Seasonal Variation in The Biology of *Chrysichthys Auratus* (Geoffroy Saint-Hillaire, 1809) in Ogun State Estuary, Nigeria

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Abstract

This study examined the seasonal variation in the biology of *Chrysichthys auratus* (Geoffroy Saint-Hillaire, 1809) in Ogun State estuary, Nigeria. Fish were collected in the wet season (May-June, 2018) and dry season (November-December, 2018) from commercial fishermen at the estuary using the bamboo trap. The fish length, weight and other biological parameters were measured and estimated using standard procedures. A total of 432 samples with length ranging between of 10 to 25.9 cm and corresponding weight ranging between 10g to 91g were examined during the two seasons. The wet and dry season showed the peak frequency at size class 14 – 14.9cm and 19 – 19.9cm respectively. The study revealed a the sex ratio (M:F) of 1:0.7 and of 1:0.47 in the wet season and in the dry season respectively. The length-weight relationship showed a negative allometric growth in the wet dry and combined seasons with a “b” value less than 3. Size at maturity were 19.5 cm, 17.30 cm and 18.5 cm for males, females and combined sex respectively in the wet season while in the dry season, all the males were immature and the females attained maturity at a length estimated to be 17.00 cm. The study showed a positive relationship between fecundity and total length of *C. auratus* in the wet (r^2 = 0.41) and dry (r^2 = 0.45) while a positive relationship was also observed between ovary weight and fecundity in the dry season (r^2 = 0.88) and wet season (r^2 = 0.83). Seasonal assessment of biology and distribution of *C. auratus* is recommended to provide requisite information for sustainable management of the species.

Introduction

Chrysichthys species are among other species that have been reclassified to the family Claroteidae (Paugy et al., 2003; Olaosebikan and Raji, 2004) and *Chrysichthys auratus* commonly known as Long fin catfish belongs to this family. *C. auratus* is abundant in many African waters playing a pivotal role in the ecology of fisheries particularly in Nigeria, considering the significant trophic level in occupies in aquatic ecosystem (Abdul and Adekoya, 2016). According to Kuton and Akinsanya (2016), *Chrysichthys* species tolerates both fresh water and brackish water conditions and they thrive abundantly along the coastal waters with littoral mangrove belts where roots and tangles of plants exist (Ezenwa, 1978). Not only is it considered as a valuable fish species amongst the indigenous and ubiquitous freshwater fish of the coastal waters of Nigeria (Akinsanya et al., 2007), it is sought after for its flavour and chemical composition (Uneke, 2018) and this have called for the considerations of its culture that have also resulted in several studies on its biology.

The goal of sustainable fisheries in meeting the growing fish demand of many populace worldwide have driven studies on the biology of fisheries resources, their exploitation and the potential yield of water bodies in terms of fish production (Abdul and Omoniyi, 2011). Extensive studies have been done on diet composition and trophic ecology of fish species from different water bodies especially reservoirs, lakes and lagoons. However, fish population and structure are altered by reproduction, recruitment, growth, mortality, environmental factors and season (Adeyemi et al., 2009). These factors have also made the pattern of fish population unpredictable affecting its assemblage and exploitation.

Despite the array of information (Abdul, 2015; Abohweyere and Falaye, 2008; Akombo et al., 2011, 2014; Victor et al., 2013; Nwadiaro and Okorie, 2013) about fish species biology, populations dynamics and fish community structure of fish species in Nigeria, the need to monitor the changes in the biology of *C. auratus* will sustainably guide its exploration, sustainability and established results will also guide the development of fisheries policy options, allowing to evaluate and foresee the possible effects of seasons on the biology of aquatic resources. Thus this study, which aimed to provide information seasonal variation in the biology of *Chrysichthys auratus* (Geoffroy Saint – Hillaire, 1809) in Ogun State coastal estuary, Nigeria.

