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Research Article

Some aspects of fish growth in Redbelly Tilapia (*Coptodon zilli*) and Largemouth Bass (*Micropterus salmoides*) in Lake Naivasha, Kenya

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ABSTRACT

Coptodon zilli and *Micropterus salmoides* were introduced into Lake Naivasha in 1929 and 1959 respectively. The reasons for introduction were to boost the fisheries and for recreational fishing respectively. However, the numbers of the two fish species in the lake have been declining over the years due to human activities and other ecological changes within the lake. Length-weight relationship, condition factor, sex ratio and length at first maturity of the fish were studied from October 2016 to November 2018. A total of 303 fish samples; 193 C. zilli and 110 M. salmoides were used in this study. Results showed that *C. zilli* and *M. salmoides* had an allometry coefficient value of 2.9 and 3.1 and K value of 1.77 and 1.39 respectively. The sex ratios (male: male) of *C. zilli* and *M. salmoides* were 1.1: and 1.3:1 respectively. The shortest total length for mature *C. zilli* and *M. salmoides* recorded were 12 cm and 26.5 cm while 21.8 cm and 51 cm were for the longest respectively. The fish growth pattern therefore failed to obey the cube low of b=3 thus exhibiting allomentric growth. The fish were in good condition with K factor above 1. It can therefore be concluded that the fish are generally in a good condition though the early maturity especially for *C. zilli* could be a sign of pressure either from environmental factors or as a result of overfishing within the lake. Investigations should be centered on breeding and population dynamics to better understand the two species within the lake.

Keywords: *Coptodon zilli*; *Tilapia zilli*; *Micropterus salmoides*; Length-Weight relationship; Condition factor; Lake Naivasha

INTRODUCTION

The Redbelly tilapia (*Coptodon zilli*), formerly *Tilapia zilli* is widely distributed in Africa and was introduced in Lake Naivasha in 1959 [1]. The introduction of *C. zilli* into Lake Naivasha was motivated by the need to provide an alternative cheap source of protein [1]. The fish prefers shallow marginal waters in all stages of growth and development [1]. The piscivorous largemouth bass, *Macropterus salmoides* (Lacépède) is native to North America where it inhabits rocky areas in both rivers and shallow lakes (Wheeler, 1978) and was introduced into Lake Naivasha in 1929 and 1946 for sport fishing [2-4]. Before the accidental introduction of *Cyprinus carpio* in 1997 and the re-introduction of *Oreochromis niloticus* in 2011 by the Government of Kenya, Lake Naivasha fishery was being dominated by *C. zilli*, *M. salmoides* and *Oreochromis leucostictus* [5-7].

It has been observed with interest that the numbers of *C. zilli* and *M. salmoides* in Lake Naivasha have been declining over the years, as indicated by both experimental and commercial catch records for various locations in the lake and for different years. Presently, the fish have been reported to show habitat preference in their distribution with *C. zilli* occurring in large numbers in

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sections of the Oserian Bay while *M. salmoides* has a preference for rocky habitats of Crescent Island Lake and Hippo Point (personal observation) both habitats being protected fish breeding areas. The decline has been at a rate which if left unchecked, will eventually cause total disappearance of the two species.

Length-weight relationship is a useful tool in fishery assessment since it helps in predicting length from weight required in yield assessment [8] and in the calculation of fish biomass [9]. It provides important information concerning the structure and function of fish populations [10]. Fish condition factor, sex ratio and length at first maturity are also important concepts in fisheries management.

Condition factor and length at first maturity can be used to assess the health and potential of any fishery to support the fishing pressure.

Sex ratio is important in determining population viability Since it shows which sex is more dominant- in terms of numbers, a population dominated by male fish is more unpredictable than one dominated by female fish [11]. It is also an important factor in determining the balance of the males and females in the habitat. The condition factor provides information on the general well-being of a fish and its health condition within a mixed population with other fish species while length at first maturity (length at which 50% of the fish are mature) is very useful in fish stock management [12]. Information on length at first maturity is crucial in formulation of management options especially in the choice of gear to be used in capture fisheries. It can guide the managers in setting mesh sizes that will target only the mature and ageing fish while giving juvenile fish time to grow to maturity [12]. These growth parameters were investigated in order to understand the general characteristics of the population of the two fish species within the lake in light of the intense human activities and pressures within the lake.

