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Aspects of Growth Pattern and Reproduction of a Population of *Auchenoglanis occidentalis* (Cuvier and Valenciennes, 1840) Reared in Concrete Tank in Sokoto, Nigeria

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Abstract

This study assessed the potentials of *Auchenoglanis occidentalis* for culture. Fifty eight samples of the species (32 females and 26 males) were obtained from River Rima, North-western Nigeria. They were reared in a concrete tank at Teaching and Research Fish Farm, Usmanu Danfodiyo University, Sokoto, from February 2006 to September 2008. Negative allometric growth pattern was established in females (b=2.789) and males (b=2.686). Condition factor was Kn= 2.28±0.05 in females and 2.25±0.05 in males. Four and three gonad maturation stages were found in females and males, respectively. Mean Gonadosomatic Index (GSI) was 1.12±1.18 for females and 0.07±0.04 for males. Mean fecundity was 465.75±285.37, Mean egg size was 1.29±0.22mm. The species could not spawn naturally in the tanks, but gonads reached advanced maturity stages with full grown eggs. The findings indicated the possibility of breeding this species in captivity and its potentials as aquaculture candidate.

Keywords:
Auchenoglanis occidentalis, length-weight relationship, relative condition factor, Gonadosomatic index, Fecundity and Egg Size

Introduction

Catfishes are the fourth most widely cultivated freshwater fish after carp, salmon and tilapia (Etim *et al.*, 1999). Many of them do not readily breed under captivity as they are not able to exhibit their natural spawning behaviour in artificial ponds (Lamai, 1993), as they generally like to spawn in enclosed spaces such as hollow logs (Davy and Chouinard, 1981), thus limiting their culture and mass production.

Auchenoglanis occidentalis is a prominent member of the catfish Family, Claroteidae (Mo, 1991). It is commonly known as the giraffe nosed catfish or *bubu* in Africa and is found in lake and river systems located throughout the continent (Foster and Smith, 2005), inhabiting shallow waters with muddy bottoms (Eccles, 1992). It is very common and among the most fished species in most water bodies of Africa (Quarcoopome *et al.*, 2008; Geerinkx and Vreven, 2013 and Dankwa *et al.*, 2014). It is of considerable commercial importance in Nigeria (Ikongbeh *et al.*, 2014). The species is noted to have ripe and ripening gonads between July and September, generally spawning during the floods and are common from October to December (Olaosebikan and Raji, 1998). It can grow up to 50cm and 4.5kg (Reed *et al.*, 1967). Its flesh is firm and tasty, possessing few spines which make them suitable for all forms of processing.

Several workers have reported on different aspects of the biology of this species from Nigeria in recent times due to its prominence and commercial importance. These include the works of Ogbe *et al.* (2003), Onimisi *et al.* (2009), Ibrahim *et al.* (2009),Shinkafi and Ipinjolu (2010), Shinkafi *et al.* (2011)Shinkafi and Ipinjolu (2012), Ibrahim (2012), Dan-Kishiya *et al.* (2012), Ikongbeh *et al.* (2013), Abalaka (2015), Chukwuemeka *et al.* (2015), Okpasuo *et al.* (2016), Ihie *et al.* (2018) and Nazeef *et al.*(2018). Despite these, there is limited information on the breeding and survival of *A. occidentalis* under captive condition. Though, there were reports of successful spawning of a member of the species family (*Chrysichthys nigrodigitatus*) in captivity in Togo and Nigeria (Bardach *et al.* 1972), which is a pointer that *A. occidentalis* can be manipulated to breed under captivity by simulating their natural environment.

This study is therefore aimed at determining some aspects of the growth and reproductive biology of *A. Occidentalis reared* in concrete tank in Sokoto, Northwestern Nigeria with a view to bridging the gap in knowledge.

Materials and Methods

Study Area

Samples of *A. occidentalis* were collected from River Rima in Sokoto, North-western Nigeria. Sokoto lies between longitudes 4°8'E and 6°5'E, and latitudes 12°N and 13°58'N (Mamman, 2000). The climate of Sokoto is tropical continental, with much of the rains between June and September, while the long dry season is from October and May (Ita *et al.*, 1982).

