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Length-weight Relationship and Condition Factor of *Clarias gariepinus*, *Mormyrus rume* and *Synodontis budgetti* in Dadin Kowa Reservoir, Gombe State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Length-weight relationship and condition factor of *Clarias gariepinus*, *Mormyrus rume rume* and *Synodondis budgetti* were carried out for a period of eighteen month, (October 2022 to March 2024) in Dadin Kowa Reservoir. A total of 189 specimens of *C. gariepinus*, 81 specimens of *M. rume* and 272 specimens of *S. budgetti* were purchased from the local fishermen as soon as they returned from their catch and were brought immediately to the laboratory for analysis. The

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objective of the study is to determine the physiological well-being of the fishes in Dadin-Kowa reservoir. The length weight relationship of these species were calculated using the equation: $W = aL^b$. Condition factor were calculated using the formula, $K= 100W/L^3$. Regression gained of value *b* shows the growth patterns of *C. gariepinus* as negative allometric growth and isometric growth with values ranging from 2.430908 to 3.203496. *M. rume* as negative allometric growth, isometric growth and positive allometric growth with values ranging from 0.155529 to 4.409502 and *S budgetti* as negative allometric growth, isometric growth and positive allometric growth with values ranging from 2.465982 to 4.174956. The condition factor of *C. gariepinus* ranges from 0.05-10.26, *M. rume,* 0.03- 9.61 and *S. budgetti* from 0.02- 6.67 indicating that some are in good physiological condition while others are not.

Keywords: Length-weigth; condition factor; Clarias gariepinus; Mormyrus rume; Synodondis budgetti; Dadin kowa; reservoir.

1. INTRODUCTION

"Length-weight relationship (LWR) of fish in fisheries biology is one of the complementary information that must be known in resources management" (Prince et al, 2020). "The LWR is one of fisheries biology information that is important to be known, because the knowledge about the study is useful to gain better understanding of perpetuity of life and growth of fish stock, because based on the biology information all consequences that is possible appear by all alternatives can be decreased" (Hassan and Ja'afaru, 2019).

"The importance of LWR in fisheries biology cannot be over emphasized because it affords easy prediction of average weight of a specific length group of fish population through a mathematical relationship between length and weight of the population of fish species in that habitat" (Konoyima et al, 2020). "The LWR are useful in assessing the relative well - being of a fish population as compared to others of the same species exposed to the same or different conditions of food, density, climate or environment" (Hassan and Ja'afaru , 2020). LWRs could also be used in fish stock assessment as well as in comparing ontogeny of fish population from different region (Khristenko and Kotovska, 2017), thereby enhancing management, conservation and culture of the concerned species.

"In fish, condition factor (K) reflects through its variations and provides information on the physiological state of the fish in relation to its welfare and based on the hypothesis that heavier fish of a given length are in better condition" (Stephen & Folashade, 2020). "In fisheries science, K is used in order to compare the 'condition', 'fitness', or wellbeing of fish. The condition of a fish reflects recent physical and biological circumstances, as it is strongly influenced by both biotic and abiotic environmental variables and fluctuates by interaction among feeding habits, parasitic burden and fish physiological condition" (Khristenko and Kotovska, 2017).

The K is widely used in fisheries and fish biology studies. This factor is calculated from the relationship between the weight of a fish and its length, with the intention of describing the "condition" of that individual fish (Asadi et al, 2017). "Different values in K of a fish indicate the state of sexual maturity, the degree of food sources availability, age and sex of some species" (Hassan & Ja'afaru, 2020). "When K value is higher it means that the fish has attained a better condition. The K of fish can be affected by a number of factors such as stress, sex, season, availability of feeds, and other water quality parameters" (Kefas et al, 2020).

Modern conservation and ecosystem-based management strategies for freshwater species require updating and area specific information. There is paucity of information available on the LWR and K of fish in Dadin kowa reservoir, hence the need for this study.