Materials and Methods

Description of the Study Area

The study was carried out in Ogun State estuary in Ogun Waterside Local Government Area. The Local Government is one of the twenty local government areas of Ogun State, Nigeria (Abdul, 2009). Ogun State Estuary is situated between 004^{0}15'E – 004^{0}30'E and 06^{0}20'N – 06^{0}45'N and bounded in the east by Lekki lagoon. It covers an area of 26 km^2 (Ssentengo, 1983) and it is one of the several estuaries that empties into the Atlantic ocean through Lagos harbour. Abdul et al. (2003) reported that the lack of direct access to the Atlantic Ocean makes it essentially fresh water. The four major rivers that inundate the estuary are River Ogun, River Oshun, River Mosafejo and River Oni.

Sampling duration

Samples of *C. auratus* were collected seasonally from commercial fishermen at the estuary using the bamboo trap locally called 'Apaye'. The trap is usually staked in a slant position in the water, as the fish seeks refuge in the trap. During the wet season (May-June, 2018), 209 samples were collected and during the dry season (November – December, 2018) 144 samples were collected.

Collection and identification of fish samples

The fish samples of various sizes were randomly collected immediately after capture. They were removed from the traps and kept on ice to maintain freshness. The samples were then taken to the laboratory, identified to the species level using the field guide (Olaosebikan and Raji, 2004) and sorted into sexes. The total length (TL), (a measurement

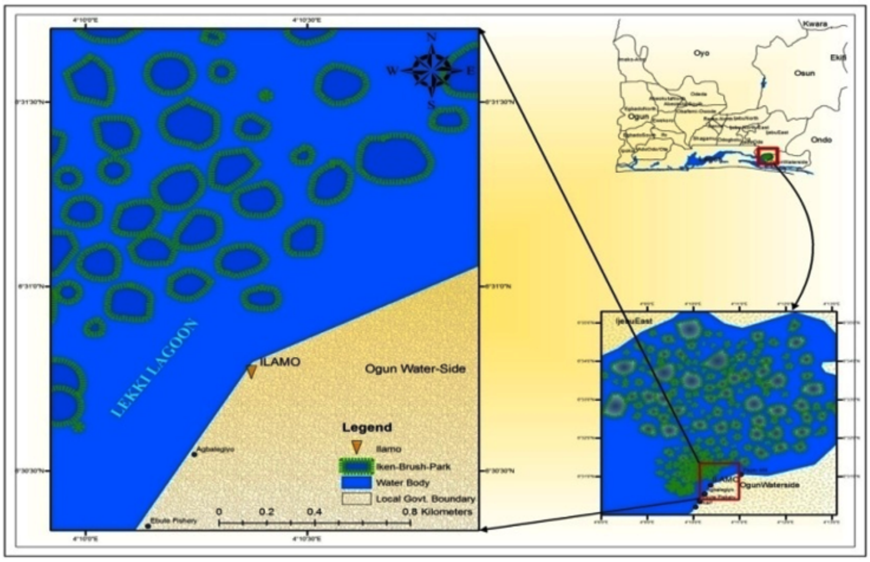

Figure 1: Map of Ogun State estuary (Source: Abdul et al., 2015)

from the tip of the snout to the extended tip of the caudal fin) was measured with a meter rule on a measuring board to the nearest 0.1 cm, while the total weight (TW) of fish was also recorded using a sensitive scale (Model: EK5350) to the nearest 0.1 g.

Sex ratio

The sex of the samples captured over each sampling period was determined. This was done by visual observation of the external features and examination of the various gonads. Females were recognized by the distended aperture and males were recognized by the presence of testes. The number of identifiable males and females of *C. auratus* for each sampling period were recorded and used to determine the sex ratio from the naturally hypothesized ratio of 1:1. Sex ratio = no of males / no of females (Akintade et. al., 2016).

Growth pattern

The length – weight relationship was determined from the formula;

$$W = aL^b \quad \text{(Pauly, 1984)}$$

Where W= Body weight in grams
L= Total length of fish in centimetres
a = Intercepts
b= Growth exponent or regression coefficient
'a' and 'b' are constants and their values were estimated from the log transformed relationship of length-weight below. 'b' was used to determine the growth pattern of the fish at 95% confidence limit.

