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RESEARCH ARTICLE

# GROWTH AND MORTALITY OF NILE *TILAPIA*, *OREOCHROMIS NILOTICUS* (LINNAEUS, 1758) OF THE KAFUE FLOODPLAIN FISHERY, ZAMBIA

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**ABSTRACT**

Growth and mortality of *Oreochromis niloticus* of the Kafue Floodplain fishery was investigated between September, 2015 and November, 2015. Three stations that represent the major ecological habitats of the Kafue Floodplain fishery were selected. These were: Kafue Road Bridge (swamp), Namalyo (lagoon) and Kakuzu (riverine). Fish specimens were collected using gillnets that were set in the evening and hauled the next morning. Length measurements were taken from each fish specimen using a fish measuring board. Weight was measured using and electronic balance to the nearest one gramme. One-way Analysis of Variance was performed on all quantitative data using Statistix 9.0 software. *Oreochromis niloticus* showed a growth coefficient (k) of 0.22.The exploitation ratio was 0.4, implying that the decrease in *Oreochromis niloticus* catches in the Kafue Floodplain fishery cannot be attributed to over-fishing but may be due to natural mortality.



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## INTRODUCTION

The Kafue Floodplain is an important fishery in Zambia ranking fourth after Lake Tanganyika, Lake Bangweulu and Lake Kariba in terms of fish output The Kafue Floodplain fishery is located in the Kafue Floodplains on the Kafue River between the Itezhi-tezhi dam and the Kafue Gorge dam, covering an area of 6,500km$^2$(Zambia Department of Fisheries, 2008). There are Fifty-five known fish species in the Kafue Floodplain fishery, of which Twenty-three are of commercial importance. Cichlids account for eighty percent of all economically important fishes in the Kafue Floodplain fishery (Zambia Department of Fisheries, 2008). Total fish catches from the Kafue Floodplain fishery have been reducing gradually and the fishery seems not to be recovering from decreasing fish catches (Figure 1). For instance, in 1966 the Kafue Floodplain fishery produced a total catch of 10,709 metric tonnes but in 1980 this fishery recorded a total catch of only 7,741 metric tonnes (FAO-Fisheries report, 2010). Reasons for the decline in fish harvests have not been properly understood and investigated. The possible explanation to the decrease in *Oreochromis* fish catches from the Kafue Floodplain fishery is that the average water levels in the Kafue Floodplains have increased due to the construction of dams at Kafue and Itezhi-tezhi (Mung'omba, 1992).

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The other explanation to the decrease in fish yields from the Kafue Floodplain fishery can be attributed to the increase in fishing pressure (Mbewe, 2006). The general objective of the study was to investigate the growth, mortality and exploitation of *Oreochromis niloticus* of the Kafue Floodplain fishery. It is expected that the study will help to know whether or not there is over-exploitation of *Oreochromis niloticus* in the Kafue Floodplain fishery.

## MATERIALS AND METHODS

***Study area:*** This research was conducted in the Kafue Floodplain fishery (Figure 2) which is located about 50 Kilometres south from Lusaka, the capital city of Zambia. Three stations that represent the study area, were selected: Kafue Road Bridge (station I), Namalyo (station II) and Kakuzu (station III). These stations represent the different ecological habitats in the Kafue Floodplain fishery. Station I is the lower part of the Kafue River at a grid reference of 15˚50'218"S and 28˚14'110"E. It had still water and many hydrophytes ranging from submerged, floating and emergent types. Station II had a grid reference of 15˚50'185"S and 28˚14'126"E. This station is representative of a lagoon. It was characterized by low gradient and low water velocity. It was a typical Floodplain with high deposition of debris. Station III was within latitude 15˚50'166"S and longitude 28˚14'149"E. It is the upper part of the Kafue River. Kakuzu was characterized by relatively fast running water (Cowardin *et al*., 1979).

***Sample collection:*** Fish samples were collected from the selected sampling study sites using a fleet of gillnets of the mesh sizes ranging from 25mm to 190mm (Table1) according to methods described in the Gillnet survey Manual (Zambia Department of Fisheries, 2008). Gillnets of different mesh sizes were intended to catch fish specimens of different sizes. Fish were collected for three consecutive days at each station. The gillnets were set between 16:00 and 18:00 hours and hauled between 6:00 and 7:00 hours the following day.

