Length-weight relationship and Fulton's condition factor of Oreochromis mossambicus from Vellayani lake and Veli lake in Southern Kerala

Bindulekha D.S
Department of Zoology, Christian College, Kattakada, Kerala, India

Abstract - The Mozambique tilapia, Oreochromis mossambicus, was the first tilapia species spread at a global scale for aquaculture purposes. In this study, we examined the length-weight relationship and condition factor of tilapia living in two different natural habitats in Southern Kerala. The values of constants 'a' and 'b' (growth exponent) were determined from the length and weight data which transformed into the linear equation of log W= log a + b log L. These parameters were then fitted to the exponential equation $W = aL^b$. Based on this equation, the same species in two different sampling sites shows negative allometric growth pattern. Similarly, the condition factors of the fish species sampled from two different locations revealed that the fish species in both lakes showed good condition. The study further indicated that the values of b and K of O. mossambicus living in Vellayani Lake were higher than those from Veli Lake probably because Vellayani Lake habitat provides more suitable environment and better food supply for tilapia than Veli Lake.

Keywords: Length-weight relationship, Condition factor, Growth Pattern, Cube Law, Oreochromis mossambicus

I. INTRODUCTION

Length-weight relationship (LWR) is of great importance in biological studies of fishes, allowing to estimate the weight of a specimen easily when the total length is known and are useful when rapid estimation of biomass is necessary (Froese, 1998). Therefore, this measurement is widely considered as an important tool in fisheries science especially in ecology population dynamic and stock management (Abdoli and Rasooli, 2008).). Likewise, it provides important information on the condition of fish, which is frequently used for interregional comparisons (Moutopoulos and Stergiou, 2002). The relationship of length-weight estimates condition factor of the fish species and fish biomass through the length frequency (Fishbase, 2013). Fish can attain either isometric growth or negative or positive allometric growth (Reidel *et al*., 2007). Isometric growth is associated with no change of body shape as an organism grows. Furthermore, negative allometric growth implies the fish becomes more slender as it increase in weight while positive allometric growth implies the fish becomes relatively stouter or deeper-bodies as it increases in length (Reidel *et al*., 2007).

The condition factor of fishes is the most important biological parameter which provides information on condition of fish species and the entire community and is of high significance for management and conservation of natural populations (Sarkar *et al*., 2009; Muchlisin *et al*., 2010). It is also a quantitative parameter used to compare the "condition", i.e., fatness or wellbeing of fish (Seher and Suleyman, 2012) that determines present and future population success because of its influence on growth, reproduction and survival (Richter, 2007). The condition factor is an index reflecting interaction between biotic and abiotic factors in the physiological conditions of fishes and is based on the hypothesis that heavier fish of a given length are in better condition (Bagenal and Tesch, 1978). Weatherley and Gill (1987) suggested that this factor is frequently used in cases like comparison of two or more co-specific populations living in similar or different conditions of food, density or climate, among others, for determination of the period and duration of gonadal maturation and for the observation of increase or decrease in feeding activity or population changes, possibility due to modifications in food resources (Weatherley and Gill, 1987). Condition factor decrease with increase in length (Bakare, 1970; Fagade, 1979) and also influences the reproductive cycle in fish (Welcome, 1979). Likewise, it is used as an index for monitoring feeding intensity, age, and growth rates in fish (Ujjania *et al*., 2012). Therefore the present work has been carried out to study the length-weight relationship and condition factor of *Oreochromis mossambicus* from Vellayani Lake and Veli Lake, two different natural habitats in Southern Kerala.

II. MATERIALS AND METHODS

Sampling Area

The fish samples were obtained from two different locations, Vellayani Lake and Veli Lake from Thiruvananthapuram District, Southern Kerala. The Veli Lake is a small and shallow lake in the southwest coast of India which is located in 8°31'39'N latitude and 76°54'30'E longitude (area=1 km^2 ; depth= <1m), which remain separated from the Arabian sea by a sand bar during most months of the year (Abhijna and Bijukumar, 2017), except during monsoon season (Fig. 2). Similarly, Tilapia were collected from Vellayani Lake or Vellayani Kayal as known in local language, the largest freshwater lake in Thiruvananthapuram District, Kerala which is located in 8°24'N latitude and 76°59'E longitude (Fig. 1). The length of the lake is about 3.15 km and maximum width is about 1000 m; depth of the lake varies from 2 to 6 m. It has a water spread area of 450 ha. The depth of the lake varies from 2 to 6 m. The northwestern part of the lake is converted to a temporary reservoir for irrigation purpose and this lake act as a major source of drinking water supplies (Abhijna and Bijukumar, 2017). The specimens from both lakes were collected during February 2018.

