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Morphometric Relationships and Relative Condition Factor of *Auchenoglanis occidentalis* (Cuvier and Valenciennes) from River Rima, North-Western Nigeria

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Abstract: This study was carried out on *Auchenoglanis occidentalis* (Cuvier and Valenciennes) from River Rima, North-Western Nigeria to provide information on morphometric relationships and relative condition factor. A total of 800 samples of *A. occidentalis* of which 398 were females and 399 males (giving a ratio of about 1:1) were examined between November 2005 and December 2008. Biometric data such as Total Length (TL) and Total Weight (TW) measurements were recorded in the laboratory. The samples ranged in total length from 6.60-33.00 cm with a mean of 19.51±4.50 SD and from 2.26-462.90 g total weight with a mean of 100.05±70.09 SD. For the length-length relationships, the b values were 0.814 for TL-SL; 0.242 for TL-HL; 0.200 for GTH-TL and 0.779 for HL-GTH, suggesting negative allometry or faster increase in Total Length (TL) than in all the other length parameters. The species exhibited isometric growth pattern in the overall samples (b = 3.023), females (3.001), males (3.002), dry season samples (2.969) and those ≥15 cm (3.030). Samples <15 cm exhibited negative allometry (2.851) while those caught during rainy season exhibited positive allometry (b = 3.113). The species were found to be in good condition with an overall Kn value of 2.27±0.08 SD in females and 2.26±0.08 SD in males in the river. In both sexes, samples ≥15 cm were in significantly ($p<0.05$) in better condition than those <15 cm and likewise, samples in the rainy season had higher ($p<0.05$) Kn values than those in the dry season. Based on gonad maturation stages, samples in the mature, ripe and running, spent and resting stages were in significantly ($p<0.05$) better condition than those in the maturing and immature stages.

Key words: *Auchenoglanis occidentalis*, length-length relationship, length-weight relationship, relative condition factor, River Rima, Nigeria

INTRODUCTION

Knowledge of biometric variations is necessary for the description of species (Hajjej *et al*., 2011). Standing stock, yield and biomass most often estimated from length-frequency data converted with length-length and length-weight relationships are useful for standardization of length type when data are summarized (Froese, 1998). Length-length relationships are also important in fisheries management for comparative growth studies.

Length-weight relationships of fishes are most frequently used in the calculation of fish's average weight for a certain length-class and the conversion of an equation of growth in length into an equation of growth in weight, besides morphological comparisons between populations of the same species or between species by Pauly. The mathematical parameters of the relationship between the length and weight of a fish further furnish information on the weight variation of individuals in relation to the length that is condition factor which estimates the general well-being of an individual (Benedito-Cecilio *et al*., 1997). This is frequently used in comparison of two or more co-specific populations living in similar or different conditions of food, density or climate among others, determination of the period and duration of gonadal maturation and observation of the increase or decrease in feeding activity or population changes, possibly due to modifications in food resources (Weatherley and Gill, 1987).

LeCren (1951) observed that the analysis of length and weight data had usually been directed towards two rather different objects. The first being towards describing mathematically the relationship between length and weight so that one may be converted into the other this the researcher referred to as length-weight relationship. The second is to measure the variation from the expected weight for length of individual fish or relevant groups of individuals as indications of fatness, general wellbeing and gonad development. This is termed condition. Many researchers such as Moutopoulos and Stergiou (2002), Simon and Mazlan (2008), Zorica and Sinovcic (2008), Subba *et al.* (2009) and Hajjej *et al.* (2011) have studied

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the length-length and length-weight relationships of various fish species from different waters. King (1996), Letourneur (1998), Anibeze (2000), Shinkafi *et al*. (2002), Abdullah (2002) and Park and Oh (2002) also presented findings on only the aspect of length-weight relationships of many fish species. Others have reported various ranges of condition factors of fishes in Nigeria based on size, sex, maturity stages as well as seasons. These include the researchers of Shinkafi *et al*. (2002), Ikomi and Odum (1998), Anibeze (2000), Ekanem (2000) and Fagade (1983). This study aims to provide information on the length-length, length-weight relationships and relative condition factor of *A. occidentalis* in River Rima.

MATERIALS AND METHODS

Study area: The fish samples were collected from River Rima in Sokoto, North-Western Nigeria. Sokoto lies between longitudes four and 6°5'E and latitudes 12° and 13°58'N (Mamman, 2000). The climate of Sokoto is tropical with much of the rains between June and September while the long dry season is from October and May (Ita *et al*., 1982). River Rima flows in a South-western direction >100 km and joins the major River Sokoto to form the Sokoto-Rima river system. The Sokoto-Rima river flows in a southwestern direction up to Zogirma where, it changes direction and run southwards before emptying into the River Niger. The river is seasonal, usually over flooding its banks during the rainy season in August and September and up to October at times.

