Length-Weight Relationship, Fulton's Condition Factor and Sex Ratio of Nile Perch (*Lates niloticus,* Linnaeus- 1762) in Lake Abaya, Ethiopia

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Received: June 11, 2022 Accepted: October 21, 2022

Abstract: *The length-weight relationship of fish is an important fishery management tool. The objectives of the study were to determine the length-weight relationship, Fulton's condition factor and the sex ratio of Lates niloticus in Lake Abaya. Total length (TL), total weight (TW), and sex data were collected from 755 fish samples (377 females and 378 males) for one year (January to December 2021) from the commercial fishery of Lake Abaya. The collected data were summarized by using descriptive statistics and analyzed with the application of Microsoft Excel 2010 and SPSS software. There was no significant deviation in sex ratio (M: F) from hypothetical 1:1 ratio (χ^2 = 0.00; P > 0.05). The length-weight relationship was calculated using power function and obtained as TW = 0.0077*TL$^{3.1176}$, (R^2 = 0.8834), TW = 0.0078*TL$^{3.1372}$, (R^2 = 0.8548) and TW = 0.0098*TL$^{3.0723}$, (R^2 = 0.8713) for females, males and combined sexes, respectively. The regression coefficient "b" was significantly different from the cubic value "3" (P<0.05) and implied that L. niloticus of Lake Abaya follows a positive allometric growth pattern. The one-way ANOVA (P > 0.05) revealed that Fulton's condition factor between sexes was insignificant but highly significant by month's interaction (ANOVA, P < 0.05). The t-test also revealed a highly significant difference in a month's interaction (t-test, P = 0.000) indicating the seasonal variation in the mean monthly condition factor. The average value of Fulton's condition factor was higher than one and indicates that L. niloticus in Lake Abaya was in good health condition. The present study was focused only on L. niloticus and recommends that similar studies including feeding and reproductive biology should be conducted to determine the status of other fish species in Lake Abaya.*

Keywords: Allometric growth pattern, Commercial fishery, Fishery management, freshwater fish, Lake Fishery

1. Introduction

The growth of fish is a mathematical function of length and weight which varies due to biological changes and seasonal dynamics (Das, 2004). The length-weight relationship of fish is an important fishery management tool. The relationship is pronounced in estimating the average weight at a given length group and assessing the relative well-being of a fish population (Abowei *et al*., 2009). Length-weight relationships of freshwater fishes are useful in determining weight and biomass when only length measurements are available and are required in fishery management and conservation (Froese, 1998; Oscoz *et al*., 2005). Knowledge of the sex ratio of fish is important to ensure proportional fishing of two sexes and provides information necessary for assessing the reproductive potential of a population (Vazzoler, 1996).

The condition factor (K) is a method by which the physical condition and seasonal variation in the well-being of an individual fish could be known (King, 1995). The condition factor is a quantitative parameter of the well-being and state of the fish that reflects recent feeding conditions (Le cren, 1951). The growth of any fish is related to the prevailing environmental conditions. Many authors have explained the importance of the condition factor as a useful tool for assessing fish growth rate, age and feeding intensity (Abowei, 2006; Kumolu-Johnson and Ndimele, 2010; Oribhabor *et al*., 2011; Onimisi and Ogbe, 2015; Abu and Agarin, 2016). The well-being of fish is considered a good indicator of various water bodies' health in relation to water pollution due to its cheapest means of determining the stress of water pollution on the fish's body condition (Gupta and Tripathi, 2017).

The *L. niloticus* is one of the four commercially important fish species in Lake Abaya. Lakes Abaya and Chamo are the main sources of *L. niloticus*. It is a widely accepted fish species as a food commodity and is economically important for the fishing societies in Lake Abaya. The biology of fish from different water bodies in Ethiopia has been studied by various scholars. But such important information in Lake Abaya is null or little. Therefore, the present study aimed to generate crucial information on length-weight relationships, sex ratios and Fulton's condition factor of *L. niloticus* in the lake to provide the necessary scientific information for proper utilization and management of the lake fishery.

2. Materials and Methods

2.1. Description of the study area

Lake Abaya is one of the two southernmost Rift Valley lakes in Ethiopia. It is the second largest lake in the country next to the highland lake, Lake Tana. It is located between 5˚55'9"N to 6˚35'30"N latitude and 37˚36'90"E to 38˚03'45"E longitude. The lake, including its islands, has a total area of 1108.9 km^2. It is located at an average altitude of 1235 meters above sea level (Bekele, 2007). It has a maximum length of 79.2 km with a maximum width of 27.1 km. The mean and the maximum depths are 8.6 m and 24.5 m, respectively (Arne, 2013).

