

## Full Length Research Paper

# Morphometric relationships of African big barb, *Labeobarbus intermedius* (Rüppell, 1836) in Lake Koka, Ethiopia

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Morphometric relationships of African big barb, *Labeobarbus intermedius* (Rüppell, 1836) (Pisces: Cyprinidae) in Lake Koka, Ethiopia was studied based on the total number of 266 adult fish samples collected in April-May and July-August 2011. Fish ranging from 23.3 to 49.0 cm in total length ( $35 \pm 4.1$  cm) and from 95.4 to 1200 g in total weight ( $434.4 \pm 206.5$  g) were randomly sampled. Of these, 55.6% (n=148) were males and 44.4% (n=118) were females. The length-weight relationship of the males, females and combined fish were curvilinear and statistically significant ( $P < 0.01$ ). *L. intermedius* in Lake Koka has positive allometric growth pattern, which was statistically significant ( $p < 0.01$ ). Females were more allometric in their growth pattern, but statistically not significant ( $P > 0.01$ ). Length-length relationships between total length (TL) and fork length (FL), fork length (FL) and standard length (SL), TL and SL were linear and statistically significant ( $P < 0.01$ ). Result of Fulton condition factor showed no significant differences between males and females ( $P > 0.01$ ). The overall condition factor for all sampling period was 1.0.

**Key words:** Allometric growth, *Labeobarbus intermedius*, condition factor, Lake Koka, length-weight relationship.

## INTRODUCTION

The African big barb, *Labeobarbus intermedius* is a widely distributed fish species in Northern Kenya and in most parts of Ethiopian drainage basins (Dadebo et al., 2013). It is present in Ethiopian rift valley basin, Abay basin and Baro-Akobo basin part of Ethiopia, where Lake Tana harbor the largest population (Vijverberg et al., 2012; Awoke, 2015). It is one of the most commercially important fish species in the country (Desta et al., 2006;

Bjørklis, 2004). The total annual yield of *L. intermedius* from the total inland water bodies is estimated to be about 365 tonnes per year (LFDP, 1997). However, recently the consumption of *L. intermedius* from rift valley lakes (Lake Hawassa and Lake Koka) declined, because it was found to be unsafe for human consumption due to its high mercury concentration (Mengesha, 2009). In addition, the reduction of fish in the natural environments

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overfishing and parasitic infection has resulted in less accessibility of the fish in the local markets (Desta et al., 2006; Mengesha, 2009; Dadebo et al., 2013).

Length-weight relationship (LWR) is one of the most important biological tools in fishery management. It is used to estimate the average weight a fish can attain at a given length (Lawson et al., 2013). It also provides valuable information, such as the effect of environmental factors, habitat changes, species interaction and food availability in ecosystem, which is used for aquatic ecosystem modeling (Dan-kishiya, 2013). Therefore, the length-weight relationship of fishes under various environmental conditions should be known.

Fish can attain either isometric, negative allometric or positive allometric growth in its life (Nehemia et al., 2012). Isometric growth occurs when all the body parts grow at an approximately the same rate as an organism grows. In another way, negative allometric growth is the type of growth in which fish become slender as it increases in weight, while positive allometric growth occurs when fish become relatively stouter or deeper-bodied as it increases in length (Riedel et al., 2007).

The difference in LWR is based on the inherited body shape and condition of individual fish (Yousuf and Khurshid, 2008). Condition factor shows the degree of wellbeing of fishes in their habitat, which can be expressed by coefficient of condition. It is a measure of various biological and ecological factors with regard to their feeding conditions (Nehemia et al., 2012). Fish attain a better body condition when the condition factor value is higher. Different factors, such as stress, sex, season, availability of food and other water quality parameters can affect the condition of fish (Ighwela et al., 2011).

