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Challenges for Management of the Fisheries Resources, Biodiversity and Environment of Lake Victoria

Editors:
J. S. Balirwa,
R. Mugidde,
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Fisheries Resources Research Institute

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LAKE VICTORIA ENVIRONMENT MANAGEMENT PROJECT LAVEMP FOR MAXIMUM SUSTAINABLE BENEFITS

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4.4 Evolution of the tilapia fishery with specific reference to the Nile tilapia (*Oreochromis niloticus* Linné)

J.S. Balirwa, M. Nsega, R. Roijackers & W. Nkalubo

Introduction

As a fishery, the immensely large (c. 68,800 km^2) Lake Victoria is a unique ecosystem which together with a riverine connection to the Lake Kyoga basin share a common endemic "*Victorian*" fish fauna (Greenwood 1966). Until the 1950s, the single socio economically most important species of fish in these two lakes was the native *Oreochromis esculentus* Graham (Graham 1929) even though the lake also contained a second native tilapiine, *O. variabilis*, and over 300 other fish species (Beauchamp, 1956).
The two native tilapiine species also occur in satellite lakes such as Manywa, Kayanja, Kayugi of the two basins (Ogutu-Ohwayo 1993), the Victoria Nile above the Murchison Falls, Malaba River (Witte & van Densen, 1995) and several other water bodies (e.g. Lakes Kanyaboli in Kenya, and Ikimba in Tanzania). Due to the presence of large stocks of the endemic *O. esculentus*, Graham (1929) described Lake Victoria as a tilapia lake. Over fishing and species introductions of Nile perch (*Lates niloticus*) and Nile tilapia (*Oreochromis niloticus*) have altered the fisheries to the extent that Lake Victoria is primarily a three species fishery (Nile perch, Nile tilapia, *Rastrineobola argentea*)

Following the exponential increase in the stocks of the introduced Nile perch since 1980s, an export industry based on Nile perch has become firmly established. Due to natural variations and over-fishing of the Nile perch, Nile tilapia has also assumed the status of an export commodity while retaining its local consumer preference over other fish. However, in comparison to studies of the Nile perch from the early 1980s, there has been limited research coverage of Nile tilapia as an important component of the Lake Victoria fishery.

From 1988, studies were started focusing on the biological and ecological aspects of the Nile tilapia in its new habitats as well as its increasing importance as a commercially exploited species. Records kept by the Lake Victoria Fisheries Service

(EAFFRO: 1952-1966), results of fishing experiments targeting Nile tilapia between 1993 - 1998, catch assessment surveys (CAS) carried out between 1988 and 1990, trawl (1999/2000) and frame survey (2000) reports have been analysed. Results from these analyses provide an indication of the trends in the evolution of the tilapia fishery.

Historical trends in the native tilapia fishery of Lake Victoria

During the period 1905 to 1916 gill nets were introduced as a fishing method on Lake Victoria (Graham 1929). Traditional fisher-folk started to commercially exploit abundant tilapia stocks for an expanding market associated with urbanization, and *O. esculentus* became the main commercial target species (Mann 1970; Keenleyside & Miles 1991; Balirwa 1992). There had previously been no impact on these stocks by subsistence requirements up to the beginning of the 20th century. With the introduced gill nets, tilapia catch rates rapidly decreased from 25 - 100 fish in the recommended 5-inch mesh net (c.p.n) in 1916 to 4-7 (c.p.n) in 1928 (Graham 1929). This encouraged the introduction of illegal smaller mesh gill nets to exploit the smaller sizes of fish, which caused a temporary boom in numbers of tilapia caught (Mann 1970). From the 1930s to 1950s the catch dropped further and the fish size became smaller due to increased fishing pressure (Fryer & Iles, 1972; Fryer 1973) and the use of smaller mesh sized gill nets (Witte & van Dansen 1995), which also captured the small-size growing *O. variabilis*. Experimental fishing by EAFFRO in 1955/56 showed that the rich *O. esculentus* fishing grounds could be rapidly depleted by intensive fishing effort and that such areas could not be rapidly repopulated by immigrant fish (Garrod, 1959).

By the middle of 1957 about 40,000 nets were being set in the northern Lake Victoria each month and the monthly yield was in the neighbourhood of 100,000 fish. By December of the same year, the numbers of nets set in the month fell to about 20,000 (EAFFRO, 1956/57) i.e. a 50% reduction, and there was a corresponding fall in the yield which should have been an early warning regarding the capacity of this fishery to withstand further intense exploitation. Since there was no compensatory increase in the catch of non-cichlids from these small mesh nets, the total weight of fish landed annually began to fall further, and by 1960, the last reserves of breeding fish could have been depleted (Mann, 1970). This made *O. esculentus* one of the most threatened fish species and deprived the people who depended on it for food and employment. Nile tilapia, which was already known to grow to bigger sizes, was considered a more suitable introduction that would allow a return to the 5-inch gill-net mesh size that had been recommended by Graham (1929) and a recovery of the tilapia fishery.

