

## Length-weight relationship and condition factor for five common fish species in a recently constructed reservoir (Tugwi-Mukosi Dam) - Zimbabwe

Nyasha MABIKA<sup>1</sup>, Terence MAGQINA<sup>2</sup>, Tendai MAKONI<sup>3</sup>

### Cite this article as:

Mabika, N., Magqina, T., Makoni, T. (2024). Length-weight relationship and condition factor for five common fish species in a recently constructed reservoir (Tugwi-Mukosi Dam) - Zimbabwe. *Aquatic Research*, 7(2), 83-92. <https://doi.org/10.3153/AR24008>

<sup>1</sup> University of Zimbabwe, Department of Biological Sciences and Ecology, Harare, Zimbabwe

<sup>2</sup> Matopo National Park, P. Bag 5142, Bulawayo, Zimbabwe

<sup>3</sup> Great Zimbabwe University, Department of Mathematics and Computer Science, Masvingo, Zimbabwe

### ORCID IDs of the author(s):

N.M. 0000-0002-8101-6340

T.M. 0000-0001-5778-8167

T.M. 0000-0003-0853-7761

Submitted: 11.08.2023

Revision requested: 21.09.2023

Last revision received: 16.01.2024

Accepted: 21.01.2024

Published online: 30.03.2024

### Correspondence:

Nyasha MAKIKA

E-mail: [nmabika09@gmail.com](mailto:nmabika09@gmail.com)



© 2024 The Author(s)

Available online at

<http://aquatres.scientificwebsites.com>

### ABSTRACT

Tugwi-Mukosi is a recently constructed reservoir in the Masvingo Province of Zimbabwe. The objective of the study was to estimate the length-weight relationship (LWR) and condition factors (K) of five freshwater fish species collected from the dam. Three hundred eighty-seven fish samples were caught by gill nets and sein between January and September 2021. The estimated exponent value  $b$  varied between 2.814 and 3.228 among the fish species. The  $b$  values indicated that three species (*Oreochromis niloticus*, *Coptodon rendalli* and *Micropterus salmoides*) followed negative allometric growth ( $b < 3$ ). In contrast, *Clarias gariepinus* showed isometric growth ( $b = 3$ ), while *Oreochromis mossambicus* exhibited positive allometric growth ( $b > 3$ ). More than 94% ( $R^2 > 0.94$ ) of the weights (responses) variations were explained by the models, so the models fit the data well. The K values of all the fish species, except for *C. gariepinus*, ranged between 1.3 - 2.2; this indicates that these species are doing well in the reservoir. This observation suggests that Tugwi-Mukosi currently provides a favourable habitat for the fish species. The current study's findings will give valuable baseline data for assessing the status of fish populations and conducting ecological surveys for future fish conservation and management.

**Keywords:** Tugwi-Mukosi, Fish growth, Conservation, Monitoring, New reservoir

## Introduction

Fish in tropical and subtropical water systems exhibit variability in growth due to changes in diet composition, environmental changes, and spawning conditions (Anderson & Neumann, 1996). Fish body length and body weight are useful empirical measures in studying fish growth, stock assessment and, more generally, population ecology, community, and ecosystem ecology studies (Giarrizzo et al., 2015; Baitha et al., 2018). Size reflects age, food, and other physiological and environmental parameters in fish. In theory, size represents age because fish never stop growing, and size is governed by external circumstances rather than vice versa. Size variation, therefore, has important implications for diverse aspects of fisheries science and population dynamics (Erzini, 1994).

Since direct weight measurement in the field can be time-consuming, length-weight regressions have been commonly used to estimate weight from length (Sinovic et al., 2004). The length-weight relationship (LWR), also known as the biometric relationship model, is a mathematical model that enables length-to-weight and weight-to-length conversions in stock estimation models and biomass calculation using the length frequency distribution.

According to the cubic law ( $W=L^3$ ), fish often grow in equal lengths (Lagler, 1952). However, deviations in length-to-weight ratios from the cube rule are always possible due to the many environmental factors that influence the physico-chemical properties of the waters in which different fish species exist. Be that as it may, length-weight parameters of the same species may change within populations due to feeding, fishing and reproductive activity, etc. Therefore, data on the functional LWR of fish species are important for fish stock assessment and parameters  $a$  and  $b$  can be used for length-weight conversion (Hajje et al., 2010). However, it has been argued that  $b$  may vary at different periods, reflecting gastric fullness, general appetite condition and gonadal stages (Zaher et al., 2015).

Length-weight is also used to estimate the condition factor of the fish species (Blackhart et al., 2006), which shows the degree of well-being of the fish in their habitat (Mac Gregor, 1959). A high condition factor indicates that a fish is heavier than a fish of the same length with a lower condition factor and thus always refers to a deviation from the average LWR for a population (Le Cren, 1951; Froese, 2006). The condition factor of fish can be affected by factors such as stress, sex, season, availability of feeds and other water quality parameters (Khallaf et al., 2003). Studies of LWR and condition factor are important in fishery assessment and management as

these biometric units allow us to gain insight into fish stocks' overall health and development.

