

# Length–weight relationship of *Tilapia mariae* in Lower Ogun River, Akomoje Water Reservoir, Nigeria

Oyekanmi, F. B.<sup>1</sup>, Adeosun, O. M.<sup>2</sup>, Adeosun, F. I.<sup>3</sup>, Akin-Obasola, B. J.<sup>4\*</sup> and Olemoh, O. E.<sup>3</sup>

<sup>1</sup>Department of Agricultural Science Education, University of Ilesa, Ilesa, Nigeria.

<sup>2</sup>Agricultural Media Resources and Extension Centre, Abeokuta, Nigeria.

<sup>3</sup>Department of Aquaculture and Fisheries Management, Federal University of Agriculture Abeokuta, Nigeria.

<sup>4</sup>Department of Fisheries and Aquaculture Management, Ekiti State University, Ado Ekiti, Nigeria.

\*Corresponding author. Email: [fumboye17@gmail.com](mailto:fumboye17@gmail.com), Tel: +2348033841422.

Copyright © 2023 Oyekanmi et al. This article remains permanently open access under the terms of the [Creative Commons Attribution License 4.0](https://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Received 20th September 2023; Accepted 24th November 2023

**ABSTRACT:** The length-weight relationships and the condition factor of the fish *Tilapia mariae* were examined in the laboratory. The fish species attained a mean standard length in the range of 13.12±0.61 cm in male, while it was 19.83±0.76 cm in female. The growth in length relative to weight was negative allometric. There was variation in condition factor (k) for both sexes. The females were in better condition than the males whose k-values were higher during the dry and wet seasons. The sex ratio of *Tilapia mariae* in the reservoir was 1:3.12 (M: F), with September showing the highest sex ratio of 1:3.17 (M:F) and October showing the least 1:2.05 (M:F).

**Keywords:** Condition factor, growth, *Tilapia mariae*, Ogun River.

## INTRODUCTION

Fish is a high-quality food; apart from its protein contents, it is also rich in vitamins and contains variable quantities of fat and minerals for human health (Bard *et al.*, 1976). Fish protein represents a crucial nutritional component in some densely populated countries where total protein intake levels is very low (Akin-Obasola *et al.*, 2022). In addition, fish supplies to the body a range of inorganic minerals such as Phosphorus, Fluorine, Potassium, Iron, Zinc, Magnesium, Copper, and in marine species, Iodine as well as vitamins A and B complex (Adeniyi *et al.*, 2010). Fish oil contains vitamins A, D, E and K, which have been successfully used in controlling coronary heart diseases, arthritis, atherosclerosis, asthma, auto immune deficiency diseases and cancer (Bhuiyan *et al.*, 1993). Fish is often recommended for cardio-vascular disease patients because of its unique fat, which is composed mainly of Omega-3 polyunsaturated fatty acid. In addition to its nutritious flesh, vitamins A and D present in fish oil is important especially in infants and children (Holcik, 1991).

Knowledge of length-weight and food content of fishes is important in the study of fisheries biology.

Interest in the farming of the Cichlids has continuously been on the increase (Atindana *et al.*, 2016; Ikomi, 2006). They have been widely cultured and are recorded as species of high economic importance in Tropical Africa (Soyinka and Ayo-Olalus, 2009). This importance could be attributed to their hardy nature and prolific breeding ability. Cichlids generally can be cultured in crowded ponds (earthen, concrete, and tanks) and cages. In terms of nutrition, these species (*Tilapia*) have high protein content (26 g/100 g of muscle). They are also rich in vitamins and minerals, especially niacin, vitamin B12, phosphorus, selenium and potassium (Pearson, 2017). According to Agbabiaka (2010), their distribution is wide in Nigeria waters. Therefore, they are of high economic viability and play an important role in the ecology of freshwater bodies in Africa (Ikomi and Jessa, 2003). Some studies conducted on food and feeding habits and length-

weight relationships of Cichlids in Nigeria and Africa, include those of Atindana *et al.* (2016) on the food ecology of three Cichlid species in the Mankessim reservoir, Central Region of Ghana. Uneke (2017) on food and feeding habit and condition factor of Tilapia species in Ebonyi River. Ecoutin *et al.* (2005) on length-weight relationship and condition factor of five fish species from a tropical water supply reservoir in Abuja (Atama *et al.*, 2013) on Cichlids species from Anambra River.

Existing facts from the World Conservative Union for the Cichlids is that 43 species are extinct. Of the wild species, five (5) have gone into extinction, thirty-seven (37) species are critically endangered, eleven (11) species are endangered, thirty-four (34) species are of high vulnerability to extinction and one specie is least concern (The World Conservation Union, 2002). This study was therefore designed to investigate the growth pattern of *Tilapia mariae* for rational exploitation, cultural practice, and domestication purposes.

