International Journal of Research Studies in Science, Engineering and Technology
Volume 8, Issue 3, 2021, PP 1-9
ISSN : 2349-476X
DOI : https://doi.org/10.22259/2349-476X.0803001

Ichthyofauna Diversity and Composition of Zimbabwe's Largest Inland Reservoir: a Case Study of Tugwi Mukosi Dam

Terence Magqina [1,2*], Chipomungenge[2] and Kuzivakwashe A Mawoyo[2]

[1]*University of Zimbabwe, Department of Biological Sciences, Mt. Pleasant, Harare*
[2]*Zimbabwe Parks and Wildlife Management Authority, P. O Box CY140, Causeway, Harare*

***Corresponding Author:** Terence Magqina, University of Zimbabwe, Department of Biological Sciences, Mt. Pleasant, Harare*

ABSTRACT

Fish diversity in Tugwi Mukosi Dam in the south-eastern lowveld of Zimbabwe was investigated to determine the community structure. The aim of this study was to determine the current status of an artificial fish community in Zimbabwe's largest reservoir post dam impoundment and to assess how the fish have adapted to this new environment. Nine species belonging to four families were collected from the reservoir. The cichlids Oreochromis niloticus, Oreochromis mossambicus, Tilapia rendalli, Oreochromis macrochir and Serranochromis thurmbergi made up 66.65 % by number of the sample, the Centrarchidae Micropterus salmoides made up 12.66 % of the sample and Labeo cylindricus the least numerous species, made up 2.61 % of the sample. The population of O. niloticus which was recently introduced in 2017 seemed to be growing and stable, whereas O. mossambicus which formerly dominated the riverine catches, appeared to be still dominant in the new environment. M. salmoides, O. niloticus and O. mossambicus had active ripe and ripe-running individuals throughout the year whereas O. macrochir, S. thumbergi and L. cylindricus had no clear trend in terms of breeding. The growth performances of O. mossambicus, M. salmoides and O. niloticus were assessed by means of the growth performance index (Ø') with values ranging from 2.06 - 3.1. The rates of total mortality (Z) were estimated for four species; the highest rate was 8.91 for M. brevianalis and the lowest was 1.35 for O. mossambicus. There is no pre-impoundment data that exists for Tugwi Mukosi dam and therefore this case study of the dam has provided baseline data 3 years after impoundment, a benchmark for future studies and new insights into the fish communities of large reservoirs. Future fish studies in Tugwi Mukosi should investigate how this fish community continues to evolve over time.

Keywords: *O. niloticus, community structure, O. mossambicus, impoundment, gillnets, seine net*

INTRODUCTION

Tropical freshwaters contribute 15% of the world's reported capture fishery production from only 0.2% of the global aquatic surface area. The relative contribution may be even higher, as less than half of the inland capture production is officially reported (Vilar et al., 2013). Reservoirs are created by human activity and therefore host semi-natural ecosystems that can be manipulated in various ways.

The productivity of reservoir fisheries can be increased by using a number of approaches that combine better harvesting strategies, fertilization, carefully adapted stock enhancement and aquaculture (Mosipele&Kolding, 2006).

Reservoirs are also an essential component of most irrigation systems worldwide and, together with those built for flood control and power generation, retain large volumes of water. In most cases these reservoirs are created for electricity generation, irrigation or domestic usage. Regardless of the main objective of construction, fish yield from such reservoirs may constitute a substantial contribution to a country's total domestic fish production (Revenga et al., 2005). Most of the small-scale fishers in the world work in inland fisheries (FAO, 2005).

In southern Africa alone, the estimated number of water bodies reservoirs ranges from 50 000 to 100 000 (Verheust, 1998). Zimbabwe has about 14 000 small reservoirs, which is 86% of the total in southern Africa excluding South Africa however the lack of knowledge on fish diversity and abundance of these reservoirs may be limiting the development of their fisheries potential (Marshall and Maes 1994). Tokwe Mukosi dam which is Zimbabwe's largest dam is located in the south eastern lowveld of

Zimbabwe. The Dam is built on the point where two rivers namely, Tugwi and Mukosi converge, giving rise to the use of the name Tugwi Mukosi Dam. Consequently, its fish population is made up of mainly riverine species which previously inhabited the Tugwi and Mukosi rivers before dam impoundment.

