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Overview of Length-Weight Relationship, Condition Factor and Size at First Maturity of Nile tilapia Oreochromis niloticus (L.) in Different Water Bodies of Ethiopia: A Review

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Abstract
Length-weight relationship, condition factor and size at first maturity of Nile tilapia *Oreochromis niloticus* (L.) in different water bodies of Ethiopia have indicated that nearly isometric (b≈3) growth pattern. The Fulton condition factor (K) of *O. niloticus* was higher in Lake Chamo (2.35) and in Baro River (2.05) than in Gilgel Gibe Reservoir (1.87) and in Lake Langano (1.77). However, it was lowest in Lake Beseka (0.05). Size at first maturity (L_{50}) of *O. niloticus* was high (42.0 cm TL) for both sexes in Lake Chamo. However, declined in most water bodies of Ethiopia and also exhibits both sexual and seasonal variations. There was variation in size at first maturity with respect to sex in which males had larger size at first maturity than females. Generally, the length-weight relationship, condition factor and size at first maturity of *O. niloticus* was correlated with availability of food, feeding rate, gonad development, spawning period, water quality parameters can determine the growth rate and the condition of fish and therefore, proper management of this fish stock for conservation and sustainable fishery is critical.
Keywords: Condition Factor, Length-weight, *Oreochromis niloticus*, Size at first maturity, Water bodies of Ethiopia

INTRODUCTION

In Ethiopian water bodies, Nile tilapia (*Oreochromis niloticus*) contributes more than 50% of total landings of fish catch per year (Tesfaye and Wolff, 2014). In addition to this, the Nile tilapia are the most important fish species in both tropical and subtropical freshwater bodies and often playing a significant role of commercial fisheries in various African countries (Mohammed and Uraguchi, 2013). This is most probably due to, their high range tolerance to environmental conditions and the ability to accept artificially formulated and natural available food items that makes them commercially feasible (Adeyemi et al., 2009). In Ethiopian context, *O. niloticus* is the most edible fish species (Mitike, 2014). The Nile tilapia is widely found in the rift valley Lakes, Abay, Awash, Baro-Akobo, Omo-Gibe, Tekeze and Wabishebele-Genale basins (Awoke, 2015; Golubtsov and Mina, 2003). Furthermore, it is also found in some other Ethiopian highland lakes and rivers (Golubtsov and Mina, 2003).

The relationship between length-weight is very essential for proper fish exploitation and management schemes and it is possible to estimate the average weight of fishes at a given length (Lawson et al., 2013; Assefa, 2014; Ahmed et al., 2017; Getso et al., 2017; Kumar et al., 2017; Melaku et al., 2017; Muchlisin et al., 2017). The relationships of length-weight are also vital in aquaculture and wild fishery for management purposes (Gupta and Tripathi, 2017). In similar way, the wellbeing of the fishes is considered as a good indicator of various water bodies health in relation to water pollution (Gupta and Tripathi, 2017; Kumar et al., 2017). This is because length-weight, condition factor and size at first maturity investigations are the cheapest means of determining the stress of water pollution on the fishes' body condition (Gupta and Tripathi, 2017). Furthermore, the length-weight relationships among the fish population indicates that their wellness (Hamid et al., 2015 Gupta and Tripathi, 2017).

The difference in length-weight is obtained by the biotic and abiotic environmental factors as well as the trophic status of a given aquatic ecosystem. Condition factor is good parameter that shows the wellbeing of fishes in their natural habitat or in aquaculture and it is represented as by the coefficient of body condition. It is an indicator of different biological and ecological factors in relation to fishes feeding habits (Nehemia et al., 2012). Better body condition is correlated with high values of condition factor. Similarly, poor body condition is obtained when the values of condition factor is less (Gupta and Tripathi, 2017). Although, it is influenced by stress, sex, season, availability of food and the water quality in the environment in which they live (Ighwela et al., 2011).