The introduction of exotic tilapiines especially the Nile Tilapia in Lake Victoria and their impact on the fisheries

Of all the tilapiine fishes described so far (Trewavas 1983), *Oreochromis niloticus* Linne' is the most widely distributed species having been introduced to most parts of the world. Before fish transfers early in the last century, this fish was restricted to its natural range extending from the Nile system to Israel, to West Africa, Lakes Turkana and Albert (Lowe-McConnell 1958). Within East Africa, the species was known only from Lakes Albert, George, Edward and Turkana and the Nile system.

The first introduction of *O. niloticus* into Lake Victoria probably occurred in the early 1950s. Welcomme (1966a, b; 1967) reports that *O. niloticus* was stocked into Kagera river (Uganda part) in 1954 via the Koki lakes which had earlier been stocked in 1936 from Lake Bunyonyi. The origin of these stockings was Lake Edward. Later stockings of Lake Victoria in Kenya and Tanzania waters between 1956 and 1958 with fry from Kajjansi Fish Ponds relied on broodstock from Lake Albert. More stockings were carried out from Entebbe (Uganda) between 1961 and 1962. There were also direct escapes into the lake and other water bodies in the basin following the El-nino rains of that period. Still, towards the end of 1950s to mid -1960s, *O. esculentus* and *O. variabilis* were the dominant species by number landed in Kenya (61.6%) and Uganda (72.7%) (Balirwa *et al.*, 2003). Even with the stocking of the tilapias including the Nile tilapia, the native O. *esculentus* and *O. variabilis* still accounted for 54% of the fish catch from the Ugandan part of the lake up to1967, and the influence of the introduction of the exotic species on the indigenous species populations was more noticeable only after 1977 (Balirwa *et al.*, 2003). The trends clearly show that the impacts of species transfers can take long to manifest.

Several of the introductions in Lake Victoria may have occurred as a result of hybridisation experiments carried out at the Kajjansi Aquaculture Centre, and from dams that were stocked in 1951 with fry from Kajjansi (Welcomme, 1981). For example, records show that the Kajjansi experiments also involved *O. aureus* (brought from Israel in 1962), *O. honorum* and *O. mossambicus* (from Zanzibar in 1964), *O. niloticus* (from Lake George in 1953) and *O. niloticus* (from Lake Turkana).

Genetic and population impacts due to introduced tilapiines

Tilapias interbreed under both natural and artificial conditions (Lowe-McConnell, 1958,1959; Elder & Garrod, 1961; Elder *et al.*, 1971). *O. esculentus* x *O. niloticus* hybrids were produced under experimental conditions (Lowe-McConnell 1958). Welcomme (1967) reported two naturally occurring hybrids (*T. rendallii* Boulenger x *T. zillii* Gervais and *O. variabilis* x *O. niloticus*). The network of sources and destinations of tilapia in the Lake Victoria basin suggests that even though the most common tilapia from the lake is the "Nile tilapia", there are several genetic variants from the original pure "Nile tilapia" stocks of Lake Albert. Hybrids between *T. zillii* and *O.variabilis* have often been encountered in fishing experiments since 1988. FIRRI has also been carrying out further hybridisation experiments at Kajjansi that involve crossings between Lakes Albert and George strains and experiments involving "Red tilapia" from Thailand have been considered. It is thus clear that for the most part, the 'Nile tilapia' in Lake Victoria has a mixture of traits that have not fully been genetically characterised.

The possible divergence between tilapia populations within the Lake Victoria basin could be due to several factors including inter-specific hybridisation, founder population effects, multiple sources of seed, escapes, and isolation of populations in the diverse lake habitats and satellite water bodies in the Lake Victoria basin. For example, the Lakes Albert-Edward origin of *O. niloticus* was considered to represent *O.niloticus eduardianus* (Trewavas 1983). Apart from *O.niloticus*, other tilapines introduced into Lake Victoria between 1951 and 1962 were *O. leucostictus*, *T zillii*, and *T.rendalli* - the last originating from Zambia. *T. zillii* Gervais were stocked in Lake Victoria in 1954, while *O. leucostictus* Trewavas and *T. rendalli* are thought to have also gained access to the lake from fish ponds (Lowe-McConnell 1956). The picture of introductions is somewhat confused as Trewavas (1983) points out that *O. leucosticus* came originally by accident with *T. zillii* from Lake Albert. She also notes that the lake was stocked with the Lake Turkana subspecies of *O. niloticus* (*O. niloticus vulcani*). However, due to the dominance of *O. niloticus* morphological patterns (e.g. the banded caudal fin), the most dominant tilapia in Lake Victoria could be described only as a form of *O. niloticus* (Balirwa 1992) with mixed traits.

