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Short Communication

Seasonal changes in length-weight relationship and condition factor of Nile tilapia, *Oreochromis niloticus* (Linnaeus, 1758) (Cichlidae) in Lake Naivasha, Kenya

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Abstract: The study compared the length-weight relationship and condition factor (K) of Nile tilapia (*Oreochromis niloticus*) in Lake Naivasha, Kenya, between the wet and dry seasons. Fish samples were collected monthly by gill netting from February to December 2015. A total of 372 samples of *O. niloticus* were analysed. The *b* values in the length-weight relationships were observed as 3.077 and 3.366 in the wet and dry seasons, respectively. The values of *b* exhibited positive allometric growth which were the important indication that the species was growing faster in weight than length. The K values of the fish ranged 1.18-4.1 during the wet season and 0.8-3.0 during the dry season. All mean monthly K values were found to be greater than 1, the highest being in June (2.33±0.05) and lowest in February (1.31±0.28), an indication of a healthy status and general well-being of the *O. niloticus* population in Lake Naivasha. The study concluded that seasonal variation has no great influence in the length-weight relationship and condition factor of *O. niloticus* in Lake Naivasha.

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Introduction

The fishery of Lake Naivasha mainly depends on six non-native fish species: *Oreochromis niloticus* (Nile tilapia), *O. leucostictus* (Blue spotted tilapia), *Tilapia zilli* (Gervais), *Micropterus salmoides* (Black bass), *Cyprinus carpio* (Common carp) and *Clarias gariepinus* (African catfish). The riverine *Barbus amphigramma* and *Procambarus clarkii* (Red Louisiana Crayfish) have been supporting the fishery of Lake Naivasha significantly since 1980s (Oyugi et al., 2011). *Oreochromis niloticus* (Nile tilapia) was first introduced in Lake Naivasha around 1967 but disappeared by 1971 for reasons unclear to date (Hickley et al., 2008). Anthropogenic disturbance of the littoral vegetation, particularly through clearance and burning could have previously reduced its spawning areas as reported by Hickley et al. (2008) resulting to its disappearance in the 1970s. The Government of Kenya through the Economic Stimulus Package (ESP) reintroduced the Nile Tilapia between 2010 and 2013 to boost the local fisheries in Lake Naivasha. The fingerlings were sourced locally in accredited government fish hatcheries. Since its reintroduction, Kenya Marine and Fisheries Research Institute (KMFRI) data shows a constant increase in landings by fishermen in all the fish landing beaches around Lake Naivasha. The same has been witnessed during the monthly fish stock assessment exercises on the lake.

Length-weight relationship (LWR) is a useful tool in a wide range of applications such as estimation of biomass from length data, estimation of a species condition factor and comparisons among life history and morphologic differentiations of the same species in other aquatic systems (Binohlan and Pauly, 2000). LWR measurement is also a useful tool that provides important information concerning the structure and function of fish populations in any aquatic systems

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(Anderson and Neumann, 1996). When the *b* value is less than 3, the fish has a negative allometric growth but when it is greater than 3, it has a positive allometric growth and when it is equal to 3, the fish has isometric growth (Khairenizam and Norma-Rashid, 2002). Change of *b* values depend primarily on the shape and fatness of the fish species as well as physical, chemical and biological factors such as temperature, salinity, food, stomach fullness, sex and stage of maturity (Sparre and Venema, 1998; Sarkar et al., 2013).

Fish condition factor is an important concept in fisheries management and can be used to assess the health and potential of any fishery to support the fishing pressure. The condition factor often referred to as K provides information on the general well-being of a fish and health condition of a population. Condition factor is estimated by comparing individual fish weight of a given length to a standard weight. Fish body condition is known to vary seasonally depending on changes in gonadal development, food availability, and other environmental factors (Pope and Willis, 1996). It is usually influenced by the type of fish species, sex, season, maturity stage among other factors (Anyanwu et al., 2007). The role of the condition indices as stated by Stevenson and Woods (2006) is to quantify the health of individuals in a population or to tell whether a population is healthy relative to other populations. When fish of a given length exhibits higher weight it means they are in better condition (Anwa-Udondiah and Pepple, 2011).