Tugwi-Mukosi (formerly Tokwe-Mukosi) Reservoir was constructed across the confluence of the Tugwi and Mukosi Rivers in the Chivi district of Masvingo Province in Zimbabwe. Construction of the reservoir began in 1998, was completed in December 2016 and commissioned in May 2017. The reservoir started impounding water during the 2016/2017 rainy season but has not yet been fully utilised (Magqina et al., 2021). There are 17 fishing cooperatives with fishing licenses, and the dam yields about 200 tonnes yearly. In addition, more than 100,000 kapenta and 200,000 fingerlings of *Oreochromis niloticus* species were put in the dam in late 2021 for breeding purposes out of a target of 1,5 million fingerlings (Herald, 2021). To date, nine fish species (*Oreochromis macrochir*, *Oreochromis niloticus*, *Oreochromis mossambicus*, *Coptodon rendalli*, *Clarias gariepinus*, *Serranochromis thurmergi*, *Labeo cylindricus*, *Mesobola brevipinnis* and *Micropterus salmoides*) have been identified in the lake with the cichlids constituting 66.7% of the fish community (Magqina et al., 2021). Despite their commercial importance, no information on these fish species' length-weight relationships and condition factors is available. Therefore, the present study aimed to generate baseline data on these parameters of the five common fish species: *Oreochromis niloticus*, *Oreochromis mossambicus*, *Coptodon rendalli*, *Clarias gariepinus* and *Micropterus salmoides*. The study is expected to provide valuable information on the health of the fish populations in the reservoir.

## Materials and Methods

### Study Area

Located at the confluence of the Tugwi and Mukosi rivers, the Tugwi Mukosi Dam (20°43'40" S, 30°54'11" E) is Zimbabwe's largest inland water body. The dam is located in the semi-arid region of the Masvingo province (Figure 1). The area lies in Zimbabwe's agro-ecological Region IV, which has a long-term mean average precipitation of less than 600 mm/year, with the majority of rain falling between October and April and a precipitation peak reached in February and mean annual temperature is approximately 20°C (Chazireni & Chigonda, 2018). Chromic luvisols with isolated patches of caloric fluvisols occur in the area, and the geology is composed of paragneiss and other high-grade sediments (Gumindoga et al., 2014)

Sampling was conducted at Zunga, Kushinga, Gororo and Rarangwe (Figure 1). The sampled sites are also fishing

grounds for both artisanal and commercial fishermen. Sampling was done twice monthly using multifilament gillnets and a seine net between January and September 2021, except in July, where no sampling was done. The sampling effort remained constant throughout the study. For the seine netting, two hauls at each sampling site were performed using a 50 m net with a mesh size of 12.7 mm in shallow areas less than 1.5m deep. At each site, multifilament gillnets of different mesh sizes (38.1 mm- 177.8 mm) and 150 m long were laid in a zigzag pattern late afternoon (1630 hours) and left overnight. The nets were then pulled out the next morning at 0630 hours. All fish caught were identified to the lowest practical taxon using external morphological characteristics and identification keys (Marshall, 2011; Skelton, 2001). The number of fish caught for different species was recorded, and each individual's total length (TL) and standard length (SL) were measured to the nearest 0.1 mm. Weight was measured to the nearest 0.1g

**Data Analysis**

The log transformation formula of Le Cren was used to establish LWRs (Le Cren, 1951). The length-weight equation  $W = a L^b$  was used to estimate the relationship between the weight (g) of the fish and its total length (cm). Using the linear regression of the log-transformed equation:

$\text{Log}(W) = \text{log}(a) + b \text{ log}(L)$ , the parameters a and b were calculated. Where:

W= Weight (g)

L= Total length (cm)