Fish samples

Fifty eight samples of *A. occidentalis* were collected in February 2006 from fishermen fishing with Malian and Nduruttu traps, cast net and seine net, at various landing sites of River Rima. Samples were conveyed to the concrete tanks (Dimension 5m x 6m x 1m) using two 50litre jerry cans whose top was cut out, partially filled with water from the river. The fish were acclimatized and then slowly released into the tank. A week later, the tank was partially drained early in the morning and measurements of length and weight and external observations of the genitalia of the samples were carried out. At the end of the culture period (September, 2008) growth and reproductive indices were taken.

Feeding of Cultured Fishes

The fish were fed artificially formulated diet composed of a mixture of vegetable and animal feed stuff, supplemented with vitamins and minerals. The diet was compounded to 35% protein level and 3,000 ME Kcal/Kg found suitable for culture of *Clarias gariepinus* (FAO, 1996), as *A. occidentalis* is also a catfish. They were fed twice daily (7am and 7pm) by estimating the quantity of feed which was in the form of sinking pellets and broadcasting it in the tank.

Water Supply and Maintenance

Water supply to the tank was from untreated borehole and the tanks were designed to maintain flow-through system. The water quality parameters monitored included dissolved oxygen, Hydrogen Ion concentration, Conductivity, Total Alkalinity and Temperature. Water was partially drained and refilled bi-weekly, and occasionally on a weekly basis (Davy and Chouinard, 1981).

Measurements and Data Collection

All the samples were sacrificed after being maintained for two and a half years. Measurements of lengths (in cm), weights (in g) were taken. Observations were carried out on the external genitalia for sex identification. The samples were then dissected and gonads detached from the viscera and weighed. The weighed gonads which were in pairs were then separated and the length and width of each gonad measured to the nearest centimetre.

A six-stage maturity scale based on macroscopic characteristics (White *et al.,* 1998) was used to classify the gonads. Features examined to identify the maturity stages were the degree of opacity of the gonads, consistency and vascularization, oocytes or sperm visibility and overall coloration of the gonads.

Fecundity was determined by preserving the ovaries of stage III in Gilson's fluid and left for at least 24 hours to be liberated from ovarian tissues after which the eggs were washed with 70% alcohol (Bagenal, 1978). The fully liberated eggs were then counted by gravimetric sub-sampling (wet method) after McGregor (1922) as described by Bagenal (1978).

Twenty eggs from each ovary were picked at random, and the diameter of the oocytes was measured using a calibrated micrometer mounted on the eyepiece of a monocular microscope (1 division = 0.05mm). From this, the size of oocytes for each ovary was then estimated.

Gonadosomatic Index (GSI) was determined by using the formula:

$$GSI = \frac{\text{Weight of gonad}}{\text{Body weight}} \times 100$$ (Gabr *et al.*, 1998).

Length-weight relationships

The relationship between length (L) and weight (W) of a fish was calculated by a mathematical curvilinear relation as:

$$W = aL^b$$ (Weatherly, 1972; Bagenal and Tesch, 1978)

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:

$$\text{Log } W = \text{Log } a + b \text{ Log } L$$ (Bagenal and Tesch, 1978).

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

Relative condition factor

For calculating relative condition factor or Kn (Weatherly 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 and a = Constant.

Analysis for the length–length relationships and the length-weight relationships were carried out based on sex while that of relative condition factor was based on sex and gonad maturation stages.

Statistical analysis

Descriptive statistics was employed to determine the minimum, maximum and means of the three reproduction parameters namely, GSI, Fecundity and Egg size being studied. SPSS statistical computer package version 11 was employed for the descriptive statistics of the morphometric features and gonad dimensions, while DMRT at 95% was employed to separate the means.

Results

A total of 38 samples of which 19 were females and 19 males were analysed in this study
The body lengths and weights of samples are presented in Table 1. The minimum total length was 15.00cm, while the maximum was 29.90cm with an overall mean of 19.69±3.49. The total weight ranged from 37.20g to 273.80g with a mean of 88.44±49.33g.