Sampling of Fish

Total 50 fish samples each were collected randomly from two sampling stations, Vellayani Lake and Veli Lake. Fish were wiped on a filter paper before they were weighed to remove excess water from their body in order to ensure accuracy. Total length (cm) of each fish was taken from the tip of the snout (mouth closed) to the extended tip of the caudal fin using a measuring board. Body weight was measured to the nearest gram using electronic balance. Parameters of the length-weight relationship of sampled fish species were estimated using the Le Cren (1951) formula or its logarithmic form.

For calculating the length-weight relationship method suggested by (LeCren, 1951) was followed. The length-weight relationship can be expressed as: $W = aL^{b}$.

Where, W and L are weight (g) and length (cm) of the fish respectively. The constants ‘a’ and ‘b’ are initial growth index and regression constants respectively. The values of constant ‘a’ and ‘b’ are determined empirically from data, as the coefficient of condition (Richer, 1975).

Logarithmically the above equation becomes straight line of the formula:

$\text{Log } W = \log a + b \log L$.

The constants ‘a’ represents the point at which the regression line intercepts the y-axis and ‘b’ the slope of the regression line were estimated by the method of least square (Snedecor and Cochran, 1967).

Condition factor K, a measure of the well-being or plumpness of a fish, was calculated according to the equation presented in (Carlander, 1977):

$K = W \times 10^{N} / L3$.

Where W is the weight of the fish in grams and L is the total length of the fish in centimeters. The number 10^{N} is a scaling factor when metric units are used (grams and centimeters) and is used to bring the value of k near unity.

Statistical Analysis

Statistical analysis of Length-weight relationship was calculated according to the method mentioned by Le Cren (1951). Linear relationship between the logarithm length and logarithm weight was found from the examination of scatter diagram. All data were calculated in MS-Excel 2010 and Graphpad Software (Graphpad Instat-3 San Diego) used for analysing the data.

Fig.1. Vellayani Lake

Fig.2. Veli Lake

Fig.3. *Oreochromis mossambicus*

III. RESULTS

The present study analyzed the length-weight relationship of the tilapia fish species collected from two major lakes from Southern Kerala. Table 1 shows the number of specimen, maximum and minimum length and average mean length and weight. Data from all measurements taken were converted to the linear form by means of natural logarithm transformation (Table 2). Log transformed values of total body length and weight were used as the independent and dependent variables, respectively. The length-weight relationship was examined by simple linear regression analysis. It appears that the minimum and maximum recorded range of TL varies from 6.0cm – 13.4 cm in Vellayani Lake and 6.3cm-13.4cm in Veli Lake (Table 1). TW range varies from 15.25gm - 222.75gm in Vellayani Lake and 25.15gm-225.13gm in Veli Lake (Table 1). Average value of total length and weight of fishes in Vellayani and Veli Lake was 10.928, 113.285 and 10.99, 121.557 respectively (Table.1). The slope (b) of the length-weight relationship was conducted to perform comparisons of the condition of fish between the different sampling sites. The slope (b) of the length-weight relationship is 2.938 (Fig. 5) and the mean condition factor 1.5477 (Fig.7) in Vellayani Lake specimens and the slopes (b) value is 2.793 (Fig.6) and the mean condition factor value is 1.3316 in Veli Lake specimens (Fig.7).

Fig. 4: Measurement of weight during study of *Oreochromis mossambicus*

The equations for the length-weight relationship in this study were as follows:
Log W = -1.937 + 2.698 Log L (Vellayani Lake Specimens) and
Log W= -2.133 + 2.811 Log L (Veli Lake Specimens).

