AFRICA ENVIRONMENTAL REVIEW Journal
ISSN: 1727-8341

AER Journal Volume 5, Issue 2, pp. 181-190, Nov, 2022

RESEARCH ARTICLE
Available Online at *http://ojs.uoeld.ac.ke/index.php/aerj*

Length-Weight Relationship and Condition Factor of *Labeobarbus altianalis* along River Molo in Lake Baringo Basin - Kenya

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Abstract

The condition of fish in an aquatic ecosystem is normally studied using the length-weight relationship because this provides allometric and isometric parameters, which informs the general wellbeing of the fish. The aim of this study, therefore, was to analyse the length-weight relationship and condition factor of Labeobarbus altianalis along River Molo in the Lake Baringo basin, Kenya. The parameters 'a' and 'b' of the length – weight relationship were estimated using the formula $W=aL^b$. *The length and weight relationships of L. altianalis samples studied were found to be highly correlated (r is equal or greater than 0.932). The 'b' values in the length-weight relationships of the fishes in the 7 sampled sites ranged between 1.93 and 3.2, implying that in most of the fish were exposed to poor environmental conditions hence poor growth. However, the fish in most sites exhibited positive allometric growth. Further, the relative condition factor ranged between 0.79 to 1.53, implying that the condition of the fish in most sites along R. Molo was good. Further study is recommended to cover both dry and wet seasons in order to provide sufficient data and information to inform management for sustainable exploitation and conservation of L. altianalis in River Molo.*

Keywords: Length-Weight Relationship, Condition Factor, *Labeobarbus altianalis*, Lake Baringo Basin, Allometric Growth, Isometric Growth

INTRODUCTION

Rivers provide the water for industrial, domestic use of the riparian communities and also for fisheries. Fisheries in the rivers are in small scale and are critical in local livelihoods because they provide food and other sources of income (Béné et al., 2016). The land use for the varied human activities including deforestation, agriculture and wastes from domestic and municipal sewage outflows, overfishing, illegal fishing methods and equipment tend to threaten the biodiversity of riverine fishery environments and its biological integrity (Arthington et al., 2006; Acreman et al., 2014; Oeding et al. 2018; Nyakeya et al., 2018a). Chemoiwa et al. (2017) and Tonkin et al. (2018) reported that anthropogenic activities may affect the riverine ecosystems at different rates based on the intensity of the activity, size of the catchment and the volume of water discharged. These riverine ecosystem changes alter the ecosystem structure by affecting the aquatic assemblages and the structure of the aquatic community (Hering et al., 2016).

In fisheries management, length-weight relationship and condition factor is used to establish the status of fish populations (El-Aiatt, 2021; Ighwela et al., 2011) in an aquatic environment. Further, Fulton, (1904) indicated that the length-weight relationship in fish is also important in determining the fish stock composition, mortality, growth and production. According to Shinkafi et al., (2011), fish weight and condition factor are parameters that show the general condition of fish and is normally denoted as 'K' and is used to indicate the performance of fish in terms of foraging, and the prevailing environmental conditions. Spawning period and the extent to food utilization in aquatic system can also be determined by the fish length-weight relationship and condition factors (Ighwela et al., 2011). Therefore, in essence, length-weight relationship and condition factors are important key attributes to indicate the life cycle and helps to understand a fishery for sustainability (Kleanthidis et al., 1999).

The length-weigh relationship, log 'a' is plotted against log 'b' to give a straight line to distinguish and detect outliers. The 'r' coefficients in the regression model is used to confirm the reliability and well fitted data, therefore r coefficients of above 0.7 depicts that the body weight of the fish species under study increase proportionately as the total length increases. On the other hand, when the r coefficient is below, <0.4, is evidence of poor growth rate (Le Cren, 1951).