Table 1: Morphometric features of concrete tank reared *Auchenoglanis occidentalis* (N=38)

Parameter	Minimum	Maximum	Mean	SD
Total length(cm)	15.00	29.90	19.69	3.49
Standard length(cm)	12.00	24.50	16.08	2.88
Head length cm)	3.50	8.50	5.39	1.01
Girth (cm)	2.50	5.50	3.47	0.65
Total weight (g)	37.20	273.80	88.44	49.33
Gutted weight (g)	35.20	259.50	82.91	46.78

Table 2: Length- weight relationships of concrete tank reared *Auchenoglanis occidentalis*

Equation	Sex	No. of samples	a	b	SE of b	r
Log TW = a + b Log TL	Overall	38	-1.578	2.699	0.079	0.985
	Female	19	-1.706	2.789	0.121	0.984
	Male	19	-1.553	2.686	0.105	0.987
Log GW = a + b Log TL	Overall	38	-1.596	2.690	0.082	0.984
	Female	19	-1.770	2.816	0.121	0.985
	Male	19	-1.495	2.619	0.111	0.985
Log TW = a + b Log SL	Overall	38	-1.277	2.646	0.092	0.979
	Female	19	-1.463	2.789	0.128	0983
	Male	19	-1.168	2.561	0.141	0.975
Log GW = a + b Log SL	Overall	38	-1.292	2.635	0.096	0.977
	Female	19	-1.529	2.821	0.124	0.984
	Male	19	-1.107	2.486	0.154	0.969
Log TW = a + b Log HL	Overall	38	0.108	2.469	0.129	0.954
	Female	19	0.023	2.582	0.188	0.958
	Male	19	0.218	2.313	0.198	0.943
Log GW = a + b Log HL	Overall	38	0.086	2.459	0.130	0.953
	Female	19	-0.017	2.599	0.196	0.955
	Male	19	0.224	2.264	0.190	0.945
Log TW = a + b Log GTH	Overall	38	0.682	2.278	0.188	0.896
	Female	19	0.597	2.422	0.360	0.853
	Male	19	0.742	2.169	0.177	0.948
Log W = a + b Log GTH	Overall	38	0.660	2.267	0.190	0.894
	Female	19	0.550	2.455	0.360	0.856
	Male	19	0.746	2.107	0.181	0.943

All equations significant (P<0.01)

The length-weight relationships of pond reared samples of *A. occidentalis* are presented in Table 2. The overall regression coefficients (b) of the total length–total weight relationship was 2.699, indicating negative allometric growth pattern. In female and male samples, the b values were 2.789 and 2.686, respectively, both indicating negative allometric pattern.

Table 3 presents the results of the relative condition factor (Kn) of the samples based on sex and gonad maturation stages. The overall mean Kn for female was 2.28±0.05, which was only slightly higher than that of the male, with mean value of 2.26±0.05. In females, the highest Kn value was obtained in the atretic stage or stage VII (that is when the eggs that could not be released in the pond are being reabsorbed by the body) which was significantly higher than those of the other stages. For males, highest Kn was in the mature stage, but was not significantly higher than those of the other stages.

Table 3: Relative condition factor of concrete tank reared *Auchenoglanis occidentalis*

Parameter	Female			Male		
	No. of samples	Mean	SD	No. of samples	Mean	SD
Overall	19	2.28	0.05	19	2.26	0.04
Maturity stage						
Immature(I)	01	2.24^{c}	-	07	2.25	0.06
Maturing (II)	11	2.27^{b}	0.04	09	2.26	0.03
Mature(III)	04	2.27^{b}	0.04	03	2.27	0.06
Atretic(VII)	03	2.36^{a}	0.03	-	-	-

Means in column with same letter were not significantly different (P>0.05).

The means and standard deviations of the gonad weight, left gonad length, left gonad width, right gonad length and right gonad width for the female and male pond reared samples are presented in Table 4. In females, only immature, maturing, mature and atretic stages were found. The eggs matured but could not be released in the ponds, thus, the mature eggs became a dark, hard mass and that stage was labelled as the atretic stage. The stages obtained for the males were immature, maturing and mature. The ovaries were heavier, longer and wider than testes. Based on the gonad maturation stages obtained, in female samples gonads were significantly (P<0.05) heavier and larger in the mature stage (2.73g), followed by the atretic in the stage (1.10g), and were smallest in the immature stage (0.06g). The testes were significantly (P<0.05) heavier and larger in mature stage (0.10g), followed by the maturing stage (0.07g), while they were smallest in the immature stage (0.02g).

