# Conservation and improvement of the stocks of the originally most important Lake Victoria tilapiine, *Oreochromis esculentus*, Graham 1929

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## Abstract

The tilapiine fish species *Oreochromis esculentus* was endemic to only lakes Victoria and Kyoga, and was the most important commercial fish species in these two lakes. This species started to decline steadily after the introduction of modern fishing technology until 1960 when the last reserves were depleted and is now apparently extinct from these two lakes. This situation prompted a search of water bodies in the two basin lakes for evidence of its possible survival in some localities. Therefore a study of four satellite lakes in the Lake Victoria basin (Mburo, Kachera, Kayanja and Kayugi) and three (Nabisojjo, Kawi and Lemwa) in the Kyoga basin were investigated for the presence of *O. esculentus* using an experimental fleet of gill nets to try and assess the populations that would be useful in conservation efforts. *O. esculentus* were relatively most abundant in Lake Nabisojjo (58.1 %), followed by Kayanja (22.6 %), Lemwa (14.2 %), Mburo (6.3 %), Kachera (5.9 %), Kawi (1.7 %) and Kayugi (1.4 %). The fish examined was 7.5- 38.7 cm total length (tl) with a modal size of 16-21 cm tl compared to records of 30-32 cm in Lake Victoria. The largest fish was from Lake Kayugi 38.7 cm, followed by Kachera (28.5 cm), Kayanja (28 cm), Nabisojjo (26.7 cm), Mburo (26 cm) , Kawi (25 cm) and Lemwa (24.5 cm) tl. The fish had an overall mean condition factor k of 1.77±0.02 as compared to historical records of 2 in Lake Victoria. Fish from Lakes Kawi and Kachera had the highest k (1.92± 0.02) followed by Kayugi (1.90 ± 0.03), Lemwa (1.78 ± 0.03), Mburo (1.71 ± 0.01), Nabisojjo (1.65±0.02 and Kayanja (1.50 ± 0.02). Diatoms were previously recorded as the best food for *O. esculentus*. Blue green algae especially *microcysts,* were the most dominant item ingested in Lakes Kachera, Mburo and Lemwa. *Planktolyngbya* was most important in Kayanja, while the diatom *aulacosira* was most important in Kayugi and Kawi and detritus in Nabisojjo. Size at first maturity was 20.5 cm tl in Kayugi, 19.4 cm in Nabisojjo, 17.2 cm in Lemwa, 16.8 cm in Mburo and Kachera, 15.6 cm in Kayanja and 12.5 cm in Kawi. Originally, *O. esculentus* matured at 26-27 cm in Lake Victoria and 21 cm tl in Kyoga. There were more males than females (1:0.83) as was the case in historical records. Sex ratios were in Lake Mburo 1:1.1, Kachera 1:0.9, Kayanja 1:0.85, Kayugi 1:0.97, Nabisojjo 1:0.69, Kawi 1:0.52, and 1:0.75 in Lemwa. Fecundity was directly proportional to size of *O. esculentus* and the highest was (963±148 eggs) in Lake Kayugi, followed by Lemwa (532 ± 18), Kachera (518 ± 24), Kawi (507± 32), Kayanja (468 ± 184), Nabisojjo (429±11) and Mburo (341±19). *O. esculentus* from Lake Kayugi where diatoms (*aulacosira*) dominated in their diet were the largest and had the highest condition factor. This indicates that diatoms were important food and is valuable in the survival of *O. esculentus*. On this basis, Lake Kayugi is the best source of *O. esculentus* either for restocking or for captive propagation. However, with the shift of algal communities to blue greens the capacity for *O. esculentus* to assimilate blue greens should be investigated further.