The determination of seasonal variations of *b* and K values of *O. niloticus*, a reintroduced fish species in Lake Naivasha, is therefore useful in assessing the well-being, growth performance and feed utilization of the fish in the lake. The main focus of this paper is to assess the seasonal variations in LWR and condition factor of *O. niloticus* in Lake Naivasha between February and December 2015.

Materials and Methods

The study was carried out at random sampling sites in Lake Naivasha, an equatorial rift valley lake with an annual atmospheric temperature that rarely falls below 20°C (Hickley, 2008). The lake is a shallow freshwater body, situated in the eastern rift valley of Kenya (0°46'S, 36°20'E) at an altitude of about 1890 m above sea level. It covers a surface area varying between 120 Km^2 and 160 Km^2 depending on the wet and dry seasons respectively (Hickley et al., 2008). The lake's mean depth varies 4-6 m (Hickley et al., 2008). The lake is the major source of fish for the surrounding community and fresh water for the numerous horticultural industries in the area. Apart from transient streams, the lake is fed by the perennial Malewa and Gilgil rivers with the former being the main one (Kitaka et al., 2002). There are 2 wet seasons in the months of March-May (long rains) and October-November (short rains) characterized by high lake water levels (Oyugi et al., 2011).

Sampling procedure comprised setting of gill nets of variable mesh size ranging from 25-70 mm at dusk, with lifting after approximately 12 hours of fishing. Fish caught in the nets were identified at the species level, length and weight of individual fish were measured *in situ* and recorded for each sampling occasion. The total length (TL in cm) of each fish was measured using a meter rule. Weight of each fish was measured using the SF-400 digital weighing balance. The length-weight relationship was calculated using the formula by Wooton (1990) as:

$$W = aL^b$$

Where W is the body weight of fish in grams, L the total length in centimeters, *a*, the intercept and *b* the slope of the regression line. Condition factor (K) was estimated following Fulton (1902) and Le Cren (1951):

$$K = W/L^3 \times 100$$

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

Results and Discussion

A total of 372 specimens of *O. niloticus* (191 during wet and 181 during dry season) were used in this

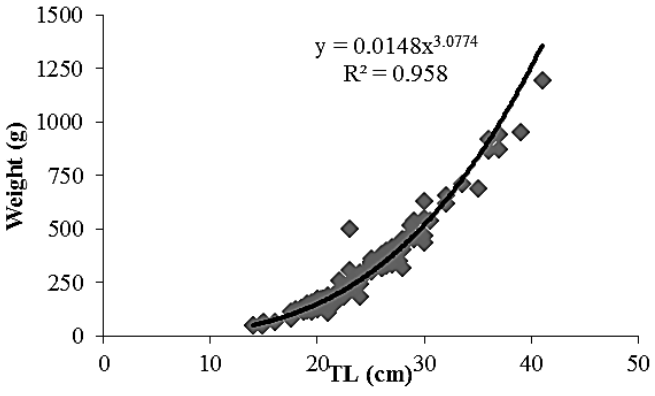

Figure 1. Length-Weight relationship of *Oreochromis niloticus* in Lake Naivasha during the wet season in 2015.

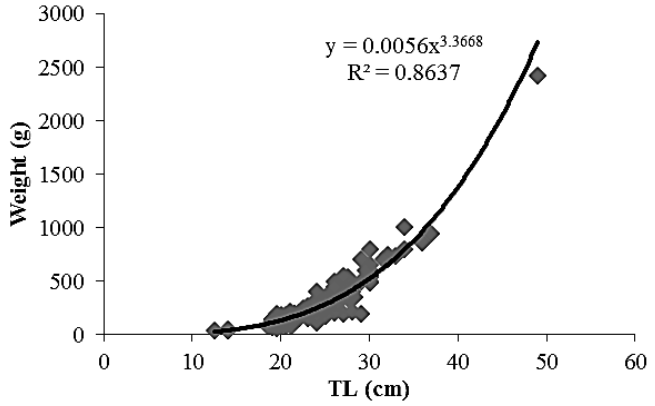

Figure 2. Length-Weight relationship of *Oreochromis niloticus* in Lake Naivasha during the dry season in 2015.

study. Allometry coefficient values *b* obtained were 3.077 and 3.366 in the wet and dry seasons, respectively (Figs. 1, 2).