a= Intercept or the initial growth index

b= Slope/ growth coefficient/ an exponent.  $b < 3$  = negative allometry

$b > 3$  = positive allometry

b equal 3 = isometric allometry

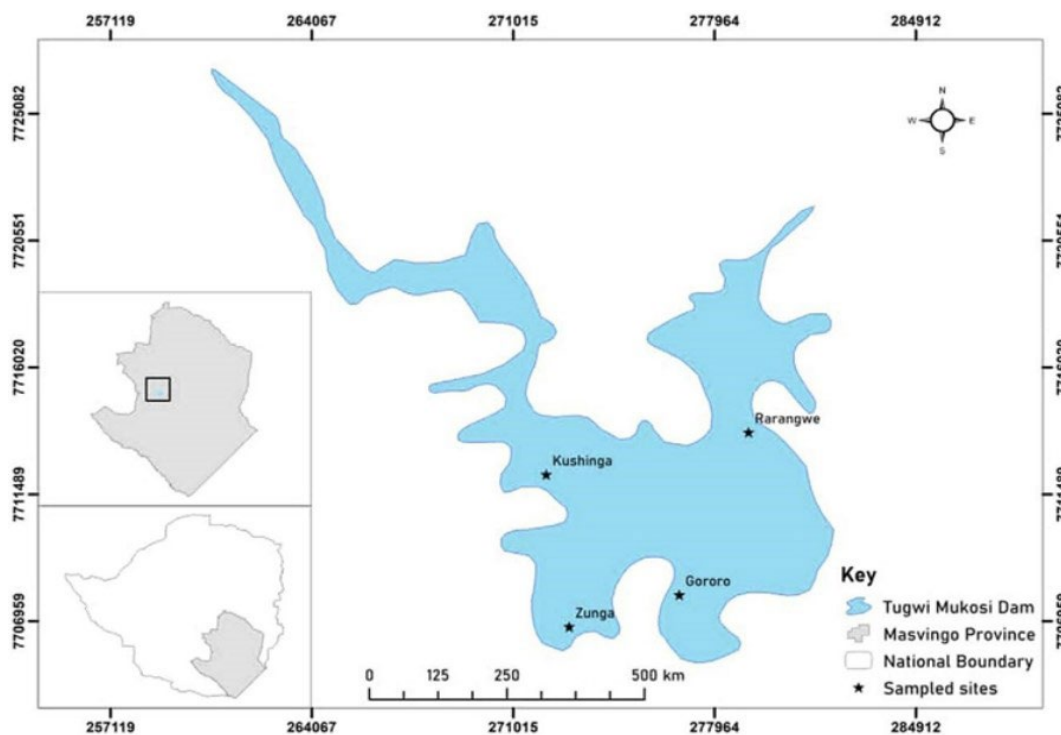
Additionally, 95% confidence limits (CL) of the b coefficient were estimated for each species.

The condition factor 'K' was calculated by using the model,  $K = W \times 100 / L^3$  according to Pauly (1983), Where:

W is the weight of the fish (g)

L is the Total length of the fish (cm).

The degree of correlation between the length and weight was computed by the determination coefficient  $R^2$ .



**Figure 1.** The location of the Tugwi-Mukosi dam in Masvingo province, Zimbabwe (adapted from Magqina et al., 2021).

## Results and Discussion

Five fish species, namely, *O. mossambicus*, *O. niloticus*, *C. gariepinus*, *C. rendalli* and *M. salmoides*, were collected in the study. The total number of fish collected was 387, and the most abundant species was *O. mossambicus* (151), followed by *C. rendalli* (93), *M. salmoides* (60), *C. gariepinus* (47) and *O. niloticus* (36). Total lengths ranged from 5 cm (*O. niloticus*) to a total length of 64 cm (*C. gariepinus*), while weights ranged from 4.0 g (*O. niloticus*) to 2550 g (*O. niloticus*).

### Length-Weight Relationships (LWR)

Regression equations obtained from the log and length data for all fish species showed a positive linear relationship between the weight and length variables (Figure 2). The intercepts ( $a$ ) and growth coefficients ( $b$ ) of the regression models of the fish species are shown in Table 2. The slope  $b$  for *O. mossambicus* was 3.229 (3.079, 3.379 CL). This indicates that *O. mossambicus* exhibits positive allometry ( $b > 3$ ) within the dam. The  $b$  values for *O. niloticus*, *C. rendalli* and *M. salmoides* were 2.877 (2.796, 2.957 CL), 2.712 (2.449, 2.925 CL) and 2.814 (2.408, 3.220 CL) respectively. These fish species showed negative allometry ( $b < 3$ ). *Clarias gariepinus* showed isometric allometry ( $b = 3$ ) (2.660, 3.360 CL). All the fish species had a coefficient  $R^2 > 0.94$  (Figure 2), indicating that most of the variation in the weight (response) was explained by the model; hence, the model gives a good fit for the data.

### Condition Factor (K)

Table 2 shows the average condition factors for the five fish species. *O. niloticus* and *C. rendalli* had the highest K value (2.2), followed by *O. mossambicus* (1.7) and *M. salmoides*

(1.3). *Clarias gariepinus* had the lowest (0.7) condition factor.

The fish length and weight distributions in Tugwi Mukosi Reservoir showed large variability in fish size, indicating that the sampling methods were non-selective. The sizes of the fish caught ranged from the smallest (5.0 cm) to the largest (64 cm). As for weight, *O. niloticus* registered both the lightest (4.0 g) and the heaviest (2550 g) specimens. The high abundance of certain species, such as *O. mossambicus*, may be evidence of shoaling behaviour within the reservoir.

The slope of regression line  $b$  expresses the relative body shape of a fish (Le Cren, 1951). Differences in  $b$  value can be attributed to combining one or more factors such as the number of specimens, gonad maturity, sex, health, habitat, seasonal effect, etc (Wootton, 1991). According to Bagenal and Tesch (1978), values between 2 and 4 are consistent for freshwater fish. The values of  $b$  observed in the current study ranged from 2.814 to 3.228. These  $b$  values are in the range 2-4 suggested by Bagenal and Tesch (1978). In the case of *C. gariepinus*,  $b$  was almost equal to 3.0, implying that the fish were growing isometrically. This isometric growth pattern in the length-weight relationship indicated that the fish species did not increase in weight faster than the cube of their total length. Therefore, as the body length increases, so does the weight of the fish. When the value of  $b$  is less than 3.0, the fish experiences a negative allometric growth, as was the case with *O. niloticus*, *C. rendalli*, and *M. salmoides* in the current study. This observation suggests that these species have relatively slow growth rates and tend to be thinner. Positive allometric growth, observed in *O. mossambicus*, occurs when  $b$  exceeds 3.0. In this regard, the fish becomes heavier, reflecting the optimal growth conditions.