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

Condition Factor

The condition factor (K) was estimated using the formula below;

$$K = 100 * W/L \quad \text{(Pauly, 1984)}$$

Where;
K= Condition factor
W= Weight of fish (g)
L= Length of fish (cm)
b = Growth exponent from LWR

Fecundity Estimation and Oocyte/Egg Diameter

Ripe eggs were removed from gravid fish, weighed and preserved in Gilson's fluid. The preserved ovaries were washed several times in distilled water to get rid of the preservative, then eggs were separated from the ovaries, placed on filter paper to remove excess water. The number of eggs was estimated using gravimetric method, the diameters of ten oocytes from each ovary were measured, and the mean oocytes diameter was determined. Thus, fecundity is calculated as

$$\text{Log } F = \log a + b\text{LogTL}$$

Where;
F = fecundity
TL = total length
a and b are constant and exponent respectively.

Maturity Stages

Determining the maturity stages of *C. auratus* was done through the use of hand lens. Slight pressure was put on the abdominal area of the samples to see if milt or eggs were released and afterwards dissection took place by cutting away the abdominal wall with a scissors to expose the gonads, which were removed, weighed and stored in Gilson's fluid for preservation. Stages of gonads were classified as described by Nikolsky (1963) and Bucholtz et al. (2008).

Results

Size distribution and Abundance of Chrysichthys auratus

A total of 432 samples with length range of 10 – 10.9cm to 25 – 25.9cm and corresponding weights of 10g to 91g were examined during the two seasons. As shown in Table 1, the wet season, the distribution was at its peak at size class 14 – 14.9cm while during the dry season, distribution was at its peak at size class 19 – 19.9cm. However, the mean length in May was 16.14±3.37cm and 16.07±2.71cm in June and November with respective mean weights of 36.64±20.83 and 39.63±13.5g. In November, the mean length and weight was 17.23±2.47cm and 33.97±14.67g while in December, the mean length and weight was 16.57±2.93cm and 33.80±15.6g. In the wet season, *C. auratus* was more abundant in June with a total of 151 samples and in the dry season, with a total of 83 samples in November.

Sex Ratio of Chrysichthys auratus

Table 2 shows 432 samples were examined, which 288 were examined during the wet season and 144 during the dry season, sex determination revealed that there were 168 males (58.33%) and 120 females (41.67%) with a sex ratio (M:F) of 1: 0.7 in the wet season and in the dry season, there were 98 males (68.06%) and 14 females (31.94%) with a sex ratio (M:F) of 1:0.47 as illustrated in Table 4. The average ratio was 1:0.6 which was significantly ($p<0.05$) different from the hypothesized ratio of 1:1.

TABLE 1
Seasonal size distribution and mean weight of 193 *Chrysichthys auratus* in Ogun State estuary

	Wet Season		Dry Season		
Length (cm)	May	June	November	December	Mean weight
10-10.9	0	1	0	0	10
11-11.9	5	0	1	1	12.8
12-12.9	4	9	12	2	15.7
13-13.9	8	5	11	2	23.1
14-14.9	51	31	0	2	20.8
15-15.9	32	43	1	11	30.1
16-16.9	7	7	24	1	33.7
17-17.9	16	8	5	4	44.3
18-18.9	5	17	1	23	45.7
19-19.9	5	9	16	15	49.6
20-20.9	11	5	12	0	52.2
21-21.9	1	1	0	0	64
22-22.9	1	0	0	0	78
23-23.9	3	1	0	0	83
24-24.9	0	0	0	0	0
25-25.9	2	0	0	0	91
Total	151	137	83	61	-
MeanL(cm)	16.14±3.37	16.07±2.71	17.23±2.47	16.57±2.93	-
Mean weight (g)	36.64±20.83	39.63±13.5	33.97±14.67	33.8±15.6	40.88±27.53

TABLE 2

Seasonal sex ratio (Male: Female) of *Chrysichthys auratus* in Ogun State estuary

Season	Frequency	Male	Female	Sex Ratio M:F	P<0.05
WET	288	168	120	1:0.7	S
DRY	144	98	46	1:0.5	S
TOTAL	193	266	166	1:0.6	