For most tropical and sub-tropical fish species, information on LWR is still very rare (Hossain, 2010). Lake Koka is one of the tropical lakes harboring different types of fish species. Various authors have studied the length-weight relationship and condition factor of *L. intermedius* in Ethiopian water bodies (Admasu and Dadebo, 1997; Dadebo et al., 2013; Wakjira, 2013; Engdaw, 2014; Gebremedhin et al., 2014; Awoke et al., 2015; Abera, 2016; Temesgen, 2017). However, there is no available information on length-weight relationship and condition factor of *L. intermedius* in Lake Koka. Therefore, this study aimed to investigate the length-weight relationship and condition factor of *L. intermedius* in Lake Koka.

## MATERIALS AND METHODS

### Description of the study area

Lake Koka is located in the central Ethiopian Rift Valley, 100 km from the capital Addis Ababa at an altitude of 1590 m a.s.l (Figure 1). It covers about 180 km<sup>2</sup> surface area with mean depth of 9 m (Kibret, 2010). The area is characterized by a semi-arid to sub-humid climate (Peder, 2009). The main rainy season starts in June

and extends to the end of September, while the short rainy season occurs from March to May. The maximum and minimum annual mean temperature of the surrounding air is 30.4 and 14°C, respectively. The pH and conductivity of the lake is about 8.03 and 412  $\mu\text{S cm}^{-1}$ , respectively. The phytoplankton biomass of the lake is about 5.9  $\text{mm}^3\text{L}^{-1}$ , which is dominated by *Microcystis* (Mesfin, 1998). The zooplankton diversity is however, very low (Peder, 2009). The lake serves different purposes, such as hydroelectric generation and irrigation (which accounted for about 6000 ha Wonji Sugarcane Project). As a result, the holding capacity of the lake has reduced from 1650 million m<sup>3</sup> in 1959 to 1186 million m<sup>3</sup> due to sedimentation over 25 years. The lake is also important for fishing activities, mainly for the people living in the vicinity of the lake. The fishery of Lake Koka is dominated by five fish species: Nile tilapia (*Oreochromis niloticus*), Common carp (*Cyprinus carpio*), the African catfish (*Clarias gariepinus*), African big barb (*L. intermedius*) and small cyprinodont minnow (*Aplocheilichthyes antinorii*). The total annual fish landing from the lakes is estimated to be about 625 tonnes/year, where Nile tilapia takes the largest part of the catch (cover about 59% (327 tonnes) of the total landings per year) (LFDP, 1997).

### Fish sample collection and measurements

The fish samples were collected from April through August 2011 from the regular fishermen. The fishermen use gillnets with 100-160 mm stretched mesh sizes. They set the nets in the late afternoon (from 4 to 6 pm), left overnight and collected them the following morning, two hours after sunrise (between 6 to 7 am). In addition, the fingerlings were sampled in the shallow littoral area using a beach seine with 6 mm mesh size. The total length (TL, cm) and total weight (TW, g) of fish were measured using a measuring board to the nearest 0.1 cm, and sensitive balance with sensitivity of 0.1 g (Figure 2).

### Length-weight relationships (LWRs)

The data generated were subjected to statistical analysis by fitting length-weight relationship following Le Cren (1951). Length-weight relationship was calculated based on the Bagenal and Tesch (1978) method as:

$$TW = aTL^b \quad (1)$$

Where TW = total weight in g, TL = total length in cm, a = a constant being the initial growth index (regression line intercepts of y-axis), and b = growth coefficient (slope of the regression line).

The relationship between length and weight was determined for males and females separately by the regression and correlation analysis methods.

### Length-length relationships

The relationships between total length (TL) and fork length (FL), fork length and standard length (SL) and total length with standard length were calculated using linear regression as:

$$TL = aSL^b \text{ or } TL = aFL^b \quad (2)$$

Where, TL = total length, SL = standard length, a = intercept and b = slope.