The value of coefficient 'b' depicts the general condition of fish in its environment where 'b' is less than 3 and/or equivalent to or more than 3, displays allometric and isometric conditions of the fish respectively. The allometric growth of fish indicates poor growth conditions while the isometric growth is an indicator of favourable environment conditions thereby a good growth condition (Kleanthidis et al., 1999). The current study focused on length-weight relationship and condition factor of sites along R. Molo which originates from the Eastern arm of Mau catchment complex and traverses a wide terrain complex before it drains into Lake Baringo. The river stretches over 100 km length, because of this, the river is exposed to many anthropogenic activities (Nyakeya et al., 2018b). It is one of the rivers with the highest number of erected dams and unregulated water abstraction downstream. In spite of this, it is a habitat for various fish species including *Clarias theodore*, *Enteromious cercops*, *Labeo cylindricus*, *Enteromious neumayeri, Oreochromis niloticus* and *L. altianalis* (Nyakeya et al., 2018b) which make the river exposed to artisanal fisheries for food and local trade. However, currently there is limited information, as far as the length-weight relationship and condition factor of *L. altianalis* along R. Molo and therefore this study seeks to address the issue and hence contribute to the conservation and management of *L. altianalis* in R. Molo.

MATERIALS AND METHODS

Study Area

This study was conducted along R. Molo (Figure 1) which stretches from Kuresoi area of North-East part of the Mau Complex, which is a highland plateau in Nakuru County to Lake Baringo in plains of Baringo County, Kenya. The river traverses a mixed environmental terrain that is highly impacted anthropogenically (Nyakeya et al., 2018b). The catchment of R. Molo has an altitude ranging between 2400 to 3100 m asl, which enjoys adequate rainfall that is evenly distributed with two peaks occurring from April to June and September to October, and a dry spell is normally experienced from November to March. The region has a mean annual rainfall of 1100 mm although some areas receive up to 1500 mm in the upper Mau escarpment. The average temperature in the sampling area ranges between 23°C during the wet season with a maximum of 27°C during the dry season and in the coolest season, a minimum of 12°C. The reddish to brownish volcanic soils dominates, but the brown loam soils occur mainly in the high altitude. The soils are also characterized by the thin layer and drains freely with friable texture (Nyakeya et al., 2018b).

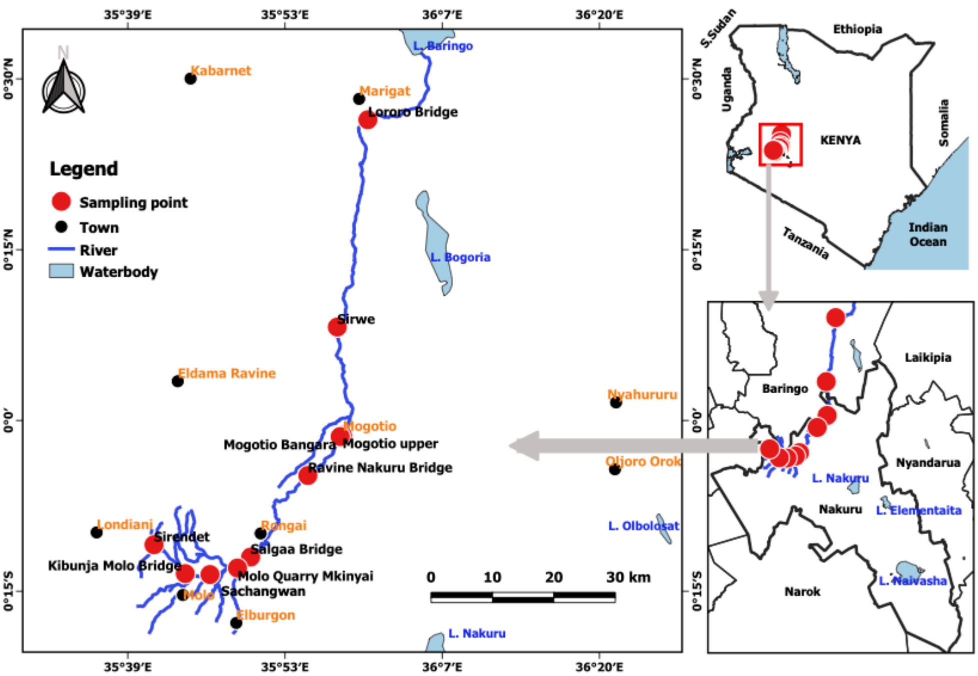


Figure 12: A map showing the sampling sites in Molo River (Nyakeya et al., 2018b).