The main aim of this research was to assess the growth parameters and biology of the two threatened and endangered fish species in Lake Naivasha for use in management and policy making. This will eventually aid in curbing the decline and enhancing recovery and establishment of their populations within the lake.

MATERIALS AND METHODS

Study area

Lake Naivasha, a shallow freshwater lake with a surface area of approximately 139 km^2 is situated in the Eastern arm of the Great Rift Valley, about 100 km north-west of Nairobi, Kenya [13]. It has an average depth of 3.35 m with the deepest area being 7 m [14] though these values vary with change in rainfall patterns. The lake was declared a Ramsar site in 1995 due to its unique flora and fauna [15]. It is the major source of fish for the surrounding community and fresh water for the numerous horticultural industries in the area (Figure 1). Apart from transient streams, the lake is fed by the perennial Malewa and Gilgil rivers with the former being the main one [15].

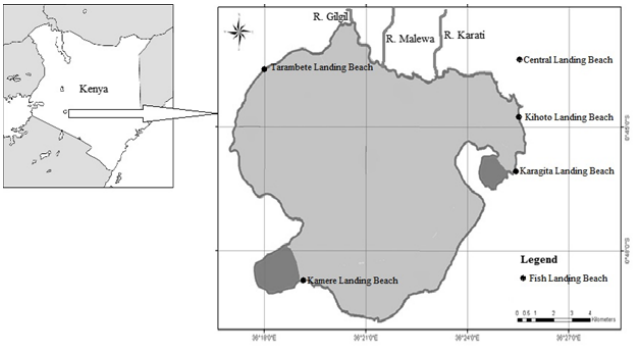

Figure 1: Map of Lake Naivasha.

Sample collection and analysis

Gill nets of variable mesh size ranging from 2.5 – 6 inches were used to collect *M. salmoides* and *C. zillii* samples in Lake Naivasha from October 2014 to November 2016. Collected fish samples were identified and classified by species. Sexual maturity status was assigned as stage I–VI according to Witte and Densen [16]. Fish in maturity stages I, II, III were considered immature, while those in stages IV-VI were considered mature. Length and weight of individual fish were measured and recorded. The total length (TL) in cm from snout to the end of the caudal fin of each fish was measured using a meter rule. Weight of each fish was measured using the Digitron T745 top weighing balance. The length-weight relationship was calculated using the formula by Wooton [17]:

$$W=aTL^b$$

Where W is the total body weight of fish in grams, TL is the total length in centimeters, a, the intercept and *b* the slope of the regression line.

Condition factor (K) was estimated following Le Cren [18]:

$$K=\frac{W}{L^b}$$

Where K is the condition factor, W is the total body weight of fish in grams, L the total length in centimeters and *b* is the regression slope.

Sex ratio was determined for only those fish whose gonads were identifiable as male and female. Maturity status was assigned as stage I–VI according to Witte and Van Densen [16]. Stages I, II, III were considered immature, while those in stages IV-VI were considered mature for the purpose of calculating the size at first maturity (Lm_{50}) by fitting frequency data of mature individuals by length class to a logistic curve using the least-square method [19].

RESULTS

Length-weight relationship was calculated for a total of 303 fish made up of 193 *C. zilli* and 110 *M. salmoides*. The total length of *C. zilli* ranged from 11 to 21.8 cm and their weight from 11 to 195 g while *M. salmoides* ranged from 18.6 to 51 cm in total length and 85 to 2120 g in total weight. Length-weight relationships were evaluated separately for the two fish species and the regression equations derived (Figure 2). Results showed

that *C. zilli* and *M. salmoides* had an allometry coefficient value of 2.9 and 3.1 respectively, an indication of negative allometric growth in *C. zilli* and positive growth in *M. salmoides*. Both fish species did not obey the Cube Law which assumes that the regression slope *b* is equal to 3. *C. zilli* had a negative allometric growth ($b<3$) while *M. salmoides* had a positive allometric growth ($b>3$).