Table 4: Gonad dimensions based on maturation stages of concrete tank reared *A. occidentalis*

Parameter	Ovary			Testis		
	No. of samples	Mean	SD	No. of samples	Mean	SD
a. Gonad weight (g)						
Overall	19	1.04a	1.22	19	0.05[b]	0.04
Gonad maturation stage						
Immature	01	0.06[d]	-	07	0.02[c]	0.01
Maturing	11	0.49[c]	0.22	09	0.07[b]	0.03
Mature	04	2.73[a]	1.85	03	0.10[a]	0.01
Atretic	03	1.10[b]	0.46	-	-	-
b. Left gonad length (cm)						
Overall	19	4.03[a]	0.62	19	2.97[b]	0.74
Gonad maturation stage						
Immature	01	3.30[c]	-	07	2.47[b]	0.14
Maturing	11	4.04[b]	0.39	09	2.53[b]	0.06
Mature	04	4.80[a]	0.44	03	3.81[a]	0.55
Atretic	03	4.50a	0.54	-	-	-
c. Left gonad width (cm)						
Overall	19	0.56[a]	0.23	19	0.21[b]	0.08
Gonad maturation stage						
Immature	01	0.20[b]	-	07	0.17	0.08
Maturing	11	0.45[b]	0.14	09	0.21	0.08
Mature	04	0.80[a]	0.14	03	0.27	006
Atretic	03	0.77[a]	0.21	-	-	-
d. Right gonad length (cm)						
Overall	19	3.93[a]	0.75	19	2.95[b]	0.76
Gonad maturation stage						
Immature	01	2.88[c]	-	07	2.37[b]	0.14
Maturing	11	4.04[b]	0.39	09	2.47[b]	0.32
Mature	04	4.73[a]	0.49	03	3.81[a]	0.56
Atretic	03	4.50[a]	0.63	-	-	-
e. Right gonad width © m)						
Overall	19	0.56[a]	0.23	19	0.21[b]	0.08
Gonad maturation stage						
Immature	01	0.20[b]	-	07	0.17	0.08
Maturing	11	0.45[b]	0.14	09	0.21	0.08
Mature	04	0.80[a]	0.14	03	0.27	006
Atretic	03	0.77[a]	0.21	-	-	-

Means in column with same letter were not significantly different (P>0.05).

Gonadosomatic Index (GSI) of female samples ranged from 0.01 to 4.57%, while that of males ranged from 0.01 to 0.13%. The mean values of GSI for the females and males are presented in Table 5. Female samples had higher GSI than males. In both sexes, GSI values of mature stage of gonad maturation were significantly (P<0.05) higher than those of the other stages, while the lowest GSI values were found in the immature stage.

Table 5: Gonadosomatic index (%) of concrete tank reared *A. occidentalis*

Parameter	Female			Male		
	No. of samples	Mean	SD	No. of samples	Mean	SD
Overall	19	1.12^{a}	1.18	19	0.07^{b}	0.04
Maturing (II)	11	0.66^{b}	0.35	09	0.09^{b}	0.03
Mature(III)	04	3.09^{a}	1.16	03	0.12^{a}	0.01
Atretic(VII)	03	0.51^{b}	0.07	-	-	-

Of the 19 females analysed, only 4 were fecund and all were in the mature stage. Smallest female with eggs numbering 175 measured 17.00cmTL, 53.90gTW and had 1.60gGNWT. Largest female with the highest number of eggs (736) measured 21.50cmTL and 118gTW with 5.40gGNWT. The smallest eggs of 1.00mm were found in females that measured 19.50cmTL, 80.60gTW, and 1.40g GNWT, while largest eggs of 1.50mm were found in females of 21.50cmTL, 118.20gTW and 5.40g GNWT.

Table 6 shows the range, means and standard deviations of fecundity and egg size of the samples. The mean number of eggs was 465.75±285.37SD and mean egg size was 1.29±0.22SD.