2.2. Methods of sampling and data collection

Samples of *L. niloticus* were collected from the three commercial fisheries that are actively practicing fishing in Lake Abaya. Fishes were randomly collected for three days a week at four landing sites of the commercial fisheries from January to December 2021. The trained fishermen were involved in data collection with regular following-up of the researcher. The total length and total weight of fresh fish samples were measured to the nearest 1 mm and 1 g using a measuring board and sensitive electronic and hanging balances, respectively. Small-sized fish was weighed with sensitive electronic balance while the larger sized was weighed with hanging balance. Sex determination was made visually based on external sexual characteristics as well as dissecting the abdomen and observing the gonads.

2.3. Data analysis

The length-weight relationship was calculated using the power function described by Le Cren (1951).

$$TW = aTL^b \quad [1]$$

Where

- TW = total weight (g)
- TL = total length (cm)
- a = the intercept
- b = the slope of length-weight regression

The Fulton's condition factor (K) is often used to reflect the nutritional status or well-being of an individual fish and was calculated by using the formula described by Fulton (1904) which is indicated below.

$$K = \left(\frac{TW}{TL^3}\right) * 100 \quad [2]$$

Where

- TW = total weight of fish in gram (g)
- TL = total length of fish in centimeter (cm)

The data analyses were done using Microsoft Office Excel (2010) and SPSS (Version 16.0) software. A chi-square test (χ^2 test) was employed to determine if the sex ratio varies between the male and female *L. niloticus*.

3. Results and discussion

3.1. Sex ratio

About 755 samples of *L. niloticus* were collected. Among these samples, 377 (49.93%) were females and 378 (50.07%) were males (Table 1). The monthly sex ratio (M: F) was statistically insignificant between males and females except for August, October and December. But the total sex ratio (M: F) was 1:1 and statistically insignificant (χ^2 = 0.00; P > 0.05). The finding indicates the presence of a normal and expected sex ratio of one male to one female of *L. niloticus* in Lake Abaya. Sex ratio is one of the reproductive parameters to determine the availability of mature males and females expected to spawn. In normal conditions, the male-to-female ratio is indicated as a 1:1 ratio. It is therefore evident that the *L. niloticus* in Lake Abaya tends to have an equal population of males and females. Unlike the present study, the sex ratio of *L. niloticus* was dominated by males in Lake Chamo (Dadebo *et al*., 2005) and in Lake Victoria (Edwine *et al*., 2017).

Table 1: Sex ratio of *L. niloticus* in Lake Abaya

Month	Female	Male	Total	Expected frequency	Sex ratio (M: F)	Chi-square (χ^2)	P-value
January	20	18	38	19	1:1.11	0.05	0.75
February	20	20	40	20	1:1	0.00	1.00
March	17	24	41	20.5	1:0.70	0.60	0.27
April	37	31	68	34	1:1.19	0.26	0.47
May	43	41	84	42	1:1.05	0.02	0.83
June	48	57	105	52.5	1:0.84	0.39	0.38
July	20	17	37	18.5	1:1.18	0.12	0.62
August	72	106	178	89	1:0.69	3.25	0.01*
September	25	23	48	24	1:1.09	0.04	0.77
October	27	10	37	18.5	1:2.7	3.91	0.01*
November	28	22	50	25	1:1.27	0.36	0.40
December	20	9	29	14.5	1:2.22	2.09	0.04*
Total	377	378	755	377.5	1:1	0.00	0.97

* Significant value

3.2. Length-weight relationship

The values of the regression coefficient "*b*" for females, males and combined sexes were 3.1176, 3.1372, and 3.0723, respectively, where the relationships are presented in Figures 1, 2, and 3, respectively. Based on the analysis of variance (one-way ANOVA), there was a significant difference between the regression coefficient "*b*" and the expected cubic value of "*b"* ($P < 0.05$). The t-test revealed the presence of a significant difference between the regression coefficient "*b*" in female, male and combined sexes ($P < 0.05$). According to the results of this study, the growth patterns of *L. niloticus* was positive allometric and curvilinear in Lake Abaya. The positive allometric growth patterns implied that the fish became relatively stouter and deep-bodied as they increased in length.