Length at first maturity of fish is considered as a minimum harvestable size of a given fish spp. (FAO, 1984). According to Muluye et al. (2016) the number of eggs spawned to recruit a number of young fish in a given aquatic ecosystem is related to the availability of sexually matured fish. Sexually matured fish are a key for recruitment and the next harvestable fish stock (LFDP, 1997). Therefore, the number of fishes attaining recruitment depends on sexually matured fishes in the water bodies (LFDP, 1997; Muluye et al., 2016).

The study of length-weight relationship, size at maturity and condition factor of freshwater fish species is a subject of continuous research as it is a basis for the development of a successful management program on fish capture and culture (Dadebo et al., 2012; Shalloof et al., 2009) in wild and controlled environments. In addition, the information is vital for management of the fish taken from different habitat types, feeding habits and species interaction under culture systems. The length-weight relationship, size at first maturity and condition factor of *Oreochromis niloticus* have been reported from several water bodies of Ethiopia (Senait, 2015; Bjorkil, 2004; Muluye et al., 2016; Dadebo et al., 2012; Fasil et al., 2012; Tadesse, 1998; Admasu, 1994; Teferi and Admasu, 2002; Melak, 2009; Temesgen, 2017; LFDP, 1997; Tesfaye and Tadesse, 2008; Tesfaye et al., 2016; Wudneh, 1998). However, there is no compiled information on the length-weight relationship, size at first maturity and condition factor of *Oreochromis niloticus* in different Ethiopian water bodies. Therefore, this review paper is aimed to summarize the length-weight relationship, size at first maturity and condition factor of the Nile tilapia *Oreochromis niloticus* in Ethiopian water bodies.

MATERIALS AND METHODS

Data sources were collected from December, 2017 through March, 2018. A range of literature sources were used for this review including journal articles, books and book chapters, workshop proceedings, FAO reports, bulletins, legal documents, and unpublished reports including PhD dissertations. The documents were collected from University libraries and Ethiopian Ministry of Livestock and Fishery, from individual researchers, and from the Internet data bases.

SOME BIOLOGICAL ASPECTS OF NILE TILAPIA *Oreochromis niloticus* IN ETHIOPIAN WATER BODIES

Length-weight relationship

Several authors (Hamid et al., 2015; Assefa, 2014; Getso et al., 2017; Kumar et al., 2017; Melaku et al., 2017; Muchlisin et al., 2017) reported that the wellbeing of fishes is determined by the length-weight structured data. Because of, it can predict the average weight of the fish at a given length group by establishing a mathematical relation between length-weight (Ahmed et al., 2017). Based on this, fishes can achieve isometric, negative allometric or positive allometric growth pattern throughout its life (Nehemia et al., 2012). Isometric growth pattern (b=3) is all the body parts grow at nearly the same rate as the fish increases in size. The isometric growth pattern of this fish species was reported in different water bodies of Ethiopia e.g. in Lake Beseka (Senait, 2015), Gilgel Gibe Reservoir (Wakjira, 2013), Lake Hawassa (Admasu, 1990), Lake Ziway (Tadesse, 1998), Lake Chamo (Teferi and Admasu, 2002), Baro River (Melak, 2009), Lake Hawassa (Bjorkil, 2004), Lake Koka (Engdaw et al., 2013) and Lake Langano (Temesgen, 2017) (Figure 1). The nearly isometric growth pattern is common for this fish species in both running and standing water bodies. However, several authors documented that the allometric growth pattern is the most appropriate for describing morphometric growth of fishes (Karpouzi and Stergiou, 2003).

But, it should be rare in nature and the estimation is not optimally applicable to all measurement comparisons, because the relationship tells the effect of different factors, such as habitat type and feeding habits on the fish growth. In addition, Fulton (1904) stated that the growth performance of fish could vary in different habitats and at certain period of the year. Mostly, difference in biological factors, such as availability of food items, quality and quantity of food items, feeding rate and spawning period of fish affects the b value of fishes in the environment where they live (Suquet et al., 2005). Moreover, the regression coefficient of length weight relationship value (b) is used as an indicator of food availability, water quality and growth pattern, where the feeding availability is influenced by spatial and temporal variations of food items (Wotton, 1995). In addition, to the variation between habitats, physiological and biological factors of the fish that influence the fish growth pattern (Zdanowski et al., 2001). The gonad development also affects the fish weight and b values in the length-weight relationship (Wotton, 1995; Zdanowski et al., 2001). In other way, the differences in regression coefficient b (growth parameters) might be due to seasonal variations in water quality parameters, food availability, feeding rate, gonad development and spawning period (Bagenal and Tesch, 1978).