This fish population consists of several species including Tilapia rendalli, Mesobola brevianalis, Serranochromis thumbergi, Micropterus salmoides, Oreochromis macrochir,Clarias gariepinus, and Oreochromis mossambicus.

The distribution and assemblages of fish within a reservoir are driven by a number of factors. Primary among these are physical and ecological barriers. Included in these driving factors are a species' physiological and biological tolerances (the ability to live within a specific range of environmental parameters) and behaviour patterns (e.g. feeding preference, shoaling vs. solitary, utilisation of different habitats during the lifecycle) (Skelton, 2001). The introduction of non-native fish species often has unintended consequences in a water system for example the introduction of O. niloticus in Lake Kariba and Lake Chivero (Nhiwatiwa, 2004), as such, the impacts of the introduction of O. niloticus in Tugwi Mukosi Dam are yet to be seen. Hence the ability to accurately track and detect changes in a particular fish community requires an initial estimate to base future comparisons against, as well as a definite understanding of inherent variations in the selected measures of that community. There have been a lot of fish community studies done over the past years in Lake Kariba and Lake Chivero yet there is no documented study on the fish communities in Tugwi Mukosi which is the largest inland dam in Zimbabwe. One of the most important descriptors of a community is the number of present species and their relative abundances (species richness and diversity). Hence, the aim of this study is to assess the Ichthyofauna composition and diversity in Tugwi Mukosi dam. This study also acts a baseline study for future fish studies in Tugwi Mukosi dam.

Materials And Methods

Study Area

Tugwi Mukosi Dam is Zimbabwe's largest inland water body with a 90-metre dam wall, a back throw of over 35 kilometres and capacity to hold more than 1.8 billion cubic metres of water; capable of irrigating more than 25 000 hectares (Chazireni&Chigonda, 2018; Maponga, 2017). It situated in the semi-arid area of the Masvingo province in ChiviDistrict (Figure 1). The area lies in Zimbabwe's agro-ecological Region IVwhich has a long term mean average precipitation of less than 600mm/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 ºC (Chazireni&Chigonda, 2018).

The geology of the area is composed of Paragneiss and other high-grade sediments with structural trends which results in soils that are mainly chromic luvisols with isolated patches of calcaricfluvisols. The dam started impounding water in December 2016 and held 210 million cubic metres of water from January 2017 (Maponga, 2017).

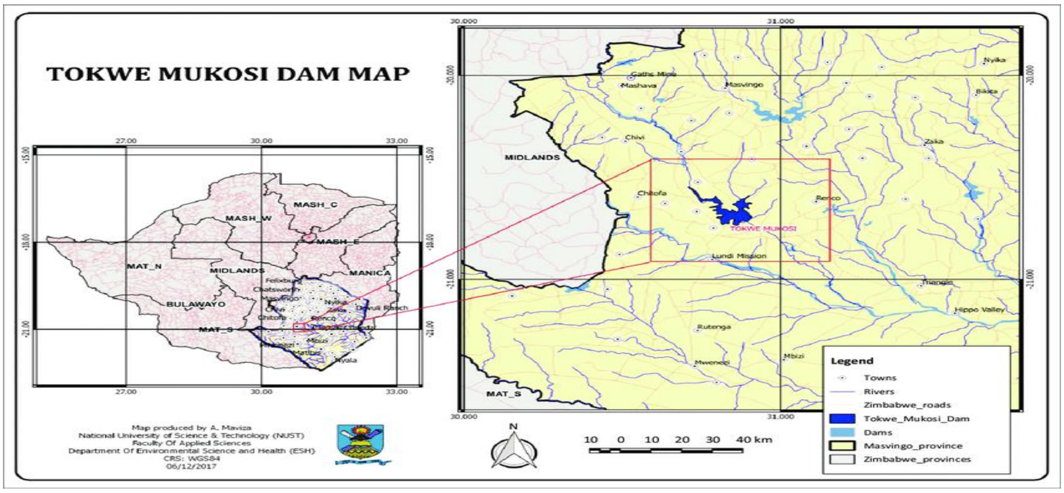

Figure1. *The location of Tugwi Mukosi Dam in Masvingo Province, Zimbabwe (Chipangura et al. 2019)*