**Keywords**: *Oreochromis esculentus*, tilapiines, Lake Victoria, Lake Kyoga, satellite lakes.

## Introduction

*Oreochromis esculentus* Graham, (1929) is endemic to lakes Victoria and Kyoga and a few satellite lakes in the basins of these lakes (Ogutu-Ohwayo, 1993). Up to the 1900s *O. esculentus* together with *O. variabilis* were the most important commercial fish species in these two lakes. Lake Victoria then contained large stocks of *O. esculentus* Graham, (1929). During the period 1905 to 1916, when gill nets were introduced into different parts of Lake Victoria, coupled with the growth of urban centers and communication around the lake, fishing industry assumed a commercial role with *O. esculentus* as one of the main target species (Mann, 1969; Miles and

Keenleyside, 1991; Balirwa, 1992). From 1930s to 1950s the catch dropped and the fish became smaller due to increased fishing pressure (Fryer and Iles, 1972; Fryer, 1973) and increasing use of small mesh sized gill nets (Witte and van Dansen, 1995). This made *O. esculentus* one of the most threatened fish species and deprived the people who depended on it for food and employment.

In Lake Victoria, Graham, (1929) recorded *O. esculentus* of 30 cm tl in Kavirondo gulf and 31 cm tl in the open lake. According to Greenwood, (1966), the modal adult size was 30-32 cm tl, although specimens 40-50 cm tl long were caught in the southern waters of Lake Victoria (Graham, 1929). In Lake Kyoga *O. esculentus* never exceeded 26 cm tl (Worthington, 1929).

Overall weight was proportional to the cube of the length ($100w= 2l^3$) and the condition factor **k** was **2** in Lake Victoria (Graham, 1929).

In Lake Victoria, *O. esculentus* fed on planktonic material collected from suspension (Fryer and Iles, 1972) especially diatoms (Fish, 1951; 1955; Lowe-McConnell, 1956; Welcomme, 1967; Bailey *et al.*, 1978). Schools of *O. esculentus*, followed concentrations of diatoms in the lake (Gee and Gilbert, 1967) suggesting that this was its preferred food item, although maximum growth in aquaria could be obtained on an unnatural diet of chopped worms S*tuhlmannia* spp., (Cridland, 1964). *Aulacosira* was usually the most abundant item in the gut contents and comprised 48.75 % of the total cells present in all fish stomachs (Payne, 1971).

The size at initial breeding seemed to be determined by the environment. In aquaria, breeding occurred at 10 cm tl, at the age of 5 months (Garrod, 1956). In a pond at Korongwe, Lowe (1955) found that both sexes had bred at 16-19 cm when they were less than seven months. In Lake Victoria, the smallest mature *O. esculentus* was 20-21 cm. Sexual maturity in both sexes occurred at a length of 25-27 cm tl (Graham, 1929, greenwood, 1966). The size at first maturity (in Lake Victoria) in the early 1950s was 19-23 cm tl, and 50% at 22-28 cm tl (Lowe-McConnell, 1956; Fryer and Iles, 1972). At the end of the 1950s the smallest mature fish were 18-20.5 cm tl and 50% maturity was at 22.5-23.8 cm tl in Smith Sound (Tanzania). In the Tanzanian waters of Lake Victoria it was 28 cm tl, in the Kavirondo Gulf (Kenya) 22 cm tl, in Jinja area 25-26 cm tl and in Sesse island 28 cm (Fryer and Iles, 1972). *O. esculentus* is a female mouth-brooder, without well-marked spawning seasons. Highest breeding activity occurred between September and May (Greenwood, 1966), although breeding fishes were found throughout the year (Trewavas, 1983). Females could have a succession of 3 or more broods in a spawning period and fewer eggs were produced in the last brood of a series than the first. The average interval between broods in *O. esculentus* in aquaria was 2 months, 28 broods being recorded from 10 pairs in 23 months. The number of eggs produced increased with the size of the female, ranging from 324 eggs in a fish of 17 cm tl to 1672 eggs in one of 36 cm tl (Graham, 1929).

