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Gonadosomatic Index, Fecundity and Egg Size of *Auchenoglanis occidentalis* (Cuvier and Valenciennes) in River Rima, North-Western Nigeria

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ABSTRACT: Study was carried out on *Auchenoglanis occidentalis* from River Rima, North-Western Nigeria to provide information on gonadosomatic index, fecundity and egg size. Eight hundred samples of the fish (398 females, 399 males and 3 with unidentified sexes were examined between November 2005 and December 2008. GSI, fecundity and diameter of the eggs were analysed. Linear regression analysis was used to determine the relationship between GSI, fecundity and egg size with total length (TL), total weight (TW), gonad weight (GW) and gonad maturation stages (MS). Six stages of gonad maturation were established. Mean gonadosomatic index (GSI) for female and males were 2.01±2.75SD and 0.17±0.32SD, respectively. It varied with sex, size class and gonad maturation stage, and exhibited significant ($P<0.05$) correlation with fish TL, TW and MS in females but not in males. Mean fecundity was 2834.45±2530.87SD and it correlated significantly ($P<0.05$) with GW, MS and inversely with egg diameter but not with TL and TW. Mean egg size was 1.31±0.33mm. It correlated significantly ($P<0.05$) with TL, TW and GW but not with MS. Egg size distribution was bimodal, with different sizes of egg in ovaries indicating multiple spawning. This study provided baseline information on some aspects of reproduction which is important in the management of *A. occidentalis* in River Rima.
Keywords: Gonadosomatic index, fecundity, egg size, *A. occidentalis*

INTRODUCTION

Auchenoglanis occidentalis, commonly known as the giraffe nosed catfish; "bubu" around Africa comes from lake and river systems located throughout Africa (Foster and Smith, 2005). *Auchenoglanis occidentalis* belong to the Family Claroteidae, which are separated from Bagridae after a detailed osteological and phylogenetical study by Mo (1991), thus splitting the Bagridae into three families namely, Bagridae, Claroteidae and Auchenoglanididae. The family *Claroteidae* is further classified into 2 sub-families Claroteinae and Auchenoglanidinae, to which *A. occidentalis* belongs. However, the monophyly of the family is sometimes contested (Otero *et al*., 2007). Most species were noted to have ripe and ripening gonads between July and September and thus, they generally spawn during the floods (Reed *et al.*, 1967).

In order to formulate any rational management policy for a fishery, the biology of reproduction must be understood. Comprehensive knowledge of reproduction of fish populations is important for increased fish productions in natural waters and in aquaculture. Knowledge of the fecundity of fishes is important for the comprehension of their life history (King, 1997). Fecundity assessments have been useful in racial distinction, progeny survival studies, stock evaluation and aquaculture-based induced spawning and egg incubation (Bagenal, 1978; Marcus, 1982; Coates, 1988). Colour, shape and size of eggs are also important parameters used in reproduction studies to characterize fish species and can also be used to predict the spawning frequency of fish (Wootton, 1979). Gonadosomatic index (GSI) is one of the parameters used in reproduction studies of fish. The use of GSI to detect hydrated ovaries and therefore detect reproductive period from increase in weight has been established by Hunter and Macewicz (2001).

Several workers have reported on the GSI, fecundity and egg size of different fish species from Nigerian waters and these include Ikomi (1996); King (1996 and 1997); Ikomi and Odum (1998); Shinkafi *et al*. (2002); Saliu and Fagade (2003); Anene and Okorie (2008) and Fawole and Arawomo (2009). However, none of these researches was on *A. occidentalis.* This study is therefore aimed at determining some aspects of reproduction, namely GSI, fecundity and egg size of *A. occidentalis* in River Rima, northwestern Nigeria, with a view of bridging the gap in knowledge and providing scientific information for enhancing its management.

MATERIALS AND METHODS

Study Area

The fish samples 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).

River Rima flows in a south-western direction over 100km 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 (Mock, 1963).

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 (in cm) and total weight (in g) were taken. The sex of each specimen was identified firstly by visual examination and later confirmed after dissection and examination of the gonads.

The gonads were detached from the other visceral organs and weighed. The weighted gonads, which were in pairs, were then separated and the length and width of each gonad measured to the nearest centimeter. 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 stages III to V 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). Eggs from each jar containing the clean eggs of an ovary were weighed after removing excess water on filter paper. A small portion of the eggs was weighed and counted. From this, the number of eggs in a whole ovary was extrapolated.