Fish Sampling

Sampling was carried out at the Zunga and Chepore fishing grounds using multifilament gillnets and seine nets between January and November 2019. Sampling was done every month during the sampling period except for Julywhen no sampling was done. Sampling effort was kept constant throughout the study. Seine netting, 2 hauls at each sampling site were performed using a 50m netin the shallow habitat areas less than 1.5m deep. Multifilament gillnets of varying mesh sizes ranging from 1.5-7 inches were set overnight (late afternoon at 1630 hours and collected the next day in the morning at 0630 hours) at each sampling site. All captured fish were identified in the field to the lowest practical taxon using external morphological characteristics and identification keys (Skelton, 2001; Marshall, 2011). The number of fish caught for different species was recorded and the total length (TL) and standard length (SL) of each individual was measured to the nearest 0.1mm. Weight was measured to the nearest 0.1gand gonad maturation for each individual was visually assessed using a simplified scale (Bagenal &Braum 1968) as follows:

- Inactive — immature fish and adults in resting stage with sexual gonads not yet developed, gonads very small and eggs indistinguishable to the naked eye
- Active ripe — eggs distinguishable to the naked eye, testes a pale white colour
- Ripe–running —eggs clearly distinguishable to the naked eye, testes white in colour and sometimes enlarged: sexual products can be discharged in response to light pressure on the fish's belly
- Spent — sexual products have been discharged and gonads appear deflated; ovaries may contain a few eggs and testes some residual sperm.

An index of relative importance was used to measure relative abundance and/or commonness of each species j in the gillnet fleet per year:

$$IRI_J = \frac{(W_j + N_j)F_j}{\sum_{i=1}^{m}[(W_j + N_j)F_j]} \times 100$$

Where Wjand Nj are percentage weight and number of each species of total catch. Fj is the percentage frequency of occurrence of each species.

Statistical Analyses

FAO-ICLARM Stock Assessment Tool (FiSAT) version 1.2.2 software was used to analyse length frequency data (Gayaniloet al., 1997). FiSAT was also used to estimate the von Bertalanffy parameters (growth performance index and mortality), and the total mortality coefficient (Z) was also determined. The fish population diversity indices were calculated using Paleontological Statistics (PAST) software Version 3.14 (Hammer et al., 2001).

Ethical Statements

The study was approved by the University of Zimbabwe Joint Research Ethics Committee.

RESULTS

Fish Communities, Abundance and Diversity

A total of 2 410 individual fish, representing 9 species from 4 families, were captured during the study period. O. mossambicus was the most abundant fish species comprising of 31.29 % of the total catch followed by T. rendalli (19.13 %), M. salmoides (12.66 %), C. gariepinus (9.96 %), M. brevianalis (8.13 %), O. niloticus (7.55 %), O. macrochir (5.48 %), S. thumbergi (3.2 %) and L. cylindricus (2.61 %).

The total catch weighed 409.65 kg, with O. mossambicus being the dominant species again with a total weight of 87.52 kg, followed by C. gariepinus (80.12 kg), O. niloticus (64.97 kg), T. rendalli (74.1 kg),M. salmoides (34.13 kg), O. macrochir (29.37 kg), S. thumbergi (19.13 kg), L cylindricus (16.15kg) and M. brevianalis (4.16 kg) (Table 1).

Table1. *Number (N) percentage number (N %), weight (W), percentage weight (W %) and index of relative importance (IRI) of the fish species recorded in Tugwi Mukosi dam throughout the study period.*

Family	Species	N	N%	W (kg)	W (%)	IRI
Centrarchidae	Micropterus salmoides	305	12.66	34.13	8.33	11.3
Cichlidae	Oreochromis niloticus	182	7.55	64.97	15.86	6.5
	Oreochromis mossambicus	754	31.29	87.52	21.36	31.9
	Tilapia rendalli	461	19.13	74.10	18.09	15.6
	Oreochromis macrochir	132	5.48	29.37	7.17	6.8
	Serranochromis thurmbergi	77	3.2	19.13	4.67	5.9
Claridae	Clarius gariepinus	240	9.96	80.12	19.56	9.6

Cyprinidae	Mesobala brevianalis	196	8.13	4.16	1.02	7.5
	Labeo cylindricus	63	2.61	16.15	3.94	4.9

The five most commonly caught fish species were O. mossambicus, M. salmoides, T. rendalli, O. niloticus and M. brevianalis as they were caught in each month of the study period, whereas L. cylindricus and S. thumbergi were only occasionally caught. C. gariepinus was mainly caught during the hot-rainy months (January, October and November). S. thurmbergi was only caught in shallow grounds close to the dam wall whilst L. cylindricus was most abundant in the rocky areas of the reservoir. M. brevianalis and most cichlids were evenly distributed in the reservoir. The population of O. niloticus which was introduced in 2017 seemed to be increasing and stabilising. Species diversity in Tugwi Mukosi was quantified by the use of diversity indices which are shown in Table 2. The Shannon index calculated for the dam was low (1.935) and the calculated Simpson index was low (0.8226) indicating low species richness and evenness in the reservoir.