Because of its high economic value, and since O. esculentus is only endemic in the Victoria and Kyoga lake basins, it was one of the first fish species to be extensively studied in lakes Victoria and Kyoga. It's ecology and biology in Lake Victoria was investigated by Graham, (1929) and in Lake Kyoga it was investigated by Worthington, (1929). However, very little was known on *O. esculentus* in the satellite lakes where remnants of its population are still present. The purpose of this research

therefore, was to gather information on the biological characteristics of this species in the satellite lakes and to compare the results with the historical records for lakes Victoria and Kyoga. These two lake basins have been sampled for comparison because they share a common evolutionary history, have similar native fish faunas (Graham,1929; Worthington, 1929) and have also had similar impacts by introduction of Nile perch, *Lates niloticus*, therefore, they can be considered to be similar for ichthyogeographical studies.

## Materials and methods

The study was carried out on lakes Kachera, Mburo, Kayanja and Kayugi in the Victoria lake basin and lakes Nabisojjo, Lemwa and Kawi in the Kyoga lake basin. Sampling was done using three fleets of identical multifilament nylon gill-nets. Fish were measured for total and standard lengths (tl and sl) in centimeters, weighed in grams and recorded. The specimens were dissected and the stomach fullness, sex and maturity stage of the fish determined. Female gonads at maturity stage v and vi and stomachs which had any food were removed and preserved in 5 % formalin solution in separate numbered bottles. The stomach contents were allotted a number of points according to the scheme modified from Hynes (1950) and the food categories were rated in proportion to their relative percentage volumes as spread out in a petri dish or slide. The importance of each of the food items was obtained from these points by calculating the percentage relative importance of the food in the stomachs. All the eggs in the two gonads of an individual fish were counted and was taken as the 'absolute fecundity'.

## Results

### Relative abundance

A total of 2495 *O. esculentus* were examined. *O. esculentus* were most abundant (relative to the rest of the species caught per lake) in Lake Nabisojjo (58.1 %), followed by Kayanja (22.6 %), Lemwa (14.2 %), Mburo (6.3 %), Kachera (5.9 %), Kawi (1.7 %) and Lake Kayugi (1.4 %) as shown in Figure 1.

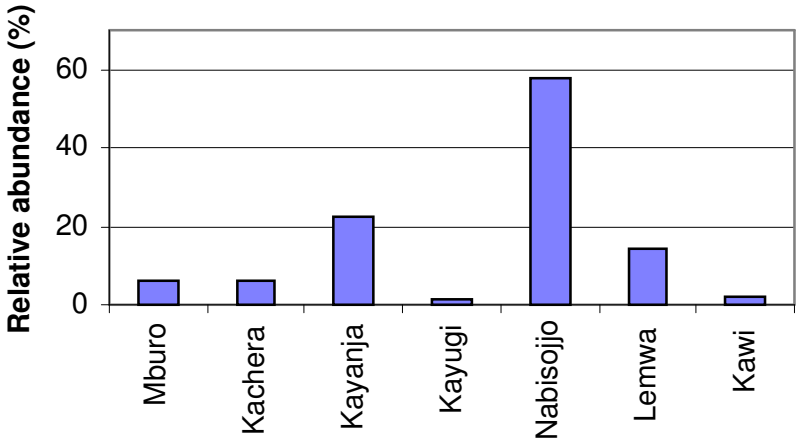


Figure 1. Abundance of *Oreochromis esculentus* in the sampled lakes in relation to other species

**Length frequency distribution of *Oreochromis esculentus***

A total of 2495 fish were examined from all the sampled lakes. The number of fish examined in the different size groups is illustrated graphically as shown in Figure 2. The size range of *O. esculentus* examined in all the lakes was 7.7 cm to 38.7 cm tl. Most fish lay in the size range of 16-20 cm. The biggest fish (38.7 cm tl) was encountered in Lake Kayugi. In Lake Kachera, the range was from 7 cm to 28 cm tl; Lake Mburo 11 cm to 26 cm tl, Lake Kayanja, 7 cm to 28 cm tl; Lake Kawi, 14 cm to 25 cm tl; and Lemwa, 10 cm to 24 cm tl and Lake Nabisojjo 7.5 cm to 26.7 cm tl.

