E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2020; 8(3): 44-48

www.fisheriesjournal.com
Received: 23-03-2020
Accepted: 24-04-2020

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Comparison of body length-weight relationship and condition factor for Nile tilapia (*Oreochromis niloticus*) cultured in two different climatic conditions in Tanzania

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Abstract
This study compared length-weight relationship and condition factor of male Nile tilapia raised in two districts experiencing different climatic conditions in Tanzania, Mbarali and Mufindi. Fish were raised for six (6) months and measurements were done biweekly. The results suggests negative allometric growth pattern ($b < 3$) for the fish grown in both experimental locations. The "b" values for the length-weight relationships were 2.87 and 2.94 in Mbarali and Mufindi, respectively. The correlation coefficient and coefficient of determination indicated strong relationship (>99%) between length and weight of the fish. The condition factor (K) ranged from 2.74 to 3.50 in Mbarali and 1.96 to 2.40 in Mufindi, throughout the experimental period. Significantly higher condition factor was observed for fish grown in Mbarali (3.168 ± 0.056) than those in Mufindi (2.166 ± 0.056). It is concluded that, the climate of Mbarali provides better conditions for growth of fish than that of Mufindi.

Keywords: Allometric growth, condition factor, correlation coefficient, Isometric growth, length-weight relationship, regression coefficient.

1. Introduction
In many organisms growth occurs in various patterns. In fishes both isometric and allometric growth pattern occurs. Isometric growth occurs when an organ grows at the same rate as the rest of the body while allometric growth is when an organ grows at a different rate from the rest of the body [1, 2]. When length increases in equal proportion with body weight, the fish is said to exhibit isometric growth. The regression coefficient for isometric growth in fish is '3' and values greater or less than '3' indicates allometric growth [3,4].

The comprehensive knowledge of growth rate and pattern of fish plays an important role in fishery management. Various biometric relationships are often used to transform data collected in the field into appropriate indexes. The most common relationship used in analysis of fishery data is Length-weight relationship [5]. The length-weight relationship (W/L) serves several purposes, such as estimation of the biomass from known length and computation of condition factor [6, 7].

Condition factor gives an indication for fitness and general well-being of the fish. It reflects interaction between biotic and abiotic factors in the physiological conditions of fish in relation to its welfare [3, 8]. Condition factor in the lifetime of fish may vary with change in various factors such as climatic condition, locations, time and stages of development [9, 10]. Higher value of condition factor reflects better condition experienced by fish [11]. Therefore, in fisheries science, the condition factor (K) is used to compare the "condition", i.e. fitness or wellbeing of fish, with the hypothesis that "the heavier fish of a certain length are in a better physiological condition" [12, 13]. It is also a useful index for monitoring feeding intensity, growth rates, age, life span, reproduction and mortality in fish [14].

In Tanzania, Nile tilapia (*Oreochromis niloticus)* is the most preferred fish species for aquaculture and it is grown almost all over the country. This is probably due to its good qualities for instance; ability to survive in diverse environmental conditions, high growth rate, high food utilization efficiency, good fecundity and good flesh quality [15, 16]. However, variations in climatic conditions around the country have been influencing its productivity. A number of environmental factors, such as water temperature, oxygen concentration, pH,

salinity and alkalinity influence the rate of growth of cultured fish [17]. In Tanzania, different agro-ecological zones in the country have different climatic conditions, resulting into variation in physic-chemical and biological qualities of water in fish ponds. However, information on the influence of environmental conditions prevailing in different parts of the country on growth performance, condition factor and length-weight relationship of cultured Nile tilapia is scant. Therefore, the objective of this study was to assess the length-weight relationship and condition factor for fish (*O. niloticus*) grown in two regions of Tanzania which experience different climatic conditions.

2. Materials and methods

2.1. Experimental location

The study was conducted in two districts located in different regions of Tanzania; Mufindi and Mbarali districts in Iringa and Mbeya regions, respectively. Mufindi district lies between latitude 8^0 00'– 9^0 15' S and longitude 34^0 35' –35^0 55' E. The mean annual rainfall ranges from 950 to1600 mm. Temperatures are often below 15 ^{0}C, the mean monthly is 18.4 ^{0}C (maximum temperature experienced in November and February) and the minimum is 13.1 ^{0}C and it is observed in July. The altitude ranges from 1700 to 2200 meters (m) above sea level [18]. Mbarali is located between latitude 7^0 and 9^0 S and between longitude 33.8^0 and 35^0 E. The altitude ranges from 1,000 to 1,800 m above sea level. Average temperature ranges between 25 and 30 ^{0}C and annual rainfall is about 450 to 650 mm [19].