S: Significant at $p < 0.05$

Growth pattern of Chrysichthys auratus

The length-weight relationship of *C. auratus* is presented in Table 3. The parameters were grouped by the season and sexes. The 'a', 'b' and r^2 values were – 1.51, 2.50 and 0.8761 for males in the wet season, - 1.72, 2.68 and 0.9044 for females in the wet season, and -1.61, 2.58 and 0.8892 for both sexes in the wet season. In the dry season, -1.83, 2.73 and 0.9120 were the 'a', 'b' and r^2 values for the males, -1.43, 2.43, 0.9120 were the values for the females in the dry season and -1.72, 2.66 and 0.9063 were the values for both sexes in the dry season. The seasonal 'b' value was 2.58 during the wet season and 2.66 during the dry season. However, there was a positive correlation 'r^2' in males (0.8761and 0.9120), females (0.9044 and 0.9120) and combined sexes (0.8892 and 0.9063) in the wet season and dry season respectively.

Size at Maturity of Chrysichthys auratus

The fitted logistic ogive curves for size at maturity of male, female and combined sex of *C.auratus* in Ogun State estuary are shown in Figure 2. Size at maturity estimates were 19.5cm, 17.30cm and 18.5cm for males, females and combined sex respectively in the wet season. In the dry season, all the males were immature and the females attained

TABLE 3

Seasonal length-weight relationship of Chrysichthys auratus in Ogun State estuary

Parameters	a			b			r^2		
Season	(Male)	(Female)	(Both sex)	(Male)	(Female)	(Both sex)	(Male)	(Female)	(Both sex)
Wet	-1.51	-1.72	-1.61	2.50	2.68	2.58	0.8761	0.9044	0.8892
Dry	-1.83	-1.43	-1.72	2.73	2.43	2.66	0.9120	0.9120	0.9063
Mean	-1.67	-1.58	-1.67	2.62	2.56	2.62	0.8941	0.9082	0.8978

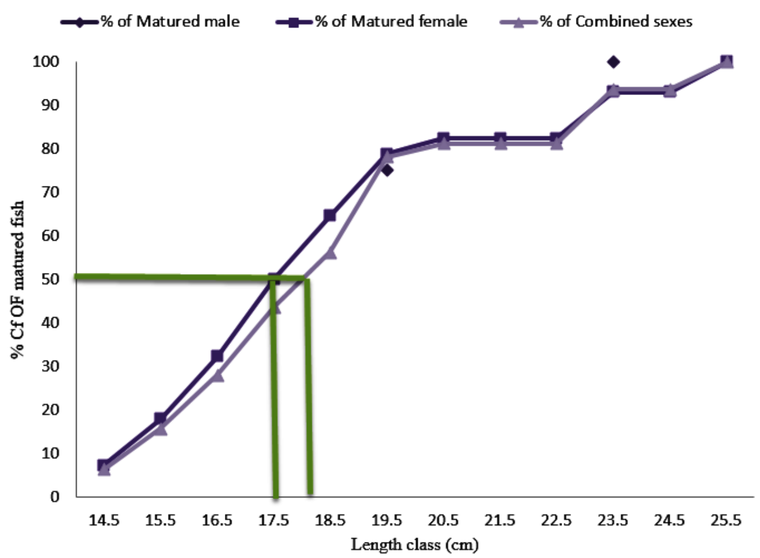

Figure 2 Logistic ogive showing length-class at 50% maturity of males, females, and combined sexes in the wet season

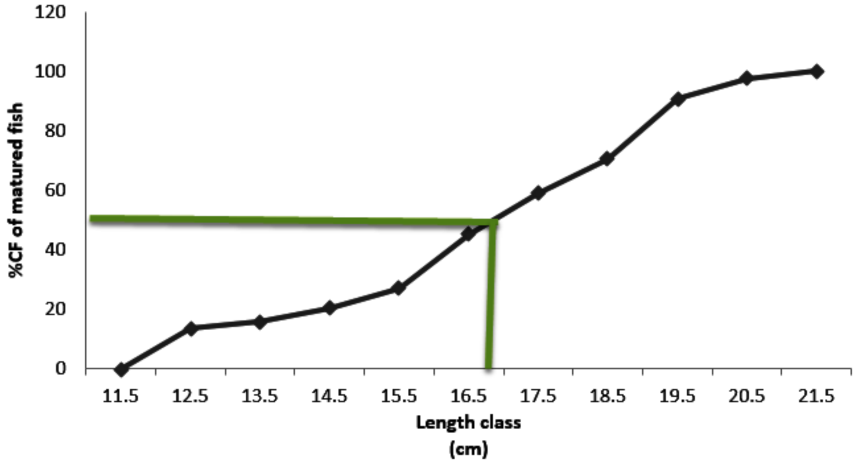

Figure 3 Logistic ogive showing length-class at 50% maturity of females in the dry season.
Fecundity of *Chrysichthys auratus*

maturity at a length estimated to be 17.00cm as shown in Figure 3.