***Data collection:*** Data for this research was collected from both the field and in the laboratory. Field techniques were used to collect length (mm) and weight (grammes) variables from each fish species while laboratory techniques were used to age (in years) each fish species. In the field, total length and standard length of a fish sample were measured to an accuracy of one millimetre using fish measuring boards. The Total length of each *Oreochromis niloticus* specimen was measured from the tip of the anterior part of the mouth to the posterior end of the caudal fin. Standard length was measured from the tip of the anterior part of the mouth to the mid-base of the caudal fin. A total of 259 *Oreochromis niloticus* specimens were sampled using gillnets. Body weight of individual tilapiine fish species was determined to the nearest 1.0 gramme using a kitchen balance. Using strong forceps, six (06) scales were removed from each fish; all from just above the lateral line three from each side of the trunk. The extracted scales were put in paper envelopes. The envelopes were then labelled by a unique code (for example ON1), location and date of extraction.

In the laboratory at the University of Zambia, the scales were cleaned by soaking them in warm distilled water (at 25˚c) for about ten minutes to soften them. The scales were then soaked in 10% hydrochloric acid in order to remove flesh attached to them. The scales were then made razor thin by rubbing them with a fine sand paper before embedding them between two glass slides and sealed with sellotape to prevent them from curling. The scales were then examined under a light microscope at low power (x10 magnification) to determine the age (in years) of each fish species by counting the number of annuli. The annuli were determined from the face of the centrum. The number of annual rings in each scale indicated the age of the fish in years. Fish growth was estimated using the von Bertalanffy growth equation (1938): $L_t = L_\infty (1-e^{-k(t-to)})$; where $L_t$ is the predicted length at different ages, $L_\infty$ is asymptotic length, $t-t_0$ is the change in time and k is the growth coefficient. Total mortality coefficients of *Oreochromis niloticus* were determined using linearised catch curves, and Beverton and Holt equation (1957). The linear regression curves were obtained using the ages of fish against natural logarithm of the number of fish at each age, using Microsoft Excel (Analytical software, 2007). The gradients of regression analysis denoted total mortality (Z) coefficients of the *Oreochromis niloticus* (Pauly, 1980). The Beverton and Holt equation (1957): $Z = \frac{k(L\infty - Lm)}{Lm - Lc}$ where: $L_m$ is the mean length of the catch samples and $L_c$ is the length for which all fish of that age and longer are under full exploitation. Asymptotic length ($L_\infty$) was determined using the equation by Pauly (1979) which is: $L_\infty = \frac{Lmax}{0.95}$ Lmax is the largest length among the measured total lengths of the fish species. The natural mortality coefficient, M was estimated using Pauly (1983) equation expressed as $M = 0.8 \exp(-0.0152 - 0.279 \ln L_\infty + 0.6543 \ln K + 0.4634 \ln T)$. T is the mean temperature of the water body where fish is found.

Using the estimated values of total mortality (from Beverton and Holt equation of 1957) and natural mortality (from Pauly equation of 1983) above, the exploitation ratio (E) was then determined from the formula of Gulland (1982): $E = \frac{Z-M}{Z}$. Values of exploitation ratios were used to determine whether or not *Oreochromis niloticus* of the Kafue Floodplain fishery was over-exploited. An exploitation value of 0.5 denotes optimal exploitation; an exploitation value above 0.5 denotes over-exploitation while an exploitation value below 0.5 signifies under-exploitation.

***Data analysis:*** The ages, growth coefficients, growth rates, mortalities and exploitation ratios of *Oreochromis niloticus* at each study sites were compared to determine differences, if any. The overall values of age, growth rate, growth coefficient, mortality and exploitation of *Oreochromis niloticus* in the Kafue Floodplain fishery were also tabulated.

## RESULTS

***Growth results of Oreochromis niloticus:*** The growth coefficients, ages, growth rates (average age at different ages) and asymptotic lengths of *Oreochromis niloticus* at the study sites and in the entire Kafue Floodplain fishery are given in Table 2. The results showed that *Oreochromis niloticus* had the largest asymptotic length (612mm) at Kafue Road Bridge and the smallest asymptotic length at Namalyo. Total lengths that were obtained using the von Bertalanffy growth equation ranged from 104mm at Kakuzu to 400mm at Kafue Road Bridge.

***Mortality and exploitation variables of Oreochromis niloticus:*** The mortality variables and exploitation ratios of *Oreochromis niloticus* at the study sites and the accumulated results of the Kafue Floodplain fishery are given in Table 3.

## DISCUSSION

***Growth:*** The results of the study are in conformity with the studies of Zambia Department of Fisheries report (2008) and Chikopela (2011) which revealed that *Oreochromis niloticus* grows very fast and attains adulthood quickly. The fast growth of *Oreochromis niloticus* of the Kafue Floodplain fishery is attributed to the fact that *Oreochromis niloticus* is very adaptive, hardy and it is able to colonise a wide range of habitats (Schwanck, 1994).