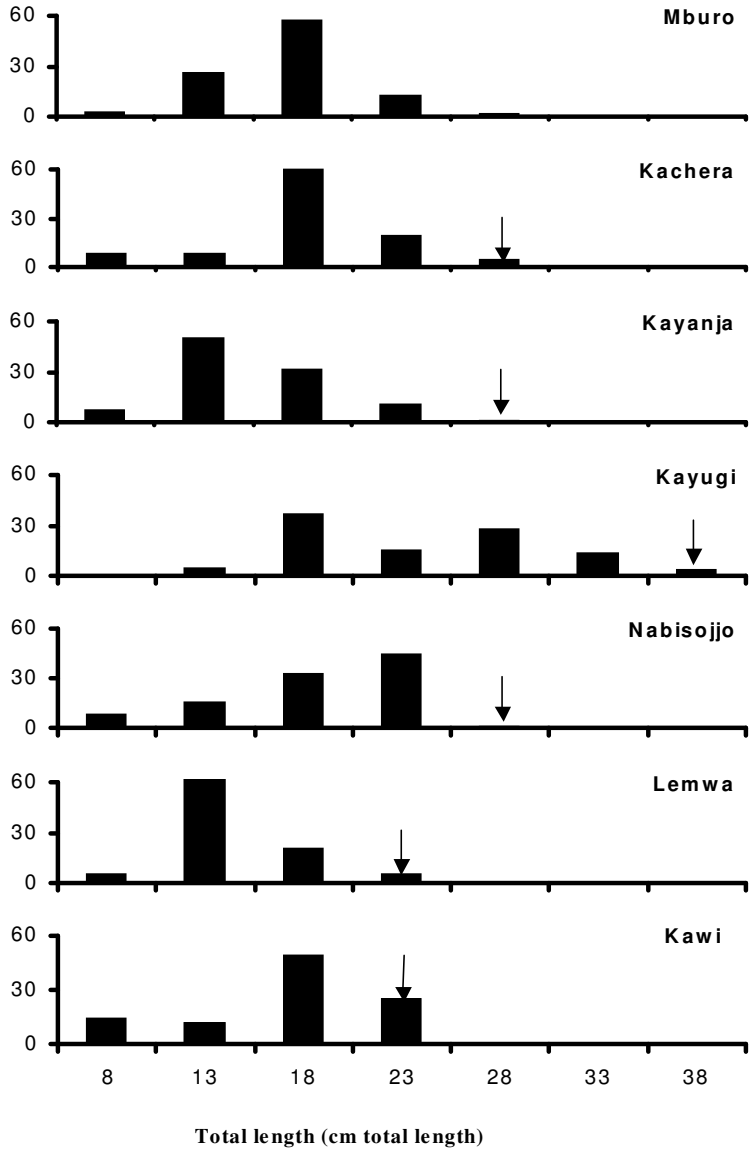


Figure 2. Length frequency distribution of *Oreochromis esculentus* sampled from the various lakes. Arrows show the largest fish encountered per lake.

**Condition factor**

On the overall the average condition factor k was 1.79±0.02 pooled data for all the sampled lakes. K factor was highest for *O. esculentus* from Lake Kawi (1.92 ± 0.02), followed by lakes Kachera and Kayugi, (1.89 ± 0.03/2), Lake Lemwa (1.77±0.03), Mburo (1.71±0.01), Lake Nabisojjo (1.65±0.02) and the smallest was (1.50 ± 0.01) from Lake Kayanja (Figure 3).