A similar relationship has been reported by Edwine *et al*. (2017) for *L. niloticus* in Lake Victoria and Pendjari River (Simon *et al*., 2009). Fishes can attain an isometric, negative or positive allometric growth pattern. In isometric growth, the fish does not change the shape of its body as it continues to grow while negative allometric growth shows the fish becomes thinner as its body length increases as opposed to a positive allometric growth that implies the fish becomes relatively broader and fatter as its length increases (Riedel *et al*., 2007). The variation in the value of *b* takes place due to season, habitat, gonad maturity, sex, diet, stomach fullness, health, preservation techniques and annual differences in environmental conditions (Bagenal and Tesch, 1978; Arslan *et al*., 2004; Froese, 2006; Yilmaz *et al*., 2012; Ali *et al*., 2016). Furthermore, variations in fish growth patterns could also be related to the condition of the species itself, its phenotype, specific geographic location, and its environment (Tsoumani *et al*., 2006).

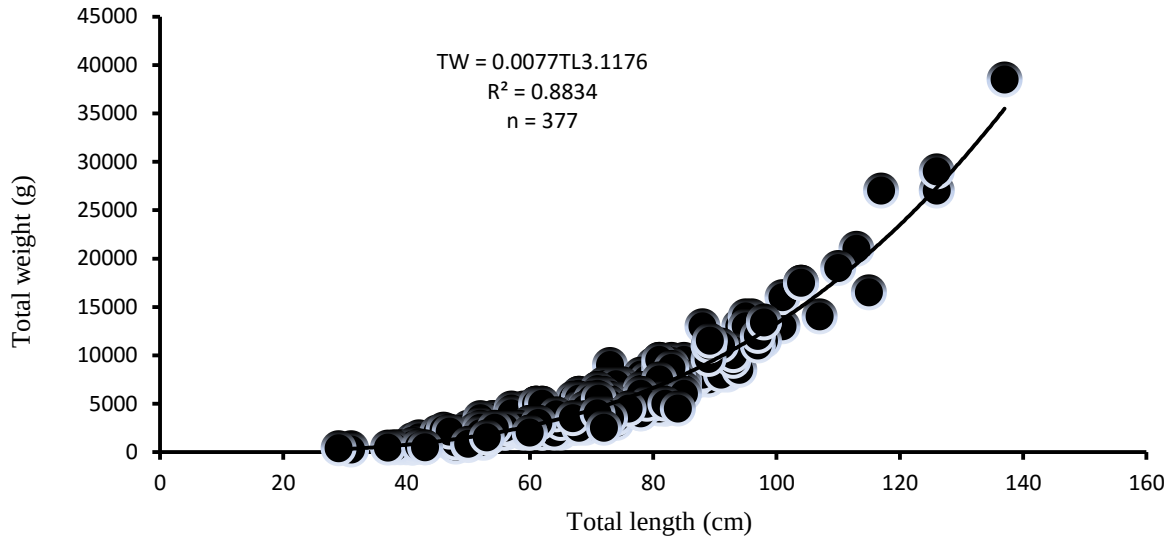

Figure 1: Length-weight relationship of female *L. niloticus* from Lake Abaya

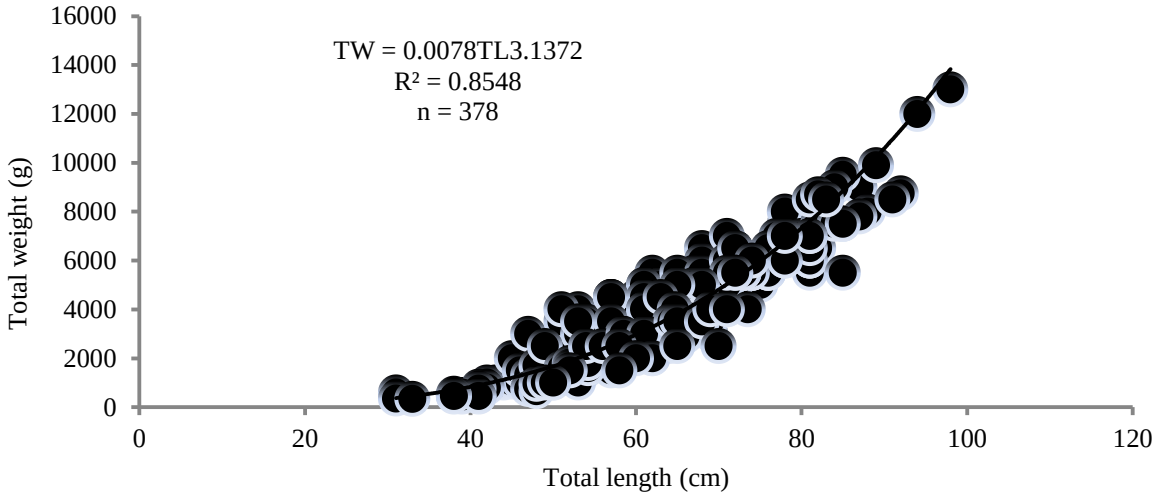

Figure 2: Length-weight relationship of male *L. niloticus* from Lake Abaya

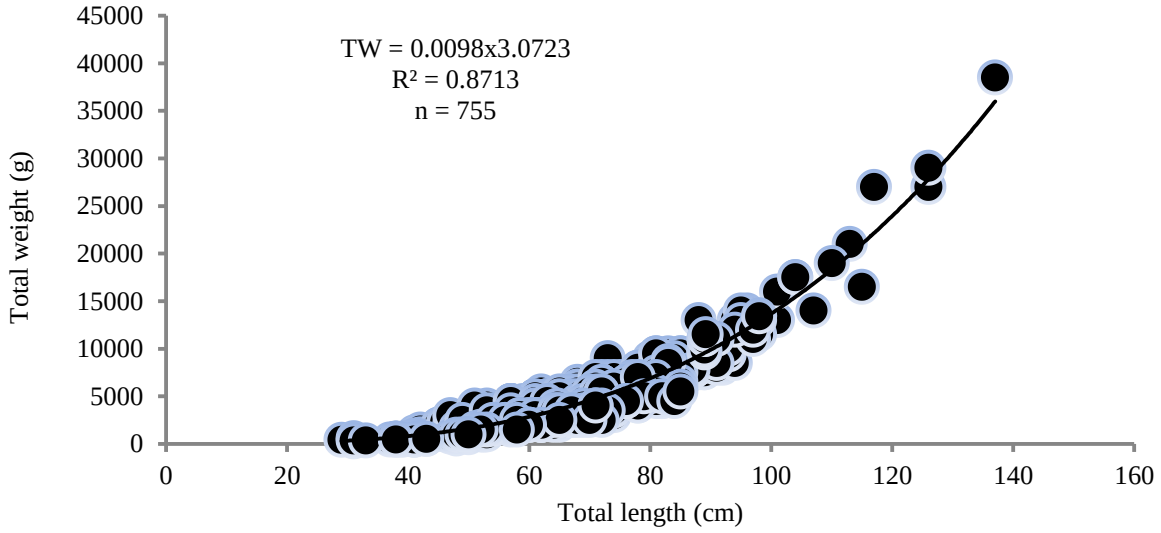

Figure 3: Length-weight relationship of combined sex *L. niloticus* from Lake Abaya

3.3. Fulton's condition factor

