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INTERPRETATION OF ALLOMETRIC GROWTH PATTERNS OF FISH SPECIES FROM DADIN-KOWA RESERVOIR

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ABSTRACT

The study examined and interpreted the allometric growth patterns of fish species of Dadin-Kowa Reservoir employing "Regression" function. A total of 25 fish species were examined for their Length Weight Relationships (LWR). Of which seventeen fish species had negative allometric growth with major scourge on *Pollimyrus isidori* (*b-index* = 1.94), while *Brycinus nurse* conformed to the peak LWR positive allometric growth (*b-index* = 3.46). The vast distribution of the landed fish species indicated signs of overfishing. These signs may lead to growth and recruitment overfishing in the possible future. If managed properly; the reservoir can yield fish species with good table size and sustainable economy.

Keywords: Length Weight Relationship; Regression; *Pollimyrus isidori*; *Brycinus nurse*; Recruitment overfishing and Sustainable development.

INTRODUCTION

Growth is a biochemical process of increase or progressive development of an organism including fish species (Renjithkumar, 2014). Growth typically can be defined as the change in size (length or weight) over time. Conversion of food matter into building block/mass through nutrition brings about increase in size of species (Khan & Khan, 2014). However many factors influenced/affect fish growth; these factors includes the size, quality and amount of available food, number of fish utilizing the same food source (inter or intra specific competitions), temperature, salinity, oxygen (Orio, 2019) and other water quality parameters enveloping fish (Viadero, 2019).

Fish species were thought to exhibit growth both in length and weight with time, the relationship between the two has both applied or basic importance (Ambily, 2016).

Renjithkumar (2014) indicated that the length-weight relationship is one of the standard methods yielding to genuine biologic information with two objectives (1) establishes the mathematical relationship between two variables: length and weight, so that unknown variable can be readily computed from known variables (2) to know the variations from expected weight, for the known length groups (Ambily, 2016; Falaye, Opadokun, & Ek, 2015), which reflects its fatness, gonadal maturity and wellbeing (Falaye *et al*., 2015).

However, above these expressions, the LWR can be used to (1) estimate weight from length of individual fish or length class (Hoang, 2020; Renjithkumar, 2014) (2) it is applicable to understand the standing crop biomass/yield of fish species if length frequency data is known (Matos, Carvalho, & Parisotto, 2017), (3) to convert growth in length equations to growth in weight for prediction of weight-at-age (Renjithkumar, 2014) and used in stock assessment models (Matos *et al*., 2017), (4) assessment of condition index of a fish species can be achieved through LWR (Renjithkumar, 2014), and (5) comparison of life-history and morphology among populations from different regions can be

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achieved via LWR (Renjithkumar, 2014; Sidney *et al*., 2020).

Ambily, (2016) justified that, the exact relationship between length and weight differs from and among species according to their innate body shape, gravity and to the condition of individual fish.

Over 90% of fish species in the world are managed without formal stock assessment (Sun *et al*., 2017) and indicates that only 10% or below of global fish species biological parameters were analyzed (Hommik, Fitzgerald, Kelly, & Shephard, 2020), these analyses includes LWR, which is an important tool for fisheries resources management policies (Sidney *et al*., 2020).

Quite a large number of studies were conducted to the aspects of length, weight and LWR of fish species across the globe (Asriyana, Irawati, & Halili, 2020; Piria *et al*., 2020; Sanjay, Abujam, Mofidul, & Nilam, 2016).

MATERIAL AND METHODS

Study Area

The Dadin-Kowa is located in Yamaltu-Deba Local Government area, Gombe State in the north east of Nigeria. Dadin-kowa town is located between Latitudes 10°19′19″N and 10.32194°N; Longitude 11°28′54″E and 11.48167°E. It shares common boundary with Akko Local Government area, to the South and West, Yamaltu-Deba to the East and Kwami to the North. Dadin-kowa has an altitude of about 370 meters above sea level (Nazeef & Abubakar, 2013).