1.1 Study Area

Dadin-Kowa Reservoir is in Yamaltu Local Government Area of Gombe State in the North East of Nigeria. It lies within latitude 10°17 '18" N and longitude 11°30'32 "E of the equator (Muhammad et al, 2018). It has total capacity of 800 million m^3 and a surface area of 300km^3. The dam is located about 35 km to the East of Gombe town (Muhammad et al, 2018). The Reservoir was built with the major objective of providing domestic water supply to Gombe State, hydroelectric power supply, irrigation farming

around Dadin Kowa and many areas around the town and has potentials as a source of fisheries (Muhammad et al, 2018). The study is aimed at studying the growth pattern and general fitness/well-being of the fishes in the reservoir.

2. MATERIALS AND METHODS

2.1 Sample Collection

The species *Clarias gariepinus (tarwada), Mormyrus rume (sawanya),* and *Synodontis budgetti*. *(Karaya/Kurungu)* were purchased monthly from artisanal fishermen from the landing site for the period of 18 months and transported immediately to the laboratory for analysis in boxes with ice.

2.2 Species Identification

The collected samples were identified by taxonomical keys of identification of fish provided by Olaosebikan and Raji (2013).

2.3 Length and Weight Measurements

The morphometric characters measured include total length (TL), and weight (W). The total length were measured as length from the tip of snout to the end caudal fin with a measuring board. The weight was measured using a digital weighing balance. Length values were recorded in centimetre (cm) while the weight values recorded in grams (g) (Ramses et al, 2020).

The length weight relationship of the fishes were calculated using the equation:

$$W = aL^b$$

Where,

W= the observed total weights of the fishes
L= the observed total lengths
a and b are constant (Ramses et al, 2020).

2.4 Determination of Condition Factor (K)

Condition factor were calculated using the formula,

$$K= 100W/L^3$$

Where,

K= Fulton's condition factor,
W= the weight of the fish, and
L= the length (usually total length) (Konoyima et al., 2020).

3. RESULTS

3.1 Determination of Length-weight Relationship

The length-weight relationships of *C. gariepinus* in Dadin-Kowa Dam is presented in Table 1. The table indicates the intercept of regression (*a*), slope of regression curve (*b*) and coefficient of determination (R^2) with the corresponding allometric growth pattern of each of the fish species. Fish growth pattern (LWR) depends on its *b*-value. If *b*-value is less than 3; it implies it is a negative allometric growth pattern, if *b* –value is greater than 3; it denotes a positive allometric growth pattern. If *b*-value is equal to 3, it denotes an isometric growth pattern.

Clarias gariepinus had a highest *a* value of 0.043658 and least *a* value of 0.002716, highest *b*-value of 3.203496 and least *b*-value of 2.430908 and Highest R^2 values of 0.978277 and least R^2 value of 0.168887. *Clarias gariepinus* in nine (9) of the months specifically November 2022, January 2023, February 2023, May 2023, June 2023, August 2023, September 2023, February 2024 and March 2024 had negative allometric growth pattern of *b*-value less than 3. *Clarias gariepinus* in eight (8) of the months specifically October 2022, December 2022, March 2023, April 2023, October 2023, November 2023, December 2023, January 2024 had Isometric growth pattern of *b*-value equal to 3.

The LWR of *M. rume* in Dadin-Kowa reservoir is presented in Table 2. *M. rume* had a highest *a* value of 2.139765 and least *a* value of 0.001397. Highest *b*-value of 4.409502 and least *b*-value of 0.155529 and Highest R^2 values of 0.999883 and least R^2 value of 0.109529. *M. rume* in thirteen (12) of the months had negative allometric growth pattern of *b*-value less than 3 and positive allometric growth pattern of *b*-value greater than 3 in July. *M. rume* in October 2022, November 2022 and December 2022 had Isometric growth pattern of *b*-value equal to 3.