***Mortality:*** The Natural mortality variable that was found in this research was higher than the one obtained by Schwanck (1994). This could be attributed to the general increase in surface temperature which is making the habitat loosely unbearable for fish of the Kafue Floodplain fishery. The mean surface temperature of the Kafue Floodplain fishery has increased from a mean of 24˚C to a mean of 27˚C (Smardon, 2009). Pauly (1980) showed a correlation between increase in surface temperature and increase in natural mortality. Natural mortality coefficients obtained were generally larger than fishing mortalities. The larger contribution of natural mortality can be attributed to the changed habitat in the Kafue Floodplain fishery because dam construction promotes growth of weeds such as *Eichhornia crassipes* and *Salvinia molesta* at the lower end which is permanently denudated while the upper end of the Kafue Floodplain fishery that is dry has less nesting grounds for fish (Schwanck, 1994).

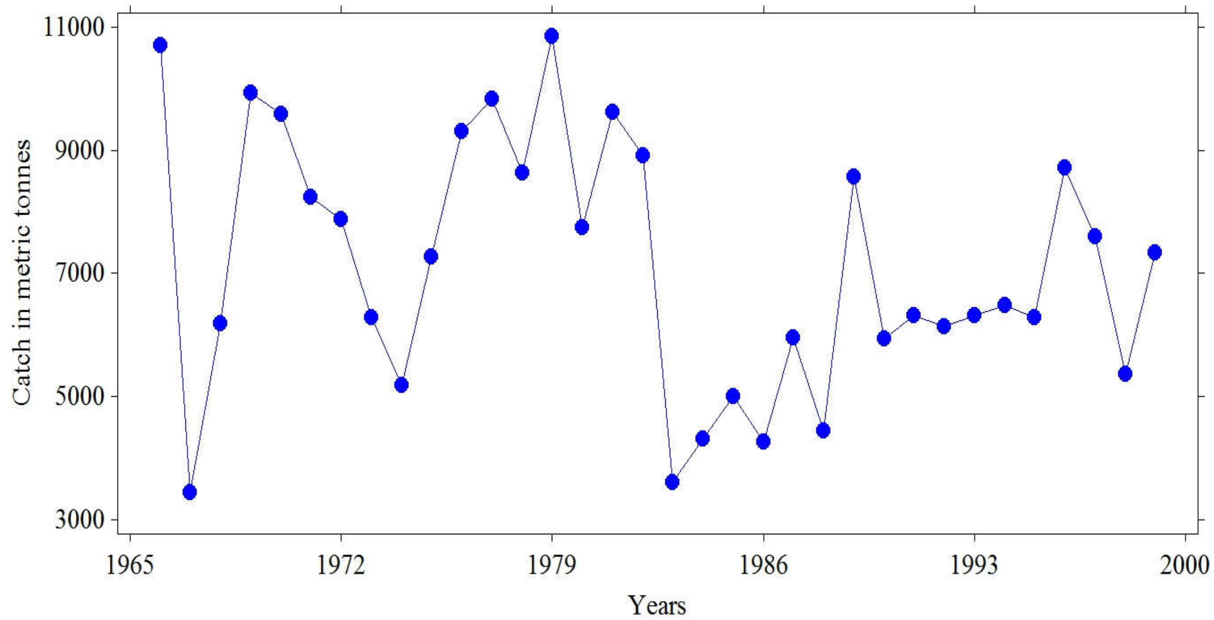


**Figure 1. Fish catches from the Kafue Floodplain fishery from 1965 to 2000 (source: FAO-Fisheries report, 2010)**

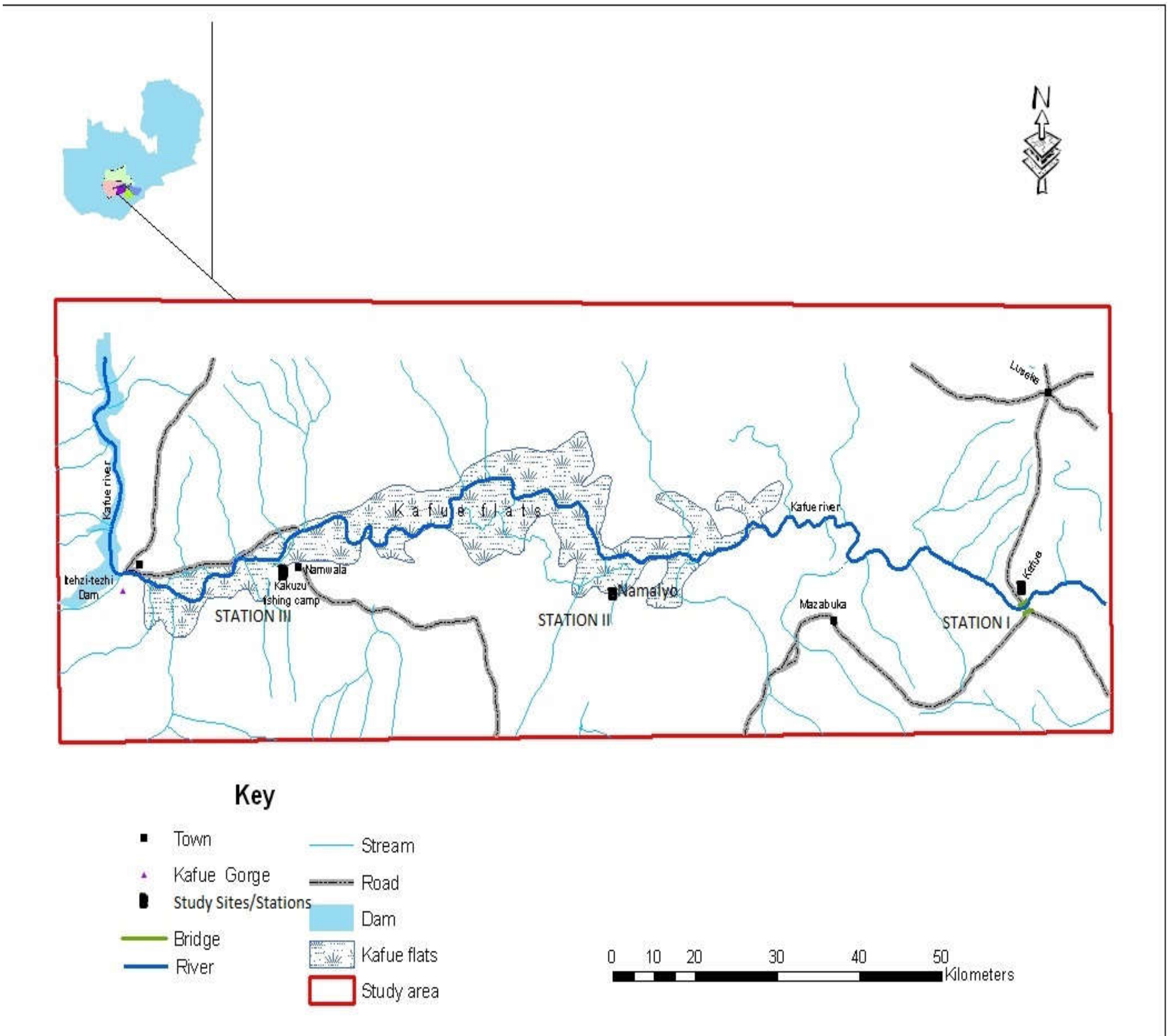