The relative condition factor of *O. niloticus* in Lake Naivasha ranged from 1.18 to 4.1 during the wet season and 0.8 to 3.0 during the dry season. The wet and dry seasons had fish with mean K values of 1.92±0.09 and 1.89±0.49, respectively. The highest and lowest K values recorded during the sampling period were 2.33±0.05 and 1.31±0.28 in June and February 2015 respectively, both falling within the dry season (Fig. 3).

The results showed that *O. niloticus* had positive allometric growth patterns ($b>3$) in both the dry and wet seasons indicating that the fish is growing faster in weight than length. This could be linked to the high productivity of Lake Naivasha in both the wet and dry seasons (Kitaka et al., 2002). However, these results differed with a study by Outa et al. (2014)

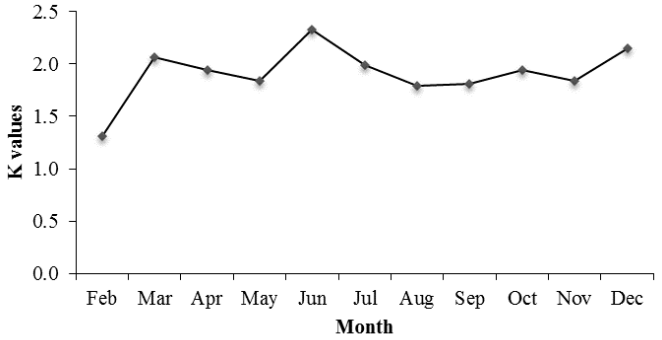

Figure 3. Mean monthly condition factor of *Oreochromis niloticus* in Lake Naivasha in both wet and dry seasons of 2015.

done between November 2013 and January 2014 in the same lake who recorded the *b* value as 2.3. 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 (Moutopoulos and Stregiou, 2002). The marked difference in the *b* value obtained by Outa et al. (2014) could also be attributed to the short period spent by the fish in Lake Naivasha since its introduction in 2011. The current study showed no marked differences in *a* and *b* values between *O. niloticus* in Lake Naivasha and populations elsewhere. This is supported by a study of *O. niloticus* in Lake Baringo, a Rift Valley lake in Kenya, by Kembenya et al. (2014) where *b* values were 3.08 and 3.04 in the wet and dry seasons, respectively.

Based on these results, *O. niloticus* in Lake Naivasha had mean monthly K values of greater than 1 in all the months sampled an indication of general well-being and stable physiological status of the fish in the lake. However, the condition factors were relatively higher than the values (1.97-2.63) documented by Outa et al. (2014) in an earlier study of the same fish species in Lake Naivasha. The present higher K values might be attributed to adaptation of feeding habits of *O. niloticus* in Lake Naivasha to the different trophic levels in the lake enabling it to comfortably obtain food all year round. According to Canonico and Arthington (2005), *O. niloticus* is known to adapt readily to a range of

environmental factors such as salinity, low oxygen levels and can feed at different tropic levels when need arises. Deekae et al. (2010) noted that several factors affect the condition factor of fishes. These range from feeding, spawning, food nutrient composition and fat accumulation. The variations of condition factor (K) in fish according to King (1995) may be due to food abundance, adaptation to the environment and gonadal development. The mean condition factor in the wet and dry seasons in this study varied slightly with those obtained by Kembenya et al. (2014) in Lake Baringo, where *O. niloticus* were observed to have K values ranging from 0.59 to 1.89 during the dry season and 0.80 to 3.70 during the wet season.

Conclusions

This study revealed that seasonal variation has no great influence in the length-weight relationship and condition factor of *O. niloticus* in Lake Naivasha. The faster growth of *O. niloticus* in weight than length favours the fishermen and fish traders around Lake Naivasha as it enhances its profitability. The K values obtained for the fish showed that the population was in good condition, an indication of the healthy status of the population. It is equally an indication of the ability of Lake Naivasha to sustain a healthy population of *O. niloticus*.

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