### Fulton condition factor (K)

The well-being of the fish was calculated using Fulton condition

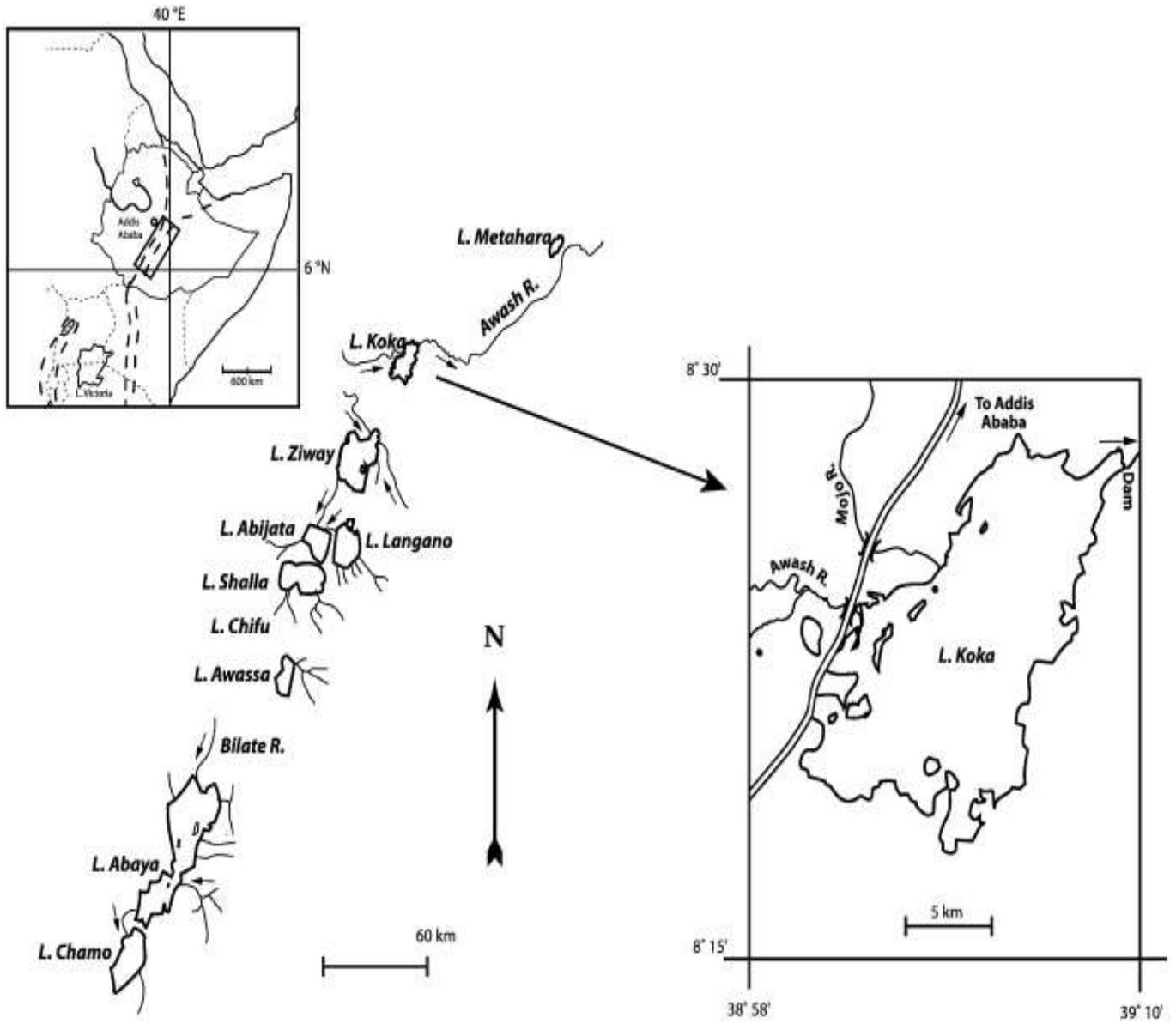
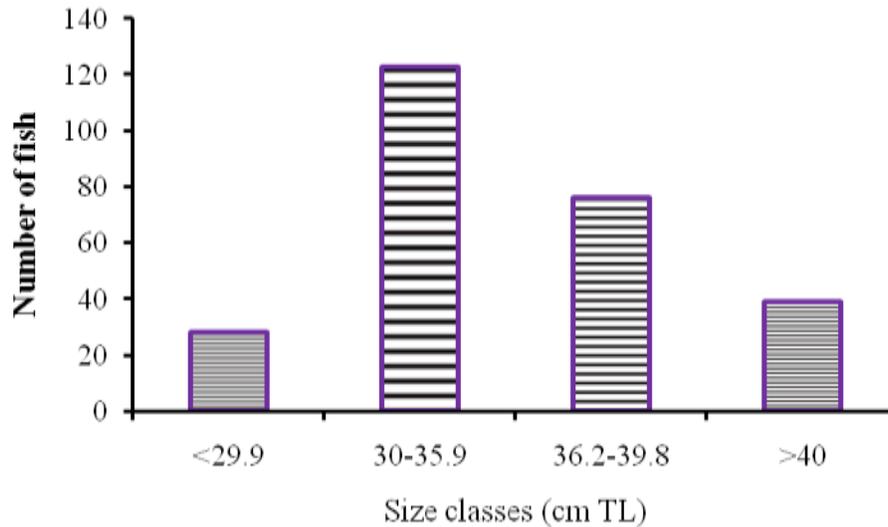