Spatial distribution and stock density of tilapiines

In the main Lake Victoria, the two native tilapiine species usually occurred in shallow water habitats with *O. esculentus* found over mud bottoms located in sheltered bays and *O. variabilis* occurring more abundantly off exposed parts of the shores (Lowe-McConnell 1956,1982; Fryer 1961). In some African lakes where *O. niloticus* is endemic, shallow areas have been shown to be important in the biology of the species. For example, in Lakes Albert and Turkana, Lowe-McConnell (1957, 1958) observed that *O. niloticus* was found only around the edges of the lakes; in Lake Edward, the species was found well away from the shore while in Lake George, it was found all over the lake but was less common near papyrus-fringed shorelines.

Studies in Lake Victoria suggest that the distribution of *O. niloticus* within lakes may vary with ecological conditions (Balirwa 1998). Since the disappearance of the native species due to over-fishing and hybridisation (Ogutu-Ohwayo 1990), these habitats have become dominated by the Nile tilapia, *Oreochromis niloticus*, even though several other endemic species also still occur in the same habitats.

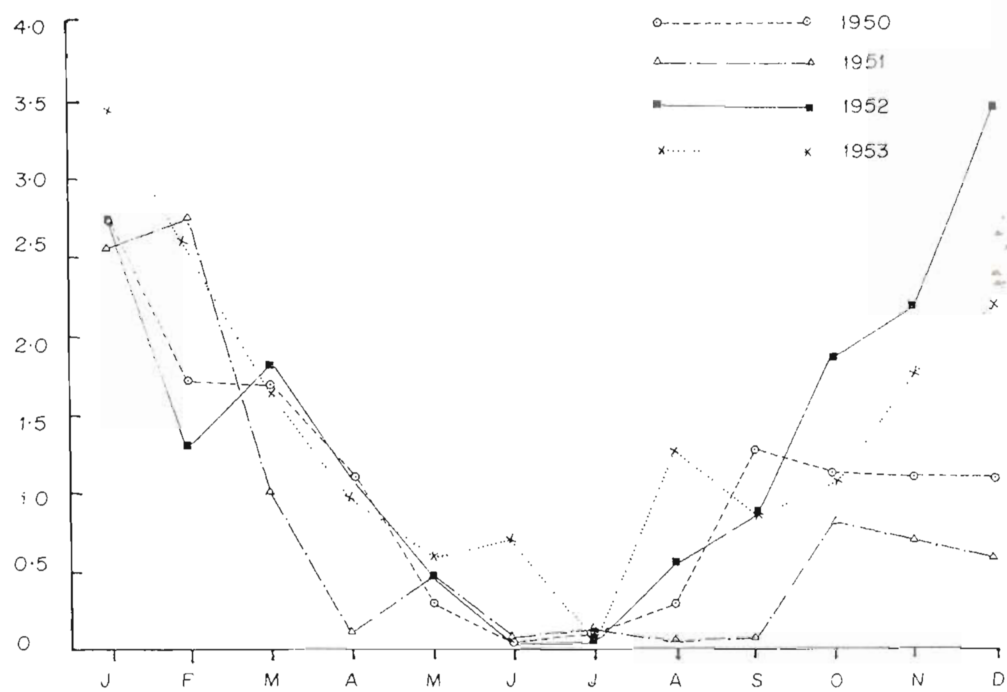

Fig. 4.4.1. Seasonal catch per 5 inch mesh gill net of *Oreochromis esculentus* at Bukakata and Nakifulube with fish originating from Sesse Islands and Kowe Islands respectively for the years 1950-1953 (Source: Lowe McConnell, 1956)