2.2. Ponds preparation, stocking and management of fish

Four ponds in each district were selected from different sites. Before stocking, all ponds were drained, cleaned, dried and then refilled with water. All ponds were fertilized with urea and Diammonium phosphate (DAP) at rate of 3 g/m^2 and 2 g/m^2, respectively. Sex reversed male Nile tilapia fingerlings (1.00 g average weight) were stocked (2 fish/m^3) seven days after initial fertilization. Fertilizations were then done fortnightly throughout experimental period using same fertilizers and same rates mentioned. Fish were fed 10% of body weights in the first month and then, the amount was reduced to 5% for the rest of experimental period. The supplemented diet contained 25% Crude protein (CP). Feeding was done twice daily (10.00 and 16.00 h).

2.3. Data collection

Initial measurements of fish body weight and length were taken after two weeks of acclimatization. Random samples of fifty (50) fish from each pond were measured individually. Body weight and total length (from the tip of the snout to the end of the caudal fin) were measured fortnightly using digital weighing balance (0.01 g) and measuring ruler (0.1 cm), respectively, alongside with measurement of water quality parameters. Water quality parameters were measured in situ, using DO meter (HI 98198 PH/EC/DO Multiparameter HANNA instruments). The experimental lasted for 180 days.

2.4. Analysis of length-weight relationships and condition factor

The relationship between length and weight of the fish was examined by using correlation analysis and simple linear regression. The Length-Weight relationships were calculated using the equation $W= aL^b$ [20]. Where; W = weight of fish (g); L = total length of fish (cm); a = intercept (exponent describing the rate of change of weight with length); b = slope of the regression line (weight at unit length). The log transformed relationship ($W = aL^b$) gives the regression equation; Log W = log a + b log L. 'a' and 'b' values and linear representations of the graphs were done using MS-Excel 2010. If "b" = 3 then growth is isometric, if b > 3 = positive allometric growth and if b < 3 = negative allometric growth) [21].

The Fulton's condition factor (K) was calculated using the equation; $K = 100\ W/L^b$. Where; W = Weight of the fish (g); L = the total length of the fish (cm); b = the value obtained from the length-weight equation formula [6]. Variances were made using the General Linear Model of SAS (version 8.1, 2000) for Windows. Significant differences were judged at a probability level of $p \leq 0.05$.

3. Results

3.2. Length-Weight relationship and condition factor

Table 1 shows the biweekly mean weights and lengths of fish grown in both experimental locations. The average final total length of fish reared in Mbarali and Mufindi for different ponds ranged from 18.85 to 22.30 cm and 15.86 to 15.98 cm, respectively. Mean body weights ranged from 131 to 459 g and 76.35 to 81.29 g for fish reared at Mbarali and Mufindi, respectively. The correlation coefficient and coefficient of determination revealed a strong relationship (>95%) between length and weight of the fish. The fish grown in both districts exhibited negative allometric growth pattern (b < 3), and the values differed ($p \leq 0.05$) between the two locations (Table 2). The coefficients of determinations (r^2) were relatively similar in both experimental locations (Figure 1).

Table 1: Weekly fish body weights and lengths (mean ± se)

	Mbarali		Mufindi	
Week	**Body weight (g)**	**Body Length (cm)**	**Body Weight (g)**	**Body Length (cm)**
2	4.65 ± 0.14	5.60 ± 0.06	1.83 ± 0.13	4.35 ± 0.06
4	12.77 ± 0.63	7.80 ± 0.12	3.51 ± 0.61	5.81 ± 0.11
6	24.62 ± 0.80	10.60 ± 0.12	6.72 ± 0.78	7.23 ± 0.12
8	36.49 ± 0.93	12.25 ± 0.12	9.04 ± 0.90	7.55 ± 0.11
10	55.83 ± 1.70	13.72 ± 0.15	11.17 ± 1.66	8.32 ± 0.14
12	65.60 ± 1.89	14.38 ± 0.15	14.08 ± 1.84	9.09 ± 0.15
14	85.24 ± 1.54	15.38 ± 0.16	23.35 ± 1.50	10.51 ± 0.16
16	118.14 ± 3.23	17.44 ± 0.16	29.93 ± 3.14	11.78 ± 0.15
18	157.87 ± 4.13	19.05 ± 0.17	38.33 ± 4.02	12.78 ± 0.17
20	181.77 ± 4.27	20.05 ± 0.17	47.47 ± 4.15	14.07 ± 0.16
22	200.61 ± 4.01	21.22 ± 0.16	62.90 ± 3.91	14.56 ± 0.15
24	234.36 ± 5.18	22.01 ± 0.16	78.62 ± 5.04	15.92 ± 0.16