Table2. *Table showing values for indices of diversity calculated during the study period for fish species recorded at Tugwi Mukosi (Bootstrap 95 % confidence).*

Diversity indices	Value	Lower	Upper
Dominance_D	0.1774	0.1699	0.1865
Simpson_1-D	0.8226	0.8135	0.8299
Shannon_H	1.935	1.906	1.959
Evenness_$e^{H/S}$	0.7692	0.7471	0.7877

Size Distributions (Length Frequency Analysis)

Length frequency distributions of O. mossambicus, M. salmoides, O. niloticus and M. brevianalis were plotted using the length frequency data and analysed with FiSAT. Age classes were not clearly identifiable in most species, with the exception of O. niloticus, O. mossambicus, M. salmoides and M. brevianalis. There were indications of growth for O. niloticus and O. mossambicus from the length frequency distributions. FiSAT indicated that all O. niloticus belonged to 5 age classes (mean± stan) (Figure 2). These age groups were (young of the year, 148.5 ± 30.52 mm, 247 ± 30.3 mm, 327 ± 40.1 mm, 451 ± 70.6 mm). The analysis showed 4 age groups belonging to M. salmoides; 101 ± 39.2 mm, 213 ± 48 mm, 330.6 ± 47 mm and 510 ± 87.9 mm (Figure 3). FiSAT also identified 2 age classes in the M. brevianilispopulation (mean±stan) (Figure 4). The first group which was also identified to be sexually immature (16.21 ± 2.6 mm). The second group with sexually mature fish (22.7 ± 1.9 mm). The analysis also identified 3 age classes in the O. mossambicus population, the young of the year size class, sexually immature size class and the sexually mature, spawning capable size class. The size of O. mossambicus fish caught throughout the study period were observed to be generally small compared to the common size of specimen normally caught in other dams (Figure 5).Age classes were not easily identifiable for other fish species.

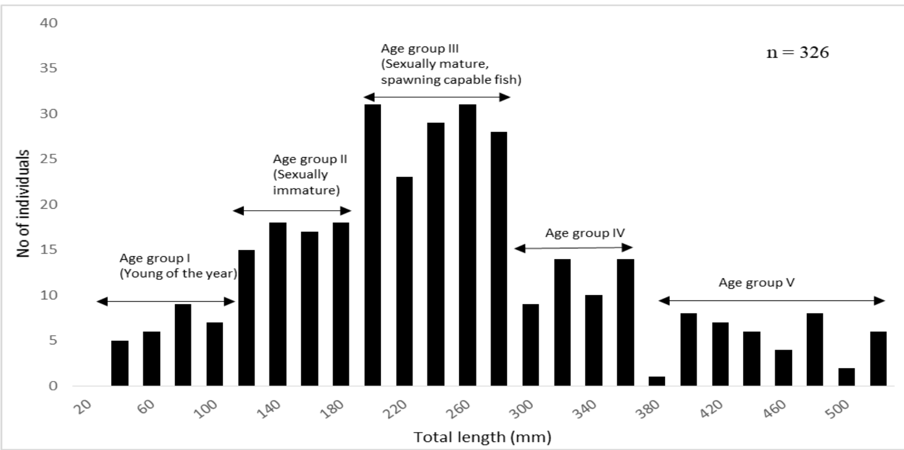

Figure2. *Length frequency analysis of male and femaleO. niloticus in Tugwi Mukosi*