The Study Sites

The selection of the sites was based on a previous study done by Nyakeya et al., (2018b). Selection of sampling sites random and based on the accessibility of the area, proximity, habitat and activities done by the riparian community along the river. The Geographical Position System (GPS) was used to identify the 7 sampled points (Figure 1). The sites with differing riparian land use activities were also considered in this study.

***L. altianalis* Sampling, Processing and Measurement**

L. altianalis were sampled at each sampling site along the river using various sampling gears for about 10 minutes at each of the 7 sampling sites, covering anpproximately 100 m for each sampling site. Different sampling gears were used proportionally according to habitats suitability within each bend. *L. altianalis* were identified and picked while the other fish captured were returned to the river., total length (TL) and standard length (SL) were measured to the nearest 0.1 cm using a ruler and the body weight (W) to the nearest 0.01 g using a digital weighing scale (5 kg Vibra Model from Shinko Devshi Co. Ltd, Japan).

Determination of the Length/Weight Relationship

To compute the length-weight relationship, a regression coefficient was used, where the "b" from the length-weight relationship was calculated using the formula of Le Cren (1951):

$W= aL^{b}$……………………Equation 1

Where:

W = the weight (g) of the sampled fish
a = exponent describing the rate of change of fish weight with length
L = the total length (centimetres) of the sampled fish
b = weight at fish unit length

The observed lengths and weights were subjected to linear transformation using natural logarithm the following formula of Ricker (1975).

Log W = b log L + log a……..…Equation 2

Relative Condition Factor
The relative robustness of the *L. altianalis* was expressed by relative condition factor (Kn) as calculated by the Fulton (1904) formula:

$$Kn = \frac{W_o}{W_p} \quad \text{………… Equation 3}$$

Kn = relative condition factor;

W_o = weight observed

W_p = weight predicted (aL^b)

Data Analysis
The length-weight relationship and condition factor between the different stations were analyzed using Microsoft Office Excel Version 16. The data were presented in tables and graphs. ANOVA was done to determine the significant difference in lengths and weights of the fish among the 7 sampling sites.

RESULTS
Mean Length and Mean Weight
The mean weight of *L. altianalis* sampled from the seven sites of R. Molo showed the range of between 10.34+0.19 g to 38.09+2.95 g in Salgaa and Sirwe respectively. It was further noted that there was no pattern in the weights between the downstream and upstream, though the weight of fish in midstream was more than 13.44 g. However, in the sites between Mogotio upper and Ravine-Nakuru bridge, the weights were less. The mean lengths followed similar pattern being longer (13.48+0.26) cm in Sirwe exhibiting a trend which is in tandem to the weights. The lengths, however, were not significant at $P \leq 0.05$.

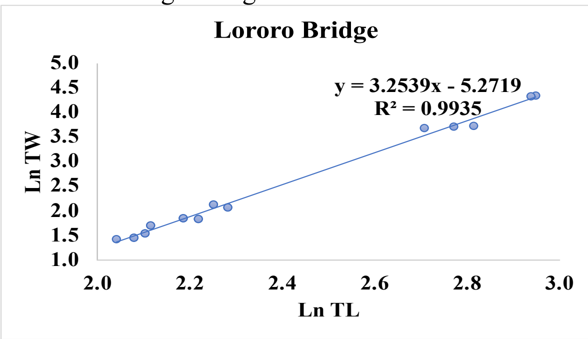
Table 1: Mean weight and total length of *L. altianalis* at the seven sampling sites along Molo River

Sampling Sites	n=?	Mean W (g)	Mean TL (cm)
Sirwe	44	38.09±2.95	13.48±0.26
Salgaa Bridge	16	10.34±0.19	10.2±0.07
Ravine Nakuru Bridge	24	13.44±0.8	10.14±0.25
Molo Quarry Mkinyai	12	24.77±1.16	12.98±0.16
Mogotio upper	48	13.41±0.88	10.68±0.14
Mogotio Bangara	28	12.39±0.75	9.91±0.23
Lororo Bridge	40	18.45±1.19	10.86±0.19