**Table 1.** Total lengths and total weights of the five fish species collected from Tugwi-Mukosi Reservoir, Zimbabwe

Fish species	N	Total length (cm)			Total weight (g)		
		Min	Max	Mean Length	Min	Max	Mean Weight
<i>O. mossambicus</i>	151	10.1	29.0	17.6	10.0	368.0	122.8
<i>O. niloticus</i>	36	5.0	52.5	25.0	4.0	2550.0	456.5
<i>C. rendalli</i>	93	9.2	31.0	17.1	17.0	597.0	134.8
<i>C. gariepinus</i>	47	18.6	64.0	28.8	58.0	1948.0	194.0
<i>M. salmoides</i>	60	11.0	33.0	21.2	15.3	488.0	137.1

Min= minimum. Max= maximum,



**Table 2.** Length-weight parameters and condition factor for the five fish species collected from Tugwi-Mukosi Reservoir

Species	Length-weight parameters			Condition factor (K)
	<i>a</i>	<i>b</i> (95% CL)	R <sup>2</sup>	
<i>Oreochromis mossambicus</i>	-2.052	3.228 (3.079, 3.379)	0.96	1.7
<i>Oreochromis niloticus</i>	-1.501	2.877 (2.796, 2.957)	0.99	2.2
<i>Coptodon rendalli</i>	-1.321	2.712 (2.449, 2.925)	0.96	2.2
<i>Clarias gariepinus</i>	-2.186	3.012 (2.660, 3.360)	0.97	0.7
<i>Micropterus salmoides</i>	-1.682	2.814 (2.408, 3.220)	0.95	1.3

The LWR parameters of the fish species were also compared with data from published literature. In the present study, the *b* value for *O. niloticus* ( $b=2.877$ ) was lower than that from Lake Chamo in Ethiopia ( $b=3.1779$ ) (Shija, 2020), Garmat Ali River in Iraq ( $b=3.109$ ) (Mohamed and