The length-weight relationships of *S. budgetti* in Dadin-Kowa Reservoir is presented in Table 3. *Synodontis budgetti* had a highest *a* value of 0.014513 and least *a* value of 0.005215. Highest *b*-value of 4.174956 and least *b*-value of 2.465982. Highest R^2 values of 0.988536 and least R^2 value of 0.661974. *S. budgetti* in seven (7) of the months specifically October 2022, March 2023, April 2023, May 2023, August 2023, September 2023, October 2023 had Negative allometric growth pattern of *b*-value less than 3. *S. budgetti* in November 2022 and December 2022 had positive allometric growth pattern of *b*-value greater than 3. *S. budgetti* in nine (9) of the months specifically January 2023, February 2023, June 2023, July 2023, November 2023,

December 2023, January 2024, February 2024 and March 2024 had Isometric growth pattern of *b*-value equal to 3.

3.2 Determination of Condition Factor

The result of K of *C. gariepinus, M. rume and S. budgetti* in Dadin-Kowa Reservoir is presented in Table 4. The K values of *C. gariepinus* ranges from 0.05-10.26, *M. rume,* 0.03- 9.61 and *S. budgetti* from 0.02- 6.67.

The values of K for all species less than 1 indicate that the fishes are not in a good state of well-being in the reservoir while those that were higher than 1 indicates that they were in a good state of well-being in the reservoir.

Table 1. Length weight relationship of *Clarias gariepinus* Dadin Kowa Reservoir, Gombe State October 2022- March 2024

Month	n	a	b	R^2	Allometry
Oct 22	13	0.003617	3.13086	0.977507	Isometric
Nov 22	8	0.004658	2.947202	0.168887	Negative
Dec 22	11	0.00642	3.001484	0.926075	Isometric
Jan 23	7	0.012219	2.790492	0.956093	Negative
Feb 23	8	0.009061	2.870779	0.970995	Negative
Mar 23	3	0.003931	3.107059	0.453237	Isometric
Apr 23	12	0.002716	3.17366	0.921813	Isometric
May23	9	0.005272	2.989121	0.863529	Negative
Jun 23	9	0.007271	2.988121	0.863537	Negative
Aug 23	11	0.020473	2.633833	0.956409	Negative
Sept 23	11	0.005503	2.992261	0.978277	Negative
Oct 23	21	0.011202	2.812927	0.954552	Isometric
Nov 23	21	0.021201	2.612927	0.854452	Isometric
Dec 23	11	0.00642	3.001484	0.926075	Isometric
Jan 24	9	0.003068	3.203496	0.968988	Isometric
Feb 24	20	0.043658	2.430908	0.806503	Negative
Mar 24	4	0.016354	2.60271	0.960296	Negative

*Key: *a = Intercept of Regression Curve, *b = Slope of the Regression Curve, *R^2 = Coefficient of Determination*

Table 2. Length weight relationship of *M. rume* in Dadin Kowa Reservoir, Gombe State October 2022- March 2024

Month	n	a	b	R^2	Allometry
Oct 22	6	0.015234	3.064947	0.516061	Isometric
Nov 22	5	0.001749	3.358226	0.962883	Isometric
Dec 22	5	0.011749	3.352226	0.972873	Isometric
Jan 23	3	0.008882	2.880084	0.999883	Negative
Feb 23	3	0.007682	2.860184	0.966883	Negative
Mar 23	5	0.010137	2.837809	0.960518	Negative
Apr 23	13	0.015858	2.741414	0.96564	Negative
Jun 23	4	0.069054	2.058322	0.43113	Negative
Jul 23	4	0.174491	4.409502	0.109529	Positive
Aug 23	7	0.084201	0.155529	0.553773	Negative
Sept 23	9	0.023312	2.595073	0.897293	Negative
Nov 23	3	0.1373	2.078125	0.66564	Negative
Dec 23	3	0.1373	2.078125	0.66564	Negative
Jan 24	4	0.010918	2.837228	0.998352	Negative
Feb 24	2	0.014519	2.709272	0.96564	Negative
Mar 24	3	0.001397	3.400102	0.965474	Isometric

*Key: *a = Intercept of Regression Curve, *b = Slope of the Regression Curve, *R^2 = Coefficient of Determination*