Fish samples: Samples were collected on monthly basis for 36 months (November 2005 to December 2008). The samples were examined fresh in the laboratory immediately after collection. On each sample, measurements of total length and (cm) and total weight (g) were taken. A total of 800 of the samples of which 398 were females and 399 males were analyzed giving a ratio of about 1:1.

Data analysis

Length-length relationships: Several studies have shown linear relationships between total length-standard length, total length-fork length and total length-head length of some fish species (Zorica and Sinovcic, 2008; Subba *et al*., 2009; Hajjej *et al*., 2011). As such linear regression analysis was used to compute the equations of these relationships. The linear relationship was represented by the equation (Steel and Torrie, 1980):

$$Y = a + bX$$

Where:
Y = Fish gutted weight (g) or standard length (cm)
X = Fish total weight or total length (cm)
a = Constant
b = Exponent

Length-weight relationship: The relationship between Length (L) and Weight (W) of a fish was calculated by a mathematical curvilinear relation as (Weatherley, 1972; Bagenal and Tesch, 1978):

$$W = aL^b$$

Where:
W = Weight of fish (g)
L = Length of fish (cm)
a = Constant
b = Exponent

Logarithmic transformation of the equation gives a linear relationship as (Bagenal and Tesch, 1978):

$$\text{Log } W = \text{Log } a + b \text{ Log } L$$

The values of a and b are then estimated through least squares regression analysis (Zar, 1984).

Relative condition factor: For calculating relative condition factor or Kn (Weatherley and Rogers, 1978), the equation used was:

$$Kn = \frac{W}{aL^b}$$

Where:
Kn = Relative condition factor
W = Weight (g)
L = Length (cm)
b = Coefficient obtained from LWR
a = Constant

An analysis for the length-length relationships was carried out by regressing each length parameter to total length. For the length-weight relationship and relative condition factor analyses were carried out based on sex, two size classes (<15 cm Total Length (TL) and ≥15 cm TL) and seasons. For the relative condition factor, gonad maturation stages were also used in the analysis.

RESULTS AND DISCUSSION

Sample size: A total of 800 samples were analyzed. The frequencies and proportions of the fish samples based on sex, size class and season are shown in Table 1.

Length-frequency distribution: Figure 1 shows the length-frequency distribution of the fish samples. The highest proportions of *A. occidentalis* samples were found in the range of 17-19 cm while the lowest

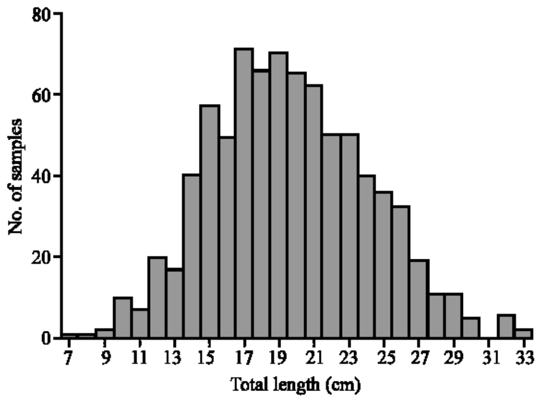

Fig. 1: Length-frequency distribution of *A. occidentalis* samples

Table 1: Frequency distribution of *A. occidentalis* samples in River Rima

Parameters	No. of samples	Proportion (%)
Overall	800	100.0
Sex		
Female	398	49.8
Male	399	49.9
Unidentified	3	0.3
Size class (cm)		
<15	119	14.9
≥15	681	85.1
Seasons		
Dry	269	33.6
Rainy	531	66.4

Table 2: Size distribution of *A. occidentalis* samples based on growth parameters (N = 800)

Parameters	Minimum	Maximum	Mean±SD
Total length (cm)	6.60	33.00	19.51±4.500
Standard length (cm)	5.00	27.00	15.70±3.710
Head length cm)	1.50	9.00	5.31±1.130
Girth (cm)	0.50	6.50	3.33±0.970
Total weight (g)	2.26	463.90	100.05±70.09
Gutted weight (g)	2.08	417.00	92.05±63.27

proportions were those from 7-9 cm range and from 24-33 cm while no sample of 31 cm was found.

Morphometric features: Table 2 shows the values for all the body lengths and weights measured on each species. The maximum Total Length (TL) was 33 cm while the minimum was 6.60 cm with overall mean 19.51±4.50 cm. The Total Weight (TW) ranged from 2.26-463.90 g with a mean value of 100.05±70.09 g. The minimum, maximum, mean and standard deviation values of all the other body dimensions such as Standard Length (SL), Head Length (HL), Girth (GTH) and Gutted Weight (GW) are also shown in the Table 2.

