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Aspects of Growth Pattern and Condition Factors of *Bagrus bayad macropterus* in River Rima and Goronyo Reservoir in Sokoto State Northwestern Nigeria

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Abstract

The study was conducted in River Rima (RR)and Goronyo Reservoir (GR). Data was collected on monthly basis for twelve consecutive months (February to January) from the artisanal fishermen catches for LWR and CF analysis against the season, sub seasons and water body types. A total of 1,097 specimens measuring between 8.20cm to 64cm total lengths and 3.5g to 1070.1g of weights were recorded in both RR and GR The b values ranged from 2.887 in early dry to 3.406 in early rain fall sub seasons with dry and raining seasons values of 2.979 and 2.947 in RR respectively. The same species recorded varied b values in GR, with b values of 2.738 and 3.140 for mid dry and late dry sub seasons. The dry season and rainfall season stood at 2.996 and 2.533 respectively in GR. The influence of seasons from the two water bodies was significant ($p<0.05$) with the lowest b value of 2.782 in early dry and highest (3.246) during early rainfall sub seasons. The mean monthly condition factors ranged from 0.57±-0.11(May) to 0.79±-0.11 (March) in RR and 0.59±-0.12 (February) to 0.76±-0.09 (September) in GR. The influence of seasonal variations produced a range of k values of 0.66±-0.13 in late dry and 0.75±-0.09 in flood sub seasons in RR while mid-dry and flood sub seasons recorded 0.63±-0.12 and 0.72±-0.15 respectively in GR. In conclusion, the fish specimens from both water bodies had exhibited negative allometric growth pattern ($b<3.0$) and the k values showed significant ($p<0.05$) difference between the sub seasons. The information on b and k values could be used to develop a strategy for development and management of the species in both water bodies. The study recommends for further investigations on the effects of sexes and feeding habits on the values of b and k.

Keywords:
Reservoir, Bagrus bayad macropterus, Chrysichthys filamentosus, Goronyo, Rima

Introduction

Bagrus bayad macropterus belongs to the bagridae family which originated from Africa and has about 245 species (Ferraris, 2007;Gupta and Gupta, 2008). *Bagrus bayad macropterus* is an important food fish, its flesh is good for eating and is of economic importance, commonly sold as food, (Froese and Pauly, 2007). It is a commercial fish species highly cherished for its white flesh and delicious taste, therefore, a very important source of protein for low protein intake Third World country like Nigeria.

Fishes in tropical waters, unlike in the temperate experience slight fluctuations in growth which may be due to changes in environmental conditions, food availability or due to spawning stress or rates, (Mshelia *et al*., 2008). The knowledge of growth indices such as length weight relationship (LWR) and condition factor (CF) is essential in assessing the influence of the above mentioned factors (Kulbicki *et*

al., 1993). The use of length weight relationship makes possible the estimation of the mean weight of a fish of given body length, determination of the condition factor, and conversion of length-growth models to corresponding weight-growth models, (Tailor and Gallucci, 1980; Bolger and Connolly, 1989). Some of the works in LWR include the work by Kingdom (2011) who reported both negative (b = 2.91 and 2.873) for lotic and lentic water bodies in Nigeria. This however, is not saying other authors have not reported isometric and positive allometric growth patterns such as Fafioye and Oluajo (2005) Ibrahim *et al.* (2009), Mansor *et al.,* (2010), Nehemiah *et al*. (2010), Dan-kishiya *et al.* (2013) and Jin *et al*. (2015). Elsewhere in North Africa, El Drawany and Elnagar (2015) studied the growth and feeding habits of *Bagrus bayad* and *B. docmac* species inhabiting Muess Channel, Sharkia Province in Egypt and reported isometric growth pattern. The b values for *B. bayad* and *B. docmac* were reportedly 3.1 and 3.05 respectively. Before this study was undertaken, only scanty information was known regarding *Bagrus bayad macropterus* LWR and condition factor (CF) in Goronyo Reservoir and River Rima, (Malami and Magawata, 2010). It is therefore the aim of this paper to provide an up -to-date information on LWR and CF of *B. bayad* in the two water bodies.