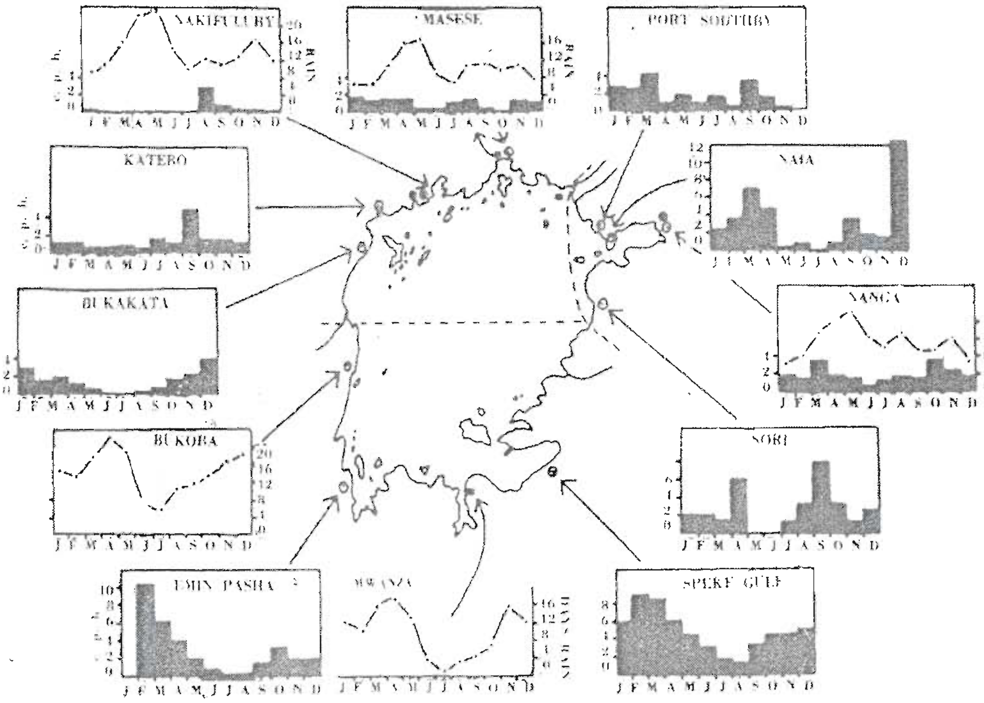

Fig. 4.4.2a. The seasonal distribution (catch per net = c.p.n) of *Oreochromis esculentus* in 5-inch gill nets from various stations during 1952 and, for five stations, the number of rainy days per months.

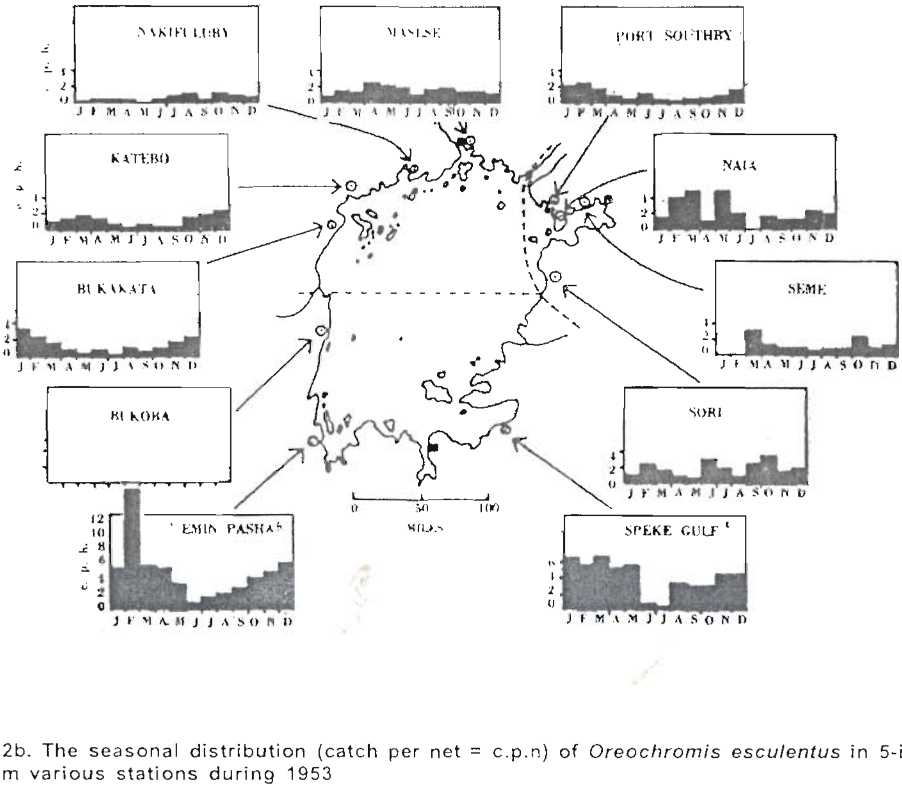

Fig. 4.4.2b. The seasonal distribution (catch per net = c.p.n) of *Oreochromis esculentus* in 5-inch gill nets from various stations during 1953

Studies carried out on the native tilapiines (*O. esculentus* and *O. variabilis*) in the 1950s confirmed seasonal and spatial variations, distribution and abundance patterns (Figs. 4.4.1, 4.4.2 a,b). Based on the importance of shallow littoral habitats for fishes in the lake (Balirwa 1998), experiments undertaken focusing on the Nile tilapia between 1988-1998 and trawl surveys of 1999/2000 revealed the following patterns:

1. Macrophyte-dominated shores are the most important habitats for the Nile tilapia in northern Lake Victoria and papyrus shores support mostly tilapia. Previously, these were the *O. esculentus* habitats.

2. *Phragmites* and *Typha*-dominated shores, which also tend to be more exposed and have mostly sandy bottoms, also support *T. zillii* in addition to *O. niloticus*. These habitats were previously occupied by *O. variabilis*.

3. Despite the dominance of the Nile tilapia, the littoral habitats also support significant quantities of endemic species (e.g. *Brycinus*, Haplochromines and *Astatoreochromis alluaudi*) but not the native tilapiines.
4. Nighttime experiments show that Nile tilapia densities were highest within a distance of 70 m from the shoreline.

5. Nile tilapia is more abundant in habitats that are usually in less than 3 m deep-water areas. Within these habitats, one night's fishing yields as much as 47±3 $kg.ha^{-1}$ of Nile tilapia equivalent to 65% of the biomass of all the fish.

6. Beyond 70 m away from the shore, in 3 - 5 m habitats the fish biomass drops to 6 $kg.ha^{-1}$ mostly made up of Nile perch juvenile fish, a pattern often reported in trawl surveys, .