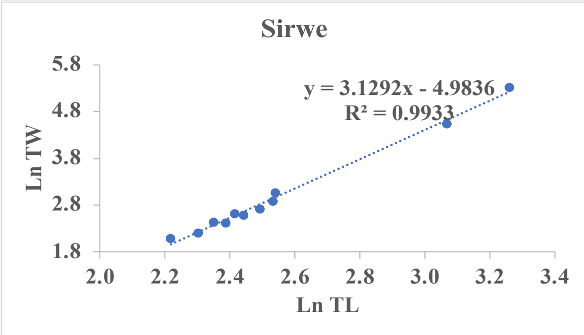
Length/Weight Relationships
The length/weight relationships of the *L. altianalis* sampled along R. Molo indicated that the '*b'* exponent value of the relationship ranged between 1.935 to 3.259 in Ravine Nakuru bridge and Lororo bridge respectively.

The sites of sampling downstream which included Loloro bridge and Sirwe was found to have 'b' exponential values of more than 3.1 similar to Molo Mkinyai quarry site (3.19) which is upstream (Figure 2) Most of the midstream stations had 'b' exponential values of less than 2 indicating a negative allometric growth in the sites of Mogotio Bangara (1.95) and Ravine-Nakuru bridge (1.93). A near isometric growth was observed in *L. altianalis* at Salgaa bridge (2.95) (Figure 2a – 2f).

The correlation coefficient 'r' of *L. altianalis* of the equation in all the sites was above 0.93 indicating a strong positive correlation at $p<0.05$ between weight and length. However, where the coefficient of 'b' was > 3.01, the r^2 coefficient was higher than 0.97, whereas in the case of 'b' below 3.0, the r^2 was found to range between 0.91 to 0.94, but they were not significantly different among the sites (Figure 2a – 2f). It was further noted that most of the fish sampled from downstream sites of Loloro bridge and Sirwe were having a similar length-weight relationship with the highest sampling point upstream at Molo quarry mkinyai (indicate the value in brackets).



a



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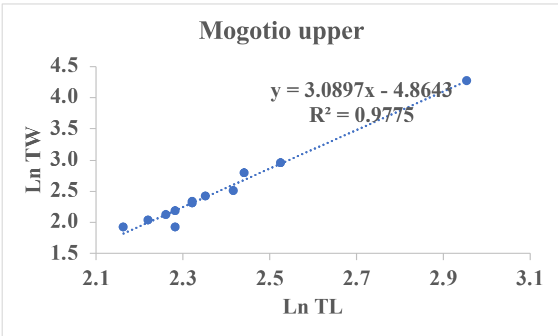

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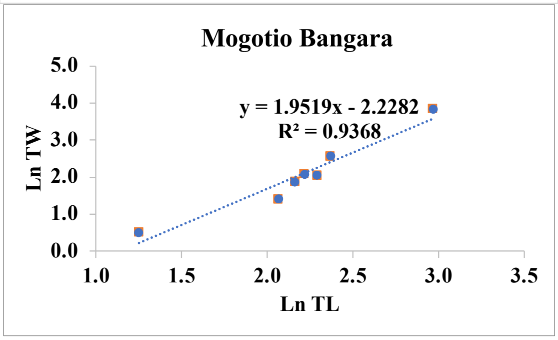

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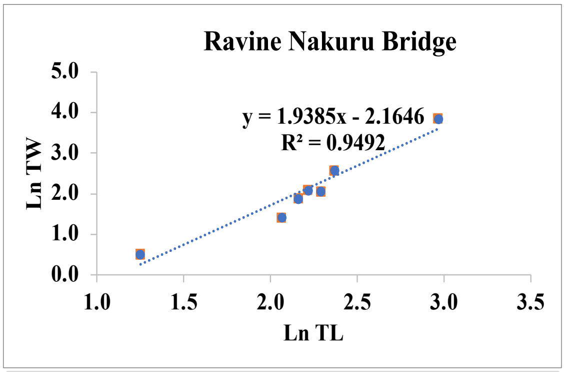
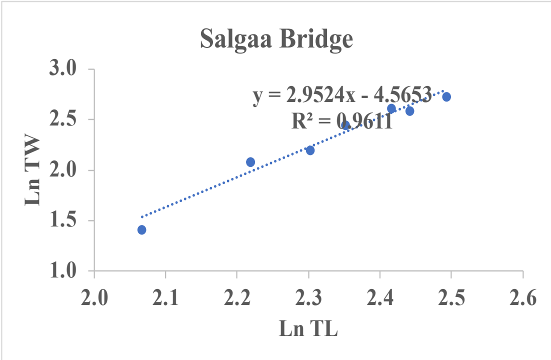