Length-weight relationship (LWR) of fishes is important in fisheries and fish biology because the information allow the estimation of the average weight of the fish of a given length group by establishing a mathematical relation between them (Sarkar *et al.*, 2009; Mir *et al.*, 2012; Riedel *et al.*, 2007). Like any other morphometric characters, the LWR can be used as a character for the differentiation of taxonomic units and the relationship changes with the various developmental events in life such as metamorphosis, growth and onset of maturity (Teixeira de Mello *et al.*, 2006). Besides, LWR can also be used in setting yield equations for estimating the number of fish landed and comparing the population in space and time. LWR parameters (a and b) are useful in fisheries science in many ways, to estimate weight of individual fish from its length, to calculate condition indices, to compare life history and morphology of populations belonging to different regions and to study ontogenetic allometric changes (Teixeira de Mello *et al.*, 2006).

Length-weight relationships can be used to predict weight from length measurements made in the yield assessment (Pauly, 1993). Fish can attain either isometric, negative allometric or positive allometric growth. Isometric growth is associated with no body shape change as an organism grows (Thomas *et al.*, 2003). Negative allometric growth implies the fish becomes slenderer as it increases in weight. In contrast, positive allometric growth implies the fish becomes relatively stouter or deeper-bodied as it increases in length (Rayner *et al.*, 2008).

*Tilapia mariae* also known as the Spotted Mangrove Cichlid is a species of the cichlid family (King and Etim, 2004). Pisces: Cichlidae is a freshwater and estuarine teleost that occurs naturally in West Africa, from Côte d'Ivoire to Cameroon, and has been introduced to at least three other continents (Welcomme, 1988). In its native range, it can be the dominant fish species in streams, rivers, lakes and estuaries (Akpaniteaku and Aguigwo,

2003), and supports local subsistence and artisanal fisheries in some catchments (Nwadiaro, 1987). Unlike other tilapine species, *T. mariae* has yet to be extensively cultured locally or globally (King and Etim, 2004), but appears to have some potential for aquaculture (Ajuzie, 1996; Vassallo *et al.*, 2007). Around the world, it has become a desirable aquarium species, owing to its attractive appearance, hardiness and ability to readily reproduce. Combined with introductions for the purpose of aquaculture, this has resulted in the species becoming naturalized in the United States, Australia and possibly Russia (Welcomme, 1988; Dan-Kishiya, 2013; Robins *et al.*, 1991). Unlike other introduced tilapiine species, only three published studies have documented potential detrimental impacts of *T. mariae* on native ichthyofauna (Courtenay and Deacon, 1982; Brooks and Jordan, 2010; Kroon *et al.*, 2011). The classification of *Tilapia mariae* according to King and Etim (2004) is as follows:

#### Physical characteristics of *Tilapia mariae*

Spotted tilapia have a short rounded snout and three anal spines. They are dark olive green to light yellowish in colour and have eight or nine bars on their sides which are more evident in young spotted tilapia than adults. They also have two six dark spots between the bars on the middle of their side and they reach a maximum standard length of 32.3 cm (1.1ft).

#### Appearance and morphology

In its native range, the maximum recorded sizes are 323 mm total length (TL) and 550 g fresh weight (Whitehead, 1962), although total lengths of 190-220 mm are more common. In Florida (USA), the maximum documented size is slightly larger (350 mm TL) but up to almost three times heavier (1350 g) (Shafland, 1996), and in Queensland (Australia), the maximum recorded size is 333 mm TL at 952 g (Russell *et al.*, 2003). The body of *T. mariae* is laterally compressed with a depth 42-54% of standard length (SL) in natural conditions (Whitehead, 1962) and a blunt head comprising 30-35% the SL (Van den Audenaerde, 1966). *T. mariae* is a polyphyodont species; that is, a species that produces several sets of teeth successively throughout its life. Tooth germs and replacement teeth in various stages of development are in the cavity of the dentary bone, *T. mariae* has internal and external morphology that reflects a cellulose diet, and foraging behaviour that includes plankton-filtering and grazing. The mouth is small, with jaws that have 4-6 series of slender-shafted external teeth, the outer row with one notch and the inner tricuspid (Whitehead, 1962). Like all Cichlidae, *T. mariae* are physoclistous; that is, there is no connection between the swim bladder and the gut, as the

connection closes and becomes reduced early in the larval stage.

