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ORIGINAL ARTICLE

Length-Weight Relationship and Condition Factor of Nile Tilapia [*Oreochromis niloticus* (Trewavas)] from White Nile, Sudan

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Abstract

The aim of this study was to investigate the length-weight relationship and condition factor of the Nile tilapia (*Oreochromis niloticus*) in the White Nile River, taking into consideration the seasonal changes and the effect of age, sex and maturity stage of fish. Fresh fish samples used for the study were collected from the White Nile at Al Shagara and Al Kalakla areas south of Khartoum, Sudan. Sampling was carried out twice a month for twelve months, during the period 2012-2013. For each fish, both total length and total weight were measured, then fish were sexed, and their age and maturity stages were recorded. The length-weight relationship and condition factor were calculated. The results showed that there was a significant correlation between the total length and total weight of *O. niloticus* (r =0.9811, and r^2 = 0.9626). During this study *O. niloticus* have shown positive allometric growth pattern, the growth coefficient equals 3.0703. Statistical analysis of data revealed significant effects of season, age, sex and maturity stage ($P<0.05$) on the condition factor of *O. niloticus.* The calculated condition factor (1.5584) indicated that the environmental conditions of the White Nile in the study area were suitable for *O. niloticus* growth, since fish investigated throughout this study were proved to be in good health.

Keywords: Fish growth, populations, wellbeing, seasonal changes, environment.

Introduction

Fisheries management and research often require the use of biometric relationships in order to transform data collected in the field into appropriate indices (Ecoutin and Albaret, 2003). Growth is an important component of biological production of fish, which affects the overall production directly. Negative changes in the growth rates may result in decreased individual health and reproductive success and increase risk of predation and mortality (Wootten, 1992).

Knowledge of some quantitative aspects such as length-weight relationship is important in studying fish biology. Length-weight relationships can be used to predict

weight from length measurements made in the yield assessment and to estimate stock biomass from limited sample size (Pauly, 1993; Petrakis and Stergiou, 1995, and Hart and Abowei, 2007). Fish can attain either isometric growth, negative allometric growth or positive allometric growth. Isometric growth is associated with no change of body shape as the fish grows. Negative allometric growth implies the fish becomes more slender as it increases in weight, while positive allometric growth implies the fish becomes relatively stouter or deeper-bodied as it increases in length (Riedel *et al*., 2007).

Condition factor compares the well-being of a fish, and is based on the hypothesis that heavier fish of a given length are in a better condition (Bagenal and Tesch, 1978, and Abowei and George, 2009). Condition factor has been used as an index of growth and feeding intensity (Fagade, 1979, and Abowei *et al*., 2009). It decreases with increase in length (Abowei, 2010). The condition factor of fish can be affected by a number of factors such as stress, sex, season, availability of feeds, and other water quality parameters (Khallaf *et al*., 2003).

Nile tilapia [*Oreochromis niloticus* (Trewavas, 1982)], of the Family Cichlidae, is among the leading farmed species around the world. It ranks among the most commercialized fishes due to its high growth rate and the consumer preference. Nile tilapia is also resistant to considerable levels of adverse environmental and management conditions. Tilapias are plastic animals because their growth and maximum obtainable size can be seriously influenced by the physical and biological composition of their environment (Olurin and Aderigbe, 2006).

In spite of the importance of length-weight relationship and condition factor in fisheries science, information about such parameters of Nile fish in the Sudan are very scarce and incomplete. The objective of this work was to study the length weight relationship and condition factor of *O. niloticus* from the White Nile in central Sudan, taking into consideration the seasonal changes and the effect of age, sex and maturity stage of fish.

Materials and Methods

A total of 240 fresh fish specimens of *O. niloticus* were obtained for the purpose of this study from the White Nile River at Al Shagara and Al Kalakla areas south of Khartoum. Sampling was carried out twice a month for twelve months during the period 2012-2013. Fish samples were collected early in the morning using gill nets, kept in ice and transferred to the laboratories of the Environment, Natural Resources and Desertification Research Institute, National Center for Research, for further investigations. The total length (TL) of the fish was measured from the tip of the anterior part of the mouth to the caudal fin using meter ruler calibrated in centimeters to the nearest mm. Fish weight was recorded using a triple beam balance to the nearest 0.1g. Each fish was sexed and its maturity stage was determined. Fish were aged through the examination of marks on vertebrae, which were proved to be one of the reliable structures for fish ageing (Bishai and Abu Gideiri, 1965; Mishrigi, 1967; Bishai, 1970; Gumaa, 1974; Tweddle, 1975, and Tahir, 1994).