The monthly mean Fulton's condition factor ranged from 0.92 to 1.47 for females, 0.89 to 1.56 for males and 0.93 to 1.53 for combined sexes (Table 2). The average K value for females, males and combined sexes were 1.29, 1.34 and 1.31, respectively. The lowest condition factor for females (0.92) was recorded in October, and the highest (1.47) was in August. For males, the lowest value, 0.89 was recorded in December and the highest value (1.56) was in August. For combined sexes, the lowest value (0.93) was recorded in December and the highest (1.53) in August. The results indicated that there was no significant difference between the mean condition factor of males and females *L. niloticus* ($P > 0.05$; Fig. 4). But the mean condition factor by month's interaction in Lake Abaya was significantly different ($P < 0.05$). The t-test also revealed a highly significant difference in a month's interaction (t-test, $P = 0.000$) indicating the seasonal variation in the mean monthly condition factor.

In the study of fish, the condition factor is used in comparing its condition, size or well-being (Ndimele *et al*., 2010). Condition factor is also important in the monitoring of feeding intensity, age and growth rates in fish (Anene, 2005). Related studies had also shown that the condition factor is strongly influenced by both biotic and abiotic environmental conditions, and can be used to assess the ecological habitat of fish species (Ayoade, 2011; Onimisi and Ogbe, 2015; Abu and Agarin, 2016). Morton and Routledge (2006) divided the K values into five categories very bad (0.8–1.0), bad (1.0–1.2), balance (1.2–1.4), good (1.4–1.6) and very good (> 1.6). On the other hand, Ayoade (2011) suggests that a condition factor higher than one is a good fish health condition.