### Coloration

The colour pattern of *T. mariae* is distinctive; however, it changes upon the fish reaching sexual maturity and shows variation among adults. Late juveniles are olive-green to creamy-white and have up to nine sharply delineated, dark vertical bands running from the dorsal fin to the under surface (Whitehead, 1962). Upon reaching the adult phase, the colour changes to a milky colour with two to six dark blotches on the middle of the flanks, and light green to yellow head and dorsal fringes (Baldaccini, 1973). Several other colour and pattern combinations are seen (Whitehead, 1962; Baldaccini, 1973), which are generally related to stages of gonad development and behaviour, but can also be associated with changes in the environment.

### Distribution, habitat and abundance

*Tilapia mariae* occurs naturally in West African coastal drainages of the Gulf of Guinea, from Tabou River in Côte d'Ivoire (4.38N, 7.28W) to south-west Ghana (5.08N, 2.08W) and then from south-east Benin (6.38N, 2.08E) to the Kribi River in Cameroon (2.78N, 10.08E). In Nigeria, where the majority of research has been conducted, the climate generally consists of a single wet season in the middle of the calendar year and a single dry season at the end and start of the calendar year. Wet- and dry-season water levels can be markedly different in both the lower and upper reaches of watercourses. *Tilapia mariae* has been classified as an estuarine species of freshwater origin (Holcik, 1991; Courtenay and Deacon, 1982). In its natural range, *T. mariae* occurs in fresh and brackish water. *T. mariae* is the most abundant exotic fish species in Florida (USA) (Loftus and Kushlan, 1987), and is locally abundant in Queensland (Russell *et al.*, 2003; Rayner *et al.*, 2008).

## METHODOLOGY

### Description of the study area

Figure 1 shows the study area and location of Ogun River. The study was carried out in the lower Ogun River, Akomoje, in Abeokuta Ogun State. The river is located at Abeokuta North Local Government of Abeokuta and lies between longitude 3°21'E and latitude 7°21'N North of Abeokuta, with a size of 1000 hectares. Ogun River, as a perennial river in Nigeria, has a coordinate of 3°28'E and 8°41'N from its source in Oyo State to 3°25'E and 6°35'N

in Lagos State, where it enters Lagos Lagoon. The dry season lasts from October to April, while the wet season lasts from May to September. The annual rainfall ranges from 900 mm in the North of the River to 200 mm towards the South (Dimowo, 2013). Total annual potential evapotranspiration is 1600 mm and 190 mm. Akomoje dam takes its source of water from the Ogun River. The dam serves as a fishing site and a source of potable water processed by the Ogun State water cooperation.

### Specimen collections

During the period of five months, August to December, 125 specimens of *Tilapia mariae* were collected randomly fortnightly with the help of artisanal fishermen using gill nets of 75 mm and 105 mm mesh sizes. The study is a preliminary study with the intent of expanding the study in the future. A 5-month period was used for the research in order to have an insight on the condition factor of the species. On each occasion, the fish caught were transported to the laboratory in an ice chest to reduce post-humous digestion to a minimum before subsequent treatment. The specimens were later preserved in the refrigerator to avoid deterioration.

### Laboratory procedures

The fish specimens were arranged serially in the laboratory and given an identification number. The sexes of each specimen were identified and recorded by observing through the papilla (protruding or flat). Each specimen's total and standard lengths were measured in centimeters by measuring from the tip of the mouth to the tip of the tail using a measuring board. The weight of each fish was taken to the nearest tenth of a gram using a top-loading mettle balance (Model PN1200) to the nearest 0.1 g after draining excess water with a pile of filter paper.

### Length-weight relationship (LWR)

The length-weight relationship was calculated by the conventional formula described by Dambatta *et al.* (2021). This is expressed as:

$$W = aL^b.$$

The relationship was transformed into logarithms graphically by plotting the observed lengths and weights as a dot diagram. Thus, the formula becomes

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

Where  $W$  = weight of the fish (g),  $L$  = standard length of the fish (cm),  $a$  = a constant, and  $b$  = an exponent.