Figure 1. Map of the study area.



Figure 2. Photos captured during morphometric measurement in the laboratory.



**Figure 3.** Length frequency distribution of *L. intermedius* (N=266) in Lake Koka, Ethiopia.

factor (Le Cren, 1951; Bagenal and Tesch, 1978) as:

$$K = (TW \times 100) / TL^3 \quad (3)$$

Where, K = condition factor, TW is total weight (g) and TL is total length (cm).

#### Data analysis

The data obtained from morphometric relationships were analyzed by linear regression of SPSS version 16.0. Chi-square was computed to test regression slope (b) and condition factor differences of the fish among the different length groups, sexes and deviant from cubic law of Bagenal and Tesch (1978).

## RESULTS

### Length frequency distribution of *L. intermedius* in Lake Koka

*L. intermedius* had total length ranging from 23.3 to 49.0 cm TL, with a mean length of  $35.06 \pm 4.4$  cm TL. The length group of 30-35.9 cm TL fish dominated the catch (Figure 3).

### Length-weight and length-length relationships

From the total 266 fish collected, about 55.6% (n=148) of them were males and 44.4% (118) were females. The LWRs for males, females, and for the combined sexes were all curvilinear and statistically significant among different length groups ( $P < 0.01$ ), with the  $r^2$  values above 0.95 (Figure 4a, b and c). *L. intermedius* in Lake Koka had positive allometric growth pattern ( $b > 3.0$ ) and the value is significantly different from the cubic law of

Bagenal and Tesch (1978) (3) ( $\chi^2$ ,  $p < 0.01$ ). Females had high allometric growth pattern than males (Figure 4b). However, there was no significant difference observed in b values between the two sexes ( $\chi^2$ ,  $P > 0.01$ ).