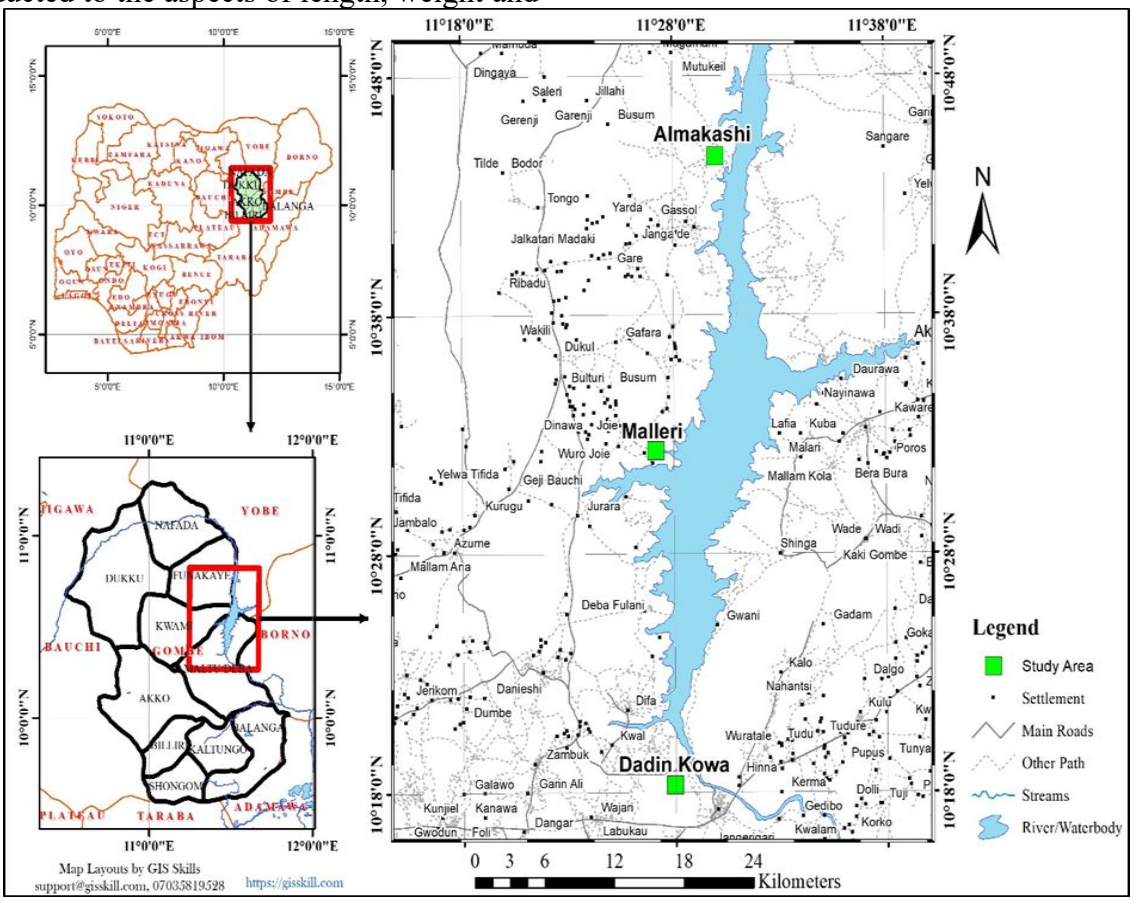

Figure 1: Map of Dadin-Kowa showing study area

Source: DGLinks Gombe State, Nigeria.

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Data Collection

Fish samples were collected from three of the four prominent landing sites on a monthly basis for the period of 12 months (January - December, 2020) from the catches of artisanal fishermen. The three landing sites were: *Almakashi*: 10°44'40.584''N, 11°30'32.574''E, *Dadin-Kowa*: 10°92'14.142''N, 11°28'43.956''E and *Malleri*: 10°18' 38.539''N, 11°9'13.582''E. The study area has bordered three local government areas of Gombe State each with at least a town having intensive fishing activities, therefore, the aforementioned landing sites were selected reflecting the entire Reservoir coverage, and the local government areas includes Funakaye (Almakashi); Yamaltu-Deba (Dadin-Kowa) and Kwami (Malleri) accordingly.