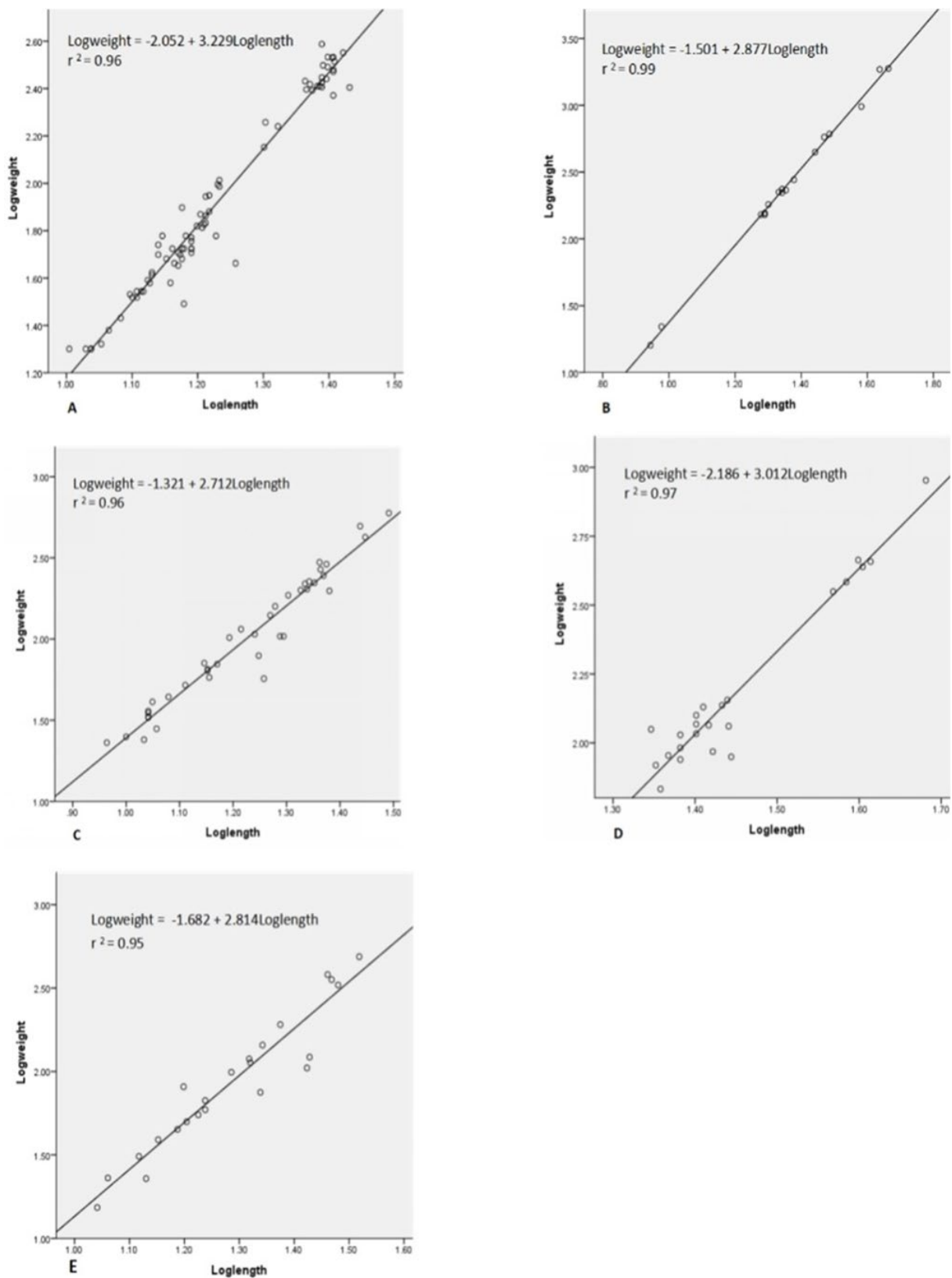
Salman, (2021).) and almost the same with that from Lake Naivasha in Kenya ( $b=2.860$ ) (Waithaka et al., 2020) and Al-Massira Dam in Morocco ( $b=2.838$ ) (Ouahb et al., 2021). However, our growth coefficient was higher than that for Lake Mutirikwi ( $b=2.4478$ ) in Zimbabwe (Runeta, 2014), Wase Dam in Nigeria ( $b=1.520$ ) (Yem et al., 2020) and Lake Coatetelco in Mexico ( $b=2.469$ ) (Gómez-Márquez et al., 2008). A few other researchers have also reported isometric growth of *O. niloticus* in tropical reservoirs ( $b=2.96$ ) and subtropical river systems ( $b=2.93$ ) in India (Alam et al., 2019). The growth coefficient for *O. mossambicus* (3.228) reported in the current study is higher than that for Bhima River ( $b=2.88$ ) and Manchar Lake, Sindh, Pakistan ( $b=3.04$ ) (Shendge, 2005). The negative allometric value of *C. rendalli* ( $b=2.712$ ) is consistent with the results of Runeta (2015) ( $b=2.8738$ ) in Lake Mutirikwi, Zimbabwe, and Asire Lake ( $b=2.88$ ), Nigeria (Ajagbe et al., 2016). The *b* value for *C. gariepinus* ( $b=3.012$ ) reported in the current study is the same ( $b=3.013$ ) as that reported by Torres (1992) in Lake Kariba and slightly higher than that reported by Nhiwatiwa (2004) ( $b=2.75$ ) in two reservoirs in the Manyame catchment, Zimbabwe, Malilangwe dam ( $b=2.81$ ), Zimbabwe (Dalu et al., 2012) and in Nigeria ( $b=2.794$ ) King (1996). For *M. salmoides*, the *b* value ( $b=2.814$ ) was similar to that by Tarkan et al. (2006) ( $b=2.830$ ) in Lake Iznik, Turkey, but lower than those by Taylor and Weyl (2017) in Mankazana ( $b=3.296$ ), South Africa and in Al-Massira Dam, Morocco ( $b=3.282$ ) Ouahb et al., (2021).

Our findings in this study show that the LWR parameters for *O. niloticus*, *O. mossambicus* and *C. gariepinus* differed from

similar studies elsewhere. These differences may be attributed to food availability (Ricker, 1975), water quality (Sparre et al., 1989), and biological, temporal, and sampling factors (Mehanna & Farouk, 2021). Examples of sampling factors are the catchment area, fish community, fish weights as measured in each work, time of collection, and laboratory personal and instrument errors. However, these factors were not taken into consideration during the present study.

The coefficient of determination (R<sup>2</sup>) provides good fitness of the regression equation. The R<sup>2</sup> values in all the fish specimens were higher than 0.94, indicating a linear relationship between the length and weight of the specimens. This observation is consistent with previous studies on fish species from various water bodies (Egbal et al., 2011). These high values of correlation coefficients obtained in the present study mean a good quality of the linear regression prediction for the analysed fish species and suggest that extrapolation in future catches can be done for this size range in the reservoir.

All fish species except *C. gariepinus* had K values greater than one, indicating perfect conditions in the reservoir (Manorama & Ramanujam, 2014). The high condition factor values for the Cichlid species in the study confirmed that they are well adapted to the reservoir environment, which is linked to their ability to support various environmental conditions (Beyeler & Dale, 2001). According to Montchowui et al. (2008), Cichlids have highly variable diets and exhibit ecological and behavioural adaptations, justifying their abundance in lake environments. The K value of *C. gariepinus* (0.7) observed in the current study is higher than that reported by Keyombe et al. (2019) (K=0.567 - 0.644) in Nigeria but smaller than that reported by Iyabo (2017) (K=0.93-0.99) in Kenya. These differences in K values could be a result of several factors such as reproductive cycles, availability of food, as well as habitat and environmental factors (Morato et al., 2001)



**Figure 2.** Size weight relationship in the five fish species. **A.** *O. mossambicus*, **B.** *O. niloticus*, **C.** *C. rendalli*, **D.** *C. gariepinus*, **E.** *M. salmoides*