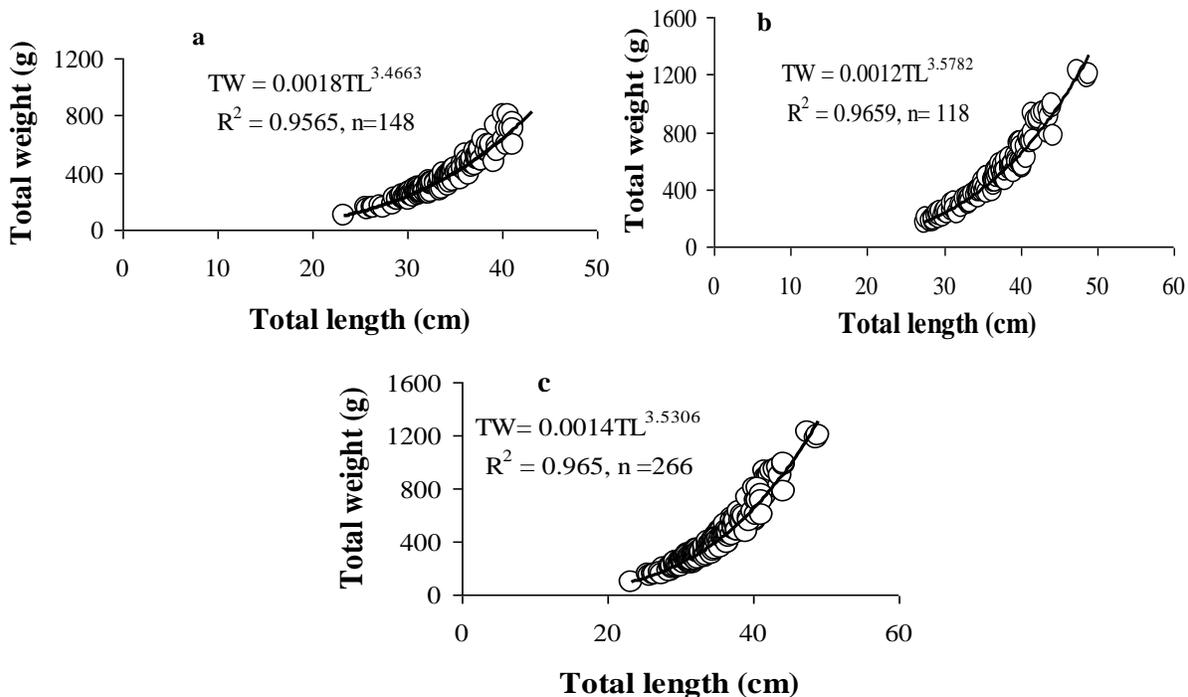
The result obtained for fork length vs. total length, fork length vs. total length, and standard length vs. total length indicated the linear relationship and the variation in 'b' value were not highly significant among the different length groups ( $\chi^2$ ,  $P > 0.01$ ), with the  $r^2$  value above 0.95 (Figure 5). Similarly, the result did not reveal a significant variation in 'b' values among the sexes for all the relationships ( $\chi^2$ ,  $P > 0.01$ ).

### Fulton condition factor (FCF) of *L. intermedius* in Lake Koka

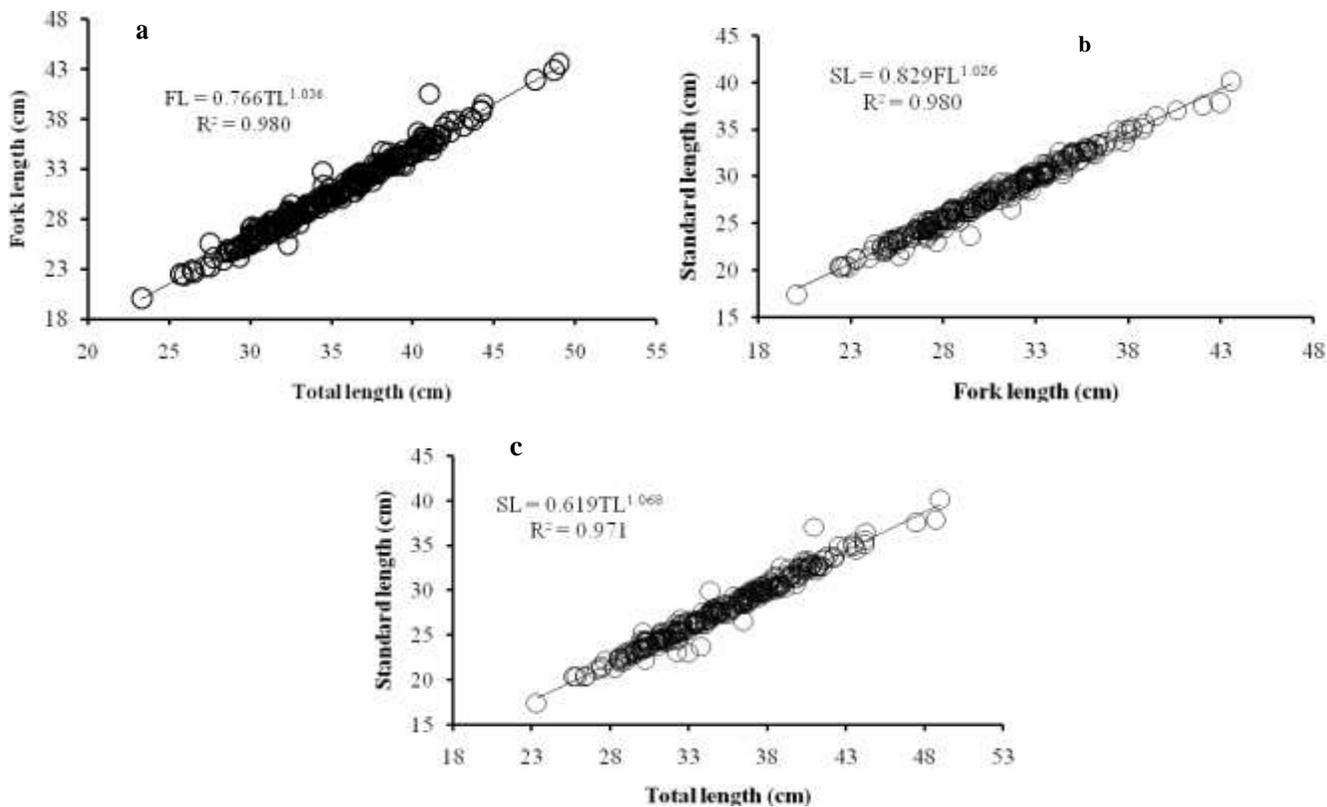
The Fulton condition factor for the males and females were 1.0 and the result did not showed variation among the sexes ( $\chi^2$ ,  $P > 0.01$ ). In addition, the combined result for condition factor of *L. intermedius* was also 1.0.