The relationship between fecundity and body size, ovary weight and egg diameter, ovary weight and fecundity is shown in Figures 4-9. Fecundity ranged from 665 – 1440 in the dry season and from 172 – 1776 in the wet season with corresponding weights of 123g and 479g. The mean fecundity of the dry season and wet season samples were 1135.71 and 775.79 respectively. As shown in Figure 5 and 6, a positive relationship was observed between fecundity and total length of *Chrysichthys auratus* in the wet ($r^2 = 0.41$) and dry ($r^2 = 0.45$) season in Ogun State estuary while a positive relationship was also observed between ovary weight and fecundity in both seasons with 'r^2' values as 0.88 in the dry season and 0.83 in the wet season as shown in figure 8 and 9. However, the egg diameter showed a stronger positive ($r^2 = 0.96$; 0.78) relationship in both seasons with the ovary weight as shown in Figure 7 and 8.

Discussion

In fisheries science, length frequency distribution of fish in aquatic systems is key in determining the status of the size structure of that fish population (Sahin and Günes, 2010).

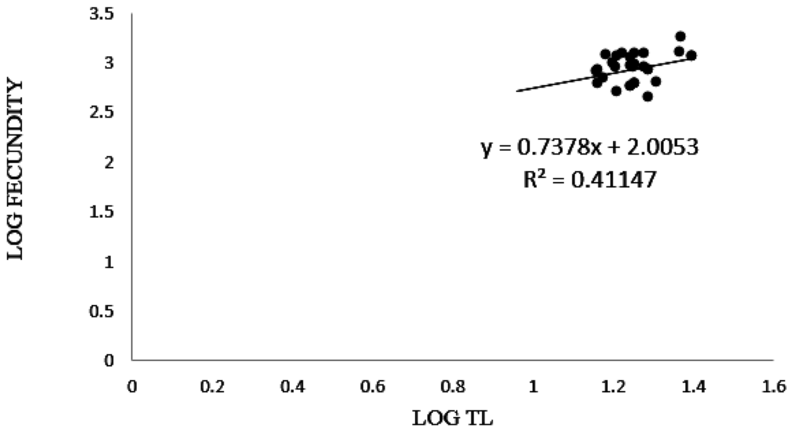

Figure 4 Relationship between fecundity and total length of *Chrysichthys auratus* in wet season in Ogun State estuary

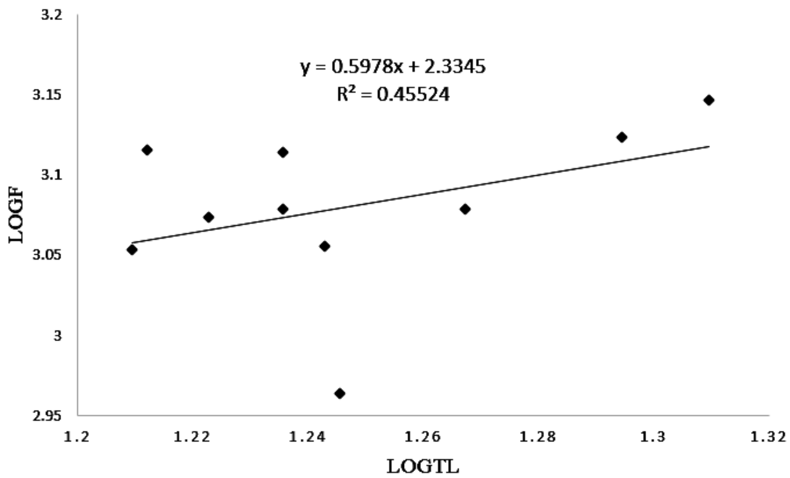

Figure 5 Relationship between fecundity and total length of *Chrysichthys auratus* in dry season in Ogun State estuary