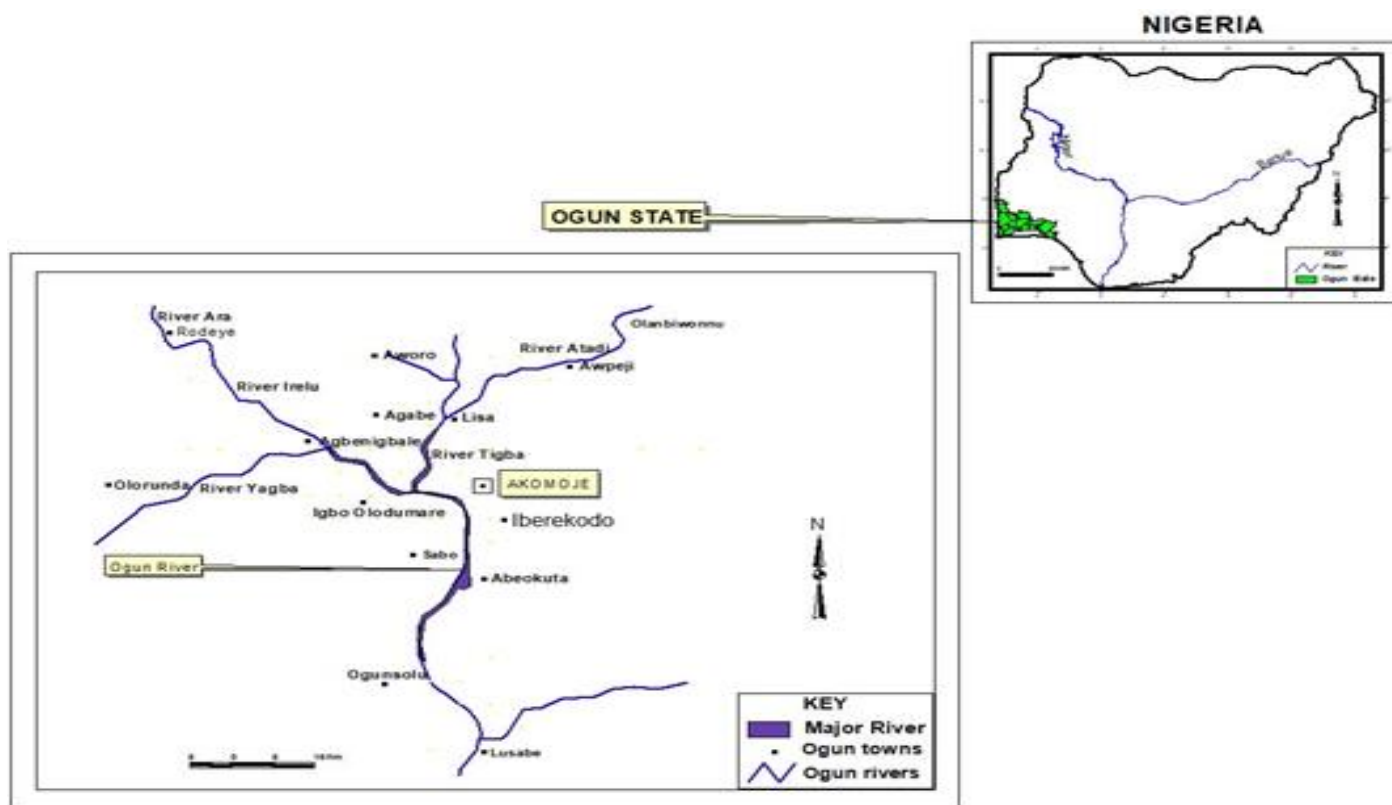


Figure 1. Map of Ogun River (Source: Field survey 2019).

**Condition factor**

The condition factor of *T. mariae* was estimated for the combined sexes in the species of fish under study. The condition factor was calculated by the formula (Pauly, 1983):

$$\text{Condition Factor (K)} = 100W/L^3$$

Where: W is weight (g) and L is total length (cm).

**Statistical analysis**

The data obtained was further statistically represented in bar charts or pie charts according to the size of fish specimen and the monthly occurrence (i.e., seasonal variation) using Excel Pro and SPSS.

**RESULTS**

**Length-weight relationship of *Tilapia mariae***

The length-weight relationship for *Tilapia mariae* is shown in Figure 2. The length-weight relationship reflected a