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

Gonadosomatic index (GSI) was determined by using the equation 1(Howaida *et al*., 1998).

$$GSI = \frac{\text{Weight of gonad}}{\text{Bodyweight}} \times 100 \qquad (1)$$

Statistical Analysis

Regression analysis was used to determine the following relationships:

1) Fecundity (F) with total length (TL), total weight (TW), gonad weight (GW), gonad maturation stage (MS) and egg size (ES);
2) Egg size (ES) with total length (TL), total weight (TW), gonad weight (GW) and gonad maturation stage (MS);
3) GSI with total length (TL), total weight (TW) and gonad maturation stage (MS);

The formula $Y = a + bX$ (Steel and Tourrie, 1980) and the curve described by the formula $Y = aX^b$

Where:
X= total length (TL), total weight (TW), gonad weight (GW), and gonad maturation stage (MS)
Y= Fecundity (F), Egg size (ES) and GSI.

RESULTS

Fish samples

A total of 800 of the samples, of which 398 were females and 399 males were analyzed, giving a ratio of about 1:1. The samples ranged in total length from 6.60 to 33.00cm with a mean of 19.51 ± 4.50 SD, and from 2.26 to 462.90g total weight with a mean of 100.05 ± 70.09 SD. Six stages of gonad maturation were established for both sexes of the species namely, immature (I), maturing (II), mature (III), ripe and running (IV), spent (V) and resting (VI).

Gonadosomatic Index (GSI)

Mean GSI values of *A. occidentalis* based on sex, size class and gonad maturation stage are presented in Table 1. In females, the value was 2.01±2.75SD and

0.17±0.32SD in males, thus, mean GSI of females was significantly higher (P<0.05) than that of males. In both sexes, there was no significant difference (P>0.05) between the GSI of small sizes (<15cm) and that of larger ones (≥15cm). In females, the highest GSI value was obtained in the mature stage, which was significantly higher than those of other stages. This was followed by the ripe and running stage, while the least GSI values were obtained in the immature and resting stages. All these differences were significant.

Relationships of GSI with Other Growth and Reproductive Parameters

Table 2 shows the regression values of GSI with TL, TW and MS in both sexes. The r values of these three relationships indicated low but significant correlation (P<0.05) between GSI with TL, TW and MS in females, while r was not significant (P>0.05) in males. For both sexes, the r values suggested highest correlation between GSI and TW, followed by GSI and TL, while the lowest correlation was with higher significant correlation in females were revealed, while in males, the r values were not significant (P>0.05) except for the GSI with gonad maturation stages where P<0.05. For both sexes, the r values indicated highest correlation between GSI and gonad maturation stage, followed by GSI and TW, while the lowest correlation was between GSI and TL.

Fecundity

Table 3 shows the values of fecundity and egg size. Of the total number of 398 females analyzed, 109 (27.39%) were fecund. The smallest fecund female with 1,366 eggs measured 15.00cm in total length, 45.52g total weight and had a gonad weight of 3.78g. The largest fecund female with 2,668 eggs measured 32.50cm total length, 370.85g total weight with gonad weight of 13.33g. Smallest number of eggs (443) in mature stage was found in a sample with 26.50cm total length, 220.10g total weight, and 14.60g gonad weight. The largest number of eggs (11,442) was found in a female measuring 30cm total length, 30l.62g total weight and gonad weight of 4.62g. This shows that the largest number of eggs was not found in the largest female, nor was the smallest number of eggs found in the smallest female.

Egg Size

The smallest size of eggs in mature stage measuring 0.60mm in diameter was recorded from a fish sample that measured 18.90cm total length, 84.23g total weight, 4.02g gonad weight and 6,256 numbers of eggs. The largest eggs in mature stage measuring 2.50mm in diameter were recorded in a fish had 26.50cm total length, 220.10g total weight, 14.60g gonad weight and 443 number of eggs. The range of fecundity and eggs size based on the two gonad maturation stages, that is mature and ripe and running stages are presented in Table 3.