The 'b' value of *O. mossambicus* in both Vellayani and Veli Lake is slightly below the isometric value of 3 but it is not significantly different from the cubic value. However, the data showed that the species grow negative allometrically in both Lake. Similarly, the condition factor of *O. mossambicus* in Vellayani Lake (1.5477) showed a higher value from Veli Lake (1.3316) specimens. The regression coefficient (R^2) values, calculated for the total LWRs, varied from 0.902 in Veli Lake to 0.932 in Vellayani Lake (Table 2).

TABLE I: Size variation of *Oreochromis mossambicus* in Vellayani Lake and Veli Lake

Sampling Station	Total Length (Cm)		Total Weight (G)		Average Size (Mean ±SD)		No. of Samples
	Min	Max	Min	Max	Total Length	Total Weight	
Vellayani Lake	6.0	13.4	15.25	222.75	10.928±1.765	113.285±49.305	50
Veli Lake	6.3	13.4	25.15	225.13	10.99±1.696	121.557±51.399	50

TABLE II: Length-weight relationships of *Oreochromis mossambicus* in Vellayani Lake and Veli Lake

Sampling Station	Mean ±SD		a	b	R^2	K (Mean ±SD)	GP
	Log Length	Log Weight					
Vellayani Lake	2.3769±0.1777	4.6125±0.5409	-2.372	2.938	0.932	1.5477±0.2223	NA
Veli Lake	2.3837±0.1706	4.6935±0.5017	-1.964	2.793	0.902	1.3316±0.2819	NA

SD=Standard Deviation, a= intercept of regression line, b=slop of regression line, R^2 = regression coefficient, K = Condition Factor, GP = Growth Pattern, NA = Negative Allometric.

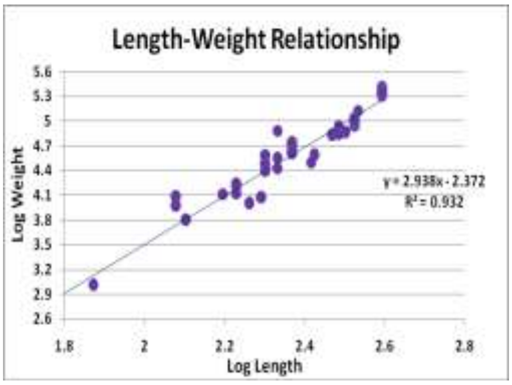

Figure 5: Length-weight relationship of *Oreochromis mossambicus* from Vellayani Lake

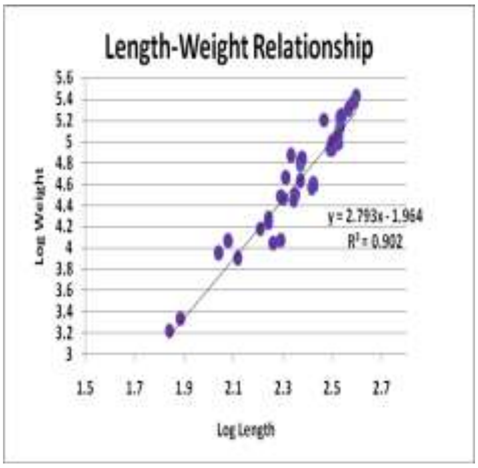

Figure 6: Length-weight relationship of *Oreochromis mossambicus* from Veli Lake

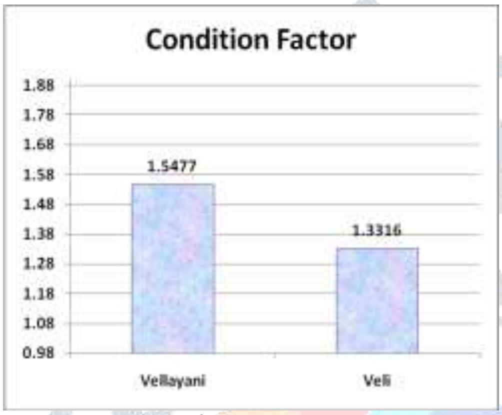

Figure 7: Condition Factor (K) of *Oreochromis mossambicus* from Vellayani Lake and Veli Lake