**Figure 2. Location of the study sites *within the Kafue Floodplain* fishery**

**Table 1. Mesh sizes of gillnets used in fish sampling**

| Mesh size (mm) | 25 | 37 | 50 | 63 | 76 | 89 | 102 | 114 | 127 | 140 | 152 | 165 | 178 | 190 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mesh size (inches) | 1 | 1.5 | 2 | 2.5 | 3 | 3.5 | 4 | 4.5 | 5 | 5.5 | 6 | 6.5 | 7 | 7.5 |

**Table 2: Ages, Growth coefficients, average length at different ages and asymptotic lengths Of *Oreochromis niloticus* at study sites and in the entire Kafue Floodplain fishery**

| Station | Maximum Age (years) | Growth Coefficient (k) | Average Total length (mm) | Asymptotic Length (mm) ($L\infty$) |
|---|---|---|---|---|
| Kafue Road Bridge | 4 | 0.48 | 400 | 612 |
| Namalyo | 5 | 0.3 | 213 | 383 |
| Kakuzu | 5 | 0.12 | 104 | 355 |
| Kafue Floodplain fishery | 5 | 0.22 | 205 | 447 |

**Table 3: Mortality variables and Exploitation ratios of *Oreochromis niloticus* at the study Sites and in the entire Kafue Floodplain fishery**

| Station | Natural Mortality (M) | Fishing Mortality (F) | Total Mortality (Z) | | Exploitation Ratio (E) |
|---|---|---|---|---|---|
| | | | Beverton-Holt | Linearised Catch curve | |
| Kafue Road Bridge | 2.12 | 0.909 | 3.03 | 2.67 | 0.3 |
| Namalyo | 0.5 | 0.8 | 1.3 | 0.9 | 0.6 |
| Kakuzu | 0.787 | 0.523 | 1.31 | 0.69 | 0.4 |
| Kafue Floodplain fishery | 0.68 | 0.45 | 1.13 | 0.82 | 0.4 |