Length-length relationships: The results of the regression analyses of all the length-length relationships are shown in Table 3. For the Total Length (TL)-Standard Length (SL) relationship, the coefficient of the regression equation was close to unity with a b value of 0.814 indicating negative allometry. The negative allometry suggests that the overall increase in total length was slightly faster than increase in the standard length. The coefficient of regression equation for the relationship between Total Length (TL) and Head Length (HL) and girth and total length were 0.242 and 0.200, respectively. The low b values showing negative allometry suggest that the head length and girth grow at a slower rate than the overall total length. The b value of the regression equation for the relationship between head length and girth was 0.751 indicating negative allometry which suggests that the girth increased at a slightly faster rate than the head length. The correlation coefficients in all the length-length relationships were highly significant ($p<0.01$) with r values of almost equal to 1 indicating the close association between each of the two length parameters.

Table 3: Length-length relationships of *A. occidentalis* from River rima

Relationships	a	b	SE of b	r
SL = a+b TL	-0.179	0.814	0.004	0.988
HL = a+b TL	0.598	0.242	0.002	0.960
GTH = a+b TL	0.573	0.200	0.003	0.931
GTH = a+b HL	-0.812	0.779	0.012	0.913

All equations significant ($p<0.01$)

Table 4: Total length-total weight relationship of *A. occidentalis* from River Rima

Parameters	No. of samples	a	b	SE of b	r
Overall	800	-1.973	3.023	0.028	0.968
Sex					
Female	398	-1.939	3.001	0.040	0.967
Male	399	-1.950	3.002	0.040	0.966
Size class (cm)					
<15	119	-1.785	2.851	0.188	0.814
≥15	681	-1.981	3.030	0.034	0.960
Season					
Dry	269	-1.899	2.969	0.056	0.956
Rainy	531	-2.092	3.113	0.031	0.975

All equations highly significant ($p<0.01$); equation: log TW = a+b Log TL

Length-weight relationship: The overall coefficient (b) of the relationship for *A. occidentalis* was 3.023, indicating an isometric growth pattern. Both female and male samples also had b values that indicated isometric growth pattern (b = 3.001 and 3.002, respectively).

In the dry season, b value was indicative of an isometric growth pattern (b = 2.969) but in the rainy season, the b value indicated positive allometric pattern (b = 3.113). Based on size, samples <15 cm indicated a negative allometric pattern (b = 2.851) while the larger samples ≥15 cm had a and b value that is indicating an isometric growth pattern (b = 3.030). In all the cases, the r values showed high correlations between total length and total weight with the highest correlation in the rainy season (r = 0.975) and the least in size class <15 cm (r = 0.814). All regressions were very highly significant ($p<0.01$) (Table 4).

Table 5: Relative condition factor of *A. occidentalis* in River Rima

	Female		Male	
Parameters	No. of samples	Mean±SD	No. of samples	Mean±SD
Overall	398	2.27±0.08	399	2.26±0.08
Seasons				
Dry	138	2.24 ± 0.09^b	116	2.21 ± 0.10^b
Rainy	260	2.28 ± 0.07^a	271	2.28 ± 0.06^a
Size class (cm)				
<15	61	2.14 ± 0.05^b	50	$2.11^b \pm 0.07$
≥15	337	2.29 ± 0.06^a	337	$2.28^a \pm 0.05$
Maturity stage				
Immature	123	2.21 ± 0.08^c	101	2.20 ± 0.10^c
Maturing	77	2.24 ± 0.08^b	102	2.26 ± 0.06^b
Mature	83	2.32 ± 0.05^a	114	2.29 ± 0.05^a
Ripe and running	51	2.31 ± 0.04^a	17	2.30 ± 0.06^a
Spent	52	2.31 ± 0.05^a	45	2.30 ± 0.05^a
Resting	12	2.31 ± 0.09^a	08	2.32 ± 0.05^a

Means in column with same letter are not significantly different ($p<0.05$)

Condition factor: Table 5 shows the relative condition of *A. occidentalis* in River Rima. The overall mean relative condition factor for the females 2.27±0.08 SD while that of males was 2.26±0.08 SD which was significantly ($p<0.05$) lower than that of females.

In both sexes, Kn was higher in the rainy season than in the dry season ($p<0.05$). In both female and male samples, there was significant difference ($p<0.05$) between the condition factor of the small samples <15 cm and the adult ones (≥15 cm) with higher values in the larger samples. Based on gonad maturation in both sexes, samples in the mature, ripe and running, spent and resting stages had significantly ($p<0.01$) higher Kn than those in the immature and maturing stages.