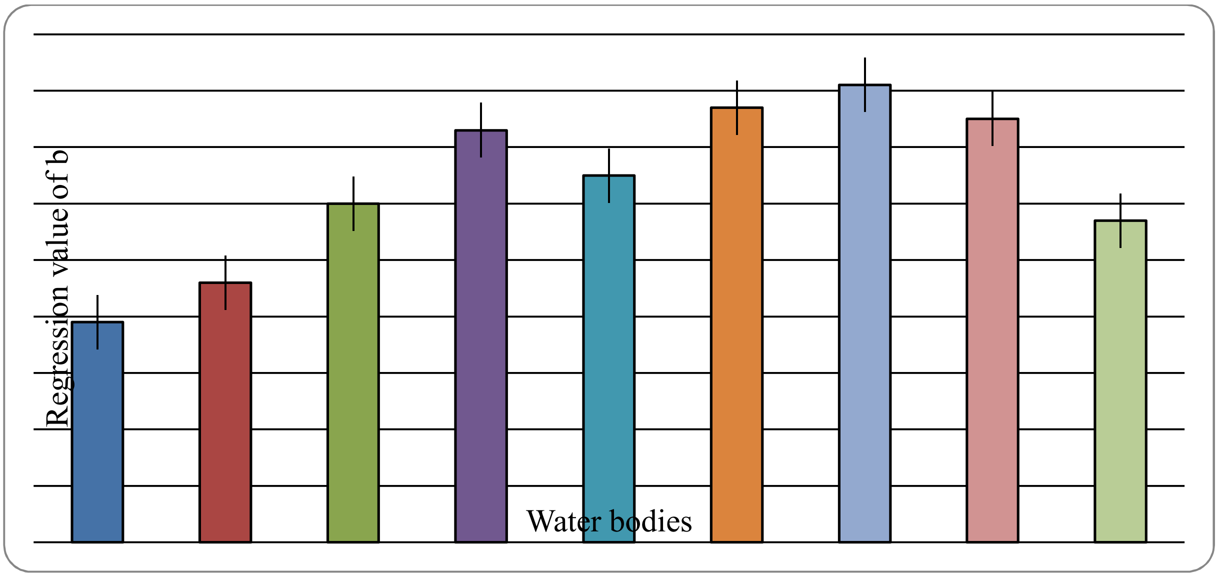

Figure 1. Regression coefficient (b) values of *Oreochromis niloticus* in Ethiopian water bodies (Senait, 2015; Wakjira, 2013; Admasu, 1990; Tadesse, 1998; Teferi and Admasu, 2002; Melak, 2009; Bjorkil, 2004; Engdaw et al., 2013; Temesgen, 2017).

Fulton Condition Factor (FCF)
Various investigators (Lawson et al., 2013; Assefa, 2014; Ahmed et al., 2017; Getso et al., 2017; Kumar et al., 2017; Melaku et al., 2017; Muchlisin et al., 2017) documented condition factor expresses the degree of wellbeing of fishes in their habitat (aquaculture and wild fishery). In other way, it is a measure of various biological and ecological factors with regard to their feeding conditions (Nehemia et al., 2012). Food availability in the water bodies are influenced by the changes in the water chemistry due to variations in the atmosphere and the surrounding environments (Pothoven et al., 2001). The condition factor of *Oreochromis niloticus* showed variations among the populations in the lakes, rivers and reservoirs. Higher body condition is correlated with high energy content, adequate food availability, reproductive potential and favorable environmental conditions (Pauker and Rogers, 2004). Relatively high condition factor was recorded in Lake Chamo (2.35) (Teferi and Admasu, 2002) and River Baro (2.05) (Melak, 2009) than in Gilgel Gibe Reservoir (1.87) (Wakjira, 2013), Langano (1.67) (Tadesse, 1998) and Langano (1.77) (Temesgen, 2017). However, recently in Lake Chamo the water quality has drastically altered due to improper land use practices such as fertilizer use, nutrient loading, agricultural activities that causes poor water quality, it is in turn stress on the fishes' body condition (Teffera et al., 2017; Utaile and Sulaiman, 2016). In the same way, the Ethiopian rift valley lakes such as Ziway, Langano, Hawassa, Koka and Beseka are under high human pressure like lake shore farming, destruction of buffer zone, effluent discharges from textile, ceramic and tannery industries drained into water bodies (Gebretsadik and Mereke, 2017; Tesfahun, 2018).