IV. DISCUSSION

Length-Weight Relationship

The value of constant ‘b’ closed to 3 indicates that the fish grows isometrically, resulting in ideal shape of fish (Olurin and Aderibigbe, 2006). Values other than 3 indicate allometric growth which occurs when the fishes change slope during growth and the cubic law was no longer obeyed (Sandon, 1950). When the value of b is less than 3, the fish experiences a negative allometric growth. However, when the value of b is more than 3, the fish grows following the positive allometric growth pattern. Ibrahim (1984) reported that, the value of b then becomes greater than 3.0 as the fish becomes fatter, or when the b value is lower than 3.0, the fish is slimmer. Nevertheless, it was found that the fish species from the two sampling sites in the present study neither showed isometric nor positive allometric growth patterns, but all suffered from negative allometric growth. However, it is noticed that the ‘b’ value was slightly higher in the Vellayani Lake specimens than in the Veli Lake. According to Goncalves *et al*. (1997) and Ozaydin *et al*. (2007), the parameter b unlikely varied from seasonally, and even daily, and between habitats. Another study by Moutopoulos and Stergiou (2002) suggested that these differences can be attributed to the combination of one or several factors like the difference in the number of specimens examined and further the size range of species (Moutopoulos and Stergiou, 2002). Similar suggestions were done previously by Petrakis and Stergiou (1995) and they reported that the use of length-weight relationships should be strictly limited to the size range used for estimating parameters of linear regressions. However, these variations are particularly reflecting specific conditions of each environmental medium such as temperature, hardness of water, changes in maturity stages and availability of food. The observed regression of *O. mossambicus*, Log W = -1.937 + 2.698 Log L, and Log W= -2.133 + 2.811 Log L respectively for Vellayani and Veli Lake and further $W = aL^b$ was found to be fit with length-weight data.

According to the theory of ‘Cube law’, if the ‘b’ value in length-weight relationship is reported as 3, then the growth in fish is isometric. When b>3, it shows a positive allometric growth which is defined hyperallometry (Froese, 1998). Here, the observed ‘b’ value was 2.938 and 2.793 respectively for Vellayani and Veli Lake, further indicate that the fish does not follow the Cube law (i.e. b=3). This results supported studies by Soni and Kathal (1979) who observed that the length-weight relationship *C. mrigala* and *Cyprinus carpio* and the observed “b” value was 4.36 and 3.75, respectively. They reported that the difference observed in ‘b’ value was due to the difference in feeding habit of fish. Similarly, Abdallah (2002) obtained a ‘b’ value ranges from 2.5 and 3.44 for fishes from different marine water bodies. While studying the length-weight relationship of over 23 species of small pelagic fishes of the Brazilian Exclusive Economic Zone, Bernades *et al*. (2000) observed that the b values vary considerably between 2.72 and 3.53. Jones (1976) indicated this may be considered only as either seasonal or regional fluctuations or may be due to different environmental conditions. It is also reported that higher b values indicates relatively productive environmental conditions and if so LWR data appear to reflect the poor growing condition of the fish in these natural waters.

Condition Factor

The condition factor (K) gives information about the physiological condition of fish in relation to its welfare (Angelescu *et al*., 1958; Perry *et al*., 1996). From this study, the condition factor value was found to be 1.5477 for Vellayani Lake and 1.3316 for Veli Lake specimens. Wootton (1996) reported that fish with higher K values (> 1) are in a better condition than fish with lower K values (< 1). In this point of view, the condition factors of the fish species sampled from two different locations in the current study point out that the fish species in lakes showed good condition with values above 1, further indicating a general well being and adaptability of fish. Similarly, Perry *et al*. (1996) suggested that fishes with a low condition reflex are presumably believed to have experienced adverse physical environment or insufficient nutrition. From a nutritional point of view, Maguire and Mace (1993) revealed that increase in K values indicates the accumulation of fat and sometimes gonadal development. According to Angelescu *et al*. (1958), from a reproductive point of view, the highest K value is reached in fully matured fish species and has higher reproductive potentiality. Since Fulton's condition factor is a measurement involving the length-weight measurement for a particular fish, it could be influenced by the same factors as LWR (Angelescu *et al*., 1958). Barnham and Baxter (1998) proposed that if the K value is 1, the condition of the fish is poor, long and thin. Further the K value of 1.20 indicates that the fish is of moderate condition and acceptable to many anglers. Similarly, a good and well-proportioned fish would have a K value that is greater than all these values (Barnham and Baxter, 1998). From this point of view, it is well supported that the sampled fishes in both lakes were in good condition. However, the present data could not clarify which factors among those described above could have led to these observations. In short, the differences in LWR and condition factor of similar species collected from two habitats in this study could be due to the factors listed earlier or a combination of factors which require further investigation.