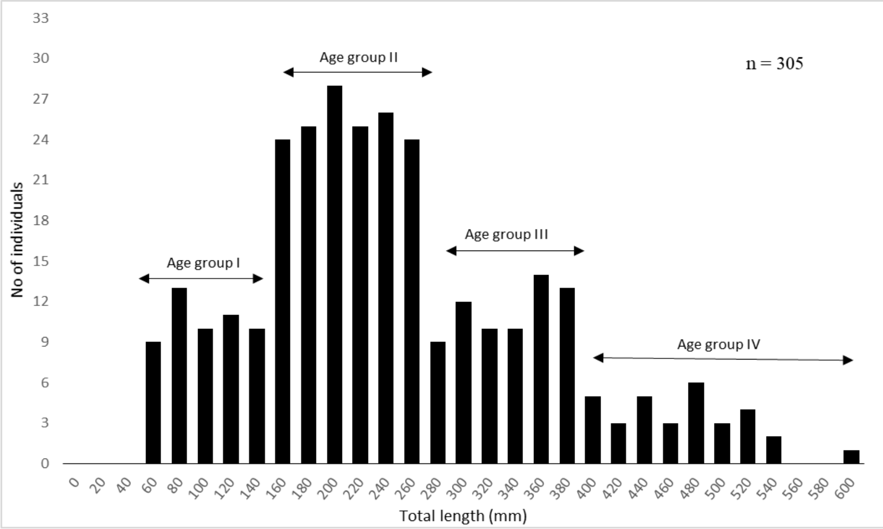

Figure3. *Length frequency analysis of male and femaleM. salmoides in Tugwi Mukosi*

Figure4. *Length frequency analysis of male and femaleM. brevianalis in Tugwi Mukosi*

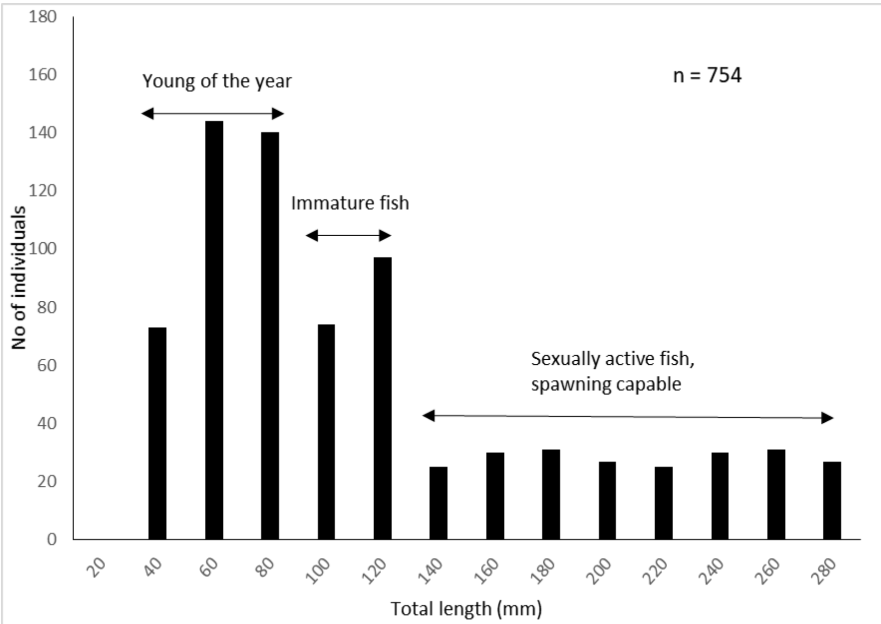

Figure5. *Length frequency analysis of male and female O. mossambicus in Tugwi Mukosi Dam*

The VBGF parameters (growth performance index and mortality) of O. mossambicus, M. salmoides and O. niloticus are shown in Table 3. The VBGF parameters (growth performance index and mortality for other fish species could not be determined.

Table3. *Growth (VBGF parameters) andmortality (Z) of four fish species from Tugwi Mukosi Reservoir, January to November 2019. Data obtained using FiSAT*

Species	K	Z ($year^{-1}$)	$Ø^1$
O. mossambicus	0.601	1.350	2.709
M. salmoides	0.49	2.81	2.971
O. niloticus	0.69	2.16	3.1
M. brevianalis	1.62	8.91	2.06