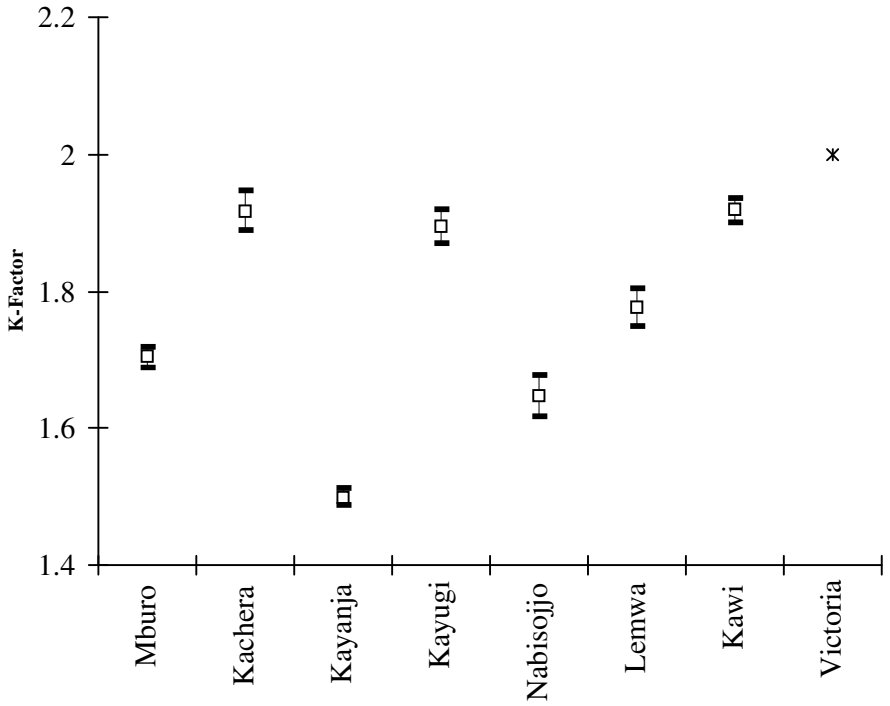


Figure 3. Comparisons of values of condition factor K of *Oreochromis esculentus* from the various sampled lakes

The tests using anova (single factor), showed no significant differences in the condition factor of *O. esculentus* between the sampled lakes, (p=0.05) as shown in Figure 3.

**Food of *Oreochromis esculentus***

In total, 615 stomachs of *O. esculentus* were examined. 51 in Lake Mburo, 157 in Lake Kachera, 91 in Lake Kayanja, 16 in Lake Kayugi, 84 in Lake Nabisojjo, 118 in Lake Lemwa, and 98 in Lake Kawi. The most important food items overall were *microcystis* (28.7 %), followed by *aulacosira* (16.4 %) and *anabaena* (13.8 %). There was variation in the diet in the different lakes.

The food items were then grouped into their various classes as green algae (chlorophyceae), blue-green algae (cyanobacteria) and diatoms (bacillariophyceae). Figure 4 shows their percentage occurrence per lake. Most of the food items belonged to the genera chlorophyceae (6 species), while the rest (cyanobacteria and

bacillariophyceae) contained one each. According to these groups the blue green algae were the most important overall (all lakes pooled together) 62.3 % followed by diatoms 16.4 % as seen in Figure 4.