The high natural mortality results relative to fishing mortality results confirm the pre-dam prediction by Carey and Bell-Cross (1967) who stated that dam construction along the course of the Kafue River would cause a natural mortality of 92% compared to a fishing mortality of about 8%. Carey and Bell-Cross (1967) predicted reduced flooding after dam construction which could make the Kafue Floodplain fishery less favourable for fish especially mouth brooding tilapiines that require a well-sheltered littoral zone. Mbewe (2006) also found higher natural mortality coefficients relative to fishing mortality coefficients.

Environmental factors such as chemical modification of the water in the Kafue Floodplain fishery could also explain the high natural mortality relative to fishing mortality. Smardon (2009) observed that industrial activities and agricultural activities in the Kafue Floodplain catchment area is responsible for a water concentration of 68mg/l to 220mg/l of dissolved solids in the Kafue Floodplain fishery which increase natural mortality of fishes in the Kafue Floodplain fishery.

***Exploitation:*** The under-exploitation of *Oreochromis niloticus* in the Kafue Floodplain fishery can be attributed to the fast growth of this mouth brooding tilapiine which makes it less vulnerable to the legally-recommended fishing gear. The FAO -Fisheries report (2010) also established that invasive species are normally under-exploited in most African countries.

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**Copyright declaration**

I, Mauris Chinyama Makeche, hereby declare that this Journal article represents my own work and that it has not previously been submitted for publication to this or another Journal.

## REFERENCES

Analytical Software, 2007. Microsoft Excell User's manual. Analytical Software. Tallahassee, USA.

Analytical Software, 2009. Statistix 9.0 User's manual. Analytical Software. Tallahassee, USA.

Berverton, R. J. H., and S. J. Holt, 1957. *On the dynamics of exploited fish populations. London, UK. Fish.* Invest. Minist. Agric. Fish. Food. G. B. (2 Sea fish) 140:67-83.

Carey, T. G., and Bell-Cross, 1967. Breeding seasons and quantitative data in gonads and ova for certain fish species. Chilanga, Zambia. *Fish Bulletin. Zambia* 3:12-22.

Chikopela, S. T., 2011. Comparative growth, reproductive biology and bundance of mouthbrooding tilapiines in the Kafue Floodplain fishery. MSc Dissertation, University of Zambia, Lusaka, Zambia.

Cowardin, L. M., Carter, V, Golet, F. C., LaRoe, E.T., 1979. Classification of wetlands and deepwater habitats of the United States. U. S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. USA. Northern Prairie Wildlife Research Centre.

FAO Fisheries Department, 2010. Status of fish stocks and fisheries of thirteen medium-sized African reservoirs. Chilanga, Zambia. 68pp.

Gulland, J. A., 1982. A manual of methods for fish stock assessment. Part II, FAO, Rome. Revised edition of FAO Fish. Tech. Pap., (97): 425p. (1970).

Mbewe, M., 2006. Frame report for Kafue Floodplain fisheries, Zambia. Department of fisheries, Chilanga, Zambia.

Mung'omba, J., 1992. Kafue Floodplain Gillnet survey data, summary tables and figures. Zambian Department of fisheries, Chilanga, Zambia.

Pauly, D., 1979. Theory and management of tropical multispecies stocks: a review with emphasis on the Southeast Asian Demersal fisheries. ICLARM Stud. Rev., (1):35 p.

Pauly, D., 1980. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175fish stocks. Michigan, USA. Journal. Cons. CIEM, 39(2): 175-192.

Pauly, D., 1983. Length-converted catch curves. A powerful tool for fisheries research in the tropics. Michigan, USA. ICLARM Fishbyte, 1(2):9-13.

Schwank, E. J., 1994. The introduced *Oreochromis niloticus* is spreading on the Kafue Floodplain, Zambia. Hydrobiol 315: 143-147.

Smardon, R, C., 2009. Sustaining the World's Wetlands: Setting policy and resolving conflicts. Springer-Verlag, USA.

Von Bertalanffy, L., 1938. A quantitative theory of organic growth. A Francke AG Verlag, Bern, Switzerland. *Journal of Hum. Biol.* 10: 181-243.

Zambia Department of Fisheries, 2008. Research Gillnet Survey Manual and Guide. Chilanga, Zambia. 1:18.

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