## Conclusion

In conclusion, the present study on the length-weight parameters and their condition factors is the first report on these five common fish species in Tugwi-Mukosi Reservoir. Three species had negative allometric growth; one had positive allometry, and another had isometric allometry. While most fish species appear to be in good condition, the results of this study suggest that Tugwi-Mukosi may not yet be an optimal habitat for some resident fish species because it is a relatively young reservoir. The high coefficient of determination values obtained in the assessment of LWRs indicates a good quality of linear regression prediction for the fish species analysed, and this may indicate that future catches in the reservoir can be extrapolated for this size range. These findings add to the understanding of conservation and sustainable management of these fish species in the Tugwi-Mukosi dam. Fisheries decision-makers are therefore advised to regularly monitor and manage anthropogenic activities on the reservoir and catchment to minimise their effects on different habitats, fish breeding areas, and littoral and pelagic zones in the interest of the welfare of the fish species. However, it is worth noting that *O. niloticus* introduced into the reservoir is an invasive species and can seriously threaten native fish communities through competition for food and habitat.

## Compliance with Ethical Standards

**Conflict of interest:** The authors declare no actual, potential, or perceived conflict of interest for this article.

**Ethics committee approval:** Ethical approval was not required for this study.

**Data availability:** Data will be made available on request.

**Funding disclosure:** No funding provided.

**Acknowledgements:** We would like to extend our sincerest regards to Alfred Mhere, who provided invaluable support during the fieldwork. We also want to express our sincerest gratitude to the Zimbabwe Parks and Wildlife Management Authority for providing logistical and equipment support during the data collection.

**Disclosure:** -

## References

- Ajagbe, S.O., Odulate, D.O., Idowu, A.A., Ajagbe, R.O., Alao, D.O., & Adekunle, A.O. (2016). Length-weight relationship and condition factor of Redbelly tilapia (*Tilapia zillii*) caught with gillnets in Asejire Lake, Nigeria. *International Journal of Fisheries and Aquatic Studies*, 4(1), 448-452.
- Alam, A., Chadha, N.K., Chakraborty, S.K., Joshi, K.D., Kumar, T., Das, S.C.S., & Kumar, J. (2019). Studies on the growth and mortality of invasive *Oreochromis niloticus* (Linnaeus, 1758) in sub-tropical Yamuna, part of Gangetic River system, India. *Aquatic Ecosystem and Health Management*, 22(4), 473-480.  
<https://doi.org/10.1080/14634988.2019.1690926>
- Anderson, R.O., & Neumann, R.M. (1996). Length, Weight, and Associated Structural Indices. In B.R. Murphy and D.R. (Eds.), *Fisheries Techniques*, American Fisheries Society (pp. 447-481). Bethesda.
- Bagenal, T.B., & Tesch, F.W. (1978). Age and Growth. In T.B. (Ed.), *Methods for Assessment of Fish Production in Fresh Water*. 3<sup>rd</sup> Edn., Blackwell Scientific Publications, Oxford, UK., ISBN-13: 9780632001255, pp: 101-136.
- Baitha, R., Sinha, A., Koushlesh, S.K. Chanu, T.N., Kumari, K., Gogoi, P., Ramteke, M.H., Borah, S., Das, B.K. (2018). Length-weight relationship of ten indigenous freshwater fish species from Gandak River, Bihar, India. *Journal of Applied Ichthyology*, 34, 233-236.  
<https://doi.org/10.1111/jai.13555>
- Beyeler, S.C., & Dale, V.H. (2001). Challenges in the development and use of ecological indicators. *Ecological Indicators*, 1, 3-10.  
[https://doi.org/10.1016/S1470-160X\(01\)00003-6](https://doi.org/10.1016/S1470-160X(01)00003-6)
- Blackhart, K., Stanton, D.G., & Shimada, A.M. (2006). NOAA fisheries glossary, revised ed, Office of Science and Technology - National Marine Fisheries Service (pp. 69). NOAA.
- Chazireni, E., & Chigonda, T. (2018). The socio-economic impacts of dam construction: A case of Tokwe Mukosi in Masvingo province, Zimbabwe. *European Journal of Social Sciences Studies*, 3(2), 209-217.  
<https://doi.org/10.5281/zenodo.1410616>