7. In the 4-10 m depth range at a distance of at least 500 m away from the shore, the 1999 trawl data revealed that Nile tilapia comprised of 13% of all the fish biomass, while in 2000, trawl data revealed a Nile tilapia contribution of 32% of the total fish biomass, indicating the need to know more about the shallowest end of the inshore zone.

Breeding cycles in the "Nile tilapia" of Lake Victoria

Nile tilapia breeds throughout the year (Welcomme, 1968) but breeding peaks can be discerned (Fig. 4.4.3). The relationship between breeding, the spent (Gonad state VII) and ripe (Gonad state V&VI) in Lake Victoria Nile tilapia suggests May - June and November - December as peak breeding period (Balirwa, 1998). Therefore, reports of high Nile tilapia catches during such periods indicate that breeding fish are being harvested. In contrast to seasonal catch trends of the native tilapiines (Fig. 4.4.1) where less fish was subjected to capture during the rainy seasons, much less is known about seasonal catch characteristics of the Nile tilapia, but generally, reports of low catches during intervening months are an indication of dispersion away from lakeshores after peak breeding.

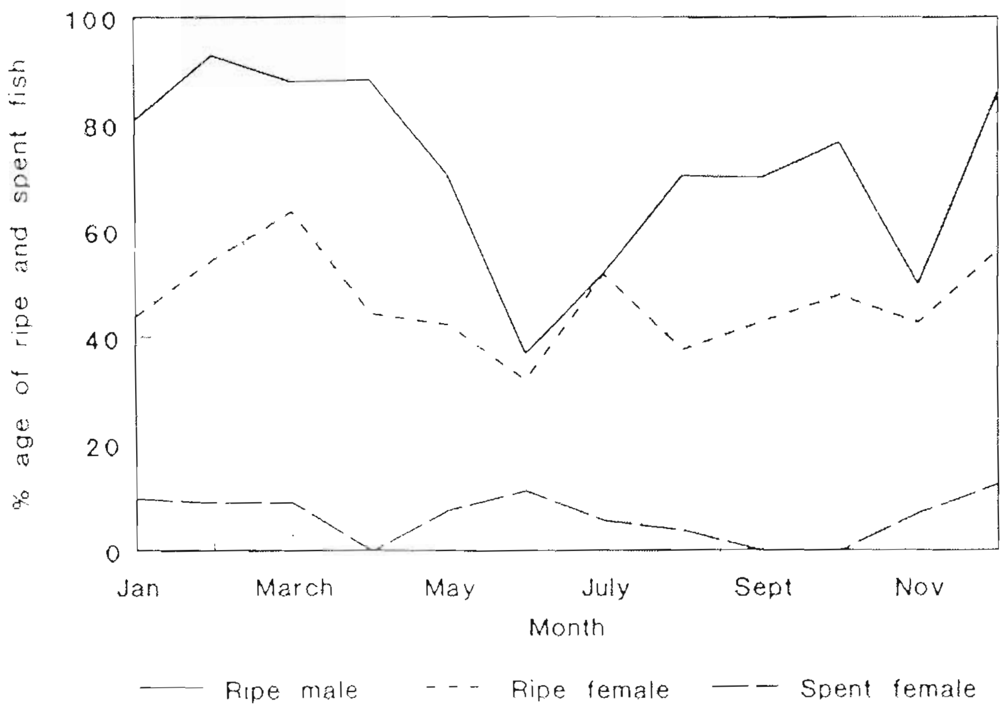

Fig. 4.4.3. Monthly ripeness (Gonad states V and VI) and the spent condition (Gonad state VII) in Lake Victoria fish (Balirwa, 1998).

Trophic ecology in the Nile tilapia

As in the native Lake Victoria tilapiines (*O. esculentus* and *O. variabilis*), the introduced *O. niloticus* was in the earlier stages of its colonisation of the lake shown to be a phytoplanktivorous and bottom feeder (Welcomme, 1968). Since the species had been shown to ingest and digest blue-green algae in Lake George (Moriarty 1973; Moriarty & Moriarty 1973), many accounts of the feeding ecology

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of the Nile tilapia (e.g. Harbott, 1975; Getachew & Fernando, 1989; Getabu, 1994) propose the same ecological niche for the species in Lake Victoria. Some of these observations underestimate the change in diet of the fish as observations have clearly shown that in Lake Victoria, the food of the Nile tilapia has become more diversified and includes *Caridina*, chironomids, chaoborids, molluscs and bottom detrital matter (Balirwa, 1992). Using stomach main contents as indicators of the relative importance of different items (Fig. 4.4.4), Balirwa (1998) has further shown that even these items (molluscs, *Caridina*, insects and algae) vary with season (Fig. 4.4.5), a reflection in the seasonal abundance of prey items. Chironomids are particularly important in the Nile tilapia's diet during the long dry season (December - February) and least important during the short dry season (July - September) when *Caridina* prawns become a common dietary item for the fish. In addition, small fishes such as *Rastrineobola* and tilapia or haplochromine fry may also be ingested by the Nile tilapia. The opportunistic-omnivorous feeding behaviour of the Nile tilapia in Lake Victoria since the disappearance of the haplochromines while demonstrating the general principle of flexibility in the feeding of fishes also shows a new trend in the species feeding habits in Lake Victoria.