The length-weight relationship (LWR) of *O. niloticus* was estimated using linear regression (Pauly, 1983, and Wahua, 1999). The technique is incorporated in the FAO ICLARM, Stock Assessment Tool (FISAT) (Gayanilo and Pauly, 1997). Accordingly, the (LWR) was obtained from the following relationship:

$W = aL^b$ (Pauly, 1983; Sparre *et al*., 1989)

Where;

W = Total weight of fish (g)

L = Total length of fish (mm)

a = Intercept (describe the rate of change of weight with length)

b = Slope (weight at unit length)

The values of (a) and (b) were given a logarithmic transformation according to the following formula:

$\log W = \log a + b \log L$ (Pauly, 1983)

The correlation i.e. the degree of association between the variables was determined by computing the correlation co-efficient (r) from the regression equation information (r^2) (Wahua, 1999, and Ogbeibu, 2005) using the relationship:

$$r = \sqrt{r^2}$$

The condition factor (K) was determined by using the equation:

$K = 100W/ L^b$ (Gomiero and Braga, 2005).

Where:

W = the fish weight (g)

L = the total length of the fish (cm)

b = the value obtained from the length-weight equation.

The exponent b value, that is equal to 3, was not used to calculate the K value, as Bolger and Connolly (1989) claim that it is not a real representation of the length-weight relationship for greater majority of fish species, therefore, the b value used was obtained from the estimated length-weight relationship equation ($W = a L^b$) as suggested by Lima-Junior *et al*. (2002).

Results and Discussion

Oreochromis niloticus are highly recommended as one of the successful culturing fish due to their excellent growth rates even on low protein diets. They also tolerate wider ranges of environmental conditions. Moreover, they are highly and widely acceptable as food, being of high delicacy, as considered by many people throughout the world. Consequently, special interest has been given to study the biological and environmental conditions related to the improvement of tilapia production (Balirwa, 1992; Khallaf *et al.*, 2003, and Barriga-Sosa *et al.*, 2004).

Fish are said to exhibit isometric growth when length increases in equal proportions with body weight for constant specific gravity. The regression co-efficient (b) for isometric growth is 3, and values greater or lesser than 3 indicate allometric growth which may be positive if (b) > 3 or negative if (b) < 3 (Gayanilo and Pauly, 1997).

The values obtained from the (LWR) of *O. niloticus* from the White Nile showed that there was a high and significant correlation (r = 0.9811) between the total length and total weight (Figure 1). Such results were in consistent with previous works (Marioghae, 1982). This means that as the length of fish increases the weight increases in the same proportion. Coefficient of determination was also high ($r^2 = 0.9626$) which indicated that the model used for the analysis fits the data (Andem *et al*., 2013). As indicated by the growth coefficient (b = 3.0703), *O. niloticus* showed positive allometric growth pattern, and likewise, the calculated condition factor (1.5584 ± 0.2373) indicated that the species was in a good health (K > 1) throughout the study period (Table 1).