Reproductive (Gonad) State

The gonad states active ripe and ripe–running are shown for all species in Table 4. M. salmoides, O. niloticus and O. mossambicus had active ripe and ripe-running individuals throughout the year. There was some indication of seasonality in the males and females of M. brevianalis. The results indicated that the number of active ripe and ripe running gonads increased towards the hot rainy season. (October, November and January). O. macrochir, S. thumbergi and L. cylindricus had no clear trend in terms of the active ripe and ripe-running gonads found throughout the study period. Female M. salmoides were observed to start breeding between 250mm and 280 mm whereas males were observed to started breeding between 190 mm and 210 mm. Male and female O. niloticus were observed to start breeding at 203 mm and 230 mm respectively. Male O. mossambicus were observed to start breeding at 121 mm compared to the 140 mm for females. M. brevianalis males and females were observed to start breeding at 20.1 mm and 20.8 mm respectively. The size at sexual maturity of O. macrochir, S. thumbergi and L. cylindricus could not be determined due to the small sample size. M. Brevianalis

Table4. *Number of fish in gonad states active ripe and ripe–running collected in Tugwi Mukosi Dam per month*

Species	Sex	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
M. salmoides	Male	22	14	5	2	0	20	0	7	37	12	22
	Female	17	3	7	9	14	9	0	2	8	18	29
O. niloticus	Male	2	14	19	15	2	0	0	21	3	11	9
	Female	0	12	3	5	6	1	0	2	13	16	21
O. mossambicus	Male	27	32	29	33	21	0	0	38	44	46	15
	Female	22	25	31	22	0	0	0	26	30	44	21
T. rendalli	Male	0	0	0	3	12	5	0	21	3	14	19
	Female	26	31	4	7	1	9	0	11	17	38	23
O. macrochir	Male	0	0	0	0	0	9	0	0	7	11	17
	Female	2	0	0	0	0	22	0	17	0	0	4
S. thurmbergi	Male	0	0	0	0	0	0	0	0	3	16	4
	Female	2	0	1	0	0	0	0	4	1	5	6
L. cylindricus	Male	0	0	3	1	0	0	0	1	4	0	5
	Female	0	5	2	0	0	0	0	2	6	1	3
C. gariepinus	Male	1	3	1	0	14	1	9	22	2	1	0
	Female	0	7	0	1	12	8	0	1	0	11	3
M. brevianalis	Male	2	5	12	7	0	0	0	26	41	29	31
	Female	0	0	2	6	12	3	0	11	14	16	2

Discussion

Tugwi Mukosi's fish population is made up of mainly riverine species which previously inhabited the Tugwi and Mukosi rivers before dam impoundment (Mherepers.comm). This fish population consists of several species including Tilapia rendalli, Mesobola brevianalis, Serranochromis thumbergi, Micropterus salmoides, Oreochromis macrochir, Clarias gariepinus, and Oreochromis mossambicus and all of these species have established well and are breeding successfully.

Apart from these species,O. niloticus which was introduced in 2017 with the aim of boosting the fisheries sector and increasing domestic fish productionis now well advanced into the 'establishment stage' on the introduction–naturalisation–invasion continuum as evidenced by its ability to survive and breed since its introduction into the reservoir. Possible explanations for this include the fact that O.niloticus is a highly invasive species with a 'hardy' nature and has a wide range of trophic and ecological adaptations. It can also thrive in disturbed habitats and opportunistically reproduce. It is a fast growing species with high reproductive potential (Welcomme, 1988; Chifamba, 2017).

Tilapia introductions are often associated with severe environmental change, especially after construction of reservoirs. Many populations of tilapia are now so well established they are a permanent part of the fish community. This was also the case with Tugwi Mukosi dam as shown by the wide extent of occurrence of O.niloticus throughout the dam during sampling.O.macrochir was also present in Tugwi Mukosi dam but abundance was lower than that of O.niloticus. This may be because of the diet overlap that exists between these two species with both O. niloticus and O.macrochir feeding mostly on blue-green algae (> 50%) in their diets, in all size classes (Zengeya& Marshall, 2008).

O. mossambicus had the highest abundance in Tugwi Mukosi reservoir. It is a remarkably robust and fecund fish, readily adapting to available food sources and breeding under suboptimal conditions. Due to their robust nature, Mozambique tilapias often over-colonize the habitat around them, eventually becoming the most abundant species in a particular area. When over-crowding happens and resources get scarce, adults will sometimes cannibalize the young for more nutrients. Mozambique tilapia are opportunistic omnivores and will feed on algae, plant matter, organic particles, small invertebrates and other fish (Skelton,2001). There was also a high abundance of T. rendalli a forage fish and this can be attributed to the good water quality observed in Tugwi Mukosi damwith the fishbeing primarily herbivorous it prefers feeding on submerged vegetation and, at times, on algae, detritus, aquatic invertebrates and small fish. (Skelton, 2001).