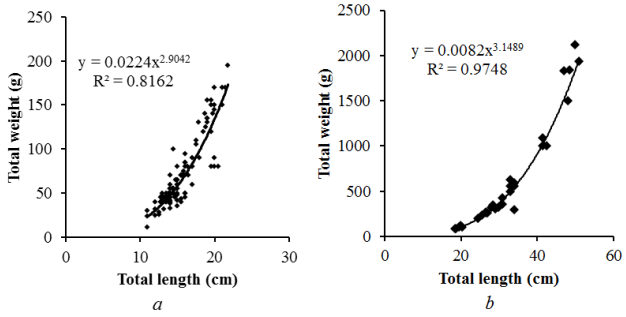

Figure 2: Length-weight relationship of (a) *C. zilli* and (b) *M. salmoides* in Lake Naivasha.

Condition factor (K) of the two species was 1.77 and 1.39 for *C. zilli* and *M. salmoides* respectively (Figure 3). K values for both fish species were greater than 1 meaning their bodies were in good condition.

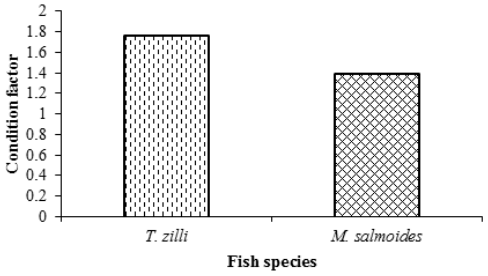

Figure 3: Condition factor of *C. zilli* and *M. salmoides* in Lake Naivasha.

C. zilli sampled had a male: female percentage composition of 52%:48% leading to a male: female sex ratio of 1.1:1 respectively. Similarly, *M. salmoides* had a male: female sex ration of 1.3:1 making up a percentage composition of 57%: 43%: respectively (Figure 4).

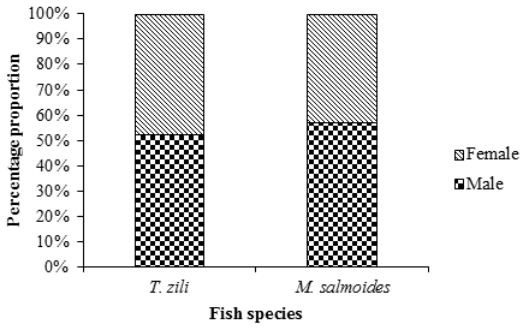

Figure 4: Percentage composition of each sex of *C. zilli* and *M. salmoides* in Lake Naivasha.

Length at first maturity was assessed separately for the mature *C. zilli* and *M. salmoides* and results presented in Figure 5. The shortest total length for mature *C. zilli* and *M. salmoides* recorded were 12cm and 26.5 cm while 21.8 and 51 cm were for the longest respectively. The length at fist maturity for *C. zilli* and *M. salmoides* was 13.5 cm TL and 32.6 cm TL respectively.

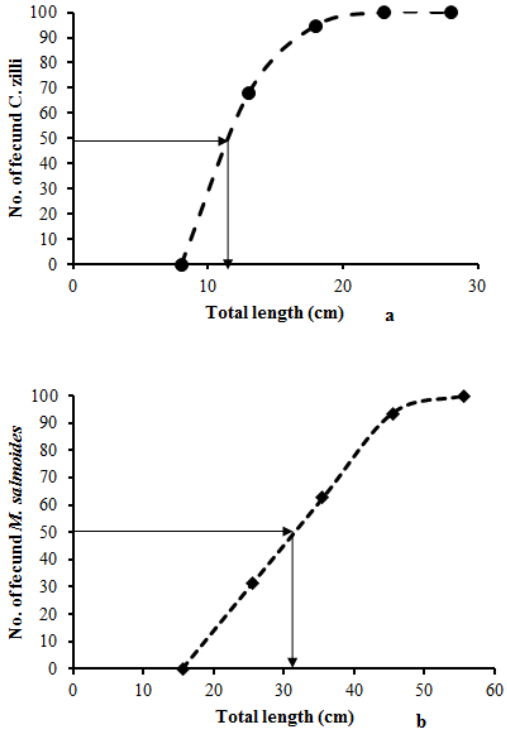

Figure 5: Length at first maturity (LM_{50}) of (a) *C. zilli* and (b) *M. salmoides* in Lake Naivasha.