Egg Size Distribution

Figures 1 and 2 show the egg size distribution in the mature and ripe and running stages of *A. occidentalis* respectively. Egg size distribution was bimodal and varied in each gonad stage. In the mature stage, the oocytes ranged from 0.70mm to 1.75mm. The highest proportions of the eggs were in the 1.30mm diameter (above 12%), followed by the 1.05mm (about 8%). The largest eggs of about 1.60mm and above were lowest in proportion (<4%) as shown in Figure 1. In the ripe and running stage (Figure 2), bimodal distribution was also evident and the oocytes ranged from 0.60mm to 1.50mm in diameter. The highest proportions (above 5%), were in the 0.90mm and 1.20mm sizes. The largest eggs of this stage were the 1.50mm diameter (3%), while the smallest eggs were the 0.60mm and were above 3% in proportion (Figure 2).

Relationships of Fecundity and Egg Size with Some Growth and Reproductive Parameters

The regression equations of fecundity and egg size with total length (TL), total weight (TW), gonad weight (GW), gonad maturation stage (GW), and egg size (ES) are presented in Table 4. The relationships of fecundity with GW, MS and ES were significant (P<0.05), while those between fecundity and TL and TW were not significant (P>0.05). In all the cases, there were low correlations between fecundity and the parameters. The correlation between fecundity and egg size was negative (r = -0.290), suggesting decrease in egg size with increase in egg number. Highest correlation was between fecundity and gonad maturation stage; the correlation between fecundity and total weight (r=0.040) was higher than that between fecundity and total length (r=0.006).

Table 1: Gonadosomatic index (%) of *A. occidentalis* in River Rima, Nigeria

	Female			Male		
Parameter	**No. of samples**	**Mean**	**SD**	**No. of samples**	**Mean**	**SD**
Overall Sex	376	2.01	2.75	382	0.17	0.32
Size class <10 (cm)						
Immature	30	0.20[b]	0.22	39	0.09	0.07
Maturing	20	0.57[a]	0.46	08	0.20	0.21
Mature			-	01	0.30	-
Ripe and running	-	-	-	-	-	-
Spent	-	-	-	01	0.17	-
Resting	01	0.03[c]	-	-	-	-
Sub-total	51	-	-	49	-	-
Size class ≥10 (cm)						
Immature	71	0.26[c]	0.18	38	0.11	0.15
Maturing	57	0.66[c]	0.72	94	0.13	0.08
Mature	83	5.47[a]	2.57	113	0.28	0.53
Ripe and running	51	4.25[b]	2.56	17	0.17	0.14
Spent	52	0.22[c]	0.18	43	0.09	0.18
Resting	11	0.09[c]	0.08	08	0.03	0.02
Sub-total	325	-	-	333	-	-

Means in column with same superscripts are not significantly different (P>0.05).

Table 2: Relationships of GSI with somegrowth and reproductive parameters of *A. occidentalis* in River Rima, Nigeria

Relationship	**No. of samples**	**a**	**b**	**SE of b**	**r**	**Test of b**
In Female						
GSI = a + b TL	376	-0.985	0.150	0.030	0.248	*S
GSI = a + b TW	376	0.967	0.001	0.002	0.265	*S
GSI = a + b MS	376	0.938	0.388	0.093	0.210	*S
In Male						
GSI = a + b TL	382	0.090	0.004	0.004	0.052	NS
GSI = a + b TW	382	0.140	0.000	0.000	0.056	NS
GSI = a + b MS	382	0.144	0.009	0.012	0.038	NS

*S= Significant (P<0.05); NS = Not Significant (P>0.05)
GSI=Gonadosomatic index; TL= Total length (cm); TW=Total weight (g); and MS= Gonad maturation stage.

Table 3: Fecundity and egg size of *A. occidentalis* from River Rima, Nigeria

Parameter	**MS**	**No. of samples**	**Minimum**	**Maximum**	**Mean**	**SD**
Fecundity	III	62	443	11,.442	3334.50	2476.28
	IV	47	327	9,152	2174.81	2474.96
	Total	109	327	11,442	2834.45	2530.87
Egg size(mm)	III	62	0.60	2.50	1.38	0.33
	IV	47	0.70	1.85	1.23	0.30
	Total	109	0.60	2.50	1.31	0.33