Size distribution of samples: The length-frequency distribution of the two species (Fig. 1) revealed several modes with no marked demarcation between the different modal groups, suggesting that the several modes represent different spawnings, though they may not be representatives of definite year-classes. Similar findings of several modes were reported for *Pellonula afzeliusi* (Balogun, 1987) and *Chrysichthys auratus* (Ikomi and Odum, 1998).

This length-frequency distribution may be used to estimate the age and growth of *A. occidentalis* in River Rima by fitting them into the Von Bertalanffy growth formula in order to assess the stock for the management of their fisheries.

The maximum total length of the samples of in this study was smaller than the maximum lengths of the species reported from other water bodies in Nigeria. This may probably be due to depletion of the stock as a result of over-exploitation by fishermen which is a common phenomenon in Africa, as in many parts of the world due to non-implementation of regulations in River Rima. The difference may also be due to better aquatic conditions in the other reported water bodies which made their stock larger than those of River Rima.

Growth pattern

Length-length relationships: The linear relationships within the length parameters revealed high correlations with coefficient values of close to one. This suggests that increase in total length would lead to increase in length of all the other length variables and thus all the length parameters can easily be predicted from total length using linear regression models. Zorica and Sinovcic (2008) reported similar observations in Sarda Sarda. The b and r values of the total length-standard length relationship were higher than those in the total length-head length and total length-girth relationships indicating that standard length increase faster with total length than does head length and girth with total length. This type of information especially that of girth may enable appropriate mesh sizes and openings to be estimated for fishing gears in the exploitation of the species in the wild. The total length-girth relationship was used by Santos *et al.* (1995) to predict gillnet selectivity in *Pagellus acarne* and *P. erythrinus* in Algarve, Southern Portugal.

Length-weight relationships: Morphometric features were used to establish the growth pattern as well as the significance of the various relationships and their applications in fish production. The relationship between the length and weight of *A. occidentalis* samples indicated that increase in length was more than the corresponding increase in weight in the smaller samples Morphometric features were used to establish the growth pattern as well as the significance of the various relationships and their applications in fish production. The relationship between the length and weight of *A. occidentalis* samples indicated that increase in length was more than the corresponding increase in weight indicating negative allometry (2.851).

As they grow larger, the increase in length corresponded with the increase in weight (b = 3.030) indicating isometry. This change in growth pattern from juvenile to adulthood is as a result of growth rate oscillations which accompany growth after the larval stages during the life span of the species as fish species are known to pass through different stanzas each with its different length-weight relationship (Weatherley, 1972).

Isometric growth pattern was also reported for *Chrysichthys auratus* (Ikomi and Odum, 1998) and for *C. nigrodigitatus* (Fafioye and Oluajo; 2005; Offem *et al.*, 2008).

Condition factor: The results of the relative condition factor (Kn) which was >2 indicated that the species was in good condition in River Rima, meaning that increase in length brought about the proportional increase in weight. Magawata (2008) also reported good condition in about 10 species of fishes from the same water body. Higher Kn values in females than in males may be attributable to heavier weight of gonads in the females.

The higher Kn recorded during the rains may also be due to more food availability and gonadal development. Similar findings were reported for *Heterobranchus longifilis* from Idodo river by Anibeze (2000). Better condition in larger samples than in the smaller ones may be due to better foraging ability and conservation of stored food energy in the adults or possibly due to increasing weight of maturing gonads in the larger samples. Similar findings were reported by Ikomi and Sikoki (2003).

Based on gonad maturation stages, the highest Kn values were obtained in the mature, ripe and running, spent and resting while the lowest were recorded in the immature and maturing stages due to the heavier weight of the gonads in the mature stages. Feeding and metabolic rate are factors known to influence condition factors during reproductive activities. According to Bhatnagar (1963) increase in feeding intensity and reduction in metabolic activity after the release of sexual products in the ripe and running and spent stages leads to accumulation of fats that maintained the high Kn value up to the resting stage while the beginning of gonadal development for the following reproductive cycle after the resting was accompanied by higher metabolic activity and reduction in feeding and these could have led to the lower Kn values in the immature and maturing stages. Similar deductions were made by LeCren (1951), Weatherley (1972) and Mde and Ambrosio (2002). These observations are in conformity with the findings of the present study.

CONCLUSION

The findings of this study on *A. occidentalis* in River Rima revealed that increase in total length would lead to increase in length of all the other length variables in the length-length relationships, growth pattern of this species is isometric and that the species is also in good condition in the river.

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