corbert (1961) stressed that hardly there is no fish species that does not include insects in their diet.

Conclussion

The study has revealed the presence of twenty (20) taxa from sediments and that the trend of taxonomic diversity increase as well as abundance from South (Emin Pasha Gulf) towards the North (Mara zone) was evident. Most taxa of macro-invertebrates observed in the sediments are food items for most fishes in Lake Victoria and constitute a major link in the energy flow from primary production to the top of the food chain and therefore important for fish production.

Recommendations

Macro-invertebrate studies should continue in various sampling stations together with the bottom measurements of physical and chemical parameters in order to detect the exact factors that determine the abundance and distribution of macro-invertebrates in different sediments of the lake and hence the abundance and distribution of fish.

References

Balirwa, J.S., 1984. Ecological separation in *Barbus* species in Lake Victoria. M.Sc. Thesis, University of Dar es Salaam.

Corbert, P.S., 1961. The food of non-cichlid fishes in Lake Victoria basis, with remarks on their evaluation and adaptation to lacustrine condition, *Proc. Zool. Soc. Lond.* 136, 1-101.

Goldschimidt, T., Witte., F. Visser, J. de., 1990. Ecological Segregation of Zooplanktivorous haplochromine (Pisces: Cichlidae) from Lake Victoria, *Oikos* **58**, 343-355.

Goldschmidt, T., Witte, F., and Wanik, J.H., 1993. Cascading effects of the introduced Nile perch in the detritivours/phytoplanktivorous species in the sub-littoral areas of Lake Victoria, *Conserv. Biol*. **7**,686-706.

Greenwood, P.H., 1974. The cichlid fishes of Lake Victoria, East Africa: the biology and evolution of a species flock. *Bull. Br. Mus. Nat. Hist.* (**2001**) Suppl. 6.

Greenwood, P.H., 1981. The haplochromine fishes of the East African Lakes. Collected papers on their taxonomy, biology and evolution (with an introduction and species index). *Krans International Publications, Munchen.*

Hecky, R.E., 1993. The eutrophication of Lake Victoria. Kilham Memorial Lectures, 25th Congress of 51L. *Verh. Internat. Verein. Limnol.* **25:**39-48.

Hoogerhoud, R.J.C., Witte, F., Barel, C.D.N., 1983. The ecological differentiation of Two closely resembling *Haplochromis* species from Lake Victoria (*H. iris* and and *H. hiatus*, Pisces, cichlidae) *Neth. J. Zool.* **33**,283-305.

Hoogerhoud R.J.C., 1986. Optimal Prey Processing in Molluscivours cichlids. Part 1: The Paradox of maximising fresh- and minimizing shell ingestion in *Astatochromi*s *alluad* and 1903 (Pieces, cichlidae). PhD Thesis, Leaden.

Katunzi, E.F.B., 1983. Seasonal variation in the food of a molluscivorous cichlid. *Haplochromis sauvager* prefer 1896. *Neth. J. Zool.* **33**,337-341.

Lehmann, J. T., Mbahinzireki, G., Ndawula, L.M., 1994. *Caridina nilotica* in Lake Victoria: abundance, biomass and vertical migration. *Hydrobiologia* **317**: 177-182.

Ligtvoet, W.,Witte,F.,1991. Perturbation through predator introduction;effects on the food web and fish yields in Lake Victoria (East Africa). Pp263-268. In: Ravera, O (ed.) *Terrestrial and aquatic ecosystem: perturbation and recovery.* Ellis hordwood, New York.

Mosile, O.I.W., 1988. The Ecology and Fishery of The African Lungfish *Protopterus aethiopicus*. App. III. In: Fish Stocks and Fisheries in Lake Victoria. *A handbook to the HEST/TAFIRI and FAO/DANIDA regional seminar, Mwanza, January/February, 1989.*

Morthersil, J.S., Freitag, R., Barnea, B., 1980. Benthic Macro-invertebrates of north western Lake Victoria East Africa: Abundance, distribution, introphletic relationships between taxa and selected concentrations in the lake bottom sediments. *Hydrobiologia* **74**,215-24

Mugidde, R., 1993. The increase in phytoplankton productivity and biomass in Lake Victoria. *Verpandhingen Internationalis Vereingung for Theorestische and Angewandte Limnology* **25,** 846-849.

Mwambungu, J.A., 2001.Assessment of Macro-invertebrates in Tanzania waters of Lake Victoria. Paper presented at the LVEMP 2001 Scientific Conference, 6-10 August 2001. Mwanza, Tanzania.

Okedi, J., 1990. Observations on the benthos of Murchison Bay, Lake Victoria. East Africa. *Afr. J. Ecol.* 8,11-122.

Witte, F., Goldschimidt, T., Winnik, J., Oijen, M., Goudwnard, K., Witte, M., Bouton, N., 1992. The destruction of an endemic species flock: quantitatively data on the

decline of the haplochromine cichlids of Lake Victoria. Environmental Biology of Fishes, 34,1-28.

Witte, F., Hoogenboezem, W., Goldschimidt, T., West brock, I., 1995. Major food types of the fish species in Lake Victoria. In Witte, F. and Van Densen, L.T. (eds). Fish stocks and Fisheries of Lake Victoria. Samara London, 337-347.

Witte, F., Oijen, M.J.P. Van., 1990. Ecology and Fishery of Haplochromine trophic groups. Zool. Verh. Leiden, 262, 1-47.