- Dalu, T., Clegg, B., & Nhwatiwa, T. (2012). Length-weight relationships and condition factors of six fish species caught using gill nets in a tropical African reservoir, Zimbabwe. *Transactions of the Royal Society of South Africa*, 68(1), 7579. <https://doi.org/10.1080/0035919X.2012.733318>
- Dieb-Magalhães, L., Florentino, A.C., Soares, M.G.M. (2015). Length-weight relationships and length at first maturity for nine fish species of floodplain lakes in Central Amazon (Amazon Basin, Brazil). *Journal of Applied Ichthyology*, 31, 1182-1184. <https://doi.org/10.1111/jai.12919>
- Egbal, O.A., Mohammed, E.A., & Afra, A.A. (2011). Length-Weight Relationships and Condition Factors of Six Fish Species in Atbara River and Khashm el- Girba reservoir, Sudan. *International Journal of Agricultural Science*, 3(1), 65-70. <https://doi.org/10.9735/0975-3710.3.1.65-70>
- Erzini, K. (1994). An empirical study of variability in length-at-age in marine fishes. *Journal of Applied Ichthyology*, 10, 17-41. <https://doi.org/10.1111/j.1439-0426.1994.tb00140.x>
- Froese, R. (2006). Cube law, condition factor and weight-length relationships: history, metaanalysis and recommendations. *Journal of Applied Ichthyology*, 22, 241-253. <https://doi.org/10.1111/j.1439-0426.2006.00805.x>
- Gómez-Márquez, J.L., Peña-Mendoza, B., Salgado-Ugarte, I. H., & Luis A.F.J. (2008). Age and growth of the tilapia, *Oreochromis niloticus* (Perciformes: Cichlidae) from a tropical shallow lake in Mexico. *Revista de Biología Tropical*, 56(2), 875-884.
- Giarrizzo, T., Oliveira, R.R.S., Andrade, M.C., Gonçalves, A.P., Barbosa, T.A.P., Martins, A.R., Marques, D.K., Santos, J.L.B., Frois, R.P.S., Albuquerque, T.P.O., Montag, L.F.A., Camargo, M., & Sousa, L.M. (2015). Length-weight and length-length relationships for 135 fish species from the Xingu River (Amazon Basin, Brazil). *Journal of Applied Ichthyology*, 31, 514-424. <https://doi.org/10.1111/jai.12677>
- Gumindoga, W., Chikodzi, D., Rwasoka, D., Mutowo, G., Togarepi, S., & Dube, T. (2014). The spatial variation of the 2014 Tokwe-Mukosi Floods: a GIS and remote sensing-based approach. *Journal of Science, Engineering & Technology*, 1(2), 4-13.
- Hajje, G., Hattour, A., Allaya, H., Cherif, M., Bouain, A., & Jarboui, O. (2010). Length-weight relationships for 13 fish species from the Gulf of Gabes (Southern Tunisia, Central Mediterranean). *African Journal of Biotechnology*, 9 (37), 6177-6181.
- Herald (2022). Fishing in Tugwi Mukosi Dam. Retrieved from <https://www.tugwimukosidam.com/fishing-in-tugwi-mukosi-dam/> (accessed 01.10.22).
- Iyabo, U.B. (2017). Length-weight relationship and condition factor of *Clarias gariepinus* of Cross River Basin (Ndibe Beach) at Afikpo, South Eastern Nigeria. *Continental Journal of Agricultural Science*, 9(1), 14-21.
- Keyombe, J.L., Waithaka, E., & Obegi, B. (2015). Length-weight relationship and condition factor of *Clarias gariepinus* in Lake Naivasha, Kenya. *International Journal of Fisheries and Aquatic Studies*, 2(6), 382-385.
- Khallaf, E.A., Galal, M., & Authman, M. (2003). The Biology of *Oreochromis niloticus* in a polluted canal. *Ecotoxicology*, 12, 405-416. <https://doi.org/10.1023/A:1026156222685>
- King, R.P. (1996). Length-weight relationships and related statistics of 73 populations of fish occurring in inland waters of Nigeria. *Naga ICLARM*, 19, 49-52.
- Lagler, K.F. (1952). Freshwater fishery biology. Second edition. William C. Brown, Dubuque, Iowa, USA.
- Le Cren, E.D. (1951). The length-weight relationship and seasonal cycle in gonad weight and condition in the Perch (*Perca fluviatilis*). *Journal of Animal Ecology*, 20, 201-219. <https://doi.org/10.2307/1540>
- Magqina, T., Mungenge, C., & Mawoyo, K.A. (2021). Fish diversity and composition of Tugwi Mukosi Dam, Zimbabwe's largest inland reservoir post impoundment. *Aqua. Fish and Fisheries*, 1-9. <https://doi.org/10.1002/aff2.24>
- Manorama, M., & Ramanujam, S.N. (2014). Condition factor and relative condition factor of an ornamental fish, *Puntius shalynius* Yazdani and Talukdar in Meghalaya, India. *International Journal of Research in Fisheries and Aquaculture*, 4(2), 77-81.