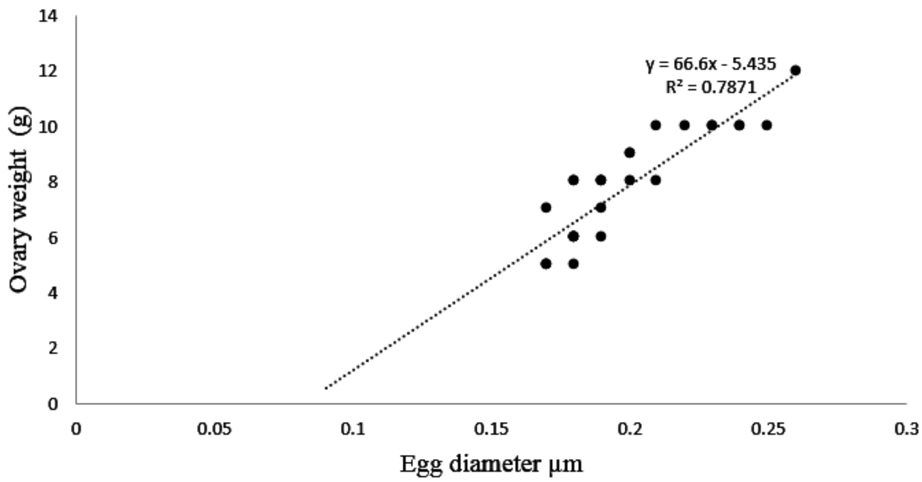

Figure 6 Relationship between egg diameter and ovary weight of *Chrysichthys auratus* during wet season in Ogun State estuary

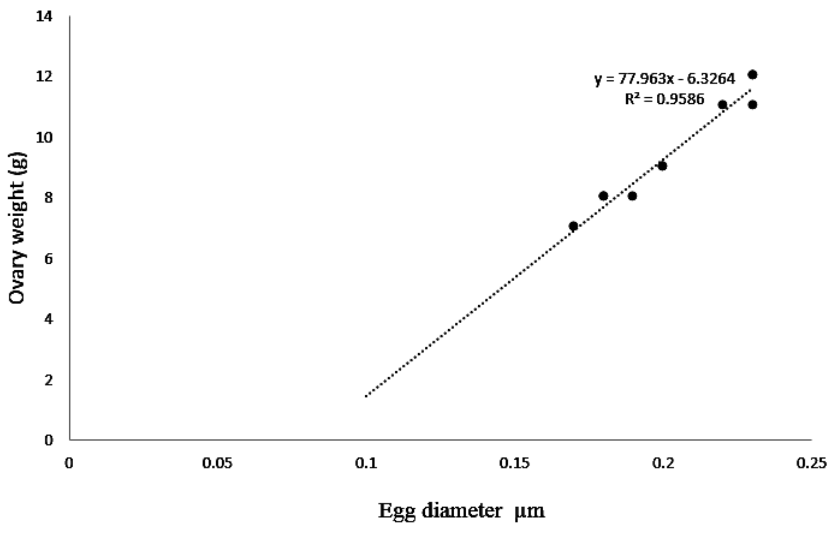

Figure 7 Relationship between egg diameter and ovary weight of *Chrysichthys auratus* during dry season in Ogun State \ estuary

