# Reproductive biology of *Oreochromis niloticus* (L.) in the Nyanza Gulf of Lake Victoria

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**Abstract:** The reproduction of Nile tilapia, *Oreochromis niloticus* (L.), in the Nyanza Gulf of Lake Victoria was studied from June 1998 to May 1999. Length at maturity ranged from 28-30 cm TL for females and from 32-34 cm TL for males. Males were more abundant in all length classes >36 cm TL. Relative condition factor was above unity, except in August, October and May for males, and October for females. Gonadosomatic index (*GSI*) was low during the post spawning period (July to October) and high during the protracted breeding period (December – June).

## *Introduction*

The Nile tilapia, *Oreochromis niloticus* (L.), was introduced into Lake Victoria in the 1950. Since then it has rapidly increased to become the most dominant species in the tilapia fishery (Ogutu-Ohwayo 1990). Presently it is the third most important commercial fish species in Lake Victoria.

There is limited information on reproductive bionomics and spawning times of *O. niloticus* (Lowe (McConnell) 1959; Welcomme 1967; Fryer & Iles 1972). Furthermore, no systematic study on gonadal development has been carried out on *O. niloticus*, supported by data on gonad weight, gonad histology or assessment of the external factors (such as light, rainfall and temperature) affecting these patterns. The present study examines the reproductive patterns of *O. niloticus* in Kenyan waters of Lake Victoria. The study on gonad histology is yet to be completed and will be reported to a future FIDAWOG meeting.

## *Materials and methods*

Fish samples were collected from both seine nets and trawl catches. For each fish, total length (TL, nearest cm) and total weight (g) were measured. The relative condition factor, *Kn* (LeCren 1951) was obtained using $Kn = W/aTL^b$. Each fish was opened and the maturity stages assigned according to the classification of Nikolski (1963). The gonads were then removed and weighed (nearest 0.01 g). The weight of the gonad relative to the body weight (W), i.e. the gonadosomatic index (*GSI*), was calculated as:

$$GSI = (Weight\ of\ ovary\ /\ Weight\ of\ fish) \times 100$$

For female fish, a small piece of the ovary, representing a complete cross-section of the gonad, was weighed and placed in Bouin's fixative for histological processing. The remainder was placed in Gilson's fluid to estimate fecundity and to assess seasonal changes in oocyte diameter at a later date.

## Results

*Length-weight relationship and condition factor*

The length-weight relationships were determined for each sex.

| | | |
|---|---|---|
| Males | $W = 0.013 \times TL^{3.13}$ | $r^2 = 0.99$, $n = 536$; |
| Females | $W = 0.012 \times TL^{3.15}$ | $r^2 = 0.97$, $n = 351$. |

No significant difference was found between the gradients of the relationships for the two sexes (t test, $P > 0.05$), so the data were pooled.

| | | |
|---|---|---|
| Combined sexes | $W = 0.0128 \times TL^{3.14}$ | $r^2 = 0.98$, $n = 887$. |

Seasonal changes in condition factor (Fig. 1) exhibit little variation and are probably influenced by change in food.

*Size at first maturity*

The length at first maturity ($Lm_{50}$), defined as the mean length at which gonadal development had advanced to at least stage IV in 50% of individuals, showed significant differences between males and females (Fig. 2). The smallest ripe male *O. niloticus* found was 26.2 cm TL while the smallest ripe female was 23.3 cm TL. Fifty percent maturity was at 30 cm TL for females and 33 cm TL for males (Figs 2a, 2b).

Sex ratio

Males dominated the population structure for the majority of the year and for the population as a whole (Table 1). The overall sex ratio for the population was significantly different from 1:1 ($\chi^2 = 62.6$, $P < 0.05$). Females were more prominent in the smaller size classes (<30 cm TL; Table 2). The proportion of females declined significantly ($P < 0.05$) above 36 cm TL and no female *O. niloticus* >50 cm TL were caught.