Fish samples were sampled from the population and their morphometric measurements (Standard length & weight) were measured using a measuring tape and a digital weighing balance (Sartorius) to the nearest 0.1cm and 0.1g respectively, following the methods explained by (Ahmad, Yola, & Suleiman, 2018)

Fish Species Length-Weight Relationship (*LWR*) Determination

Using MS Excel, the incurred morphometric data (length and weight precisely) from each of the fish species studied were transformed into their natural logarithm numbers using the "*LN*" function. Thereafter, "*Regression*" function of the same MS Excel was employed to determine the length-weight relationship ($W=aL^b$) of each of the species (Ahmad *et al*., 2018; Somy, 2014). Equations of the graphs were generated thereafter. These gave the functions and the constants of the intercepts and slopes (*a* & *b*) of the corresponding graphs (Arame, Adite, Adjibade, Imorou, & Sonon, 2020) with the corresponding R^2 values were also obtained.

RESULTS

Fish species Length-Weight Relationships (LWR) Across the Three Sampling Sites

The length-weight relationships of the identified fish species across the three sampling sites is presented on Table 1. The table indicates the intercept of regression (*a*), slope of regression curve (*b*) and coefficient of determination (R^2values) with the corresponding allometric growth pattern of each of the fish species. Data from the *a*-values indicated that *Schilbe mystus* had the least value with 0.0037, while *Synodontis budgetti* had the peak value with 0.8824, however the rest of the fish species have *a*-values within the range of 0.004 to 0.5701 (Table 1). In terms of *b*-value; *Pollimyrus isidori* recorded the least value with 1.9315, whereas *Brycinus nurse* had the highest score with a value of 3.4629, the rest of the fish species have *b*-values within the range of 2.4737 to 3.3621 (Table 1). On the coefficient of determination (R^2 value); *Schilbe mystus* with 0.0168 represented the lowest R^2 –value, but 0.999 being the peak R^2 –value was recorded for *Hydrocynus brevis*. The remaining fish species recorded an R^2 –values within the range of 0.2306 to 0.9918 (Table 1). Fish allometric growth pattern is also presented on table 1. The interpretation of fish growth pattern relies on its assessed *b*-value; specifically, (LWR). Therefore, if *b*-value is less than 3; it implies a negative allometric growth, if *b* –value is greater than 3; it denotes a positive allometric growth. However, if *b*-value is equal to 3, it denotes an isometric growth pattern. According to the results as depicted in the table; a total of eighteen (18) fish species including *Bagrus docmac, Paradistichodus dimidiatus, Hyperopisus bebe occidentalis, Tilapia zilli, Hyperopisus*

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bebe, Malapterurus electricus, Alestes leuciscus, Pollimyrus isidori, Labeo senegalensis, Labeo brachypoma, Oreochromis niloticus, Citharinus citharus, Glyptothorax exodon, Auchenoglanis occidentalis, Alestes dentex, Mormyrus rume, and *Hydrocynus brevis* showed negative allometric growth, whereas three (3) fish species including *Brycinus macrolepidotus, Erpeitoichthys calabaricus, Clarias lazera* were recorded to exhibit a positive allometric growth pattern, but *Mormyrus macrophthalmus, Synodontis budgetti, Bagrus bayad macropterus,* and *Schilbe mystus* were observed to have an isometric growth pattern.