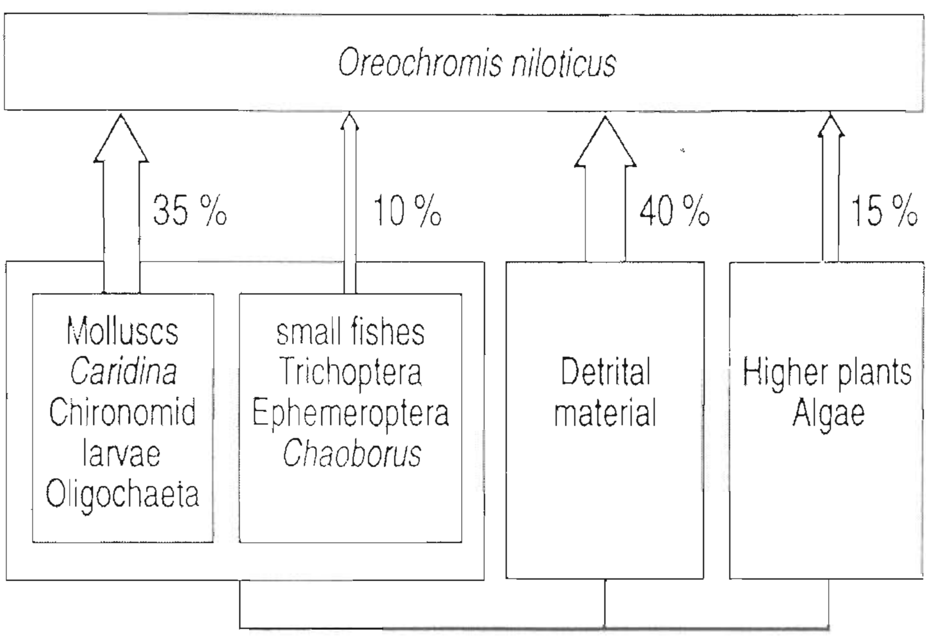

Fig. 4.4.4. Links in the trophic structure involving *O. niloticus* from the littoral zone of northern Lake Victoria; only food items regarded as main contents in stomachs of the fish between 1995 and 1999 are considered; size classes are not considered; the percentages given are estimates of the likely nutritional value in energy terms according to the relative importance of grouped categories in relation to assumed C:N ratios (Balirwa, 1998).

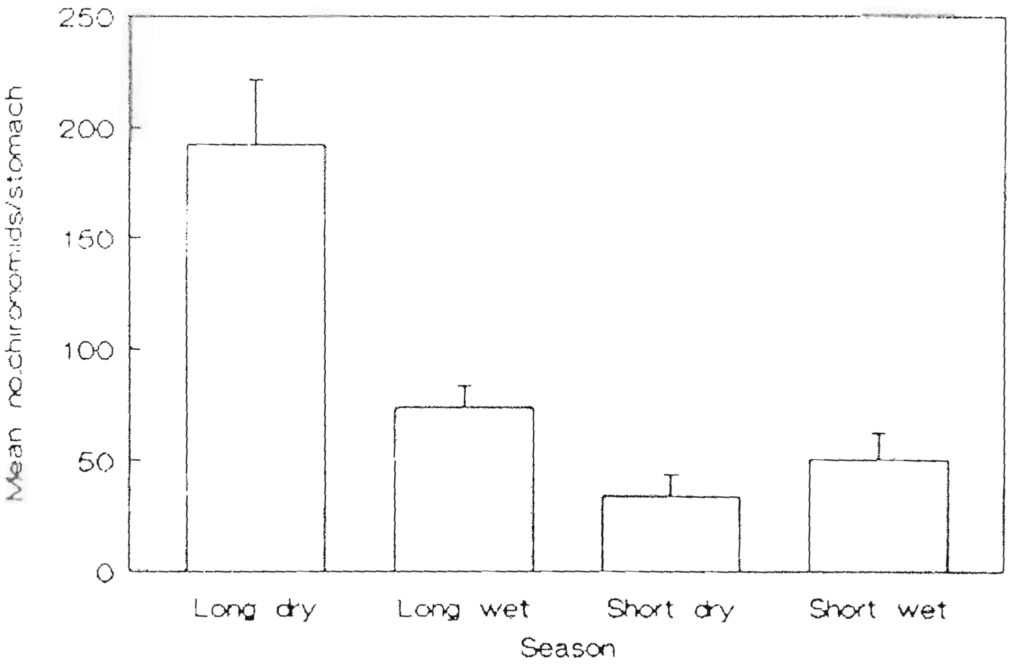

Fig. 4.4.5. Seasonal variations in the quantity (mean number per stomach ± SE) of chironomids found in *O. niloticus* stomachs (n= 451) between 1995 and 1996 in the littoral zone of northern Lake Victoria (Balirwa, 1998).