- Marshall, B. (2011).** Fishes of Zimbabwe and their biology. Smithiana Monograph 3. Grahamstown: South African Institute for Aquatic Biodiversity.
- Mac Gregoer, J.S. (1959).** Relation between fish condition and population size in the sardine (*Sardinops cacrulea*). *U.S. Fishery Wild Service, Fish Bulletin*, 60, 215-230.
- Mehanna, S.F., & Farouk, A.E. (2021).** Length-weight relationship of 60 fish species from the Eastern Mediterranean Sea, Egypt (GFCM-GSA 26). *Frontiers in Marine Science*, 8. <https://doi.org/10.3389/fmars.2021.625422>
- Mohamed, A.R.M., & Salman, A.N. (2021).** Comparison of length and weight characteristics of *O. niloticus* and *O. aureus* from Garmat Ali River, Iraq. *Asian Journal Fisheries and Aquatic Research*, 39-51. <https://doi.org/10.9734/ajfar/2021/v11i230200>
- Montchowui, E.A. Chikou, M.J. Kogbeto, & Laleye, P. (2008).** Biodiversity and structure of Hlan Lake fish communities in Benin. *International Journal of Biological and Chemical Sciences*, 2, 196-206.
- Nhiwatiwa, T. (2004).** The limnology and ecology of two small man-made reservoirs in Zimbabwe thesis, Department of Biological Sciences, Faculty of Science, University of Zimbabwe (pp. 92). Zimbabwe.
- Ouahb, S., Bousseba, M., Ferraj, L., El Moujtahid, A., & Hasnaoui, M. (2021).** Weight-length relationship and relative condition factor of *Micropterus salmoides* (Lacépède, 1802), *Cyprinus carpio* (Linnaeus, 1758) and *Oreochromis niloticus* (Linnaeus, 1758) caught in the Al-Massira Dam Lake. *E3S Web of Conferences*, 314, 01005. <https://doi.org/10.1051/e3sconf/202131401005>
- Torres, F.S.B. (1992).** Length-weight relationships of Lake Kariba fishes. *Naga, the ICLARM Quarterly*, 15, 4243.
- Pauly, D. (1983).** Some simple methods for the assessment of tropical fish stocks. FAO Fisheries Technical Paper, FAO (pp. 234: 52). Rome.
- Ragheb, E. (2023).** Length-weight relationship and well-being factors of 33 fish species caught by gillnet from the Egyptian Mediterranean waters off Alexandria. *Egyptian Journal of Aquatic Research*, 49(3), 361-367. <https://doi.org/10.1016/j.ejar.2023.01.001>
- Ricker, W.E. (1975).** Computation and interpretation of biological statistics of fish populations. *Fisheries Research Board Canada Bulletin*, 191, 1-382.
- Runeta, P.O. (2014).** BSc. Wildlife and Livestock thesis, Faculty of Department of Wildlife and Management. Faculty of Natural Resources Management and Agriculture, Midlands State University, Zimbabwe.
- Sinovic, G., Franicevic, M., Zorica, B., & Ciles-Kec, V. (2004).** Length-weight and length-length relationships for 10 pelagic fish species from the Adriatic Sea (Croatia). *Journal of Applied Ichthyology*, 20, 156-158. <https://doi.org/10.1046/j.1439-0426.2003.00519.x>
- Shendge, A.N. (2005).** Length-weight relationship and relative condition factor in *Oreochromis mossambicus* (Peters) of Bhima River. *Journal of the Inland Fisheries Society of India*, 32, 135139.
- Shija, B.S. (2020).** Length-Weight Relationship and Fulton's Condition Factor of the Nile Tilapia (*Oreochromis niloticus* L., 1758) in Lake Chamo, Ethiopia. *Journal of Agriculture and Environmental Sciences*, 5(2).
- Skelton, P. (2001).** A complete guide to the freshwater fishes of southern Africa. Cape Town: Struik.
- Sparre, P., Ursin, E. & Venema, S.C. (1989).** Introduction to tropical fish stock assessment. Part 1. Manuel. FAO Fisheries Technical Paper. No. 306.1. FAO.
- Tarkan, B.A.S., Gaygusuz, O., Acipinar, H., Gürsoy, C., & Özuluğ, M. (2006).** Length-weight relationship of fishes from the Marmara region (NW-Turkey). *Journal of Applied Ichthyology*, 22 (4), 271-273. <https://doi.org/10.1111/j.1439-0426.2006.00711.x>
- Taylor, B.G.C., & Weyl, O.L.F. (2017).** Age, growth and reproduction of non-native largemouth bass *Micropterus salmoides* (Lacépède, 1802) populations in two temperate African impoundments. *Journal of Applied Ichthyology*, 33(4), 767-775. <https://doi.org/10.1111/jai.13353>

**Waithaka, B.E., Yongo, E., Outa, N., & Mutethya, E. (2020).** Population biology of Nile tilapia (*Oreochromis niloticus*) in Lake Naivasha, Kenya. *Lakes and Reservoirs: Research and Management*, 25(2), 244-249.

<https://doi.org/10.1111/lre.12319>

**Wootton, R.J. (1991).** Ecology of teleost fishes. Fish and Fisheries Series 1. Chapman and Hall Ltd (pp. 404). London.

**Yem, B.I.Y., Bankole, N.O., Umar, R., Ibrahim, A., &**

**Ewutanure, S.J. (2020).** Food habit and growth pattern of Nile Tilapia *Oreochromis niloticus* in Wase Dam, Nigeria. *International Journal of Fisheries and Aquatic Studies*, 8(4), 257-260.

**Zaher, B., Rahman, F.M., Rahman, B.M.S., Alam, A.M.A., Pramanik, M.H. (2015).** Lengthweight relationship and GSI of hilsa, *Tenualosa ilisha* (Hamilton, 1822) fishes in Meghna River, Bangladesh. *International Journal of Natural and Social Sciences*, 2, 82-88.