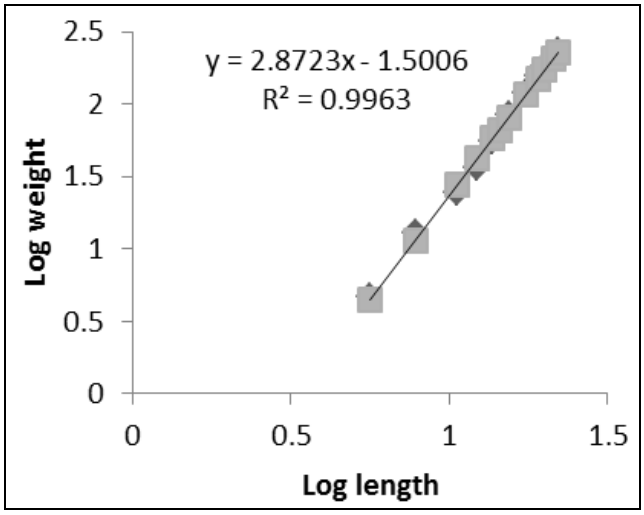
3.3. Condition factor (K)

The mean condition factors were not consistent throughout the experimental period (Figure 2). The mean condition factor ranged from 2.74 to 3.50 at Mbarali and from 1.96 to 2.40 at Mufindi. The mean values of condition factor were higher ($p < 0.05$) for fish grown at Mbarali than of those grown at Mufindi (Table 2). Table 3 shows the average values for various water quality parameters measured during the experiment.

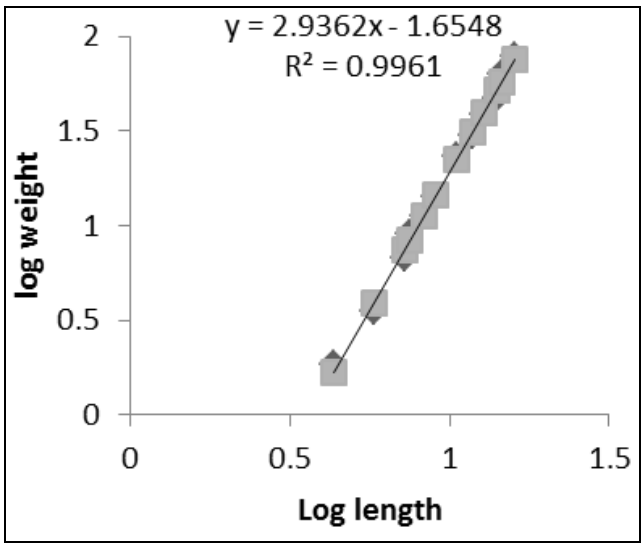
Table 2: The overall Length-Weight relationship parameters and Condition factor of Nile tilapia (*O. niloticus*) grown on warm (Mbarali district) and cold (Mufindi district)

Variables	Locations	
	Mbarali	**Mufindi**
r	0.9981	0.9980
r^2	0.9963	0.9961
a	0.22	0.19
b	2.87[b]	2.94[a]
K (LSM +SE)	3.168 ± 0.056 [a]	2.166 ± 0.056 [b]

*[ab]= *Means with the same superscript letter in the same row do not differ significantly (p>0.05).* (a and b = regression coefficients; K = condition factor; r^2 = coefficient of determination, r = correlation coefficient)



(a)



(b)

Fig 1(a) and (b): Log length-log weight relationship for Nile tilapia (*O. niloticus*) reared in Mbarali and Mufindi districts

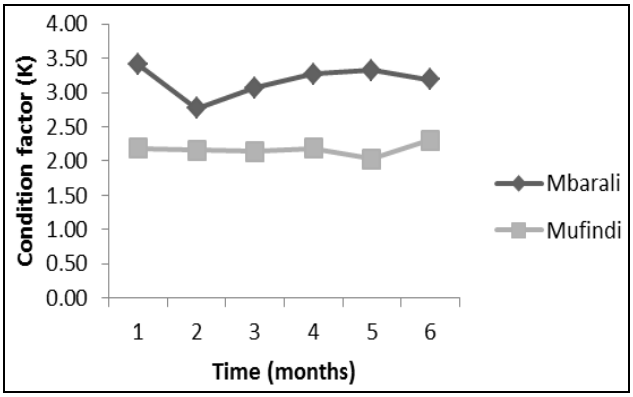


Fig 2: Comparison of condition factor (K) for Nile tilapia reared at Mbarali and Mufindi during six months of experimentation