Fishery Characteristics

Based on the estimated 2000 km long shoreline including island shores in the Uganda part of Lake Victoria, inferences can be made about spatial characteristics of the tilapia fishery. Using the 4 m depth counter as the outer limit of the littoral zone (Balirwa 1998), the corresponding area from the vegetation fringes is enclosed within 500 m. Although there are diverse shoreline features (e.g. swampy, rocky and sandy beaches), it has been observed that the Uganda part of the shoreline is associated mostly with wetland vegetation. Thus using the 2000 km shoreline length, and 500 m distance from the shore, the calculated area of the Ugandan part of Lake Victoria available as a tilapia fishery is equivalent to about 1000 km^2 supporting about 20% of total production from the lake.

From the Frame Survey Report of 2000 it has been established that, 12,848 boats (with paddles) out of a total of 15,544 fishing boats are operated. Fishing boats with paddles (i.e. without outboard engines) mostly operate inshore and thus mostly target tilapia. The Frame Survey Report also gave a figure of 597 landing sites. These data lead to the following estimates. There are about 41 landings per km of shoreline; with 82% of boats (paddled) operating mostly in near-shore habitats; there are at least six fishing boats per km of shoreline; there is one cast net per km of shoreline also occupied by about six traps. These data translate into much more Nile tilapia caught than is estimated in production figures.

Commercial Catch Monitoring

The greatest quantity of Nile tilapia occurs in shallow (less than 5 m deep) habitats but; most of the tilapia caught from the small paddled boats in the vicinity of many landing sites passes through the inspection checks by 0700h. The Fisheries staff begin recording fish usually after 0800h when most tilapia have already left the landing or exchanged hands between fishers and traders. When checked against potential tilapia landings, it is estimated that 40 ± 10% of actual catch may be unrecorded. Temporal variations in the density and composition of nets set and shifts in tilapia fishing grounds suggest that just as in the native fishery, the Nile tilapia also exhibits localised populations. A supplementary part of the catch due to cast-netting is also unrecorded. Other data (Balirwa 1998) also show strong seasonal and diurnal variations in abundance and movements associated with breeding and feeding patterns. Although the Frame Survey Report of 2000 does not mention the widespread use of 3" - 4" mesh size nets that are permanently set along the shore, these nets in addition to the active methods of capturing tilapia (e.g. using scare techniques) contribute to the existing fishing effort exerted on the fishery but is under-represented in production estimates.

The biology and ecology of tilapia introduced into Lake Victoria in comparison to the native *O. esculentus*

When in the 1960s the stocked tilapiines started appearing in commercial catches in various parts of Lake Victoria, some studies aimed at revealing emerging patterns of distribution of the introduced species. Welcomme (1966), observed an apparent recovery of the endemic tilapiines (*O. esculentus* and *O. variabilis*) which was attributed to the El-Nino rains of 1960-1961. Although *O. esculentus* grows to 24 - 26 cm total length (equivalent to a weight of 265 g) in the first three years of life and to 30 cm (516 g) by the sixth year, the selectivity range of the four and a half-inch nets covers all tilapia fish from 26 cm to larger sizes of fish.

With the establishment of all the stocked species it was also observed that large catches of *O. esculentus* (which tended to occur during the rainy season) were negatively correlated with Nile perch catches but large catches of *O. variabilis* and *T. zillii* were positively correlated with Nile perch. These patterns indicate the response trends of fisher-folk to the seasonal behaviour of the fish, with fishers of the time targeting tilapiine fishes. The fishers can thus be considered as prudent predators switching between prey (*O. esculentus*) and other "less desirable" species.

Over-fishing may explain why the apparent recovery of the native tilapiines did not last long. However, using catch in a particular season as an index of breeding period may not provide the true picture of breeding. Between 1950 and 1953, low catches of *O. esculentus* in the Ssese and Kome Islands (Fig. 4.4.1) suggest that the lowest catch occurred during the main rainy season (March-June) while more fish were caught towards the beginning, and during the dry season (November, December, January). The seasonal distribution patterns of the native *O. esculentus* in different parts of the lake (Fig. 4.4.2a,b) suggest that abundance trends vary among locations and differences are sharpest between the north and southern parts of the lake and between years. For example, in the Emin Pasha and Speke Gulfs to the south, peak abundance during 1952 occurred during February (Fig. 4.4.2a) but no such pattern can be discerned for Masese, the northern most location sampled, where, there was no distinct peaks during both 1952 (Fig. 4.4.2a) and 1953 (Fig. 4.4.2b). Similar assessments need to be carried out on the Nile tilapia.

Management challenges for the tilapia fishery of Lake Victoria

In comparison to marine ecosystems, the confined inland fisheries such as Lake Victoria are particularly prone to degradation through a combination of over-fishing, exotic species stockings and pollution from the catchment. In addition, habitat loss through removal of riparian vegetation causes changes in fish community structure similar to what can be experienced in coastal zones of the marine ecosystem.