Materials and Methods

Description of the Study Areas

Sokoto State is located between latitudes 4^0 to 6^0 North and $11^0\ 30'\ 13^0\ 50'$ East (Anon, 2002). There are two major seasons in the State, wet and dry seasons. The main annual rainfall ranges from 500mm to 1,300mm from May to October. The dry season is further subdivided into hot dry season of March/April and cold (Hamattan) dry season of November to February, (Armborg, 1988).

Goronyo Reservoir

The reservoir is located on Latitudes $13^0\ 30''$ to $14^0\ 00$ north and Longitudes $5^0\ 30''$ to $6^0\ 00''$ east, (Ita *et al.,* 1982). The reservoir was built on River Rima and has water storage capacity of 942 millions cubic litres of water. It is usually flooded in the rainy season (August – October) and as the months progress, the water level reaches its lowest levels in March/April. The reservoir is fed mainly by tributaries such as River Bunsuru, Gangare etc.

River Rima

River Rima is located between Latitudes 11^0 and 16^0 North and Longitudes 4^0 and 8^0East (Gill, 1974). River Rima has many tributaries, among them are rivers Sokoto, Bunsuru, Zamfara, Ka and Gawon gulbi. The catchment area of the river is elongated in shape and lying along the Northwest alignment covering an area of about $600km^2$ (Mock, 1963).

Sample, Sampling Technique and Sample Size

The fish specimens were obtained from the two water bodies using artisanal fishermen catches. The fishing gears used by the fishermen were mainly clap nets, gill nets and cast nets. Specimens were collected every month for a period of one year (September to October). A total of 570 and 527 specimens were collected from River Rima and Goronyo reservoir respectively (1097). The specimens were transported to the Forestry and Fisheries Laboratory of the Usmanu Danfodiyo University, Sokoto for data collection.

Data Collection

Data on the length weight relationship and condition factor were generated using length and weight measurements of each specimen. Total length (TL), standard length (SL) and fork length (FL) were

measured to the nearest centimetre using graduated measuring board. Total weight (TW) was measured to the nearest gram using an electronic top loading balance (mettle balance with maximum capacity of 16,000 gm).

Length-Weight-Relationship (LWR)

LWR of the fish specimens was determined using the equation described by Bagenal Tesch (1971) and Froese (2006); thus

$W = Al^b$ ..... (1)

Where w = total weight (g)

L = Total length (cm)

a = intercept of the regression

b = slope of the gradient (exponent)

The above curvilinear equation was transformed to a linear relationship using logarithmic transformation; thus

Log w = log a + b log L..... (2)

Condition Factor (CF)

Condition factor (k) was calculated for each fish specimen using the following equation:

$K = \frac{100W}{Lb}$ .....where

W = total weight

L = total length

b = value obtained from LWR

Statistical Analysis

Data were analysed using seasons and sub seasons and descriptive statistics on monthly basis for 12 months using SPSS computer software version 22.

Results

Size Distribution of the Fish Specimens

Table 1 shows the total length distribution of the specimens in River Rima (RR) and Goronyo Reservoir (GR). The values indicated higher means values in GR than those obtained from River Rima. The mean total length and total weight of the specimens from RR and GR ranged from 28.61±7.92 to 35.25±7.89 and 144.63±151.60 to 224.28±154.50 respectively.