DISCUSSION

The results of this research point to the fact that the two fish species are in a generally good condition, exhibiting allometric growth and the population is dominated by male fish. Fish with values of *b* being less than 3 could mean that large fish had more elongated body shape or smaller fish were in better nutritional condition at the time of sampling while the reverse could be said of *b* values greater than 3 [20]. Differences in *b* values can be ascribed to one or a combination of factors including differences in the number of specimens examined, location and season effects and distinctions in the observed length ranges of the specimens caught and the duration of sample collection [21]. However the change of *b* values may also depend primarily on the shape and fatness of the species as well as physical, chemical and biological factors such as temperature, salinity, food, sex and stage of maturity [19,22].

Both *C. zilli* and *M. salmoides* in Lake Naivasha had K values of greater than 1, an indication of general well-being and stable physiological status of the fish in the lake. This could be due to abundance of food within the lake as this has been shown to improve the condition of fish [6,7]. The >1 condition factor of the fish could also be due to the good water quality parameters (physico-chemical parameters) of Lake Naivasha which are within the tolerable range for both fish species [3]. Condition

factor is known to fluctuate with the reproductive cycle of the fish and tends to increase on the onset of reproduction.

Sex ratio in fish varies considerably from one species to another but in majority of the species; it is close to 1:1 [23]. A study by Bal and Rao [24] noted that any deviation from this ratio is an indication of dominance of one sex over the other, which is caused by the differential behavior of the sexes. In both *C. zilli* and *M. salmoides*, the males were found to be the dominant sex. Another factor that could explain the dominance of males in the two fish species is that dominance by males in the African lakes is common within the cichlid populations because of the higher growth rate they exhibit compared to the females [25]. A fish population dominated by males presents uncertainty in the future of the fisheries. This is because the contribution to the next generation is by the female members of the population.

Length at first maturity (LM_{50}) is shows that length at which 50% of the fish in the population are mature. A low LM_{50} value depicts fish under pressure from either overfishing or human activities or other ecological and environmental factors. It is a manifestation of the fish adjusting to the pressure and compensating for it by maturing and reproducing early. Nile tilapia for example has been seen to mature at lower lengths in in more stressful water bodies compared to those with less stressor. In Lake Naivasha for example it was observed to mature at 18 cm compared to 21 cm in Lake Victoria [11]. The early maturity exhibited by *C. zilli* in Lake Naivasha could be a pointer to pressures within the lake environment. It could be as result of competition from other species like the recently introduced Nile tilapia which is known to be very aggressive and strong competitor in novel environments [26].

CONCLUSIONS AND RECOMMENDATIONS

All indications are that the two fish species are in a good condition and their low population could be the effects of overfishing or using the wrong gear size for fishing. The variations in the total amount of fish caught from Lake Naivasha can be attributed to the interactions between multiple exotic fish species and fluctuations in fishing effort, lake water levels and extent of macrophyte cover. Other studies have proven that continued increase fishing effort and use of mesh size smaller than the recommended and subsequent capture of immature fish leads to a further reduction of the size of *C. zilli* and *M. salmoides* at first capture. The fishers will further reduce their mesh size and resort to unorthodox fishing to target the smaller fish. The progressive decrease in mesh sizes of gillnets which remain the predominant fishing gears on the lake is particularly worrying in the heavily exploited inshore waters. Banned fishing gear especially beach seines pose a high risk for recruitment and growth of fish. To sustain the fishery of Lake Naivasha, that management regulation that were approved and enacted in 2002, recommended 40 boats and ten nets per boat and in addition the registration of boats and license of nets should be enforced. To succeed in enforcement, all stakeholders should be involved. Community based monitoring, control and surveillance should be given priority. Co-management, if successful, would drastically reduce use of illegal gears and curb poaching on the lake. Alternative livelihood, such as aquaculture and ecotourism should be encouraged to reduce pressure on the lake fishery.

Additionally, investigations should be centered on breeding and population dynamics. Knowledge of the two species in relation to their environment ought to be stressed. Previous work has attributed the decline of the two species in Lake Naivasha to overfishing and use of efficient gillnets. It is high time more research was conducted to look into possibilities of the existence of other causes of decline. Enquiries should be made for instance into the effect of pollution on the fish species with work concentrating on the sewage plant and effluent from the horticultural farms. Parasites, food and feeding behavior should also be investigated.

Finally, restocking of Lake Naivasha with the two species should be done and proper fishing enforced and any gear likely to remove fingerlings should be banned throughout the year.

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