Table 3. Length weight relationship of *S. budgetti* in Dadin Kowa Reservoir, Gombe State October 2022- March 2024

Month	n	a	b	R^2	Allometry
Oct 22	12	0.045486	2.465982	0.661974	Negative
Nov 22	10	0.000244	4.174956	0.80969	Positive
Dec 22	10	0.000324	4.175456	0.81469	Positive
Jan 23	5	0.005215	3.096917	0.814287	Isometric
Feb 23	23	0.003535	3.235703	0.974667	Isometric
Mar 23	3	0.025906	2.629526	0.842799	Negative
Apr 23	26	0.012061	2.912981	0.711667	Negative
May 23	16	0.013823	2.754083	0.946143	Negative
Jun 23	20	0.004732	3.155786	0.868067	Isometric
Jul 23	31	0.006929	3.02871	0.94033	Isometric
Aug 23	14	0.009415	2.930523	0.845946	Negative
Sept 23	25	0.014513	2.744192	0.863903	Negative
Oct 23	16	0.011772	2.868497	0.973978	Negative
Nov 23	11	0.000719	3.844712	0.924687	Isometric
Dec 23	7	0.003166	3.215029	0.988536	Isometric
Jan 24	20	0.002857	3.26992	0.925118	Isometric
Feb 24	10	0.006522	3.000501	0.837063	Isometric
Mar 24	13	0.004222	3.13718	0.967163	Isometric

*Key: *a = Intercept of Regression Curve, *b = Slope of the Regression Curve, *R^2 = Coefficient of Determination*

Table 4. Condition factor of *C. gariepinus, M. rume,* and *S. budgetti* in Dadin Kowa Reservoir, Gombe State October 2022- March 2024

Month	*Clarias gariepinus*	*Mormyrus rume*	*Synodontis budgetti*
Oct 22	0.35-0.46	0.37-0.63	3.27-6.67
Nov 22	0.05-0.78	0.17-0.19	0.02-0.03
Dec 22	0.49-0.86	0.17-0.19	0.02-0.03
Jan 23	1.14-1.32	0.88-0.89	0.45-0.65
Feb 23	0.82-0.97	0.88-0.89	0.29-0.43
Mar 23	0.37-0.47	0.88-1.19	1.90-3.09
Apr 23	0.07-0.31	1.20-2.03	0.72-1.77
May 23	0.42-0.67	1.27-1.27	1.18-1.92
Jun 23	0.42-0.67	4.77-9.61	0.46-0.91
Jul 23	0.65-0.65	0.03-1.49	0.47-0.90
Aug 23	1.77-2.61	1.04-4.54	0.72-1.13
Sept 23	0.49-0.67	1.93-3.19	1.08-1.84
Oct 23	0.93-1.37	2.41-2.41	1.02-1.5
Nov 23	0.93-1.37	1.15-1.42	1.06-1.51
Dec 23	0.49-0.86	1.48-1.95	0.28-0.34
Jan 24	0.28-0.37	0.28-0.37	0.24-0.36
Feb 24	3.39-10.26	1.44-1.45	0.53-0.87
Mar 24	1.49-1.79	0.12-0.16	0.32-0.57

4. DISCUSSION

Fish stock assessment using LWR are important since the values obtained help in the determination of the performance of the concerned fish species in the given environment. The fish growth patterns are determined based on the value of *b*. When it equals 3, then the growth pattern is isometric, or weight gain is equivalent to the length of the fish, and when the value of $b \neq 3$, then the growth pattern is allometric. These growth patterns are divided into two, namely positive and negative allometric. Whenever the value of *b* is less than 3 ($b < 3$), it is referred to as a negative allometric (the increase in length is greater than the weight gain), and when it is greater than 3 ($b > 3$), it is called a positive allometric (increase in length is less than the weight gain) (Martinez-Polanco and Bearez , 2020).