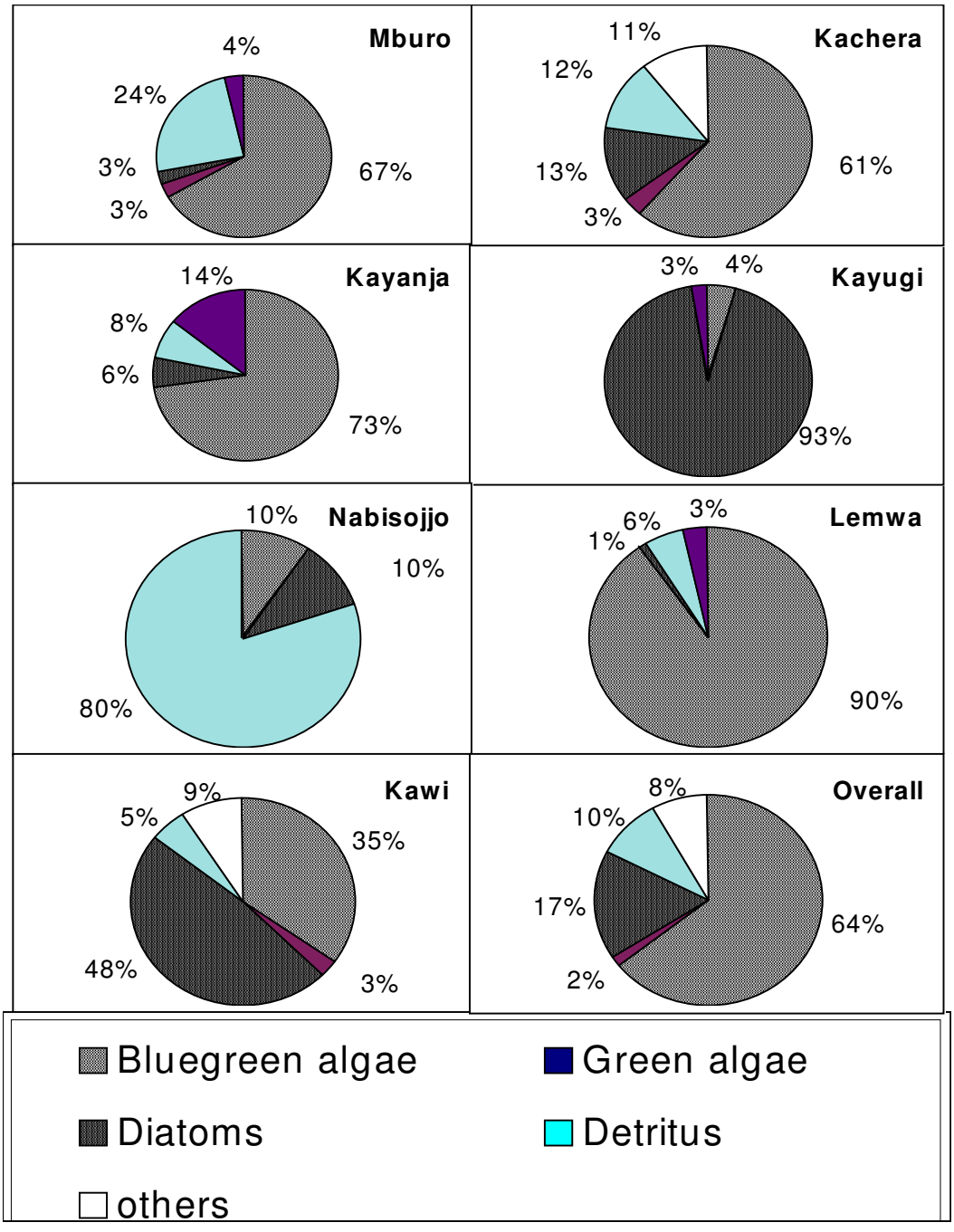


Figure 4. Percentages of the food categories encountered in stomachs of *Oreochromis esculentus*

**Size at first maturity**

There were variations in size at 50 % maturity of *O. esculentus* as shown in Table 1. Mid-classes were used in the graphical illustrations (Figure 5) which was used to

estimate size at first maturity between the different lakes. In Lake Kayugi, 50 % maturity size was approximately 20.5 cm tl and was the highest, followed by Lake Nabisojjo 19.4 cm tl that of lakes Kachera and Mburo 16.8 cm tl and 15.5 cm tl in Lake Kayanja was the lowest as seen in Figure 5.