Table 1: Length-Weight Relationship of the fish species identified from the study sites

Fish species	*a*	*b*	R^2	Allometry
Alestes dentex	0.0134	2.8926	0.8215	Negative
Alestes leuciscus	0.5701	2.6595	0.0168	Negative
Brycinus nurse	0.0040	3.4629	0.8073	Positive
Brycinus macrolepidotus	0.0131	3.0552	0.9721	Isometric
Auchenoglanis occidentalis	0.0220	2.8852	0.8529	Negative
Bagrus bayad macropterus	0.0122	2.9115	0.9009	Negative
Bagrus docmac	0.0129	3.0393	0.9918	Isometric
Hydrocynus brevis	0.0109	3.0171	0.8995	Isometric
Oreochromis niloticus	0.0562	2.7261	0.8898	Negative
Sarotherodon galilaeus	ND	ND	ND	ND
Tilapia zilli	0.1117	2.4737	0.8949	Negative
Citharinus citharus	0.0348	2.8316	0.9813	Negative
Clarias lazera	0.0123	2.8800	0.9112	Negative
Labeo brachypoma	0.0063	3.1465	0.5926	Positive
Labeo senegalensis	0.0108	3.0233	0.8315	Isometric
Paradistichodus dimidiatus	0.0044	3.2342	0.4335	Positive
Malapterurus electricus	0.0526	2.6985	0.9996	Negative
Synodontis budgetti	0.8824	2.6026	0.3036	Negative
Hyperopisus bebe	0.0131	2.9096	0.9783	Negative
Hyperopisus bebe occidentalis	0.0858	2.9704	0.8445	Negative
Mormyrus rume	0.0096	2.9420	0.8738	Negative
Mormyrus macrophthalmus	0.0516	2.6026	0.7898	Negative
Marcusenius senegalensis	ND	ND	ND	ND
Pollimyrus isidori	0.0677	1.9315	0.2306	Negative
Erpeitoichthys calabaricus	0.4820	2.9285	0.7080	Negative
Parailia pellucida	NA	NA	NA	NA
Schilbe mystus	0.0037	3.3621	0.8782	Positive
Glyptothorax exodon	0.0221	2.8455	0.8708	Negative

***a** = intercept of regression curve,* ***b** = Slope of the regression curve*
***R^2** = Coefficient of determination,* ND implies insufficient data for assessment and NA not assessed.

Ranges of Standard Length and Total Weight of Fish Species

The observed standard lengths, total weight and total observed fish species samples for analysis of length – weight relationship (LWR) is presented on table 2. As an input for LWR analyses, the standard lengths of the fish species had been applied to obtain ***a***, ***b***, and R^2, accordingly. The table indicated that *Alestes leuciscus* alongside *Paradistichodus dimidiatus,* and *Brycinus nurse* represented the least standard length values from the chart; with values within the range of 6.5cm to a maximum of 14.7cm

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accordingly. Inclusively; the next category included fish species that recorded standard length values within the bracket of 15 – 52cm having *Bagrus docmac* being the prominent upper limit alongside *Clarias lazera* with 53.5cm standard length peak values accordingly (Table 2). Reflecting on the weight category; *Bagrus bayad macropterus, Bagrus docmac, Mormyrus rume* alongside *Hydrocynus brevis* were observed to be prominent players in terms of weight gain, with a weight - range of 1400g – 2750g. Despite this weight formation from the former group, some fish species however are not forthcoming with regards to weight brackets, this included *Alestes leuciscus* (02 - 06g), *Pollimyrus isidori* (03 – 05g), and 04 – 08g was recorded against *Paradistichodus dimidiatus* accordingly (Table 2). The rest of the fish species recorded weight brackets between 32g to 1399g accordingly. For the analysis of Length Weight Relationships, the observed samples recorded against each species indicated that *Malapterurus electricus, Erpeitoichthys calabaricus,* alongside *Brycinus macrolepidotus* had recorded less than five (5) individuals each for LWR analysis, this category formed the lowest fish species abundance, but the table revealed it clearly that prominent fish species such as *Oreochromis niloticus* with 324 individuals and *Alestes dentex* (103 samples) were the highest in abundance. The rest of the fish species recorded observed samples within the brackets of ten (10) to one hundred and two (102) individuals respectfully (Table 2).