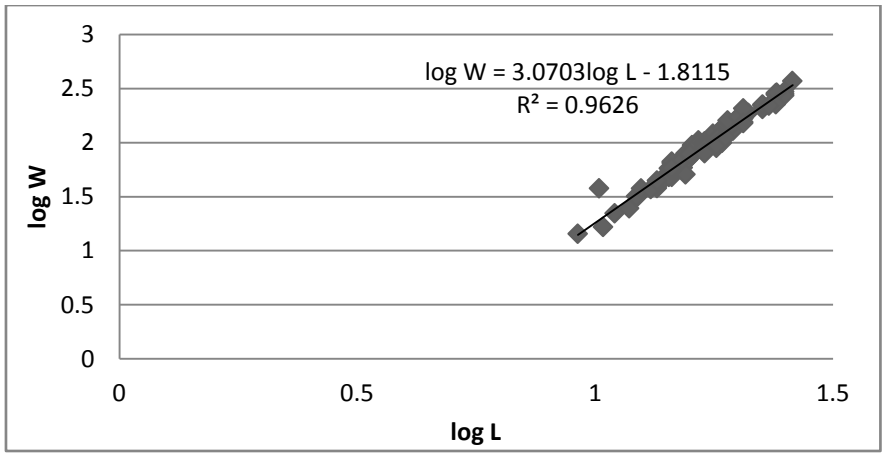

Figure 1. Length–weight relationship of *Oreochromis niloticus* from White Nile, Khartoum, Sudan (2012-2013).

Table 1. Effect of sex, maturity stage, season and age on the condition factor of *Oreochromis niloticus* from White Nile, Khartoum, Sudan (2012-2013).

Oreochromis niloticus	**b**	**r**	**Condition factor (K)**			**Sig.**
			Mean ± S.D.	**Minimum**	**Maximum**	
	3.0703	0.9811	1.5584 ± 0.2373	1.13	3.03	
Effect of sex						
Male	2.9919	0.9743	2.0207 ± 0.3566	1.5774	3.6296	0.002
Female	3.1413	0.9882	1.2469 ± 0.1324	0.9280	1.5659	
Effect of maturity stage						
Immature	2.9324	0.9505	2.2233 ± 0.5539[c]	1.7289	4.1675	0.000
Maturing	3.4331	0.686	0.5855 ± 0.0548[a]	0.4987	0.6882	
Running	3.0441	0.9673	1.7061 ± 0.1799[b]	1.3859	2.0656	
Spent	2.8921	0.9745	2.7402 ± 0.2607[d]	2.0938	3.1179	
Effect of season						
Summer	3.1761	0.9952	1.1114 ± 0.0917	0.9238	1.3297	0.000
Winter	2.8646	0.9560	2.9493 ± 0.4973	1.9810	4.8782	
Effect of age						
1 year	3.2331	0.9945	0.9831 ± 0.0910 [a]	0.8420	1.0986	
2 years	3.0693	0.9923	1.5344 ± 0.0921 [b]	1.3994	1.6897	
3 years	3.2142	0.9967	1.0128 ± 0.1147 [a]	0.8798	1.2618	

These above results were within the same range (b = 2.99 – 3.22) recorded by several investigators (Naeem *et al.*, 1992; Haruna, 2006; Nyaku *et al*., 2008, and Bala *et al*., 2009), but were different from the findings of Imam *et al*. (2010) who recorded lower values (b = 1.2 - 1.4). According to Goncalves *et al*. (1997) and Ozaydin *et al*. (2007) the parameter (b) may vary seasonally, daily, or between habitats, therefore, slight variations were observed in growth coefficient (b) of *O. niloticus* as shown in figure 2. Differences in (b) values can be attributed to the combination of one or more factors such as: number of specimens examined, seasonal effect, habitat, degree of stomach fullness, gonadal maturity, sex, health and general fish condition, besides differences in the observed length ranges of the specimens caught (Wootten, 1998).

The condition factor (K) of *O. niloticus* calculated during this study was found to be in agreement with the values obtained by a number of workers (Olurin and Aderigbe, 2006; Nyaku *et al*., 2008, and Bala *et al*., 2009), while it differ from those of others

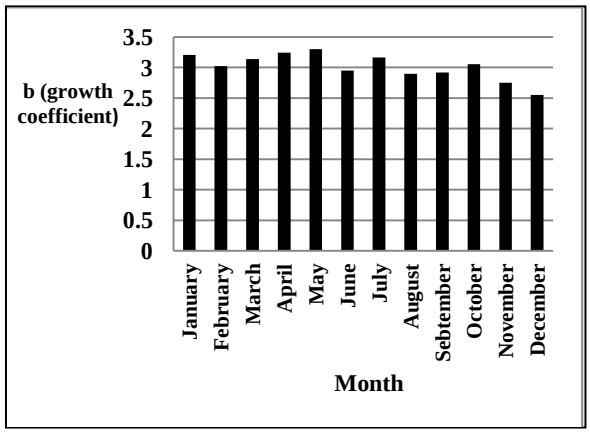

Figure 2. Monthly variation in growth coefficient of *Oreochromis niloticus* from White Nile, Khartoum, Sudan (2012-2013).