Table 3: Average water quality parameters (LSM ± SE) measure in ponds located in two experimental locations

Variables	Locations	
	Mbarali	**Mufindi**
Temperature ^{0}C	27.72 ± 0.25[a]	21.93 ± 0.25 [b]
pH	6.91 ± 0.15 [a]	6.96 ± 0.15 [a]
Dissolved oxygen (mgL^{-1})	6.17 ± 0.27 [a]	6.09 ± 0.27 [a]
Ammonia (mgL^{-1})	0.08 ± 0.19 [a]	0.07 ± 0.19 [a]
Salinity (mgL^{-1})	57.35 ± 1.86 [a]	13.18 ± 1.86 [b]
Conductivity (μScm^{-1})	121.62 ±3.27 [a]	31.81 ± 3.27 [b]

*[ab]= Means with same superscript letter in the same row do not differ significantly (p>0.05)

4. Discussion

4.2. Length-weight relationship

The length-weight relationship serves as an important tool that gives information on growth and its pattern in fish [22]. From the results in the present study, the correlation coefficients of combined data revealed a very high degree of relationship between body length and weight (above 95%) for fish grown in both experimental locations. The coefficient of determination (r^2) was also high, implying that the increase in weight gain of fish was highly attributed to the increase in body length [7, 23].

The exponential value of the length–weight relationship 'b' was significantly higher for fish grown at Mbarali where temperature was high than that of fish reared at Mufindi where it was cold. In both experimental locations, the exponential values 'b' obtained were slightly less than '3'; indicating negative allometric growth pattern of the fish [24]. However, in both locations the values were within the range (2 - 4), which has been recommended as appropriate for fresh water fishes [25, 26, 27]. The variations in the value of the exponent 'b' could be attributed to the influence of numerous factors such as seasonal environmental fluctuations, physiological conditions of the fish at the time of data collection (e.g. gonadal development and nutritive conditions of the environment), [28, 29] geographical conditions, stage of maturation, fish size, fullness of the gut and degree of muscular development [14, 30]. One author argued that, b value can also be affected by fish behaviour for instance; active swimming fish may show lower b values compared to passive swimming fish, possibly due to energy allocation for movement and growth [31]. The idea was supported by another author who argued that, fast flowing stream environment could lower b value and vice versa [32].

4.3. Condition factor (K)

Condition factor (K) reflects the physiological state of a fish

in relation to its welfare [25]. It is frequently used to compare the effects of biotic and abiotic factors on the health or general well-being of a fish population [33, 34]. The K value also gives information when comparing two populations living under certain feeding, climate, density and other conditions [26].

From the present study, the mean condition factor of sex reversed *O. niloticus* reared in both experimental environments were greater than one (>1), suggesting good fish health, good level of feeding and proper environmental conditions [14, 35]. The mean value of condition factor obtained for the fish raised at Mbarali district was significantly higher than that obtained at Mufindi district. This implies that the environmental conditions in Mbarali were more favourable for the growth and survival of the fish than those at Mufindi district [1, 36].

Results from this study also revealed that, the fish cultured in the two different study areas exhibited inconsistent condition factors during the experimental period (Fig.2). The monthly variations in condition factors could be attributed to various reasons such as changes in environmental factors with time (e.g. water quality), availability of natural food supply, physiological condition (e.g. accumulation of fat and gonads development) [29, 37] and stage of maturity [4, 38]. It has been shown that, the better the environmental conditions (physico-chemical and biological parameters), the higher the condition factor and vice versa [8, 24]. This idea agrees with the results in the present study whereby the higher condition factor and growth performance of fish were observed at Mbarali, the area where most of the water quality parameters were within the satisfactory ranges.

5. Conclusions and recommendation

It is concluded that difference in climatic conditions between the two experimental locations influence significantly the length-weight relationship and condition factor of cultured fish. In both experimental locations, fish showed negative allometric growth pattern and there is strong relationship between body weight and length of fish. Nile tilapia (*O. niloticus*) grown at Mbarali have better condition and are relatively healthier, compared to those grown at Mufindi. It is recommended that, further studies to be done on other species so as to come up with the better species that can survive well in Mufindi district which has cold environment.

6. Acknowledgement

The authors are extremely grateful to the authorities of Aquaculture and Fisheries Innovation Laboratory (AquaFish Innovation Lab) programme, for funding this research work. Nevertheless, the authors are sincerely thankful to the professors, supporting staffs and colleagues for their continuous inspiration, priceless research comments, valuable guidance and substantial recommendations in making this work possible. All contributions are highly acknowledged.

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