f



g

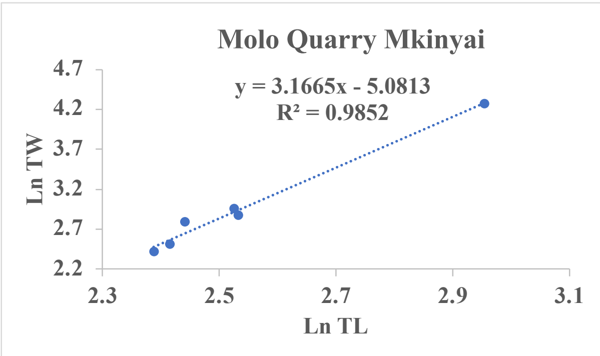


Figure 2 (a-g). Length Weight relationships of the sampled *L. altianalis* along River Molo.

Relative Condition Factor

The relative condition factor for *L. altianalis* along R. Molo was found to range between 0.79 to 1.53 in the sites of Molo quarry Mkinyai and Loloro bridge, respectively. The trend of condition factor value of the fishes along R. Molo showed that the condition of the fish was better in the downstream and midstream sampling sites than in the upstream (Figure 3), though there was no significant difference at $P<0.05$.

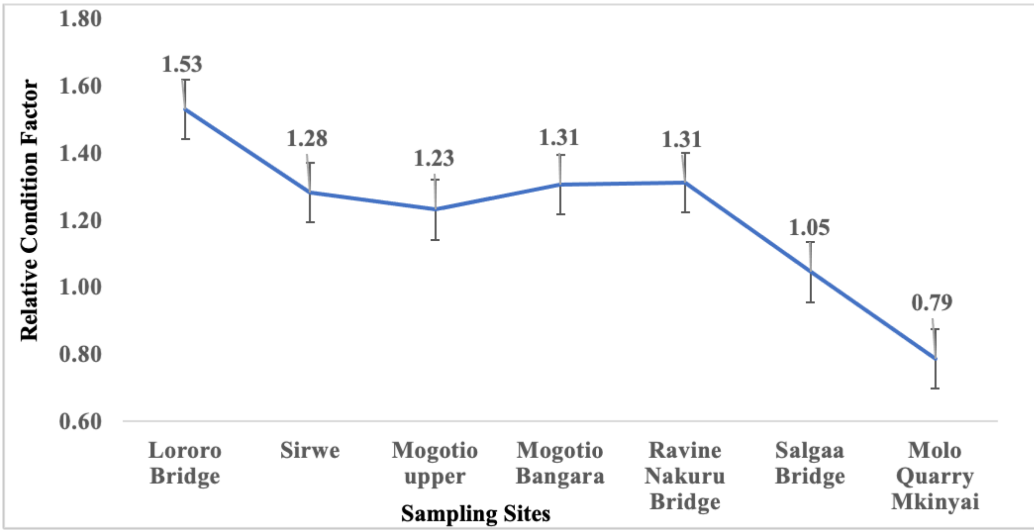


Figure 3: Relative condition factors of the sampled L. altianalis along River Molo.