Table 1: Total, Standard, Fork lengths and Total Weight of *Bagrus bayad macropterus* Species in River Rima and Goronyo Reservoir

Parameter	Sample size	Min. (cm)	Max. (cm)	Mean+/- SD
Total Length				
River Rima	570	8.20	57.70	28.61±7.92
Goronyo Reservoir	527	21.40	64.00	35.25±7.89
Standard length				
River Rima	570	6.80	40.50	20.62±5.88
Goronyo Reservoir	527	12.20	42.00	24.83±5.38
Fork Length				
River Rima	570	7.50	47.80	22.42±6.22
Goronyo Reservoir	527	15.20	188.30	28.25±15.36
Total Weight				
River Rima	570	3.50	1065.80	144.63±151.60
Goronyo Reservoir	527	32.90	1070.10	224.28±154.50

Source: Field Survey, 2017

Length-Weight-Relationship (LWR)

Table 2 shows the monthly b values of the LWR of *B. bayad* in RR and GR. The b values for specimens from RR ranged from 2.887 in early dry to 3.346 in early rainy, while those from GR ranged from 2.738 in early dry to 3.140 late dry. The results showed higher sub seasonal b values for specimens from RR than those from GR. Table 3 showed the results from the combined analysis for all specimens from the two water bodies and revealed that means b values ranged from 2.782 in early dry sub season to 3.246 in early rainy season. Overall, the mean b value of 2.89 indicated negative allometric growth pattern for all the specimens from the two water bodies.

Table 2: Length Weight Relationship Regression of *Bagrus bayad macropterus* Species from River Rima and Goronyo Reservoir

Season/Sub season	Water Body	Number of Samples	A	b	SE of b	r^2	SE of r^2
Early dry Season	RR	134	-2.138	2.887	0.114	0.923	0.066
	GR	118	-2.139	2.859	0.188	0.862	0.098
Mid dry Season	RR	105	-2.346	3.028	0.100	0.975	0.061
	GR	108	-1.973	2.738	0.164	0.912	0.090
Late dry Season	RR	114	-2.387	3.026	0.164	0.917	0.086
	GR	105	-2.563	3.140	0.158	0.945	0.074
Early rainy Season	RR	99	-2.866	3.346	0.177	0.952	0.076
	GR	90	-2.204	2.916	0.317	0.903	0.076
Flood Season	RR	118	-2.247	2.973	0.062	0.984	0.053
	GR	106	-2.108	2.875	0.137	0.949	0.064
MAIN SEASONS							
Dry Season	RR	313	-2.278	2.979***	0.073	0.973	0.074
	GR	291	-2.189	2.890	0.099	0.905	0.090
Rainy Season	RR	257	-2.227	2.947***	0.059	0.978	0.069
	GR	236	-1.602	2.533	0.195	0.832	0.112
Total Specimens		**1097**					
Overall Means			-2.163	**2.890**	0.039	0.950	0.080
Waterbodies Means	RR	570	-2.238	**2.952**	0.052	0.960	0.070
	GR	527	-2.042	**2.800**	0.091	0.888	0.098

Source: Field Survey, 2017

Monthly Mean Condition Factor (k)

Most of the values of the monthly **k** on the specimens from each water body and the two water bodies combined were significantly ($p < 0.05$) different and is presented in table 4. The highest mean (0.79±11) values were recorded in March for both water bodies while the lowest (0.69±12 and 0.57±11) were in February and May for RR and GR respectively. Using the combined analysis from the two water bodies, the highest k value for the specimens was obtained in September (0.76±0.06) but was not significantly ($p > 0.05$) different from the values in the other months, except in February and May values which were lower.

The sub seasonal mean k values for the specimens were highest (0.75±0.09) in flood season and lowest (0.66±0.13) in RR during late dry season. Similarly, in GR the highest seasonal mean k values ranged from 0.63±0.12 in mid dry season to 0.72±0.15 during flood season. In this regard, results indicated non-significant ($p > 0.05$) difference between main seasons (dry and rainy seasons) mean k values in the two water bodies.