Seasonal reproductive cycles

**Seasonal variation in the gonadosomatic index (*GSI*) of fish >12 cm was found (Fig. 3). In males the GSI rose from a low in June to August to a peak in November, followed by a slight fall through December and January. For females, a similar trend was found except the peak occurred later, in January and February.**

The proportion of each maturity stage confirms the reproductive cycles depicted by the *GSI* (Fig. 3). There was a lower proportion of mature fish between July and September. However, the high presence of stages IV and V between October and July is indicative of active gonad development. There was an increase in proportion of fish at stage VI in July and again in November and January, suggesting that spawning had taken place. Spent fish were found in most of the months indicating prolonged spawning. The seasonal changes in gonad development will be investigated as part of the histological studies.

## Discussion

*Oreochromis niloticus* in Lake Victoria shows a well-defined reproductive strategy, which has probably contributed to the success of the species in the lake.

Catches were dominated by males, especially between December and June, the main spawning period. During this time, males congregate in nesting arenas. Ripe females visit the arena to spawn but leave quickly and disperse. Active fishing methods such as trawls and seines used on nesting arenas result in catches being highly biased towards males. This is a frequent occurrence in the cichlid trawl fisheries on Lake Malawi (D. Tweddle, personal communication). This hypothesis will be further tested throughout the project.

The protracted spawning period confirms the species is a batch spawner, and probably able to rear several broods in any one spawning period. This multiple spawning behaviour has advantages in highly stressed environments. Recruitment in the population is a relatively high risk event through predation, especially on the juvenile life stages, which could potentially wipe out the reproductive output if only one spawning event occurred each year. To spawn on more than one occasion reduces this risk. Also individual fecundity is increased, by evading a trade-off between the volume of body cavity and fecundity (Nikolski 1963), and it may allow for an optimum egg size selection avoiding the possible conflict between egg number and egg quality (Miller 1979).

The earlier maturation of females in Kenyan waters contrasts with the findings of Balirwa (1998) in the Ugandan sector of the lake where males first spawn at about 28 cm TL and females at 32 cm. It also represents a reduction in size at first maturity since the early 1990s, when *O. niloticus* was reported to mature for the first time at an average length of 35 cm (Getabu 1992). This early maturation of the females in the Kenyan sector in recent years is again a tactic to maximise reproductive success (Charlesworth & Leon 1976; Stearns 1976), possibly linked to a population response to overfishing. Early maturing populations tend to grow quickly to reproductive size and then divert energy away from somatic growth to reproduction. As a consequence they do not reach such a large size. This could explain the dearth of females in the larger size groups; a phenomenon also found for Nile tilapia in Lake Turkana (Lowe (McConnell) 1959). This tactic has been adopted by many animals living in unstable environments where adverse biotic (competition, predation or overexploitation) and abiotic factors are prevalent (Charlesworth & Leon 1976), and could explain why Nile tilapias have successfully colonised the lake. This tactic contrasts with that adopted for stable environments where smaller fish put more effort into somatic growth and less into gonad development compared with larger counterparts, a mechanism that is more likely to increase their chances of survival and reproduction in subsequent years (Mann & Mills 1985; Cowx 1990). The females also show evidence of a response to intensive fishing pressure by reducing the size at first maturity. This is a common response in fish populations and it is used an indicator of overfishing (Caddy & Mahon 1996).

There is thus evidence to suggest that Nile tilapia in the Kenyan part of the lake displays a 'r'-selected life history strategy (Pianka 1970; Mann & Mills 1985) to survive the stressful conditions prevalent. The more intensive reproductive effort employed by females fits the theories of life history strategy expounded by Pianka (1970) and Stearns (1976), where natural selection has caused different fish forms to adapt to maximise fitness in specific habitats/environments. It could also be a mechanism to compensate for the intensive fishing pressure in the area.

*Acknowledgements*

The survey was funded by the European Union Lake Victoria Fisheries Research Project (Ref: ACP-RPR 227). I am both grateful to the Director, KMFRI and Lake Victoria Fisheries Research Project for their total support for this research work.