The result of regression gained of value *b* shows the growth patterns of *C. gariepinus* (2.4-3.2), to be negative allometric and Isometric growth. *M. rume* (0.2-4.4), to be negative allometric, Isometric growth and positive allometric and *S. budgetti*, (2.5-4.2) to be negative allometric, Isometric growth and positive allometric. Negative allometric growth pattern of 0.9472-1.2927, and 2.1841- 2.5437 was reported for *Oreochromis niloticus* and *Coelotilapia joka* in Lake Geriyo, Yola and Rokel/Seli River, West Africa (Kefas et al, 2020, Konoyima et al, 2020) respectively. Isometric growth pattern of 3.05-3.58 and 3.078-3.107 was reported for *Trachinotus ovatus* and *Cheilinus chlorourus*, in Trang, Vietnam and Tanjung Tiram coast, Southeast Sulawesi, Indonesia (Hoang, 2020, Asriyana et al, 2020), respectively. Positive allometric growth pattern of 4.37 and 3.72 was reported for *Ellochelon vaigensis and Garra rufa* in Narreri Lagoon, Badin, Sindh, Pakistan and Zohreh River, Iran (Awan et al, 2017, Keivany and Zamani-Faradonbe, 2016)., respectively. The observed estimation of length-weight relationships of fish can differ in the same species dwelling in diverse locations. The difference can also be attributed to diverse study periods given the biological and environmental impact (Mallawa and Amir, 2020).

According to Konoyima et al., (2020), different LWR are due to factors such as differences in length and weight, food availability in the various lotic and tapering environment, and other environmental conditions. Changes in the value of exponent *b* are due to environmental factors such as competition for food, food availability, weather, temperature, salinity, and gender (Froese et al, 2018).

Most of the samples from these study exhibited negative allometric growth. It had been shown that most inland water fish in Nigeria had negative allometric growth pattern (Maskill et al, 2017). This suggests inadequate feeding level and diets composition in the fish with the potential to affect nutritional conditions that favour growth in weight. Restrictions in mobility due to increased water, large hydro-electric power dam in the upper reach of the reservoir, fishing pressure as well as changes in environmental quality could have exacerbated the problem.

K is used to compare the 'state' or 'wellbeing' of a fish and is based on the hypothesis that states that heavier fish of a given length are in better condition (Konoyima, 2020). The condition factor is an index value that shows the health condition of fish (Abobi, 2015). K is used in comparing its condition, size or (Asadi H et al, 2017). K is also important in the monitoring of feeding intensity, age and growth rates in fish (Sohou et al, 2020). Related study had shown that the K is strongly influenced by both biotic and abiotic environmental conditions, and can be used to assess the ecological habitat of fish species (Hoang, 2020).

The result of the study shed light on the state of well-being of the fishes examined. K' values greater than 1 is an indicative of general well-being of good fish. The value of the K for some species was less than one; this implies a bad state or well-being, while the rest were more than one, implying a good state of well-being in the reservoir. Many factors such as sex, age, state of maturity, size, state of stomach, illness, sampling methods, sample sizes and environmental condition affects fish condition and parameters of length-weight relationships in fish (Sohou et al, 2020, Stephen and Folashade, 2020, Kahraman et al, 2014).

K of the black tiger shrimp (*P. monodon)* from the Andoni river system ranged from 0.5914-0.6909. These values are relatively lower compared to those of *Lates calcarifer* (15.55-21.06) from Batam Island, Indonesia (Ramses et al, 2020, Ngueguim et al, 2020, Morato et al, 2001, Jones et al, 1999).

5. CONCLUSION

C. gariepinus in Dadin Kowa Reservoir exhibited Negative allometric growth pattern and Isometric growth pattern. *M. rume* exhibited Negative allometric growth pattern, Isometric growth pattern and positive allometric growth pattern and *S. budgetti* exhibited Negative allometric growth pattern, Isometric growth pattern and positive allometric growth pattern. The condition factor of *C. gariepinus*, *M. rume,* and *S. budgetti* in Dadin Kowa Reservoir indicates that some of the species are in a good physiological well-being in the reservoir while others were not in a good state of well-being in the reservoir.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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