The least condition factor was reported in Lake Beseka (0.05) (Senait, 2015) (Figure 2). Ighwela et al. (2011) indicated that seasonal variations in food quantity and quality, water level, flow rate and temperature affect the condition factor of fishes. The measure of fish condition factor is influenced by different factors. According to Otieno et al. (2014), noted that it changes in availability of food items and water quality, and fluctuation of water level and water temperature that determine the body condition of fishes. Condition factor also reveals that variation happens seasonally due to sex and gonad development (Engdaw, 2014). This is due to large part of energy is invested for growth and spawning (reproduction), which effects in the lower body condition of fishes (Abera et al., 2014). In Lake Beseka, the Nile tilapia had the poorest body condition (0.05) when compared to other water bodies of Ethiopia. Mostly, probably due to the lake becomes shallower and shallower by natural and human induced factors since the lake is one of Ethiopian rift valley lakes and experienced with high salinity, alkaline and sodic water as well as the land use practices near by the lake which are made unsuitable for the Nile tilapia and might result the lowest body condition in the lake (Dinka, 2017; Gebretsadik and Mereke, 2017). When the water salinity alters, fish faced biological aspect problems (length-weight, maturity and body condition), and physiological changes (oxygen consumption and energy demand) in their environment in which they live. Because, each fish species has its own optimum salinity ranges for growth and metabolism (Küçük et al., 2013). In summary, the implication of the higher body condition indicates the higher energy content, adequate food availability, reproductive potential and favorable environmental condition as well as good water quality (Pauker and Rogers, 2004) and intensive fish stock assessment as well as watershed management like the vulnerable Lake beseka is critically important.

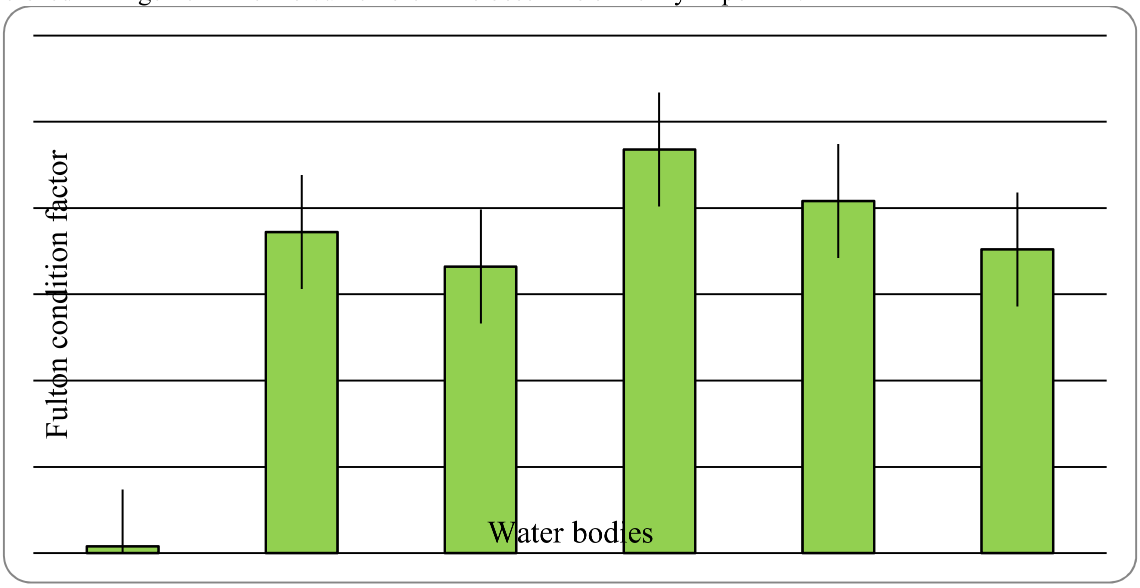

Figure 2. Fulton Condition Factor (Mean) of *Oreochromis niloticus* in water bodies of Ethiopia (Senait, 2015; Wakjira, 2013; Tadesse, 1998; Teferi and Admasu, 2002; Melak, 2009; Temesgen, 2017).