DISCUSSION

In most of the *L. altianalis* fish studied along R. Molo a 'b' coefficient of between of 1.93 and 3.25 was obtained, implying the wellbeing of the fishes varied along the river. Hile (1936); Martin (1949); Hamid et *a*l. (2015) indicated that the value of regression coefficient lied between 2 and 4.0 for an ideal fish wellbeing. These coefficient values explain whether the fish condition is exhibiting isometric when 'b' = 3.0, in this case the fish body size grows at the same rate or negative allometric ('b' < 3.0) or positive allometric ('b' > 3.0), in which there is unproportionate growth (Nehemiah et al., 2012). The current study established near isometric condition in fish at Salgaa which is one of the sites in the upstream, this agrees with the findings of (Sunda, 2018) in R. Kuja who found out that most fish achieved isometric growth in the upstream sites. Moreover, the isometric growth pattern have been reported in other rivers by Gebremedhin & Mengist (2014) and Tesfahun et al. (2018) in the tributaries of Blue Nile. The sites in the midstream such as Mogotio Bangara and Nakuru-Ravine bridge reported allometric growth in the *L. altianalis* and this is attributed to several factors which prevail and unique to these sites as compared to the other sites. These sites are near and only just after Mogotio urban centre, where there are more anthropogenic activities which can lead to the drainage into the river at these points impacting the fish. Kleanthidis et al. (1999) explained that exposure of fish to poor environmental conditions leads to poor growth as demonstrated by 'b'< 3.0 coefficient. Similarly, the riverine environment in these sites are unstable leading to poor growth as explained by Nyakeya et al. (2018b). Further, the uncontrolled usage of water for domestic and agriculture affects the water quality and quantity at these sites as earlier reported by Nyakeya et al. (2020), are possible reasons for slender and low weight fish. The negative allometric growth have previously been reported by Nyakeya et al. (2018b) in R. Molo, and some tributaries of White Nile (Wakjira, 2013; Abera, 2016; Melaku et al., 2017; Temesgen, 2017).

On the contrary *L. altianalis* in Lororo bridge, Sirwe and Molo quarry Mkinyai had positive allometric growth ('b' > 3.0) and high 'r' coefficient (> 0.97), an indication that the linear regression model used was reliable and fitted the data (Ighwela et al., 2011). The higher 'b' coefficient is an indication that the fish growth followed the cube law and may be due to the ability to forage well with probably less competition from other fish species according to Doha & Dewan (1967). The fish becomes relatively stout as the length increases, a phenomenon exhibited by fish when the conditions, food availability and less disturbance of water occurs in a site. This was obtained in the three sites along R. Molo, which contradicts the earlier studies of Nyakeya et al. (2018b). Further the positive allometric growth and weights of fish in upstream (Molo quarry Mkinyai) could be attributed to the gonadal development as reported by Zdanowski et al. (2001) and concurs with the reports of Sunda (2018). The length–weight relationship that has resulted from this study could help form basis for conservation and management on *L. altianalis* especially in River Molo.

Condition Factor

Condition factor (K) shows the fitness of a specific water body for growth of fish. Several features such as environmental factors, maturity and food accessibility in a water body (Eagderi & Radkhah, 2015) influence the conditions of the fish. The mean relative condition factor of *L. altianalis* from River Molo was between 0.79 to 1.53 which revealed a fair to good condition of the fish in the river. The seven sampling sites along the R. Molo showed varying condition factors where the upstream station at Molo quarry Mkinyai had the lowest mean condition factor, thereby contradicting the report of Sunda (2018) in R. Kuja. The low condition factor in the upstream station is probably attributable to rapid changes in the river as a result of rainfall. Similarly, the availability of plankton food resources could be poor relative to the downstream sites as reported by Ondhoro et al. (2016). Asadi et al. (2017) indicated that a condition factor of ≥ 1 imply a good feeding level and suitable environmental conditions. Loloro bridge and all the midstream stations revealed to be more suitable habitats with better environmental condition for *L. altianalis* as by their condition factors that were above 1 due to fish food resources and good environmental quality.

CONCLUSION AND RECOMMENDATION

The study reports that many sites of R. Molo had *L. altianalis* displaying a positive allometric growth relationship because their ‘b’ values were more than 3, a condition reminiscent to good environment. It is also concluded that *L. altianalis* demonstrated an isometric growth and positive allometric growth in most of the downstream due to its ability to utilize any available food resource, but negative allometric growth and fairly good condition in most midstream sites. The study recommends for a further study to cover both dry and wet seasons in order to provide sufficient data and information to inform management, conservation and sustainable exploitation of *L. altianalis* fishery in R. Molo.

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