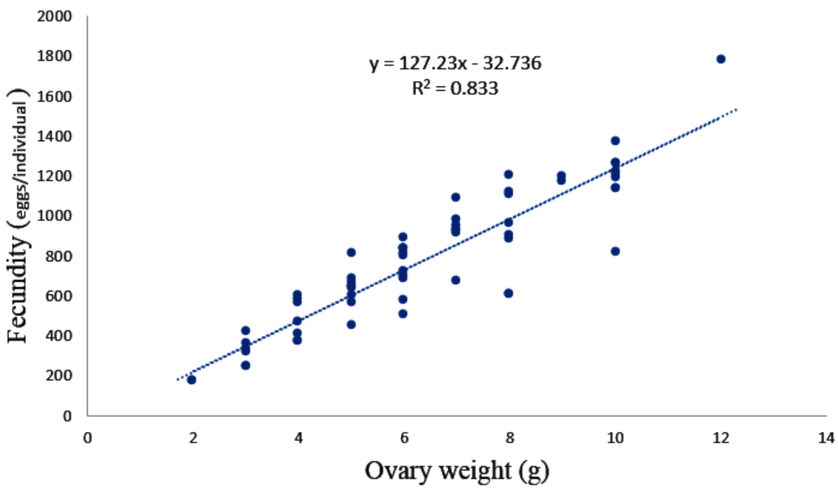

Figure 8 Relationship between fecundity and ovary weight of *Chrysichthys auratus* in wet season

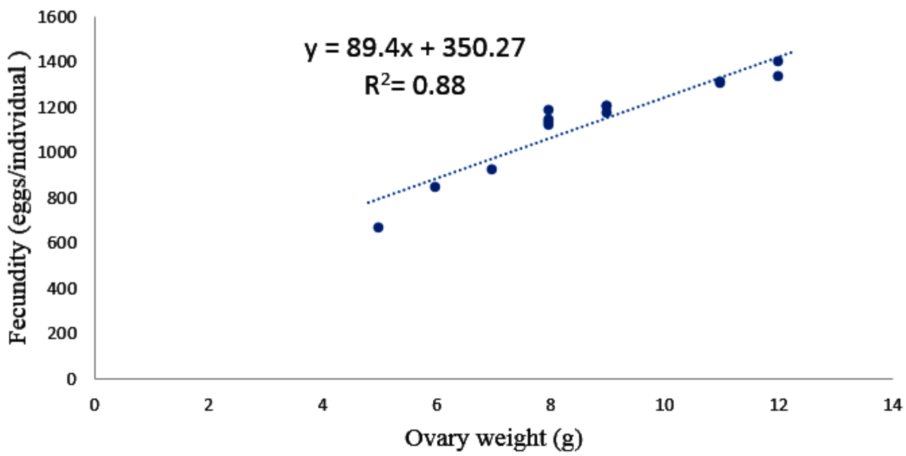

Figure 9 Relationship between fecundity and ovary weight of *Chrysichthys auratus* in dry season

In this study the length-frequency distribution of *C. auratus* showed seasonal variation in abundance, i.e. more *C. auratus* were caught during the wet season compared to the dry season. This could be due to their adaptive behaviour, tolerance to environmental changes and recruitment. The abundance of *C. auratus* in a class size during the period of study could be due to the selective nature of gear used, the available sizes in the estuary and availability of food. The high mean weight observed in the wet season could also be attributed in the availability of food resources during the wet season resulting in a significant difference in the distribution and abundance of the fish. According to Olagbemide (2010), the length composition of a fish population often exhibits nodes among fishes with short spawning season and a rapid and uniform growth, from which the modal length of the first few age groups can be easily determined. The findings of this study show a prominent peak with a preponderance of *C. auratus* of total length range of 14-14.90 cm in the wet season and 19-19.9 cm in the dry season over other length class in the estuary.

Sex ratio is an important index in fisheries science that helps in estimating the reproductive biomass and the total population fecundity and it is one of the factors determining the reproductive potential of a population (Marshall et al., 2006). In this study, the reproduction potential (sex ratio) of *C. auratus* shows that there were more males than females in Ogun State coastal estuary in both seasons. This disagrees with the findings of Ragheb (2016) in Nile river, Egypt where females were slightly more numerous than males and a sex ratio of 1:1.18 (males and females) was obtained but on the other hand agrees with, Atobatele and Ugwumba (2011) who reported an overall male to female ratio of 1:0.38 for *C. auratus* in Abia Reservoir Iwo, Nigeria.

Mahmood et al. (2011) attributed to seasonal difference in sex ratio to growth rate between sexes, mortality and/or the energy costs of reproduction. Vicentini and Araújo. (2003) also reported that sex ratio may vary from species to species or even in the same population at different times, been influenced by several factors such as adaptation of the population, reproductive behaviour, food availability and environmental conditions.