The presence of predatory species such as M salmoides and the riverine sardine M. brevianalis may be as a result of the good water quality of Tugwi Mukosi with high transparency levels as these species mainly feed by sight and therefore high water clarity is good for feeding and predation (Davis &Lock,1997).

The reproductive status of fish species in Tugwi Mukosi dam was low during the winter months of the cool-dry season (May, June, July) since they time breeding with the first rains. This was true for most of the observed species in Tugwi Mukosi which had inactive gonads during the winter period namely O.niloticus, O.mossambicus, T. rendalli, O. macrochir, S. thumbergi, L. cylindricus, C. gariepinus and M. brevianalis. However, M.salmoides did not follow this trend as there was a high number of fish which were breeding in May and June. M.salmoides had high breeding activity during the winter season and this deviates from the normal breeding patterns of Zimbabwe fish.A number of individuals were observed to have active ripe and ripe- running gonads for both males and females during the winter period. According to Marshall (2011) most native fish species in Zimbabwe do not breed during the winter period. They start breeding during the hot-rainy period (November, December, January and February). However possible explanations for this observation for M.salmoides may include the availability of adequate live food (baitfish or forage) or changes in the photoperiod or day length which has been shown to affect spawning in M.salmoides through induced spawning trials (Davis & Lock,1997)

Distinct age classes were evident for O.mossambicus, O.niloticus and M.brevianalis in this study. The presence of 3 age classes for O.mossambicus and O.niloticus may be due to regular recruitment as a result of breeding during the hot wet season(Marshall 2011). Growth and population parameters were estimated for three species namely O.mossambicus, O.niloticus and M.brevianalis. It should be noted that these estimations are not validated but are only indicative. Mortality rates (Z) for M.salmoides and O.niloticus were high compared with those from other water bodies,e.g. M. salmoides Z =1.27 (Lake Chicamba, Mozambique), O.niloticus Z = 1.84 (Lake Chivero) O.niloticus Z=1.47 (Lake Koka, Ethiopia) (Weyl&Hetcht 1999; Tiki,2016; Tesfaye& Wolff 2015). The high mortality rates of M. salmoides and O. niloticus are indicative of the high exploitation rates of these two fish species. M. salmoides is mainly targeted by both artisanal and recreational fishermen, There is no pre impoundment data that exists for Tugwi Mukosi dam and therefore this case study of the dam has provided baseline data 3 years after impoundment, a benchmark for future studies and new insights into the fish communities of large reservoirs.

Conclusion

The current fish population at Tugwi Mukosi Dam has been shaped by community interactions and human interventions such as fish introductions. It will be interesting for future assessments to be done to investigate how this fish community continues to evolve over time.

References

[1] Bagenal, T. B., &Braum, E.(1968). Eggs and early life history. In: Ricker WE (ed.), Methods for assessment of fish production in fresh waters. International Biology Programme Handbook no. 3. Oxford: Blackwell Scientific. pp 159–181

[2] Beamish, C.A., Booth, A.J.,& Deacon, N. (2005). Age, growth and reproduction of largemouth bass, *Micropterus salmoides*, in Lake Manyame, Zimbabwe. African Zoology. 40: 63-69

[3] Chazireni, E.,&Chigonda, T.(2018). The Socio-Economic Impacts of Dam Construction: A Case of Tokwe Mukosi In Masvingo Province, Zimbabwe

[4] Chifamba, P. C., (2017). The biology and impacts of *Oreochromis niloticus* and *Limnothrisamoidon* introduced in Lake Kariba. PhD thesis, University of Gronigen, Gronigen, The Netherlands.

[5] Chipangura, P., Niekerk, D., & Van der Waldt, G. (2019). An exploration of the tractability of the objectivist frame of disaster risk in policy implementation in Zimbabwe. Jàmbá: Journal of Disaster Risk Studies. 11: 102-104

[6] Davis, J. T., & Lock, J. T. Largemouth Bass: Biology and life history. Southern Regional Aquaculture Center from United States, Department of Agriculture (SRAC). Publication no. 200, Aug. 1997

[7] Food and Agriculture Organisation.(2005). 'Increasing the contribution of small-scale fisheries to poverty alleviation and food security'. FAO Technical guidelines for responsible fisheries, Rome. ftp://ftp .fao.org/docrep/fao/008/a0237e/a0237e00.pdf

[8] Gayanilo, F.C.Jr.,&Pauly, D. (1997). The FAO ICLARM stock assessment tools. FiSAT reference manual. FAO Computerized Information Series (Fisheries), Rome, FAO

[9] Hammer, Ø., Harper, D. and Ryan, P. (2001). Paleontological statistics software: package for education and data analysis. Palaeontologia Electronica (4).