(Bagenal and Tesch, 1978; Imam *et al.*, 2010, and Ahmed *et al*., 2011). Data of the mean monthly variations of (K) in *O. niloticus* were presented in figure 3. It was observed that the (K) of *O. niloticus* is fluctuating throughout the year. This could be attributed to the study season, food availability, feeding rate, gonad development and spawning period (Bagenal and Tesch, 1978; Petrakis and Stergiou, 1995, and Moutopoulos and Stergiou, 2002).

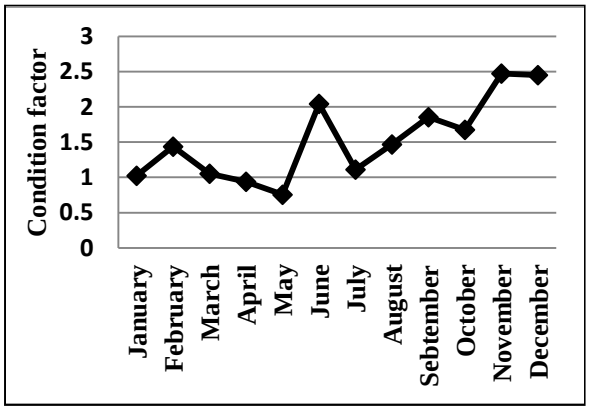

Figure 3. Monthly condition factor of *Oreochromis niloticus* from White Nile, Khartoum, Sudan (2012-2013).

The condition factor (K) reflects, through its variations, information on the physiological state of the fish in relation to its welfare. From a nutritional point of view, there is an accumulation of fat and gonads development (Le Cren, 1951). Gayanilo and Pauly (1997) reported that certain factors often affect the well-being of a fish which include sex and stages of maturity. The length-weight relationships of male and female *O. niloticus* are illustrated in figure 4. The effect of sex on the (K) of *O. niloticus* from the White Nile is shown in table 1. Results obtained showed clear significant differences ($P<0.05$) in (K) between males and females. The average (K) values of *O. niloticus* in this study were found to be comparable to values reported for both sexes of the same species from other water bodies (Tesfaye and Tadesse, 2008).

The (LWR) of *O. niloticus* in the different stages of maturity is shown in figure 5. In this study four maturity stages (i.e., immature, maturing, running and spent), out of six stages mentioned by Nikolisky (1963) were observed. Table 1 showed that the different maturity stages were significantly different in condition factor ($P<0.05$). The (LWR) of a fish species could vary according to locality and season (Medina-Reyna, 2001, and Prasad, 2001). In biological studies, (LWR) enable seasonal variations in fish growth to be followed and

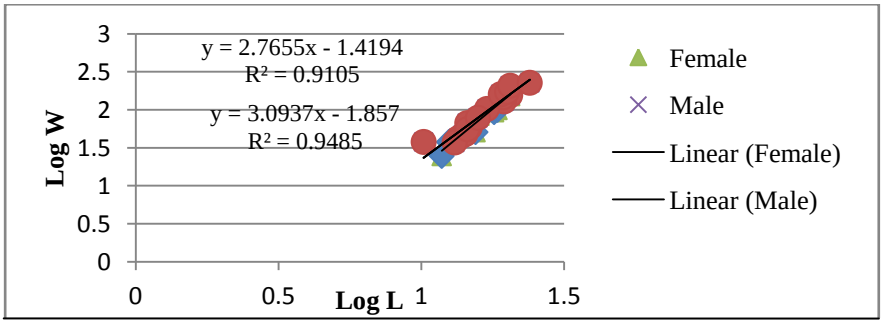

Figure 4. Effect of sex on length–weight relationship of *Oreochromis niloticus* from White Nile, Khartoum, Sudan (2012-2013).