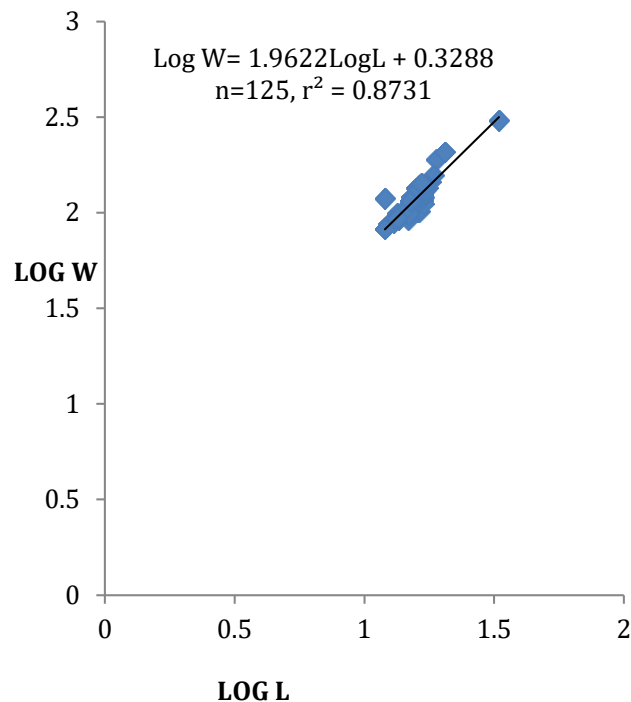
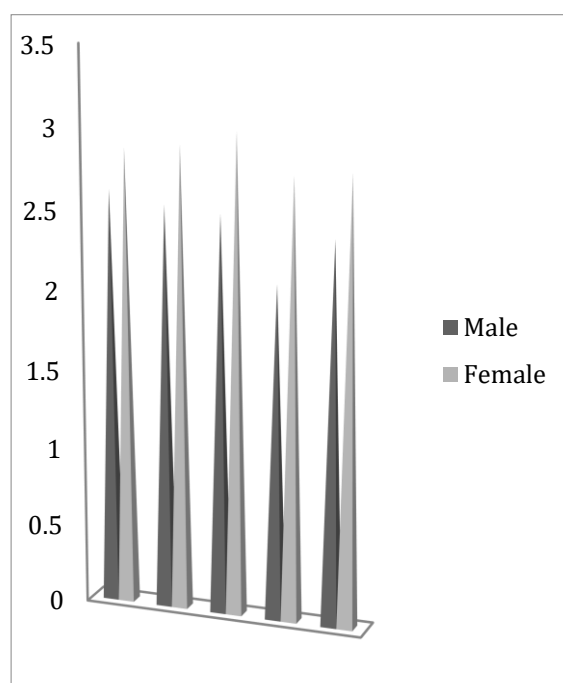


Figure 2. The length-weight relationship for *Tilapia mariae* in Akomoje water reservoir.



**Figure 3.** Monthly Variation in Condition Factor (k) for Male and Female *Tilapia mariae* in Akomoje Water Reservoir.

**Table 1.** Monthly Variation in Condition Factor, Mean Weight and Sex ratio of *Tilapia marie*.

Month	MM (cm)	MF (cm)	MwtM (g)	MwtF (g)	M:F	K (M)	K(F)
August	15.08±0.11	10.47±0.19	100.18±0.65	101±0.22	1:2.11	2.55±0.53	2.39±0.89
Sept	13.12±0.23	11.48±0.55	101.10±0.44	115±0.41	1:3.17	2.34±0.33	2.45±0.75
Oct	13.12±0.61	19.83±0.76	102.66±0.67	103±0.97	1:2.05	2.27±0.56	2.99±0.46
Nov	14.23±0.33	18.98±0.62	107.98±0.77	104±0.52	1:3.01	2.13±0.11	2.90±0.99
Dec	14.83±0.99	19.32±0.45	100.67±0.53	109±0.71	1:3.16	2.45±0.89	2.47±0.88
Mean	18.06±0.66	15.02±0.66	111.80±0.23	108.6±0.31	1:3.12	2.77±0.77	2.78±0.62

MM (cm): mean size for male, MF (cm): mean size for female, MwtM (g): mean weight for male, MwtF (g): mean weight for female, M:F: sex ratio, K (M): condition factor of male, K(F): condition factor of female (Source: Field survey, 2019).

common general increase in weight with increasing length. The least squares common fit of the transformed data gave a linear equation of  $\text{Log } W = 1.9622\text{Log } L + 0.3288$  with an  $r^2$  value of 0.8731 (n=125).

#### Monthly variation in condition factor (k)

From Figure 3, the condition factor of the male *Tilapia mariae* range between 2.13±0.11 and 2.55±0.53, with November and August having the least and highest condition factor, respectively. Similarly, in August the female *Tilapia mariae* had the least condition factor (2.39±0.89), while in October; the condition factor for female *Tilapia mariae* was 2.99±0.46. From Table 1, the

mean condition factor was 2.77±0.77 and 2.78±0.62 for both male and female *Tilapia mariae*, respectively. There were fluctuations in the monthly condition factors of the species in the reservoir.

#### Monthly variation in condition factor, mean weight, and sex ratio

From Table 1, the total mean length (TL) of *Tilapia mariae* examined was 15.02±0.66 and 18.06±0.66 cm for females and males, respectively. The males had the highest total length in August (15.08±0.11 cm) and the least in September (13.12±0.23 cm). Similarly, the females had the highest total length in October (19.83±0.76 cm) and the

least in August ( $10.47 \pm 0.19$  cm). The mean weight of *Tilapia mariae* examined was highest in November ( $107.98 \pm 0.77$  g) and lowest in August ( $100.18 \pm 0.65$  g) for males, while it was highest in September ( $115 \pm 0.41$  g) and lowest in August ( $101 \pm 0.22$  g) for females examined. The total mean weight was  $111.80 \pm 0.23$  and  $108.6 \pm 0.31$  g for males and females, respectively. The sex ratio of all the 125 *Tilapia mariae* examined was 1:3.12, with September showing the highest male to female sex ratio of 1:3.17 and October showing the least (1:2.05).