Table 3: Influence of Seasons on the Length Weight Relationship of *Bagrus bayad macropterus* Species from both River Rima and Goronyo Reservoir combined

Seasons	No. of Specimens	A	b	SE of b	r^2	SE of r^2
Early dry Season	252	-2.001	2.782	0.097	0.901	0.082
Mid dry Season	213	-2.066	2.816	0.097	0.942	0.084
Late dry Season	219	-2.450	3.069	0.102	0.940	0.080
Early rainy Season	189	-2.710	3.246	0.153	0.941	0.076
Flood Season	224	-2.200	2.935	0.046	0.985	0.058
Total	1097	-2.163	2.890	0.039	0.950	0.080

Source: Field Survey, 2017

Table 4: The monthly mean Condition Factor (CF) of *Bagrus bayad macropterus* Species in River Rima and Goronyo Reservoir

Water body	October	November	December	January	February	March	April	May	June	July	August	September
RR	0.73 ± 0.13^{bc}	0.73 ± 0.13^{bc}	0.72 ± 0.13^{bc}	0.74 ± 0.09^{bc}	0.69 ± 0.12^{bc}	$0.79\pm0,11^{c}$	0.65 ± 0.07^{ab}	0.57 ± 0.11^{a}	0.69 ± 0.09^{bc}	0.70 ± 0.19^{bc}	0.71 ± 0.08^{bc}	0.76 ± 0.09^{c}
GR	0.73 ± 0.13^{bc}	0.73 ± 13^{bc}	0.72 ± 0.09^{bc}	0.74 ± 0.09^{bc}	0.69 ± 0.12^{bc}	0.79 ± 0.11^{c}	0.65 ± 0.07^{ab}	0.57 ± 0.11^{a}	0.69 ± 0.09^{bc}	0.70 ± 0.19^{bc}	0.71 ± 0.08^{bc}	0.76 ± 0.09^{c}
Combined	0.72 ± 0.15^{bc}	0.69 ± 0.12^{abc}	0.17 ± 0.14^{bc}	0.69 ± 0.13^{abc}	0.65 ± 0.12^{ab}	0.74 ± 0.17^{bc}	0.68 ± 0.11^{abc}	0.61±0.09a	0.71 ± 0.11^{bc}	0.68 ± 0.16^{abc}	0.71 ± 0.15^{bc}	0.76 ± 0.06^{c}
Means (RR)	0.71±0.12											
Means (GR)	0.68±0.14											
Combined Means (RR+GR)	0.69±0.13											

Source: Field Survey, 2017; RR (River Rima), GR (Goronyo Reservoir). Means in a row with similar superscripts are not significantly different ($P > 0.005$) from one another

Table 5: Mean sub seasonal and seasonal condition factors of *Bagrus bayad macropterus* Species in River Rima and Goronyo Reservoir

Water body	Early dry	Mid dry	Late dry	Rainy	Flood	Overall Dry	Overall Rainy
RR	0.73 ± 0.12^{b}	0.72 ± 0.10^{b}	0.66 ± 0.13^{b}	0.69 ± 0.15^{ab}	0.75 ± 0.09^{b}	0.71 ± 0.12^{ns}	0.72 ± 0.12^{ns}
GR	0.67 ± 0.16^{ns}	0.63 ± 0.12^{ns}	0.69±0.13ns	0.69 ± 0.12^{ns}	0.72 ± 0.15^{ns}	0.66 ± 0.14^{a}	0.72 ± 0.14^{b}
RR + GR	0.70 ± 0.13^{ab}	0.68 ± 0.13^{ns}	0.67 ± 0.13^{a}	0.69 ± 0.12^{ab}	0.73 ± 0.11^{ns}	0.73 ± 0.11^{ns}	0.68 ± 0.13^{ns}
Mean RR	0.71±012						
Mean GR	0.65±0.14						
Overall Mean	0.69±0.13						

Source: Filed Survey, 2017; RR (River Rima), GR (Goronyo Reservoir). Means in a row with similar superscripts are not significantly different(P>0.05) from one another

Discussion

The maximum size (total length) reported among the specimens were lower in comparison to the size distribution of *B. bayad* reported by Reed *et al.* (1967) in the catches of fishermen in some water bodies in northern Nigeria. This was probably due to the intense fishing mortality as reported in most of our water bodies (Ita, 1993a; Balogun, 2005). Another factor worth mentioning is the fishing gears used in catching the specimens. Most of the fishermen used many types of small mesh size gillnets. The working principle of this gear portrayed it as a highly selective gear with tendency to catch a particular fish size.