[10] Kolding, J.(1993). Population dynamics and life history styles of Nile tilapia, *Oreochromis niloticus*, in Ferguson's Gulf, Lake Turkana, Kenya. Environmental Biology of Fishes 37: 25–46

[11] Maponga, G.(2017). Tokwe-Mukosi Dam complete. Accessed online 06/10/19: https:// nehandaradio.com/2017/01/19/tokwe-mukosi-dam-complete/

[12] Marshall, B., &Maes, M. (1994). Small water bodies and their fisheries in southern Africa. CIFA Technical Paper 29. Rome: Food and Agriculture Organization of the United Nations

[13] Marshall, B. (2011). Fishes of Zimbabwe and their biology. Smithiana Monograph 3. Grahamstown: South African Institute for Aquatic Biodiversity

[14] Mosepele, K., & Kolding, J. (2003). Fish Stock Assessment in the Okavango delta, Botswana preliminary results from a length based analysis, pp 363–390. In Bernard, T, Mosepele, K and Ramberg, L (Eds). Environmental Monitoring of Tropical and Subtropical Wetlands. Okavango Report Series No. 1. University of Botswana, Maun and University of Florida, Gainesville, FLA

[15] Nhiwatiwa, T. (2004). The limnology and ecology of two small man-made reservoirs in Zimbabwe. MPhil thesis, University of Zimbabwe, Harare

[16] Revenga, C., Campbell, I., Abell, R., de Villiers, P. and Bryer, M. (2005). Prospects for monitoring freshwater ecosystems towards the 2010 targets. Phillipines Transcations Royal Society. 360:397-413

[17] Skelton P. 2001. A complete guide to the freshwater fishes of southern Africa. Cape Town: Struik

[18] Tesfaye, G., & Wolff, M. (2015). Stock assessment of fishery target species in Lake Koka, Ethiopia. Revista de biologia tropical, 63: 755-770.

[19] Tiki, M., &Nhiwatiwa, T. (2016). Growth, Mortality and Exploitation of Nile tilapia, *Oreochromis niloticus* (L.) in Lake Chivero, Zimbabwe and Implications on the Management of the Artisanal Fishery. African Journal of Tropical Hydrobiology and Fisheries. 14: 12-28.

[20] Verheust, L. (1998). Obtaining basic information for the enhancement of small water body fisheries: a regional project viewpoint. In: Petr T (ed.), *Inland fishery enhancements*. FAO Fisheries Technical Paper 374. Rome: Food and Agriculture Organization of the United Nations. pp 183–203.

[21] Vilar, C, C., Joyeux, J, C., Giarrizzo, T., Spach, H, L., Vieira, J, P &Vaske-Junior, T. (2013). Local and regional ecological drivers of fish

assemblages in Brazilian estuaries. Marine Ecology Progress Series. 485: 181- 197

[22] Welcomme, R. L. (1992). A history of international introductions of inland aquatic species. ICES Marine Science Symposium, 194, 3–14

[23] Weyl, O. L., & Hecht, T. (1999). A successful population of largemouth bass, *Micropterus salmoides*, in a subtropical lake in Mozambique. Environmental Biology of Fishes. 54: 53-66.

[24] Zengeya, T. A., & Marshall, B. E. (2008). The inshore fish community of Lake Kariba half a century after its creation: what happened to the Upper Zambezi species invasion? African Journal of Aquatic Sciences. 33: 99-102.

Citation: *Terence Magqina , Chipomungenge and Kuzivakwashe A Mawoyo, " Ichthyofauna Diversity and Composition of Zimbabwe's Largest Inland Reservoir: a Case Study of Tugwi Mukosi Dam", International Journal of Research Studies in Science, Engineering and Technology, vol. 8, no. 3, pp. 1-9, 2021, DOI : https://doi.org/ 10.22259/2349-476X.0803001*