## DISCUSSION

From the analysis of the length-weight relationship, the linear equation is  $\text{Log } W = 1.9622 \text{Log } L + 0.3288$  with an  $r^2$  value of 0.8731 ( $n=125$ ). The length exponent of the length-weight relationship was less than 3 in the river, indicating that the fish exhibited a negative allometric growth pattern in the lagoons. King and Etim (2004) reported an isometric growth for the species in the Ethiopia River. The total mean length (TL) of *Tilapia mariae* examined was  $18.06 \pm 0.66$  and  $15.02 \pm 0.66$  cm for males and females, respectively. This implies that the male grows in length more than the female of the species. According to Olurin and Somorin (2006), the difference in length and weight results from differences in sex and development stages of fish. The condition factor value for females was higher than the males; the condition factor of female was higher in dry and early wet season. Ikomi and Jessa (2003) highlighted that the fish were in peak condition at the beginning of the rainy season and the peak of the flood period. The periods with low condition factor values may be associated with resource abundance and spawning activities. It was also observed that the decrease in k-values indicates unfavorable environmental conditions for the group, while improved k-values with increasing size indicates better adaptation to the prevailing environmental condition. Generally, the condition factor of fish is a state of the fish's wellbeing and condition. It shows whether the water body is conducive for the fish or not. Bagenal and Tech (1978) reported that if the condition factor "k"  $\geq 0.5$ , the fish is in good condition. From the observation of the sex ratio, the sex ratio of all the 125 *T. mariae* examined was 1:3.12, with September showing the highest sex ratio of 1:3.17 and October showing the least (1:2.05). Anene and Okorie (2008) reported that the overall male:female ratio of *T. mariae* of Umuoseriche Lake was in favour of the female. This observation was consistent with that made for the same fish species in a tropical rainforest stream (King, 2004). However, in the present investigation, the sex ratio favored the males.

## Conclusion and Recommendation

From the research, it was noted that male species had a

higher mean length of  $18.06 \pm 0.66$  cm compared to the female species that had  $15.02 \pm 0.66$  cm. The female species had a relatively higher mean weight of  $115 \pm 0.41$  g in September while the male species had  $107.98 \pm 0.77$  g in November. The male species had the highest mean weight of  $111.80 \pm 0.23$  g compared to the female species that had  $108.6 \pm 0.31$  g. The male species therefore had a better condition factor compared to the female species.

The proper management and conservation of fish in the river should be done by mesh size regulation. In addition, the reservoir's water quality should be managed to ensure a conducive environment for survival.

Further study in this research is recommended as this research is an undergraduate preliminary investigation with the aim of further investigation as a postgraduate thesis.

## CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

## REFERENCES

- Adeniyi, O. R., Omitoyin, S. A., & Aderibigbe, H. I. (2010). Profitability of aquacultural practices: empirical experience from fish farmers in Epe Local Government Area of Lagos State. *Nigerian Journal of Fisheries*, 7(1), 117-125.
- Agbabiaka, L. A. (2010). The current Ichthyofauna of River Otamiri, South Eastern Nigeria. *International Journal of Tropical Agriculture and Food Systems*, 4(1), 7-9.
- Ajuzie, C. C. (1996). *Tilapia mariae*: a possible candidate for culture in Nigeria. *Aquaculture Magazine-Arkansas*, 22, 46-53.
- Akin-Obasola, B. J., Dominic, D. N., & Oyekanmi, F. B. (2022). Range Finding and Definitive (Acute) Test of Caterpillar Granules on *Clarias gariepinus* fingerlings. *Madridge Journal of Aquaculture Research and Development*, 3(1), 49-55.
- Akpaniteaku, R. C., & Aguigwo, J. N. (2003). Seasonal variation in catch of tilapiines (Osteichthyes: Cichlidae) in Agulu and Nawfia Lakes, Anambra State, Nigeria. *Journal of Sustainable Tropical Agriculture Research*, 6, 19-22.
- Anene, A., & Okorie P.U. (2008). Some aspects of reproductive biology of *T. mariae* in a small lake in South-Eastern Nigeria. *African Journal of Biotechnology*, 7(14), 2478-2482.
- Atama, C. I., Okeke, O. C., Ekeh, F. N., Ezenwaji, N. E., Onah, I. E., Ivoke, N., Onoja, U. S., & Eyo, J. E. (2013). Length-weight relationship and condition factor of six cichlid (Cichlidae: Perciformis) species of Anambra River, Nigeria. *Journal of Fisheries and Aquaculture*, 4(2), 82.
- Atindana, S. A., Blay, J., & Yankson, K. (2016). Investigation on food ecology of three Cichlid species in the Mankessim Reservoir, Central Region of Ghana. *Journal of Fisheries and Aquaculture*, 8(5), 55-61.
- Bagenal, T. B., & Tech, F. W. (1978). *Aspects of fish fecundity. In: Methods of Assessment of Ecology of Freshwater fish production*. Gerking, S. D. (ed.). Blackwell Scientific Publication, Oxford. Pp. 75-101.
- Baldaccini, N. E. (1973). An ethological study of reproductive behaviour including the colour patterns of the cichlid fish