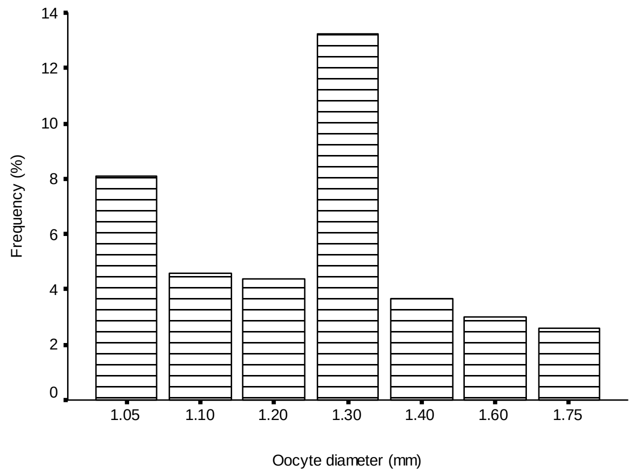

Figure1: Egg Size Distribution in the Mature Stage of *A. Occidentalis*

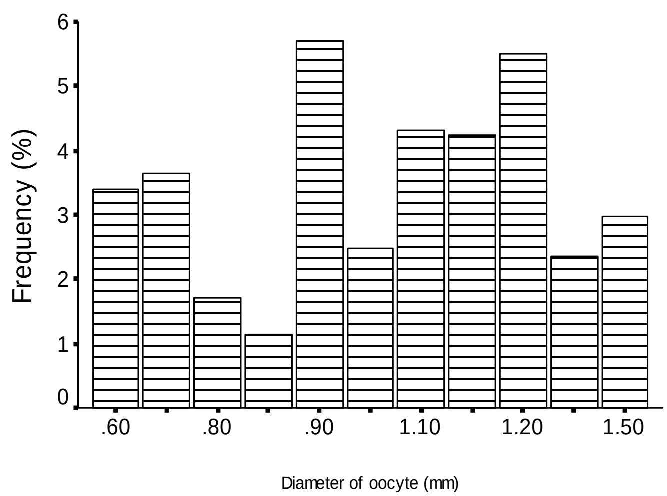

Figure 2: Egg Size Distribution in the Ripe and Running Stage of *A. occidentalis*

Table 4: Relationships of fecundity and egg size with other growth and reproductiv parameters of *A. occidentalis* in River Rima, Nigeria

Relationship	No. of samples	a	b	SE of b	r	Test of b
Fecundity						
Log F= a + b Log TL	109	-3.324	0.003	0.542	0.006	NS
Log F= a + b Log TW	109	-3.110	0.004	0.194	0.040	NS
Log F= a + b Log GW	109	3.097	0.254	0.089	0.265	*S
F= a + b MS	109	6813.574	-1159.691	478.816	0.228	*S
F= a + b ES	109	5796.643	-2251.597	719.606	-0.290	*S
Egg Size						
ES=a + b TL	109	0.934	0.003	0.024	0.319	*S
ES= a + b TW	109	0.934	-0.000	0.001	-0.479	*S
ES= a + b GW	109	0.934	0.003	0.008	0.525	*S
ES= a + b MS	109	0.934	-0.005	0.062	-0.074	NS

*S = Significant (P<0.05); NS = Not Significant (P>0.05) ES= Egg size (mm); TL= Total length (cm); TW = Total weight (g); GNWT= Gonad weight (g); and MS= Gonad maturation stage.

DISCUSSION

Gonadosomatic Index

The GSI values obtained in this study showed that females had higher GSI values than males in all the six stages of gonad maturation. This was associated with the heavier weight of ovaries which contained the eggs. Highest GSI values in the mature stage in both sexes of this species was due to the increase in gonad weight at that stage, compared to the other stages of gonad development. GSI was also observed to be higher in the rainy season than in the dry season, thus, further confirming that breeding and spawning in these species takes place during the rainy season, and that the reproductive cycle is annual as reported by Laleye *et al*. (2006), Araoye (1999) and Offem *et al.* (2008). Gonadosomatic index was found to be independent of the size of fish, as the smaller samples of the species in this study had developing gonads and were thus, already engaged in reproductive activity. However, Ikomi (1996) and Saliu and Fagade (2003) reported higher GSI values in larger samples of *Brienomyrus longianalis* in upper Warri River and *Brycinnus longipinnis* in Asa reservoir, respectively, and attributed the higher GSI in the larger samples to the heavier weight of their gonads. GSI was found to have significant correlations with total length, total weight and gonad maturation stage in females, but not in males. This may be due to the heavier weight of the female gonads.