V. CONCLUSION

Overall, it is concluded that this type of studies will help biologists to know the status of this fish and develop culture technology in their own natural habitat and will be useful for the fishery biologists and conservation biologist, for formulate suitable management measures for sustainable management, conservation and judicious utilization of such resources.

ACKNOWLEDGEMENT

I would like to express my sincere gratitude and profound appreciation to the Department of Zoology, Christian College, Kattakada for providing the facility and encouragement to carry out the present work.

REFERENCES

[1] Abdallah, M. (2002). Length-weight relationship of fishes caught by Trawl off Alexandria, Egypt. *Naga ICLARM Quart*. 25: 19-20.
[2] Abdoli, A. and Rasooli, P. (2008). Length-weight relationship of 10 Species of fishes collected from Iranian fresh waters, *J. Appli. Ichthyol*. 22: 156-157.
[3] Angelescu, V., Gneri, F.S. and Nani, A. (1958). Argentine sea hake (biology and taxonomy), *Secr. Mar. Serv. Hydrogenation. Nav. Public, H.* 1004: 1-224.
[4] Abhijna, U.G. and Biju Kumar, A. (2017). Development and evaluation of fish index of biotic integrity (F-IBI) to assess biological integrity of a tropical lake Veli-Akkulam, South India. *Int. J Fisheries Aqua. Studies*. 5(3): 153-164.
[5] Bagenal T.B. and Tesch F.W. (1978). Methods of Assessment of Fish Production in Fresh Waters. IBP Handbook No. 3, 3rd ed. Oxford Blackwell Scientific Publication, London. pp. 101-136.
[6] Bakare, O. (1970). Bottom Deposits as Food of Inland Fresh Water Fish. In: Visser SA (eds) Kainji, Lake A Nigerian man-made lake. Kanji Lake Studies. Ecology, Published for the Nigerian Institute of Social and Economic Research, Ibadan, p. 89-95.
[7] Barnham, C. and Baxter, A. (1998). Condition Factor, K, for Salmonid Fish. *Fisher. Notes*, pp. 1-3.
[8] Bernardes, R.A. and Rossi-Wongtschowski, C.L. (2000). Length-Weight Relationship of Small Pelagic Fish Species of the Southeast and South Brazilian Exclusive Economic Zone Naga, The *ICLARM* 23(4).
[9] Carlander, K.D. (1977). Handbook of freshwater fishery biology, volume 2. The Iowa State University Press, Ames, Iowa.
[10] Fagade, S.O. (1979): Observation of the biology of two species of Tilapia from the Lagos lagoon Nigeria. *Bull. Inst. Fond. Afr. Noire*. 41: 627-658.
[11] Fishbase, (2013). Online fish identification sheet. Available at http://www.fishbase.org/search.php, accessed on 10/06/2013.
[12] Froese, R. (1998). Length-weight relationship for 18 less studied fish species. *Journal of Applied Ichthyol*. 14: 117-118.
[13] Goncalves, J.M., Bentes, S.L., Lino, P.G., Ribeiro, J., Canario, A.V.M. and Erzini, K. (1997). Weight-length relationships for selected fish species of the small-scale demersal fisheries of the south and south-west coast of Portugal. *Fish. Res.* 30, 253–256.
[14] Gopakumar, G., Gopalakrishna Pillai, N. and Omana, T.A. (1991). The fishery characteristics and biology of mackerel at Vizhinjam, *J. Mar. Biol. Ass. India*, 33(1-2): 107-114.
[15] Ibrahim, A.M. (1984). The Nile: Description, hydrology, control and utilization. *Hydrobiol*. 110, 1-13.
[16] Jones, R. (1976). Growth of fishes, P. 251- 279. In D.H. Cushing and J.J. Walsh (eds.). The ecology of the seas. Blackwell Scientific Publications, Oxford. 467p.
[17] Le-Cren, E.D. (1951). The length-weight relationship and season cycle in gonad weight and condition in Perch (Perca fluviatilis). J. Ani. Ecol. 20:179–219.
[18] Maguire, J.J. and Mace, P.M. (1993). Biological reference points for Canadian Atlantic Gadoid stocks. In: Smith S.J., Hunt J.J. and Rivard D. (eds.), Risk Evaluation and Biological Reference Points for Fisheries Management. *Can. Spec. Publ. Fish. Aquat. Sci*. 120: 67-82.
[19] Moutopoulos, D.K. and Stergiou, K.I. (2002). Length– weight relationships of fish species from the Aegean Sea (Greece). *J. Appl. Ichthyol*. 18: 200-203.
[20] Muchlisin, Z.A., Musman, M. and Azizah, M.N.S. (2010). Length-weight relationships and condition factors of two threatened fishes, *Rasbora tawarensis* and *Poropuntius tawarensis*, endemic to Lake Laut Tawar, Aceh Province, *Indan. J. Appl. Ichthyol*. 26(6): 949-953.
[21] Olurin, K.B. and Aderibigbe, O.A. (2006). Length-weight relationship and condition factor of pond reared Oreochromis niloticus. World Journal of Zoology, 1 (2): 82-85.