The indiscriminate use of small mesh size gillnets and the unregulated fishing efforts by the artisanal fishermen has depleted most of our water bodies and reduced the catches to smaller catch specimens including River Rima and Goronyo reservoir, (Heikinheimo and Mikkola,2004; Gusau *et al*., 2015). Iran *et al.* (2017) reported small size *Chrysichthys furcatus* specimens which ranged from 16cm to 60cm in Cross River with corresponding weight ranges of 50g to 549g.

All the specimens showed negative allometric growth pattern (b<3.0) for all the seasons and sub seasons as well as the water body. The negative allometric growth pattern indicated that the specimens were growing faster in their non - valuable parts such as fins than in flesh tissues. In other words, the specimens are getting thinner as they were growing. Same findings (b <3.0) regarding negative allometric growth pattern in bagridae were reported by Mansor *et al*., (2010) in Kerian River Basin and Keru Lake, all in Malaysia. Similarly, Waidi (2015) reported negative allometric growth patterns (b = 2.114) for an African silver fish, *Chrysichthys nigrodigitatus* in Ogun State coastal estuary. In this study, influence of specimens and waterbody were insignificant on the growth pattern of the specimens. *Bagrus bayad macropterus* although relatively insectivorous or carnivores in feeding habits exhibited negative allometric growth patterns from both water bodies. This finding was also reported by Beniditto-cecillio *et al.* (1997) in Itaipu reservoir, Parana, Brazil where the authors observed that the mean b values ranged from 2.34 to 3.35 for about 72 fish species. This type of interaction between species and water bodies was reported by Okpasua *et al*. (2016) among bagrids inhabiting the Anambra River Basin. Iran *et al.* (2017) also reported similar findings concerning negative allometric in this regard. The isometric growth pattern exhibited by the specimens in late dry season was an indication of the gonads maturation stages by the sexes. The specimens irrespective of the water body exhibited significant different (p<0.05) b value in early rainy sub season than the other four sub seasons.

Condition factor (CF) is the state of wellbeing of the fish or its welfare status in a water body, in other words; it is a qualitative measure of how fat a given fish is (Barnham and Baxter, 2003). CF also known as Fulton's condition factor, "K", it enables a holistic view or provides a means through which the health of a given fishery is. It enables development of a viable strategy for fisheries conservation and management in the wild and in aquaculture. In the present study, the specimens appeared to have higher

k values in September when compared to other months. This could probably be an indication of the availability of food in the breeding ground due to flood experienced in that part of the State. Most of the specimens were observed to be gravid and well developed gonads in this month. Rose (2006) reported a favourable condition for the fish species in theoretical analysis. The influence of season was clearly manifested during the flood season when most of the specimens had higher values of k. In general, there was no much significant difference between dry and rainy seasons, although the k value was slightly higher in the dry season. The slightly higher k values during the dry season may have arisen due to abundance of fingerlings and juveniles the adults fed on.

The k values of the specimens were slightly higher in RR than GR, although the influence of water body types was not significantly ($p<0.05$) different among the specimens in the two water bodies. This could be due to well aerated (lotic) water in RR than in GR or due to the vast area of Fadama around the length of RR which harbored more food for the specimens than in GR. Similar findings were reported byAlex *et al*., (2012) using sea and fresh waters as culture media.

Conclusion

All the specimens exhibited negative ($b<3.0$) allometric growth pattern irrespective of the water body or seasons, although they were not significantly ($p<0.05$) different. The condition factors were more favourable to most of the specimens in September and in the dry season. The growth coefficients and condition factor (b and k values) for the specimens could be inputs for the development and application of yield and production models for the management of fish production particularly in GR. The b and k could also enable development of a viable strategy for fisheries conservation and management in RR and GR.

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