- Tilapia mariae* (Boulanger). *Monitore Zoologico Italiano-Italian Journal of Zoology*, 7(4), 247-290.
- Bard, J., De Kimpe, P. J., Lazard, J., Lemasson, J., & Lessent, P. (1976). *Handbook of tropical fish culture*. Centre Technique Forestier Tropical, France. p. 128.
- Bhuiyan, A. A., Ratnayake, W. M. N., & Ackman, R. G. (1993). Nutritional composition of raw and smoked Atlantic mackerel (*Scomber scombrus*): Oil-and water-soluble vitamins. *Journal of food composition and analysis*, 6(2), 172-184.
- Brooks, W. R., & Jordan, R. C. (2010). Enhanced interspecific territoriality and the invasion success of the spotted tilapia (*Tilapia mariae*) in South Florida. *Biological Invasions*, 12, 865-874.
- Courtenay Jr, W. R., & Deacon, J. E. (1982). Status of introduced fishes in certain spring systems in southern Nevada. *The Great Basin Naturalist*, 42(3), 361-366.
- Dambatta, M. A., Sogbesan, A. O., Dauda, A. B., & Haruna, M. A. (2021). Length-Weight Relationship and Feeding Habit of *Oreochromis niloticus* in Wudil River, Kano State, Nigeria. *Global Journal of Science Frontier Research: D Agriculture and Veterinary*, 21(2), 30-41.
- Dan-Kishiya, A. S. (2013). Length-weight relationship and condition factor of five fish species from a tropical water supply reservoir in Abuja, Nigeria. *American Journal of Research Communication*, 1(9), 175-187.
- Dimowo, B. O. (2013). Assessment of some physico-chemical parameters of River Ogun (Abeokuta, Ogun State, Southwestern Nigeria) in comparison with national and international standards. *International Journal of Aquaculture*, 3(15), 79-84
- Ecoutin, J. M., Richard, E., Simier, M., & Albaret, J. J. (2005). Spatial versus temporal patterns in fish assemblages of a tropical estuarine coastal lake: the Ebrié Lagoon (Ivory Coast). *Estuarine, Coastal and Shelf Science*, 64(4), 623-635.
- Holčík, J. (1991). Fish introductions in Europe with particular reference to its central and eastern part. *Canadian Journal of Fisheries and Aquatic Sciences*, 48(S1), 13-23.
- Ikomi, K. (2006). *Fish farming (aquaculture) made easy*. LUSIJ Publications Lagos. p. 33.
- Ikomi, R. B., & Jessa, H. O. (2003). Studies on aspects of the biology of *Tilapia mariae* (Boulenger, 1899) (Osteichthyes Cichlidae) in Ethiopie River, Niger Delta, Nigeria. *African Zoology*, 38(2), 255-264.
- King, R. P., & Etim, L. (2004). Reproduction, growth, mortality and yield of *Tilapia mariae* Boulenger 1899 (Cichlidae) in a Nigerian rainforest wetland stream. *Journal of Applied Ichthyology*, 20(6), 502-510.
- Kroon, F., Russell, J., Thuesen, P., Lawson, T., & Hogan, A. (2011). Using environmental variables to predict distribution and abundance of invasive fish in the Wet Tropics. CSIRO/MTRSF 2.6.2 Final Report, Atherton, Qld, Australia.
- Loftus, W. F., & Kushlan, J. A. (1987). Freshwater fishes of southern Florida. *Bulletin of the Florida State Museum Biological Sciences*, 31, 147-344.
- Mir, J. I., Sarkar, U. K., Dwivedi, A. K., Gusain, O. P., Pal, A., & Jena, J. K. (2012). Pattern of intrabasin variation in condition factor, relative condition factor and form factor of an Indian major carp, *Labeo rohita* (Hamilton Buchanan, 1822) in the Ganges basin, India. *European Journal of Biological Sciences* 4(4), 126-135, 2012
- Nwadiaro, C. S. (1987). Fecundity of cichlid fishes of the Sombreiro River in the lower Niger delta, Nigeria. *Revue de Zoologie Africaine* (1974), 101(4), 433-437.
- Olurin, K. B., & Somorin, C. A. (2006). Intestinal helminths of the fishes of Owa stream, South-West Nigeria. *Research Journal of Fisheries and Hydrobiology*, 1(1), 6-9.