Table 2: Ranges of standard length and weight of fish species identified

Fish species	Length range SL_(cm)	Weight range (g)	LWR observed samples
Alestes dentex	10 - 21.2	05 – 105	103
Alestes leuciscus	7.3 – 9.6	02 – 06	33
Brycinus nurse	6.5 – 14.7	03 – 31	70
Brycinus macrolepidotus	14.5 – 19.5	43 – 116	04
Auchenoglanis occidentalis	13.8 – 40.2	38 – 1400	58
Bagrus bayad macropterus	12.5 – 63	17 – 2750	25
Bagrus docmac	9.1 – 52	11 – 2200	14
Hydrocynus brevis	7.7 – 41	04 – 1500	55
Oreochromis niloticus	3.5 – 31	15 – 848	324
Sarotherodon galilaeus	ND	ND	ND
Tilapia zilli	9.7 – 17.6	08 – 131	10
Citharinus citharus	7.5 – 31.5	07 – 630	23
Clarias lazera	12.5 – 53.5	17 – 1131	20
Labeo brachypoma	8.5 – 19.4	04 – 60	17
Labeo senegalensis	8.5 – 30	04 – 394	51
Paradistichodus dimidiatus	08 – 9.5	04 – 08	09
Malapterurus electricus	13.2 – 20	56 – 171	03
Synodontis budgetti	13.2 – 18.6	53 – 126	19
Hyperopisus bebe	06 – 31.2	03 – 282	20
Hyperopisus bebe occidentalis	13.2 – 19.5	23 – 75	08
Mormyrus rume	14 – 60	27 – 1400	39
Mormyrus macrophthalmus	12.5 – 38	17 – 389	17
Marcusenius senegalensis	ND	ND	ND
Pollimyrus isidori	6.9 – 8.1	03 – 05	10
Erpeitoichthys calabaricus	18.7 – 22.1	53 – 68	03
Parailia pellucida	NA	NA	NA
Schilbe mystus	06 – 20.5	02 – 103	75
Glyptothorax exodon	07 – 18.6	04 – 77	20

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ND implies no sufficient data for the set analysis; ***NA*** implies not assessed.

DISCUSSION

Fish Species Length - Weight Relationships

The length – weight relationships of fish species of Dadin-Kowa reservoir analyzed inferred three allometric growth patterns (negative, positive and isometric) based on their corresponding exponent *b* – index. Considering the confidence interval of the growth patterns, all the analyzed fish species conformed to the expected values of the allometric coefficient *b* (2.5 – 3.5) as defined by Freitas *et al*, (2017) with the exception of *Pollimyrus isidori* (*b* = 1.93) and *Tilapia zilli* (*b* = 2.47). Fish Base has a catalogue of fish species with detailed of fish species' LWR, this catalogue had been applied to ascertain values obtained from related studies. Therefore; the recorded *b* – index of *Pollimyrus isidori* does not conformed to the documented FishBase's isometric allometry applying Bayesian Analysis. But, this negative allometry fitted that of *Parachaetodon ocellatus* (*b* = 1.93) (Ramses, Ismarti, & Syamsi, 2020). In this regard; it can be understood that sample size, as well as employed minute-mesh-size gears may have been the primary sources of these deviations. *Tilapia zilli* this fish species' allometric index also deviated from the FishBase's isometric index, however conformed to the results obtained from that of *Coelotilapia joka* (Konoyima, Mansaray, Ndomahina, & Amara, 2020)*,Aequidens tetramerus* (Sidney *et al*., 2020)*, Labeo diplostomus* (Soomro, Leghari, & Gachal, 2020) and *Cheilinus trilobatus* (Asriyana *et al*., 2020). In similar fashion to that of *Pollimyrus isidori*, low population which directly influence sample size and premature harvest may have been the sources of this differences and poor turnout.

The vast majority of the fish species analyzed in this study inferred a negative allometric growth within the exponent ***b*** **–** index range of 2.5 – 2.99 with the peak score obtained against *Hyperopisus bebe occidentalis* (*b* = 2.97). This value is in line with the FishBase's negative allometric index and agrees with the finding obtained by Esmaeili *et al*., (2020) on *Alosa braschnikowi.* The localities where this fish species is dominant lies within West African region (Nigeria and Benin), therefore there's possible tendency that this fish species has been favored by the tropical environmental conditions such as food, warm temperature, moderate competition and possible resistance to parasites.