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**Table 1** Monthly variation in sex ratio in *O. niloticus* in the Nyanza Gulf of Lake Victoria (* denotes significance at 5 % level)

| Month | No. of males | No. of females | Male: female ratio | $\chi^2$ |
|---|---|---|---|---|
| June 98 | 80 | 56 | 1.43:1 | 4.24* |
| July | 18 | 29 | 0.62:1 | 2.57 |
| August | 40 | 25 | 1.60:1 | 3.46 |
| September | 17 | 18 | 0.94:1 | 0.03 |
| October | 35 | 33 | 1.06:1 | 0.06 |
| November | 46 | 33 | 1.39:1 | 2.14 |
| December | 108 | 74 | 1.46:1 | 6.35* |
| January 99 | 107 | 93 | 1.15:1 | 0.98 |
| February | 107 | 60 | 1.78:1 | 13.23* |
| March | 231 | 134 | 1.72:1 | 25.78* |
| April | 169 | 102 | 1.66:1 | 16.56* |
| May | 67 | 29 | 2.31:1 | 15.04* |
| Total | 1025 | 686 | 1.49:1 | 67.60* |

**Table 2** Percentage occurrence of males and females of *O. niloticus* in different size groups from the Nyanza Gulf of Lake Victoria.

| Size group (TL) cm. | n | % males | % females |
|---|---|---|---|
| 12-14 | 9 | 33.3 | 66.7 |
| 14-16 | 15 | 60.0 | 40.0 |
| 16-18 | 25 | 48.0 | 52.0 |
| 18-20 | 67 | 58.2 | 41.8 |
| 20-22 | 72 | 44.4 | 55.6 |
| 22-24 | 62 | 50.0 | 50.0 |
| 24-26 | 54 | 50.0 | 50.0 |
| 26-28 | 52 | 48.0 | 52.0 |
| 28-30 | 62 | 45.2 | 54.8 |
| 30-32 | 34 | 50.0 | 50.0 |
| 32-34 | 33 | 54.5 | 45.5 |
| 34-36 | 40 | 37.5 | 62.5 |
| 36-38 | 50 | 52.0 | 48.0 |
| 38-40 | 41 | 51.2 | 48.8 |
| 40-42 | 51 | 64.7 | 35.3 |
| 42-44 | 35 | 71.4 | 28.6 |
| 44-46 | 28 | 71.4 | 28.6 |
| 46-48 | 33 | 81.8 | 18.2 |
| 48-50 | 31 | 96.8 | 3.2 |
| 50-52 | 25 | 100.0 | 0.0 |
| 52-54 | 1 | 100.0 | 0.0 |