Table 6: Fecundity and egg size of concrete tank reared *A. occidentalis* (N=4)

Parameter	Minimum	Maximum	Mean	SD
Fecundity	175	736	465.75	285.37
Egg size(mm)	1.00	1.50	1.29	0.22

Discussion

The size of the samples of *A. occidentalis* used in this study ranged from 15-29.9cm TL and 37.2-273.8g TW, which were almost the same with those reported in many studies (Olaosebikan and Raji, 1998; Reed *et al.*, 1967; Shinkafi and Ipinjolu, 2012; Dan-Kishiya *et al,.* 2012; Abalaka, 2015 and Chukwuemeka *et al.,* 2015).

Growth pattern observed in all samples in this study was negatively allometric (b=2.699) as opposed to isometric pattern (b=3.023) in the wild samples of the species from River Rima (Shinkafi and Ipinjolu, 2010). Negative allometry was also reported by Ikongbeh *et al.* (2013) and Okpasuo *et al.* (2016), while Onimisi and Oniye (2010) and Ibrahim (2012) reported positive allometry for the species from other water bodies in Nigeria.

Samples of this study were found to be in very good condition with mean Kn value of 2.28± 0.05 in females and 2.26± 0.04 in males, which was almost the same with those of samples from River Rima (Shinkafi and Ipinjolu, 2010) even though lower. However, lower values of K for *A. occidentalis* were obtained from natural water bodies in Nigeria (Ibrahim, 2012; Ikongbeh *et al.*, 2013 and Nazeef *et al.,*2018).

The gonads of both sexes in this species were almost similar in size to those of wild samples of the species as reported by Shinkafi *et al*., (2011). Based on macroscopic observations, four stages of gonad maturation were established for the species. Tsadu *et al.* (2014) also reported four gonad maturation stages in *Bagrus bayad macropterus* cultured in earthen ponds.

The GSI values were highest in the mature stage than in all the other stages. These results may therefore be useful in knowing the right time to intervene through hypophysation (Mylonas *et al.* 1995), so as to breed the species in the pond, as it is now suspected that they will not spawn naturally in captivity. Comparison of the results of GSI values in the mature stages in the pond with those of the wild samples showed that GSI values were higher in the wild samples (Shinkafi and Ipinjolu, 2012). This may be an indication that gonad development in the pond was affected by lack of a fully conducive environment for reproduction. In the same vein, fecundity of the pond samples was lower and the eggs smaller, than in the samples from the wild (Shinkafi and Ipinjolu, 2012). This may be due to better condition in the wild than in the concrete tanks, as variation in fecundity and egg size within a given species of the same size may be as a result of differences in condition factor (Kjesbu *et al*., 1991), or environment (Murua *et al*., 2003; Idowu *et al.,* 2017). Presence of different sizes of eggs in *A. occidentalis* suggests multiple spawning (Ayoade, 2009; Idowu, 2017).

Presence of atretic ovaries in the pond samples even after simulation of the natural environment by providing nesting materials during the breeding period showed that the species will not spawn naturally in captive condition. They may however be amenable to artificial breeding such as hypophysation. Therefore, hormonal treatment may be investigated, while researching on other ways of spawning naturally. Use of hormones as already carried out with great success in other species like *Clarias gariepinus* (De Graaf and Janssen, 1996) should be considered, as it may make them to spawn in the concrete tanks.

Research in this direction is important in order to promote their production in captivity, and to complement the natural stock, considering the status of the species as a good table fish and also a candidate in the aquarium industry (www.scotcat.com).

Conclusion

The overall LWR of the fish population of *A. occidentalis* reared in concrete tank in Sokoto exhibited negative allometry (*b*=2.699), same applied for the females (b=2.789) and males (b=2.686). The fish were in good condition with *Kn* values of 2.28±0.05SD in females and 2.26±0.04SD for males.

The overall mean GSI values were 1.12±1.18SD in females and 0.07±0.04SD in males. The mean fecundity was 265.75±285.37SD, while mean egg size was 1.29 ±0.22SD.

This study provides baseline information on some aspects of growth and reproduction of *A. occidentalis* reared for two and a half years in concrete tank. These are important parameters for stock assessment and understanding of the population dynamics, which could be used to promote the culture of the species.

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