## DISCUSSION

*L. intermedius* had total length ranging between 23.3 and 49.0 cm TL with a mean length of  $35.06 \pm 4.4$  cm TL. The maximum size recorded for *L. intermedius* in this study (49.0 cm TL) is comparable to the finding of Dadebo et al. (2013) in the same study area for the same species (49.0 cm). However, it was higher than the findings from Lake Tana's gulf of Gorgora (43.8 cm) (Engdaw, 2014) and Lake Zeway (44.0 cm) (Abera, 2016), but less than the findings of Wakjira (2013) in Gilgel Gibe I Reservoir (54.0 cm TL) and Temesgen (2017) in Lake Langano (53.5 cm TL). Many studies indicated that the interaction of both



**Figure 4.** Relationships between total length and total weight of males (a), females (b) and both sexes (c) of *L.intermedius* from Lake Koka.



**Figure 5.** Relationships between total length and fork length (a), fork length and standard length (b) and total length and standard length (c) of *L. intermedius* from Lake Koka.

physical and chemical properties of the water (Deepak and Singh, 2014), biological factors (Teshome et al., 2015) and the pressure of overfishing (Mohammed and Uruguchi, 2013) determine the size of fish in the water. For instance, biological factors such as availability of fish in the water, fish behavior towards the fishing gear, shape, and external features of the fish, which depends on season, age, environment and other species, determine the size of fish in the catch (Kolding et al., 2003). In addition, human factors, such as fishing effort, gear type, mesh size and other factors (e.g. time of the year, location, catchability, quotas) decide the catch volume and size distribution of the catch (Mous et al., 2004). Environmental factors, such as water temperature (Davis and Parker, 1990) and water salinity (Barton and Zitzow, 1995; Mous et al., 2004) also influence the size of fish catch.

The result obtained for LWR showed that the fish has not obeyed the cube law of Bagenal and Tesch (1978), which assumes the regression slope ( $b$ ) to be three or almost three. The coefficient obtained indicated the positive allometric growth ( $b > 3$ ), that is, the fish grows faster in weight than in length. Many authors indicated that the allometric growth is the most appropriate for describing morphometrics growth of fishes (Karpouzi and Stergiou, 2003). However, it appear to be rare in nature, and the calculation is not optimally applicable to all metric comparisons, because the relationship reflects the effect of different factors, such as habitat type and feeding habits on the fish growth.