Fecundity

The absolute fecundity ranged from 327 to 11,442. No report on the fecundity of *A. occidentalis* from other places was available for comparison with that of the present study. There are wide variations in the number of eggs, with larger samples producing more eggs than the smaller ones, even though the highest number of eggs was not found in the largest fish, nor was the lowest number of eggs found in the smallest fish. Fish species are known to exhibit wide variations in fecundity, even among individuals of the same species, size and range (Bagenal, 1957), which may be due to differential feeding success within the members of population prior to spawning (Bagenal, 1978) and probably due to release of the eggs in batches as evidenced by the large number and variation in size of eggs in the ripe and running stages (Figure 2). As such, some individuals of the same size that were caught at the same time were found to have wide range of fecundity. This may be due to the fact that some eggs may have been released by some individuals that were in different stages of gonad maturation. Variation in fecundity may also be due to the existence of varied mixture of age classes (Saliu *et al*., 2007).

Egg size was negatively correlated to fecundity, suggesting that the lower the number of eggs in this species, the larger the size of eggs. However, fecundity was independent of the size of the fish (Table 3). This was supported by the findings of Imevbore (1970), from a study on the fishes of River Niger. Fecundity was also dependent on the size of fish and thus, the larger the fish, the higher its egg number and this may be due to more available visceral volume for holding the eggs. Similar findings were reported by King (1996 and 1997), Laleye *et al*. (2006) and Offem *et al*. (2008). Fecundity exhibited higher correlation with gonad weight than with total length or total weight. Same was reported for *Liza parsia* by Rheman *et al.* (2002). However the r value in the correlation between fecundity and total weight was higher than those of fecundity and total length, suggesting that total weight was a better predictor of fecundity in this study than total length. Similar finding was reported by Ikomi and Odum (1998) in *Chrysichthys Auratus.* All the correlation coefficient values between fecundity with other parameters in this species were lower than those between egg size with the same parameters. Oboh (2006) also obtained low r values in the relationships between fecundity with growth and reproductive parameters of *Chromidotilapia guentheri*, a species with lower fecundity than *A*. *occidentalis*.

Egg Size

In this study, large size of eggs in the *A*. *occidentalis* may be related to the paternal care of eggs reported for the species (Ochi, 2001). According to Hulata *et al*. (1974), large egg size enhances fry and larval viability due to its higher yolk content, and hence, food supply to the larva. Thus, large egg size in *A*. *occidentalis* may be an indication of better larval viability and a compensation for low fecundity in the species.

Egg size distribution in this study may be a further confirmation of batch spawning. A similar finding was reported for *C. gariepinus* by Abayomi and Arawomo (1996). It is also likely that the different stages of eggs in the ovaries are indicative of the long spawning period, which extends from June to August in the study area. The larger eggs are the stocks most likely to be shed first, while the maturing stocks will mature subsequently. Thus, for captive breeding program of the two species in the study area, gravid fishes are available in the wild from June to August, while the most productive fishing period will be from October to March after the fish have spawned. Closed or less intense fishing should be from April to September so as to allow the fishes to breed at least once in their lifetimes to help in the conservation of the natural stocks (Offem *et al*., 2008).

The results of the regression analysis between egg size and other parameters suggest that gonad weight is a better predictor of egg size than the other parameters. The r values indicated that the higher the gonad weight, the larger the eggs. There was an inverse relationship between egg size and total weight of fish, suggesting that smaller samples had larger eggs than the larger ones that may have produced eggs many times before.

CONCLUSION

Based on the findings of this study, females had higher GSI values than males in all the six stages of gonad maturation. GSI was higher in both sexes in the rainy season than in the dry season. GSI was independent of the size of fish and has significant correlations with total length, total weight and gonad maturation stage in females, but not in males.

Fecundity studies showed that there are wide variations in the number of eggs, with larger samples producing more eggs than the smaller ones, even though the highest number of eggs was not found in the largest fish, nor was the lowest number of eggs found in the smallest fish. Egg size was negatively correlated to fecundity, suggesting that the lower the number of eggs in this species, the larger the size of eggs and fecundity was independent of the size of the fish

Egg size studies showed that *A*. *occidentalis* in River Rima produce large eggs and this may be related to the paternal care of eggs reported for the species from other waters. Size of eggs can be more easily predicted from total weight, total length and gonad weight of the fish than fecundity.

This study provides baseline information on some aspects of reproduction of *A. occidentalis* in River Rima. These are important parameters for stock assessment and understanding of the population dynamics, which could be used to promote the management of the species in the wild and under aquaculture.

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