The present fish populations of Lake Victoria and the commercial fishery in particular, are dominated by the stocked fishes - the introduced predator, the Nile perch, *Lates niloticus,* and several tilapiine fishes mostly represented by the Nile tilapia, *Oreochromis niloticus*, as well as one endemic cyprinid, *Rastrineobola argentea*. These fisheries can also rapidly become uneconomical. For example, by 1920, it was already suspected that the original (native) tilapia fishery was becoming uneconomical in some parts of the lake, thus demonstrating the vulnerability of stocks to unrestricted access to the fisheries. The report of the first fishing survey of the lake of 1927/1928 (Graham, 1929) and subsequent reviews of the state of the tilapia fishery (e.g. EAFFRO, 1954-1960) all emphasized the dangers of over-fishing tilapia stocks and the recommendations first put forward by Graham:

1. Collection of special statistics to be used as a measure of the annual yield;
2. Complete control of the fishing power (fishing effort);
3. Restriction of the fishery to the 5-inch mesh gill nets have never been followed in full. In fact, tilapia introductions were conceived as a measure to re-vamp the fishery.

Only the first of these recommendations could be implemented through the Lake Victoria Fishery Services (LVFS), a function later transferred to the Fisheries Department but now largely abandoned due to decentralisation and the mushrooming fish landing points especially for tilapia. In spite of the surviving licensing policy for fishing boats, there has neither been total control of fishing power (number of fishing boats and number of nets), and the restriction of mesh size to the 5-inch nets (an important function of fishing effort) has not been achieved even though the success of the Nile tilapia encouraged enforcement. In fact, within 25 years (by 1957) of Graham's recommendations, the restrictions on gill nets below 5-inch were lifted to allow for capture of the smaller *O. variabilis* and to reduce pressure from the larger remnants of *O. esculentus* which were expected to escape capture and replenish the dwindling stocks. The relaxation has never been totally reversed, and the reviewed Fish Act relies on periodical instruments to protect vulnerable stocks. However, results of the statistics collected from fished areas within Napoleon Gulf demonstrated the localized nature of fish populations, and showed that a particular bay of the lake can be over-fished in a very short time and recovery may not occur in a very long time. The increased use of gill nets of less than 5-inch may lead to growth over-fishing. There is now need to provide statistical inference on the fishery characteristics from biological observations such as variations in size at first maturity and length-frequency distributions in different zones of the lake.

The tilapia fishery in particular faces primary challenges that have more to do with the nature of activities governing all aspects of the fishery, fishing practices, fishing gears (nets etc) and people. The secondary challenges have got to do with data collection and monitoring of stocks, but the two are inter-related. With an increase in Nile perch fish exports, the immediate challenge for the consumer is affording an increase in price by the tilapia consumers whose numbers have also increased. The increased landings have as a result of decentralisation not been routinely monitored. However, an equally demanding challenge is to record tilapia catch that leaves for the market before any systematic recording can take place. Trawl surveys provide biomass estimates that do not fully take into account shallow (<5m deep) fish stocks and tilapia densities can be under-estimated. Catch Assessment Surveys (CAS) are useful in as far as they provide a more realistic impression of catch at a particular time. However, with tilapia, seasonal and diurnal variations in catch require a more effective methodology of recording and evaluation trends. Seasonal patterns are associated mostly with breeding but protecting the breeding stock by limiting fishing for two months twice a year requires the commitment of the fishers themselves. This might be achieved where the breeding and nursery sites are localised. These sites occur in very shallow waters including rocky and sandy shores.

1. The "Nile tilapia" fishery of Lake Victoria comprises of several hybrid populations and these can rapidly be depleted through intense and selective fishing.

2. The high production of Nile tilapia in Lake Victoria greatly depends on coastal zone factors and abundant food sources but it is in the shallow areas where habitat degradation is most intense.

3. The increase in catch has been sustained despite natural fluctuations in production but part of the production is due to unsustainable fishing methods along the shallow shoreline habitats such as permanently set nets

4. There is need to develop improved understanding of the shallow shoreline zone fishery, and the quality of tilapia stocks.

5. The current practice by the small-scale fishers of leaving permanently set nets along the shores should be eradicated.

6. Strengthening data collection including standardising and ensuring compatibility between the old and new data sets calls for the development of an efficient lake- wide harmonised monitoring system for fisheries management purposes.

7. Monitoring catch/effort data is crucial to evaluating whether management has an effect or not and the function needs to be assigned to some authority.

8. There have been efforts to involve fisher-folk in the management of the fisheries. Beach Management Units (BMUs) are already recognised by law. A parallel system of administration, the Local Councils, (LCs) as well as districts' agencies e.g. Fish Guards, Fisheries Assistants, etc also operate and are directly involved in fisheries management. For the tilapia fishery, the above institutions present complex interventions because of fishers' mobility.