[22] Ozaydin, O. and Taskavah, E. (2007). Length-weight relationships for 47 fish species from Izmir Bay (Eastern Agean Sea, Turkey). *Acta Adviatica*. 47, 211-216.

[23] Perry, R.I., Hargreaves, N.B., Waddell, B.J. and Mackas, L. (1996). Spatial variations in feeding and condition of juvenile pink and chum salmon off Vancouver Island, *British Columbia. Fish Oceanogr*. 5 (2):73-88.

[24] Petrakis, G. and Stergiou, K.I. (1995). Length-weight relationships for 33 fish species in Greek waters. *Fish. Res*. 21: 465–469.

[25] Richer, W.E. (1975). Computational interpretation of biological statistics of fish population. *J. Fish. Res. Bd. Can. Bull*. 191:382.

[26] Richter, T.J. (2007). Development and evaluation of standard weight equations for bridgelip suckers and large scale suckers. *N. Am. J. Fish. Manage*. 27(3): 936-939.

[27] Riedel, R., Caskey, L.M. and Hurlbert, S.H. **(**2007). Length-weight relations and growth rates of dominant fishes of the Salton Sea: implications for predation by fish-eating birds. *Lake Reser. Manage*. 23:528-535.

[28] Sandon, H. (1950). An illustrated guide to the freshwater fishes of the Sudan. *Sudan Notes and Rec*. 25: 61-66.

[29] Sarkar, U.K., Deepak, P.K. and Negi, R.S. (2009). Length-weight relationship of clown knifefish *Chitala chitala* (Hamilton 1822) from the River Ganga basin, *India. J. Appl. Ichthyol*. 25(2): 232-233.

[30] Seher, D. and Suleyman, C.I. (2012). Condition factors of seven cyprinid fish species from Çamligöze Dam Lake on central Anatolia, Turkey. *Afric. J. Agri. Res*. 7 (31): 4460-4464.

[31] Snedecor, G.W. and Cochran, W.G. (1967). Statistical Methods. Oxford and IBH Publishing Co., New Delhi.

[32] Soni, D.D. and K.M. Kathal. (1979). Length-weight relationship in *Cirrhinus mrigala* (Val.) and *Cyprinus carpio* (Ham.). *Masya*, 5: 69-72.

[33] Ujjania, N.C., Kohli, M.P.S. and Sharma, L.L. (2012). Length-weight relationship and condition factors of Indian major carps (*C. catla, L. rohita and C. mrigala*) in Mahi Bajaj Sagar, India. *Res. J. Biol.* 2 (1):30-36.

[34] Weatherley, A.H. and Gill, H.S. (1987). The biology of fish growth. Academic Press, London, England.

[35] Welcome, R.L. (1979). Fisheries Ecology of Flood Plain Rivers. Longman Press, London, England.

[36] Wooton, R.J. (1996). Ecology of Teleost Fishes. Chapman and Hall, London, 404pp.