Table 1. Size at 50 % maturity of *Oreochromis esculentus* from the various sampled lakes

| Lake | 50 % maturity size (cm tl) |
|---|---|
| Mburo | 16.8 |
| Kachera | 16.8 |
| Kayanja | 15.6 |
| Kayugi | 20.5 |
| Nabisojjo | 19.5 |
| Lemwa | 17.2 |
| Kawi | 12.5 |

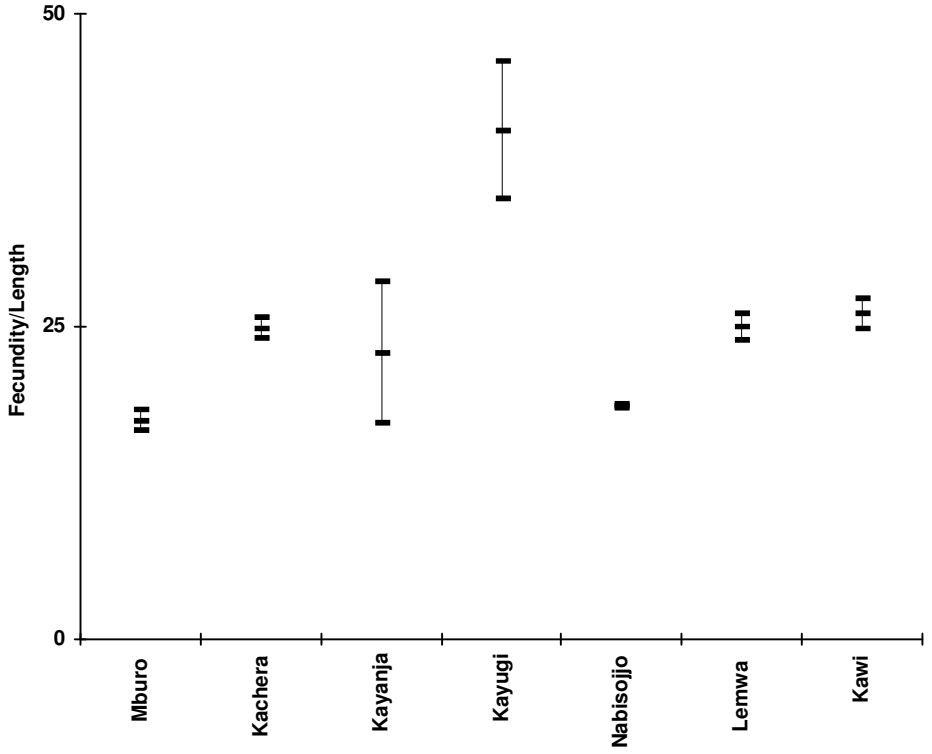


Figure 5. Comparison of fecundity per length (cm) of *Oreochromis esculentus* from different habitats

## Sex ratio

Total counts of females per male for the sampled lakes were made as ratios of male: female (m:f). This was repeated for all the lakes (pooled together) and was established as the overall sex ratio of *O. esculentus* examined. On the overall, 1297 males and 1079 females were studied giving a ratio of m:f = 1:0.96. In Lake Kachera, the sex

ratio was m:f = 1:0.9, Mburo m:f = 1:1.11. Kayanja m:f = 1:0.91, and Kayugi m:f = 1:0.97.

**Fecundity of *Oreochromis esculentus***

One hundred twenty eight ripe gonads were examined from all the sampled lakes; Twenty six (26) gonads from Lake Mburo, 42 from Kachera, 6 from Kayanja, 3 from Kayugi, 29 from Nabisojjo, 9 from Lemwa and 13 from Kawi. A total egg count per fish was regarded as the absolute fecundity as shown in Table 2. The examined gonads were from fish ranging from 14.6 to 30.2 cm tl. The smallest number was 157 eggs in a fish of 14.6 cm tl from Lake Kayanja and the largest was 1364 eggs in a fish of 28 cm tl from Lake Kayanja.