Maximum size and size at first maturity (L_{50}) of Nile tilapia

The maximum size recorded for Nile tilapia *O. niloticus* is varied in different water bodies of Ethiopia. It was greater (57.0 cm TL) in Lake Chamo (Teferi et al., 2001) than reported in Lake Beseka (25.0 cm TL) (Senait, 2015), Gilgel Gibe Reservoir (48.5 cm TL) (Wakjira, 2013), Lake Koka (32.5 cm TL) (Engidaw et al., 2013), Lake Hawassa (39.0 cm TL) (Muluye et al., 2016), Langano (29.8 cm TL) (Temesgen, 2017) and Lake Hawassa (29.0 cm TL) (Dadebo et al., 2012). Size at first maturity of fish is considered as a minimum harvestable size of a given fish species (Muluye et al., 2016). The size at first maturity of *Oreochromis niloticus* is different in different water bodies of Ethiopia. Length of maturity in many fish species depends on demographic conditions, and is determined by genes and the environment (Senait, 2015; Tesfaye et al., 2016). Generally, fish in poor condition mature at smaller size than those in good condition (Senait, 2015). For instance, the size of (50%) sexual maturity of the fish in Lake Beseka (17.0 and 14.0 cm TL) (Senait, 2015), Lake Hawassa (17.8 and 14.1 cm TL) (Bjorkil, 2004) for males and females respectively and Lake Ziway (18.8 cm TL) for females having smaller size than reported in Lake Chamo (42 cm TL) (Teferi and Admasu, 2002), Fincha Reservoir (24.5 and 21.8 cm TL) (Fasil et al., 2012), Lake Hawassa (20.8 and 20.3 cm TL) (Muluye et al., 2016) and Lake Hawassa (20.0 and 16.8 cm TL) for males and females respectively. Moreover, in Lake Tana (20.7 cm TL) for males (Wudneh, 1988) and Lake Langano (19.5 cm TL), Lake Koka (23.5 cm TL) (Tesfaye and Tadesse, 2008) and Lake Koka (24.6 cm TL) (Tesfaye et al., 2016) for unsexed specimen respectively had relatively larger size (Figure 3). Several studies revealed that the interaction of physical and chemical parameters of the water (Deepak and Singh, 2014), biological factors (Teshome et al., 2015) and the pressure of overfishing (Mohammed and Uraguchi, 2013) can determine the size of fishes in the water bodies. Accordingly, biological factors, such as presence of fishes in the water, fish's behavior towards the fishing gears, 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). Similarly, human induced factors, such as fishing pressure, type fishing gear, mesh size and other factors (e.g. period of year, location, fishing quotas) decide the catch volume and the size distribution of the catch (Mous et al., 2004). The environmental factors, such as water temperature (Davis and Parker, 1990) and water salinity (Barton and Zitzow, 1995; Mous et al., 2004) also affect the size of the fish catch. In addition, environmental factors, such as water temperature, oxygen concentration, salinity, and photoperiod can also influence the rate of fish growth in both aquaculture and wild fishery (Zdanowski et al., 2001). In summary, the present review on length-weight, condition factor and length at first maturity of the Nile tilapia (*Oreochromis niloticus*) was focused on the earlier works in Ethiopian water bodies. Now days, the aquatic ecosystems altered by human induced and natural associated impacts via water bodies. For this reason, new study is critical towards environmentalists and policy makers to enhance water quality for sustainable fishery management through the catchments of Ethiopian water bodies.