To estimate production, stock size and recruitment, age and growth determinations are essential. The relationship between the length and weight of fish population is a fundamental factor that can be used, alongside the age to give information on the stock composition, age at maturity, life span (Vandeputte et al., 2012). Therefore, predicting the growth pattern of fish. In this study, *C. auratus* revealed negative allometric growth during dry and wet seasons, an indication that, the fish gets thinner as it grows bigger. Similar negative allometric growth (b=2.9832) for *C. auratus* was reported by Ragheb (2016) in River Nile, Egypt. However, findings by Quarcoopome (2017), showed that *C. auratus* exhibited isometric growth pattern in Kpong Reservoir in Ghana, which is contrary to the finding in this study. Also, the finding of this study was in line with Uneke (2015) who reported a 'b' value of 2.512 for *C. auratus* in the Mid Cross River Flood System, South Eastern Nigeria. Meanwhile, growth model in fish according to Gulland (1987) generally follows the cube law. There is a positive correlation 'r^2' in males (0.955 and 0.936), females (0.955 and 0.951), and combined sexes (0.952 and 0.88) during both seasons. Positive correlation coefficient value 'r' between the length and weight of male, female and combined sexes of *C. auratus* indicates a homogenous population which is in line with the assertion of Konan et. al. (2007).

Size-at-maturity (L_{50}) also length-at-maturity of fish population which is a function of their size and according to Siddiqui et al. (1997) they might be influenced by environmental factors such as abundance and seasonal availability of food, predation and temperature, photoperiods and also the locality. Size – at – maturity (L_{50}) can be used to monitor if enough juveniles in an exploited population mature and spawn. It was observed in this study, that females in the dry season attain maturity earlier than females in the wet season while the males attained maturity in the wet season at a much longer length. This seasonal variation in the lengths of sexual maturity of *C. auratus* can probably due to the stochasticity of the environmental condition and the variability in food resources availability within the study period. Ragheb (2014) also reported that female fish inhabiting low productive aquatic ecosystems often mature at smaller size than conspecific females living in highly productive ecosystems.

According to Abdul et al. (2015), the reproductive success of the female is usually related to the access to resources and environmental conditions, and not to the number of mating partners as the case of the males. However, fecundity remains an important parameter in the estimation of stock size and stock discrimination of fish. It reveals useful information about the reproductive potential of fish species in the wild (Ebenezer, 2010). In this study, fecundity range from 665-1400 eggs/individual during the dry season and 172-1776 eggs/individual during the wet season.

This study has shown that the mean fecundity of *C. auratus* was higher in the dry season compared to the wet season. Nonetheless, fecundity increased as body size increased. The relationship between total length/fecundity show loose relationships during both seasons as 'r^2' value was low. A better relationship was observed between gonad weight and fecundity in both seasons, while a positive relationship was also observed between the ovary weight and egg diameter. Fagade et al. (1984) suggested that variation in fecundity might be due to differential abundance of food, Offem et al. (2008) also reported factors such as fish size, type of species, season and reproductive behaviour to have key effect on fecundity while Abdul (2015) reported that low fecundity might be attributed to phenotypic plasticity as response to intense fishing or differential feeding success and atresia resulting from unfavourable environmental conditions. According to Wooton (1998) and Offem et al. (2008), the volume of eggs a fish can produce depends on the space available in the body cavity that accommodate the eggs before spawning, which is in line with the findings of the study. The positive relationship observed in number of eggs in of *C. auratus* in relation with its weight and total length indicates that as body size increased, fecundity also increased, though little variations between fish size and number of eggs were observed.

Conclusion

The need to estimate production and develop the fish stock, stock size and recruitment, age and growth, and sex ratio are essential to fisheries management. However, to determine growth which is needed to complete the knowledge on the abundance of any fish species, Length-weight relationship predicted the growth pattern of fish as both sexes exhibited allometric growth pattern during both seasons. *C. auratus* was more abundant in the wet season and the sex ratio deviated from the hypothesized ratio of male to female 1:1 in natural population as there were more males in the dry season and more females in the wet season. This calls for a comprehensive ecosystem based approach in management of the fisheries for guaranteed long-term recruitment into the estuary and a sustainable fisheries exploitation of *C. auratus* Ogun State estuary.

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