Table 2. Means of absolute fecundity and length (± standard error) for the sampled lakes. The total number of gonads examined was included. (tl= total length, wt= weight, n= number of studied fish).

| Means | Mburo | Kachera | Kayanja | Kayugi | Nabisojjo | Lemwa | Kawi |
|---|---|---|---|---|---|---|---|
| Fecundity | 341±19 | 518±24 | 468±184 | 963±148 | 429±10.8 | 532±28.18 | 507±32.43 |
| Length (cm) tl | 19.3±0.65 | 20.6±0.5 | 18.1±2.1 | 24.6±5 | 22.9±0.2 | 21±0.66 | 20±0.7 |
| Fec/leng ($f.cm^{-1}$) | 17.5±0.82 | 24.9±0.84 | 22.9±5.65 | 40.7±5.48 | 18.7±0.2 | 25±1 | 26±1.19 |
| Wt | 132±8.07 | 181±12.4 | 129±69.6 | 390±169.9 | 206±5 | 190±16.58 | 159±13.5 |
| No. **"n"** | 26 | 42 | 6 | 3 | 29 | 9 | 13 |

Following literature conversion Ricker, (1971), a general power and linear curve of the relationship between absolute fecundity and size (length and weight respectively) of pooled data from all sampled lakes were drawn. A power curve for the fecundity-length relationship was;

$$F = 1.253l^{1.569} \qquad r^2 = 0.5146,\ n = 128 \qquad (1)$$

A linear curve for the fecundity-weight relationship was:

$$F = 1.6957w + 195.13 \qquad r^2 = 0.6483,\ n = 128 \qquad (2)$$

where F is the number of eggs, l the total length of the fish in cm and w the weight of the fish in gm.

The graphs showed that absolute fecundity was positively correlated with size.

**Discussion**

Originally, the native tilapiine *Oreochromis esculentus* was the most abundant and important commercial fish species on Lake Victoria but today, it is apparently absent in the main lakes of Victoria and Kyoga. However, remnants of these species are seen to have survived in some of the satellite lakes in these two lake basins but are not the

most abundant where they occur. The size of the different populations has reduced from a modal size of 30-32 cm tl to the present modal size of 16-20 cm tl. There is also a reduction in the mean condition factor k from 2 in Lake Victoria to 1.77 in the sampled satellite lakes. *O. esculentus* was reported to be a phytoplankton feeder with a strong preference for the diatom *aulacosira* which used to be the most abundant food item in the diet. However, in the satellite lakes the blue-green algae especially the *microcystis* were the most dominant food item. This change in diet could explain the reduced species abundance, size composition, condition factor and size at first maturity. The apparently increased nutrient input in Lake Victoria (Hecky, 1993) was accompanied by higher blue-green algal biomass relative to that observed during 1960-1961. Such a shift in phytoplankton species composition might result in a lower efficiency of energy transfer to higher trophic levels, since the blue-green algae are generally considered a poor food source. There are practical considerations to be taken on the choice of the most suitable *O. esculentus* populations depending on the investigated ecological and biological aspects. The fishes that fed on the diatom aulacosira were the best, which shows that *aulacosira* is very important food of *O. esculentus* and occurs abundantly in Lake Kayugi.

**Conclusions**

Some conclusions and recommendations are proposed as follows:

- There was still *Oreochromis esculentus* in some satellite lakes.
- The population characteristics varied between the sampled lakes.
- Generally, there was a shift in the algal communities dominance from diatoms to blue greens and this could be a sign of environmental degradation.
- *Oreochromis esculentus* from Lake Kayugi where diatoms (especially *aulacosira*) dominated in the diet, were the largest, had the highest condition factor and reproduction potential. This indicates that diatoms were important food and valuable in the survival of *Oreochromis esculentus*.
- Lake Kayugi is being protected by traditional myths (e.g no boat is allowed on the lake except rafts; no drawing water from the lake using sooty saucepans etc).
- The lakes especially Kayugi should be protected from fishing malpractices.
- With the shift of algal communities to blue greens, further research should be done to investigate the capacity of *Oreochromis esculentus* to assimilate the blue greens.

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