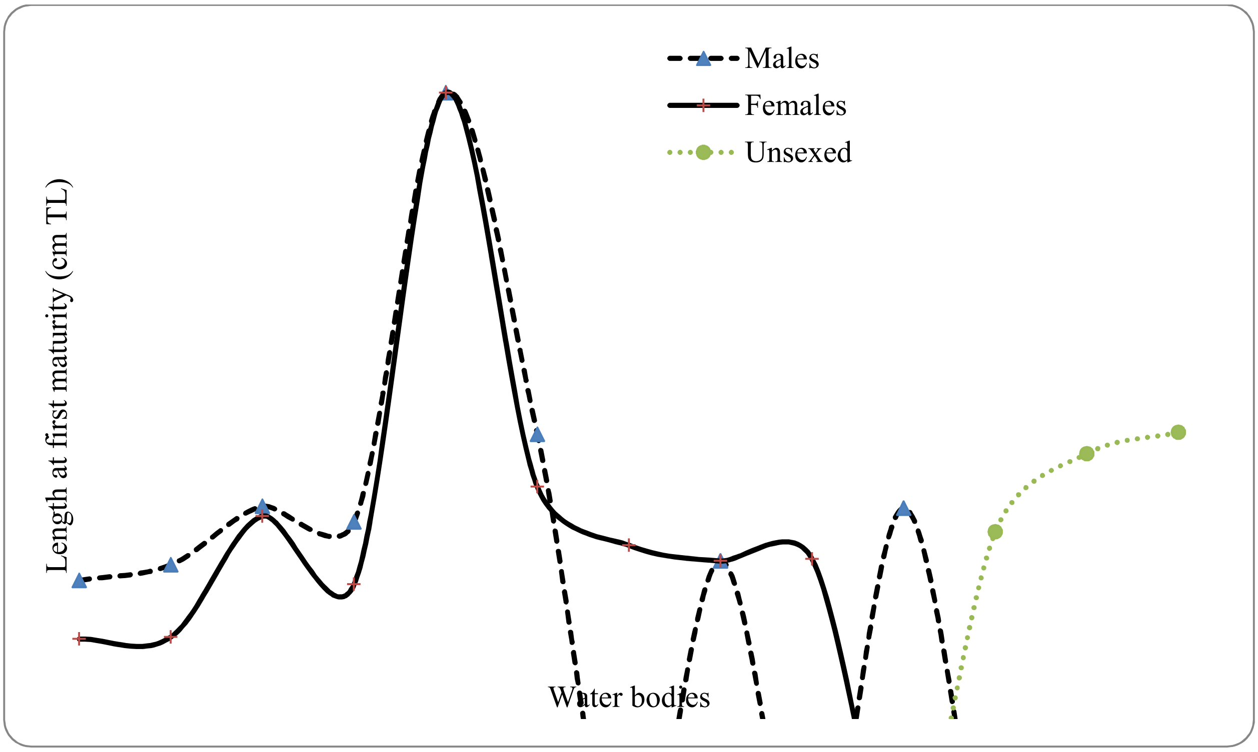

Figure 3. Size at first maturity of *Oreochromis niloticus* in different water bodies of Ethiopia (Senait, 2015; Bjorkil, 2004; Muluye et al., 2016; Dadebo et al., 2012; Fasil et al., 2012; Tadesse, 1998; Admasu, 1994; Teferi and Admasu, 2002; Melak, 2009; Langano, 2017; LFDP, 1997; Tesfaye and Tadesse, 2008; Tesfaye et al., 2016; Wudneh, 1998).

CONCLUSIONS

Nearly, isometric growth pattern of fish was recorded in different water bodies of Ethiopia. Good body condition factor was reported in the fishes collected from Lake Chamo and Baro River than other water bodies. Fish had larger size at first sexual maturity in Lake Chamo for both sexes compared to other water bodies of Ethiopia. The length-weight relationship, condition factor and size at first maturity of *O. niloticus* ultimately depend on the season, sex, gonad development, food availability and water quality of the water bodies where they inhabit. Therefore, proper management of water bodies is essential for sustainable fish stock exploitation in the country.

CONFLICT OF INTEREST

The author declares that there is no conflict of interest.

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