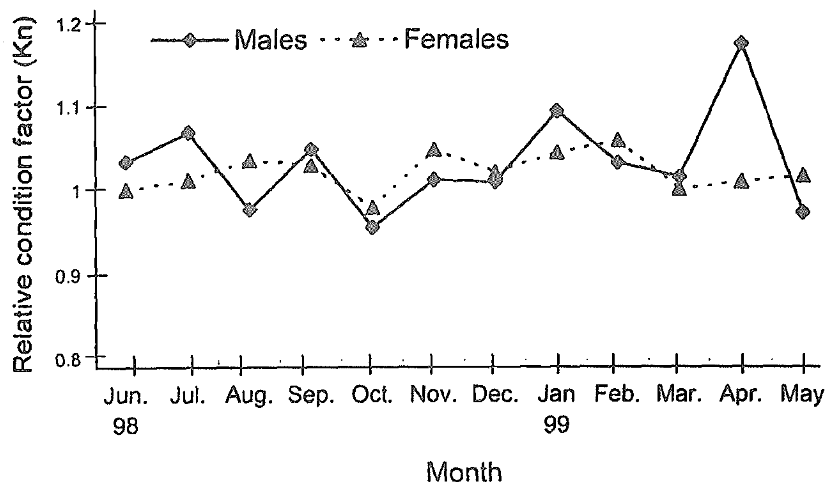


**Fig. 1.** Seasonal changes in relative condition factor of *Oreochromis niloticus* in Kenyan waters of Lake Victoria

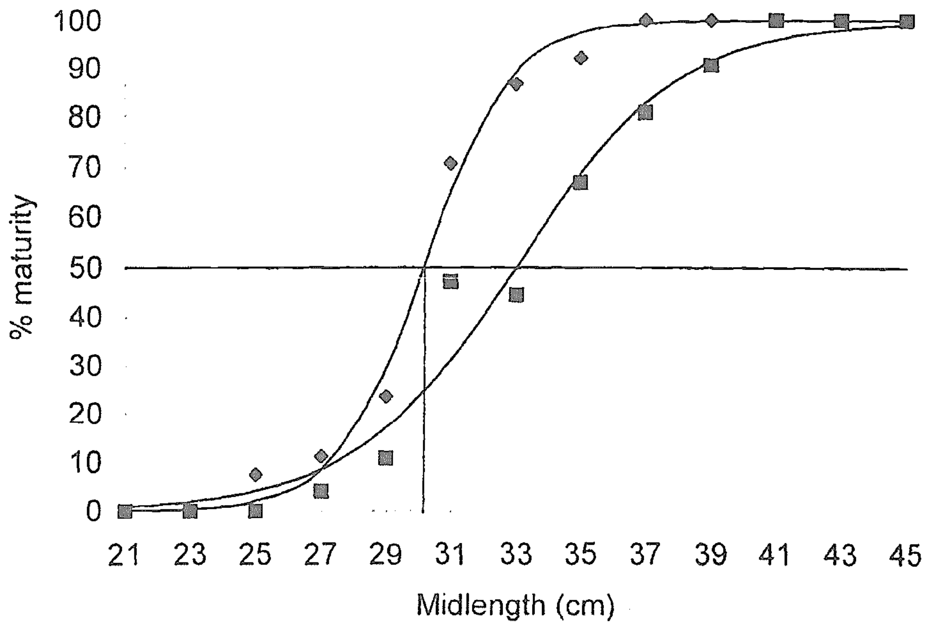


**Fig. 2.** Maturity ogives for male (■) and female (◆) *Oreochromis niloticus*.

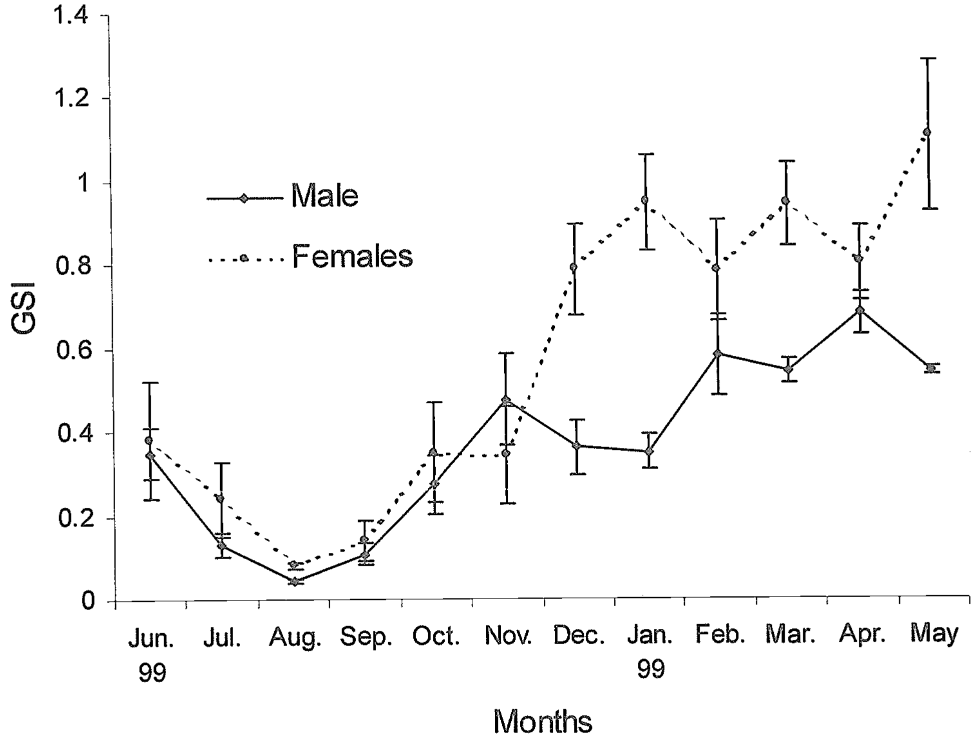


Fig. 3. Monthly variation in gonadosomatic index (GSI) of *Oreochromis niloticus* in Kenyan waters of Lake Victoria