It was observed in the present study, that the average condition factor of *L. niloticus* in Lake Abaya was 1.29, 1.34 and 1.31 for females, males and combined sexes, respectively. Variations in condition factors are influenced by many biotic and abiotic factors such as phytoplankton abundance, predation, and water temperature and dissolved oxygen concentrations among others (Ahmed *et al*., 2011). Morton and Routledge (2006) state that the fish with condition factor values ranging from 1.2-1.4 is considered to be in balance condition; while Ayoade (2011) suggests the condition factor higher than one is in good health condition. Hence, the condition factor in the present study was higher than one and *L. niloticus* in Lake Abaya was in good health condition.

The average condition factor of the fish species in the current study was similar to the condition factors reported by Edwine *et al*. (2017) in Lake Victoria, Olapade, *et al*. (2019) in River Jong, and Simon *et al*. (2009) in the Pendjari River for the same fish species. The condition factor of fish can vary based on the species type, prevailing environmental conditions, and food availability in their occupied habitats (Okach and Dadzie, 1988; Wanyanga *et al*., 2016). The condition factor of fish can also be affected by season, reproductive cycles and water quality parameters (Khallaf *et al*., 2003).

Table 2: Mean monthly condition factor of females, males and combined *L. niloticus* in Lake Abaya during 2021

Months	Female	Male	Combined sex
January	1.20	1.20	1.2
February	1.42	1.47	1.44
March	1.43	1.49	1.47
April	1.37	1.37	1.37
May	1.23	1.27	1.25
June	1.46	1.53	1.5
July	1.39	1.45	1.42
August	1.47	1.56	1.53
September	1.18	1.43	1.3
October	0.92	1.02	0.95
November	1.41	1.36	1.39
December	0.95	0.89	0.93
Average	1.29	1.34	1.31

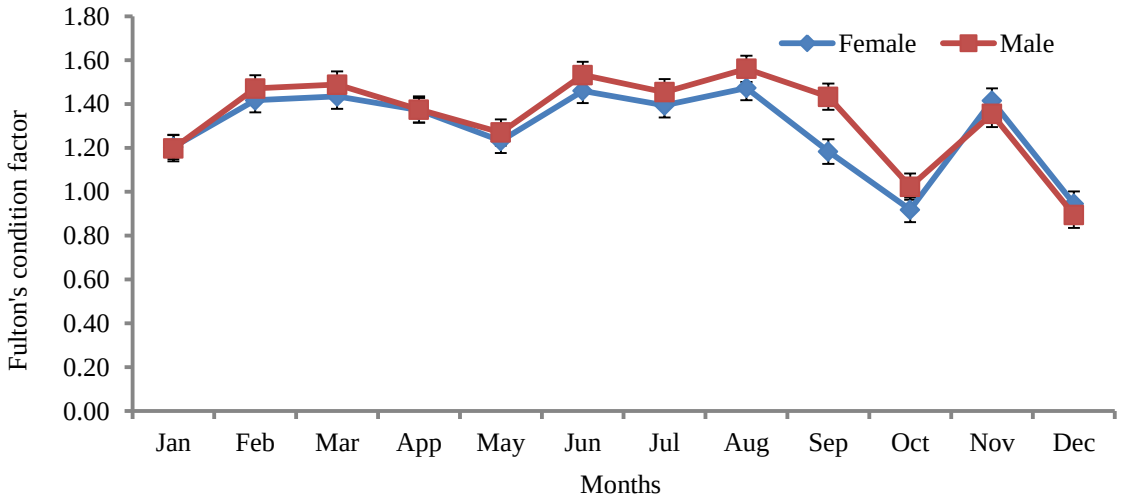

Figure 4: Monthly Fulton's condition factor (FCF) between females and males *L. niloticus* in Lake Abaya

4. Conclusion

The sex ratio of *L. niloticus* did not deviate from the expected sex ratio of one male to one female and the length-weight relationship follows a positive allometric growth pattern. The body condition of *L. niloticus* was showing seasonal variability in the monthly condition factor and it was generally good in health condition. The present study was focused only on *L. niloticus* and recommends that similar studies including feeding and reproductive biology should be conducted to determine the status of other fish species in Lake Abaya.

Conflict of interest

The author declares that there is no conflict of interest in publishing the manuscript in this journal.

Acknowledgment

The author would like to acknowledge the Ethiopian Institute of Agricultural Research (EIAR) for the financial support and Arba Minch Agricultural Research Center for accessing the necessary facilities.

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