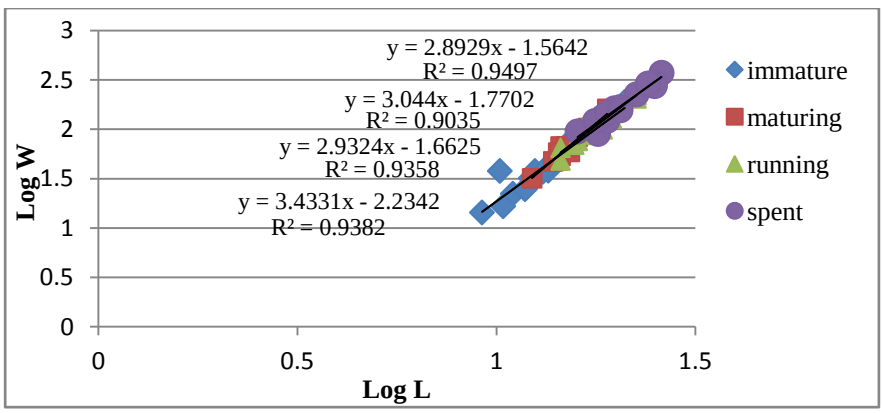

Figure 5. Effect of maturity stage on length–weight relationship of *Oreochromis niloticus* from White Nile, Khartoum, Sudan (2012-2013).

condition indexes to be calculated (Richter *et al*., 2000). The (LWR) of *O. niloticus* in summer and winter is illustrated in figure 6. Clear significant difference (P<0.05) between the two seasons was observed (Table 1). (LWR) are very useful for fisheries biology to estimate the weight at a certain age (Pauly, 1993). Variation in (LWR) of *O. niloticus* with age is shown in figure 7. According to table 1, age showed clear significant differences in condition factor of *O. niloticus* (P<0.05).

Conclusion

It can be concluded that the *O. niloticus* from the White Nile River exhibits positive allometric growth pattern, and the correlation coefficients of the length-weight relationships indicates high degree of positive correlation. The condition factor proved that *O. niloticus* fish live in a good physiological state of wellbeing in the studied part of the White Nile.

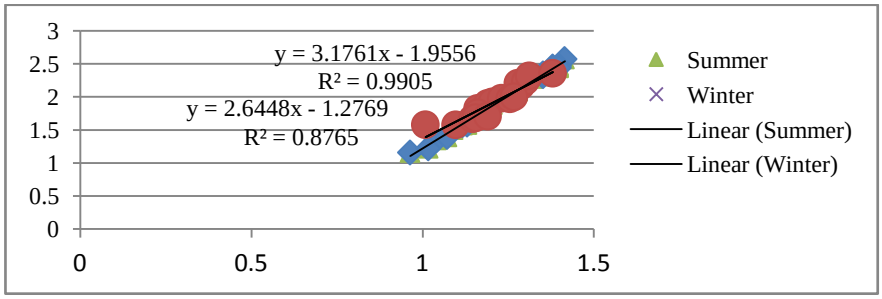

Figure 6. Effect of season on length–weight relationship of *Oreochromis niloticus* from White Nile, Khartoum, Sudan (2012-2013).

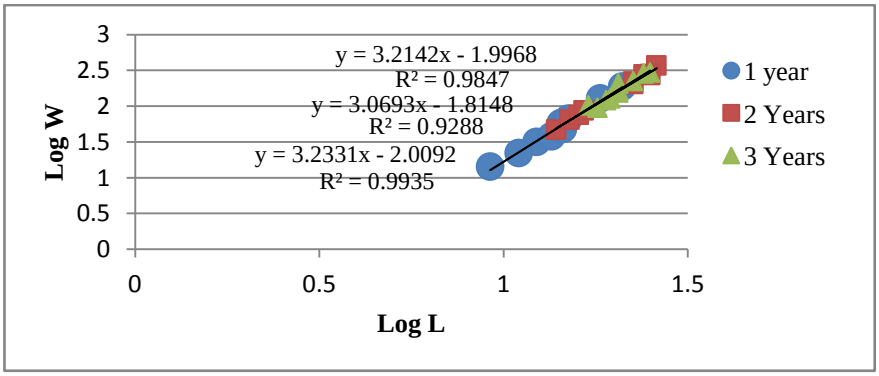

Figure 7. Effect of age on length – weight relationship of *Oreochromis niloticus* from White Nile, Khartoum, Sudan (2012-2013).

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