The  $b$  recorded in this study ( $b = 3.530$ ) contradicts the isometric growth reported in some tributaries of Lake Tana (Teshome et al., 2015), Lake Tana (Engdaw, 2014; Gebremedin et al., 2014), Lake Hawassa (Admassu and Dadebo, 1997), Blue Nile River (Awoke et al., 2015), Megech and Dirma Rivers (Anteneh, 2005), Sanja River (Tesfaye, 2006), Gendewuha, Guang, Shinka and Ayima Rivers (Tewabe, 2008), Borkena and Mille Rivers (Tessema et al., 2010) and Lake Baringo, Kenya (Kembenya et al., 2014). Temesgen (2017) also reported negative allometric growth ( $b < 3$ ) for the same species in Lake Langeno, which contradicts with the current finding. Fulton (1904) stated that the growth performance of fish could vary in different places and at certain times of the year. Mainly, variation in biological factors, such as availability of foods, quality and quantity of food, feeding rate and spawning period of fish affects the  $b$  value of fishes (Suquet et al., 2005). According to Wotton (1995), the coefficient of LWRs value ( $b$ ) is used as an indicator of food availability and growth pattern, where the feeding availability is influenced by spatial and temporal variations of foods. In addition to the variation between habitats, physiological and biological factors of the fish affect the fish growth (Zdanowski et al., 2001). Gonad development also affects the fish weight and  $b$  values in the length-weight relationship (Wotton, 1995; Zdanowski et al., 2001). Environmental factors, such as water

temperature, oxygen concentration, salinity and photoperiod can also influence the rate of fish growth (Zdanowski et al., 2001).

The measure of fish condition factor is determined by various factors. According to Otieno et al. (2014), it changes in abundance of food and water quality, and fluctuation of water level and water temperature determine the body condition of fishes. Condition factor also shows variation that occurs seasonally due to sex and gonad development (Engdaw, 2014). This is because large part of energy is allocated for growth and emptying of ovaries, which results in the lower body condition of fish (Aera et al., 2014). The higher body condition indicates the higher energy content, adequate food availability, reproductive potential and favorable environmental condition (Pauker and Rogers, 2004).

The Fulton condition factor recorded for *L. intermedius* in this study did not indicate a significant variation among the sexes, which is in agreement with that of Awoke et al. (2015) in Nile River and Berie (2007) in Gilgel Beles River. This could be due to the collection of most samples in dry season, which is not the reproductive season of the fish, which results in the body condition difference among the males and females. In addition, the availability of food items in the lake, which is unclear at this stage and needs further study, could be the reason for similar body condition of both sexes. The mean result of Fulton body condition obtained in this study (1.0) was less than the findings reported in Lake Zeway (1.73) (Abera, 2016), Arno-Garno River (1.3) (Gebremedhin et al., 2014), Aveya River (1.22) (Gebremedhin et al., 2014), Gilgel Gibe I Reservoir (1.18) (Wakjira, 2013), Geba and Sor Rivers (1.21) (Melaku et al., 2017), Lake Langeno (1.33) (Temesgen, 2017) and in some tributary rivers of Lake Tana (1.21) (Teshome et al., 2015). This indicated that *L. intermedius* in this lake had poor body condition as compared to the above water bodies. The differences in body condition obtained might be due to differences in environmental condition, quantity and quality of food, feeding rate and water level fluctuation. This is because Lake Koka is one of the Ethiopian rift valley lakes under high human pressure, mainly due to the use of the lake for agricultural activities (Gebretsadik and Mereke, 2017). As a result, the water gets shallower and shallower, which is not comfortable for the bottom feeder fishes like *L. intermedius*. This could result in poor body condition of fish in the lake.

## Conclusions

The length-weight relationships of males, females and combined sexes of *L. intermedius* have positive allometric growth pattern because the slopes of the lines were significantly different from 3. The mean condition factors of the males and females were not significantly different. The length-length relationships between TL and

FL, FL and SL and TL and SL were linear and statistically non-significant. Generally, the fishes in the lake had poor body condition when compared with other similar water bodies in the country.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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