Besides negative allometry; fish species with equal proportions of growth in length and weight termed as isometric growth patterns. the species involved includes *Brycinus macrolepidotus*, *Bagrus docmac*, *Hydrocynus brevis* and *Labeo senegalensis.* All the fish species in this category conformed to the FishBase's documented isometric allometry. In this regard *Brycinus macrolepidotus* (*b* = 3.05) had the highest isometric *b* – index, this further conformed to the findings of Sajeevan (2014) on *Etroplus maculatus,* Osman *et al*, (2020) on *Rhabdosaragus haffara*, which is also similar to that of *Acanthalburnus microlepis* (Asadi, Sattari, Motalebi, Zamani-faradonbe, & Gheytasi, 2017) and *Sparidentex hasta* (Awan, Qamar, Farooq, & Panhwar, 2017). *Brycinus macrolepidotus* is predominantly found in West Africa mostly in the Northern parts. The fish species is a generalist feeder that warrants its isometric growth which is also favored by the tropical conditions (Abari & Umar, 2018). *Bagrus docmac* this fish species also assumed similar pattern of distribution as found in *Brycinus*

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macrolepidotus, but in addition, the fish species is nocturnal which aided its ability to attain maturity before capture by fishing gear. As most of this fish species in this study were caught indicating a good table size, additionally dorsal and pelvic armored fins for defense, deter predation. Hence their micro population number which lowers intra – specific competition paving more chance of survival and growth than capture or any other forces of population decay. The piscivorous *Hydrocynus brevis* also had been favored by moderate population number and great food conversion efficiencies which warrant its isometric allometry, this favors are similar to what is obtainable from *Labeo senegalensis* and strengthen by its low palatable meat which lowers public demand for such fish species.

The present study cited four fish species which conformed to positive allometry based on their corresponding exponent ***b* – index.** *Schilbe mystus,* which conformed to FishBase's positive allometric index, but *Alestes leuciscus* was documented to have a negative allometry based on FishBase's catalogue. However, in this research a positive allometry was obtained. Whereas *Paradistichodus dimidiatus* and *Labeo brachypoma* LWR details are unavailable in FishBase.org catalogue. In this category; the peak positive allometric index agrees with other studies including *Tenulosa ilisha* (Esmaeili *et al*., 2020)*, Danio dangila* (Banerjee, Mahapatra, & Patra, 2016)and *Alburnus alburnus* (Sanchez-Gonzalez, Arbones, & Casals, 2020; Stavrescu-Bedivan, Aionanei, & Scaeteanu, 2017). *Alestes leuciscus*' allometry deviation may have been as a result of favored environment conditions, medium size with potential high growth speed, efficient food conversion and biomass accumulation may have been the possible attributes to the species growth propulsions.

Generally; it should be understood that growth patterns of fish species are related to the exponential values (***b***) of length - weight relationships (LWR) which can change. These changes are related to environmental parameters (seasonal temperature regimes) and habitat availability (Olopade, Dienye, & Nworgu, 2019); optimal temperature, adequate food, and seasonal changes; ontogenetic development; season, habitat, feeding rate, and fish health; sexual dimorphism; gonadal development and spawning period; and reproduction stage; procedures for sampling (sample size and length range); parasitic pressure; health, habitat, regional/seasonal influences, gastric fullness, samples preservation techniques, and differences in specimen size ranges. High dissolved oxygen concentration and circulation of water (Asriyana *et al*., 2020). These factors are applicable to fish species including the ones originating from this study, hence the value of exponent ***b*** determines the productivity of any originating water body(Asriyana *et al*., 2020).

CONCLUSION

The Dadin – Kowa Reservoir has recorded Length Weight Relationships data of over twenty (20) fish species; mostly bearing negative allometric growth patterns with exception of a few. It was understood that, most commercially important species were heavily exploited as revealed from their LWR outcomes. Although fish biology, genetic constitution can alter the weight gain of fish species, but there's need to properly implement and enforce correct management practices

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Disclosure of conflict of interest

The authors declared that there is no conflict of interests.

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