- Pauly, D. (1983). Some simple methods for the assessment of tropical fish stocks. FAO, Fisheries Technical Paper (234). FAO, Rome.
- Pauly, T. A. (1993). *General characters for the classification of the cichlid family*. Ricker, W.E. (ed.). Blackwell, Oxford.
- Pearson, K. (2017). Tilapia fish: Benefits and dangers. Retrieved from <https://www.healthline.com/nutrition/tilapia-fish>
- Rayner, T. S., Pusey, B. J., & Pearson, R. G. (2008). Seasonal flooding, instream habitat structure and fish assemblages in the Mulgrave River, north-east Queensland: towards a new conceptual framework for understanding fish-habitat dynamics in small tropical rivers. *Marine and Freshwater Research*, 59(2), 97-116.
- Riedel, R., Caskey, L. M., & 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 and Reservoir Management*, 23(5), 528-535.
- Robins, C., Bailey, R. M., Bond, C. E., Brooker, J. R., & Lachner, E. A. (1991). World fishes important to North Americans, exclusive of species from the continental waters of the United States and Canada. American Fisheries Society, Special Publication No. 21, Bethesda.
- Russell, D. J., Ryan, T. J., McDougall, A. J., Kistler, S. E., & Aland, G. (2003). Species diversity and spatial variation in fish assemblage structure of streams in connected tropical catchments in northern Australia with reference to the occurrence of translocated and exotic species. *Marine and Freshwater Research*, 54(7), 813-824.
- Sarkar, U. K., Deepak, P. K., & Negi, R. S. (2009). Length-weight relationship of clown knifefish *Chitala chitala* (Hamilton 1822) from the River Ganga basin, India. *Journal of Applied Ichthyology*, 25(2), 232-233.
- Shafland, P. L. (1996). Exotic fishes of Florida—1994. *Reviews in Fisheries Science*, 4(2), 101-122.
- Soyinka, O. O., & Ayo-Olalus, C. I. (2009). Aspects of ecology and biology of the cichlid, *Tilapia mariae* from two adjacent low-brackish water lagoons in Nigeria. *African Journal of Agricultural Research*, 4(5), 474-483.
- Teixeira de Mello, F., Iglesias, C., Borthagaray, A. I., Mazzeo, N., Vilches, J., Larrea, D., & Ballabio, R. (2006). Ontogenetic allometric coefficient changes: implications of diet shift and morphometric traits in *Hoplias malabaricus* (Bloch)(Characiforme, Erythrinidae). *Journal of Fish biology*, 69(6), 1770-1778.
- The World Conservation Union (2002). "IUCN 2002" (On-line). IUCN Red List of Threatened Species. Retrieved 3rd October, 2018 from <http://animaldiversity.org/accounts/Cichlidae/>.
- Thomas, J., Venu, S., & Kurup, B. M. (2003). Length-weight relationship of some deep-sea fish inhabiting the continental slope beyond 250 m depth along the West Coast of India. *World Fish Center Quarterly*, 26(2), 17-21.
- Uneke, B.I. (2017). Food and feeding habit and condition factor of tilapia species in Ebonyi River, Southeastern Nigeria. *American Association of Science and Technology Communications*, 3(6), 248-253.
- Van den Audenaerde, D. F. E. (1966). Les Tilapia (Pisces, Cichlidae) du Sud-Cameroun et du etude systematique. *Musee Royal de L'Afrique Centrale, Tervuren Belgique*

*Annales, Serie in-88. Sciences Zoologiques* 153, 1-97.

Vassallo, P., Bastianoni, S., Beiso, I., Ridolfi, R., & Fabiano, M. (2007). Emergy analysis for the environmental sustainability of an inshore fish farming system. *Ecological Indicators*, 7(2), 290-298.

Welcomme, R. L. (1988). International introductions of inland aquatic species. FAO Fisheries Technical Paper No. 294, Rome.

Whitehead, R. A. (1962). The life history and breeding habits of the West African cichlid fish *Tilapia mariae* and the status of *T. meeki*. In *Proceedings of the Zoological Society of London* (Vol. 139, No. 4, pp. 535-543). Oxford, UK: Blackwell Publishing Ltd.