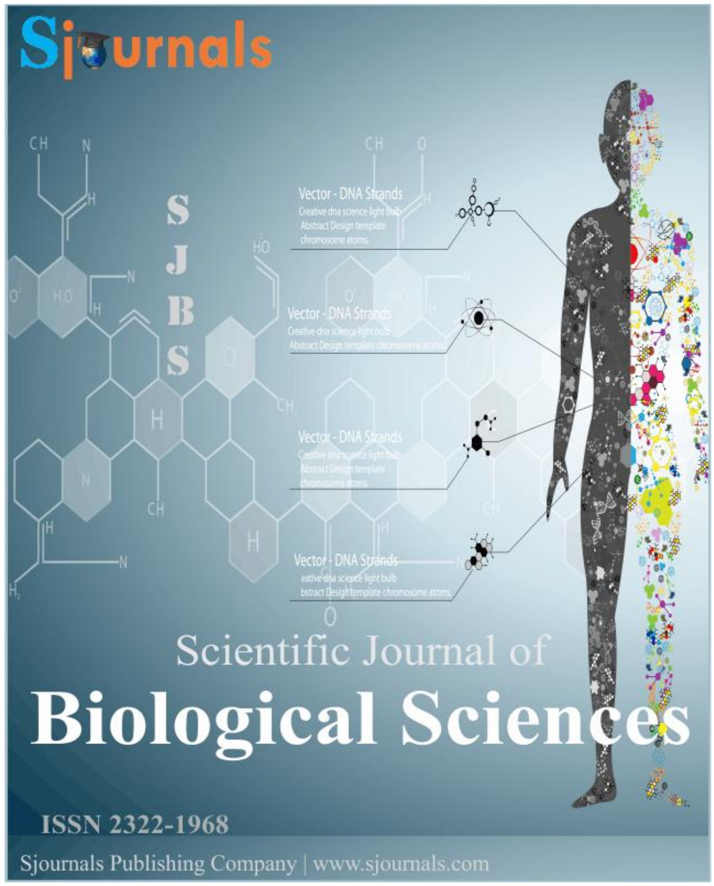
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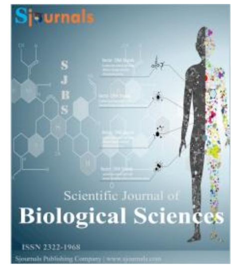


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**Original article**

# Reproductive biology of big-eye grunt *Brachydeuterus Auritus* in Ivory coast fishery (West Africa)

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Reproductive biology of Big-eye grunt, *Brachydeuterus auritus* resulting from Ivory Coast marine fishery were studied by monthly sampling from August 2013 to July 2014. Samplings were carried out along the Ivorian littoral. A total of 731 fish with a body length of 8.0 to 22.7 cm folk length (LF) and body weight of 9.2 to 204.6 g were used for this study. According this study, the sex ratio was 1:0.82 (male to female). The sex ratio was significantly different from the expected theoretically 1: 1 distribution except June, September and December. Monthly gonadosomatic index and macroscopically determined gonad stages indicated that *B. auritus* spawned from February to July with a greater activity from February to May. The condition factor indicated that *B. auritus* were in good condition, females had higher condition factor than the males. Lengths at 50% maturity were similar with 12.93 cm LF for males and 12.71 cm LF for females. The coefficient b (3.02; 3.07 and 3.04 respectively for males, females and both sexes) of the length-weight relationship was reflecting isometry.

## 1. Introduction

Ivorian coast contains many economically important fish (Troadec, 1971). Haemulidae family (formerly Pomadasyidae) (Schneider, 1992), or grunts, are small to medium-sized percoid fishes with a moderately compressed body and a convex dorsal head profile found in tropical fresh, brackish, and salt waters around the world. They are bottom-feeding predators, and named for their ability to produce sound by grinding their teeth (Ben Tuvia and McKay, 1986). *Brachydeuterus auritus* (Val. 1832) is one of the economically important, abundant and wildly distribution demersal fish species in Ivory Coast coast waters (Barro, 1979). It is economically important in both the coastal artisanal fisheries as well as trawl fisheries. *Brachydeuterus auritus* belongs to Haemulidae fish community constituting the demersal fish in the Gulf of Guinea. It can also be found in the coastal waters off the West Africa coast from Mauritania (260°N) to south Angola (17°S) (Bannerman and Cowx, 2002). It is a bentho-pelagic fish species that inhabits marine and brackish waters. In inshore waters, inhabits soft, sandy and muddy bottoms, Its distribution ranges between 10 – 100 m depth (Longhurst, 1964; Schneider, 1992) but it is most commonly found between 30 and 80 m (Adebiyi, 2013).

Bigeye grunt (*Brachydeuterus auritus*) is one of the most important demersal demersal fishery resources in the Gulf of Guinea in Eastern Atlantic Ocean (Bannerman and Cowx, 2002; Schneider, 1990). Total catch reported for this species to FAO for 1999 was 22 405 t. Ghana and Ivory Coast were caught 12 724 t and 3 964 t respectively (FAO, 1981). Studies on fecundity, Gonadosomatic index and Sex ratio of fish species are pertinent and useful for systematics in racial studies related to total population estimation and productivity (Adebiyi, 2012). The aim of the present study was to estimate reproduction parameters like sex ratio, gonadosomatic index, hepatosomatic index, condition's factor, stages of gonadal development and fecundity of *Brachydeuterus auritus* is in order to assess the stock and provide data that could be useful for management.

## 2. Materials and methods

### 2.1. Study area and sampling

From August 2013 to July 2014, *Brachydeuterus auritus* samples were obtained from maritime fisheries of Côte d'Ivoire and examined (Figure 1). A total of 731 samples ranging in size from 8.0 to 22.7 cm (LF) have been collected during the study period. The monthly length–frequency data analysed in this study were collected from artisan and industrial fisheries. All fish samples caught were packaged in ice-chests and carried to the laboratory, where they were counted and the measurements (total length, fork length and weight) were recorded to the nearest 0.1 cm and 0.1g, respectively. Gonads were weighed in the laboratory on an analytical balance (±0.01 g). The ovaries were classified macroscopically as immature, maturing, mature, spent, or at rest.

### 2.2. Sex ratio

Sex ratios were estimated [females/males]. *Chi-square tests* were used to investigate the differences in sex ratios from an expected 1:1 ratio.

### 2.3. Condition factor

Condition factor was estimated according to Bannister (1976). It was calculated for males and females as follows:

$$K = \frac{W}{L^3} \times 100$$

Where K= condition factor, W= gutted body weight (g) and L= total length (cm).

### 2.4. Gonadosomatic index

The gonadosomatic (GSI) which represent the gonad weight expressed as a percentage of the wet body weight was calculated according to Vazzoler (1996) as follows:

$$GSI = \frac{Wg}{We} \times 100$$

Where, Wg = gonad weight, Wt = eviscerate fish weight

### 2.5. Maturity

Specimens from the sub-sample with weight and length measurements were used to determine maturity stages. The gonads were dissected, weighed, and the sex and maturity stages determined by direct observation using the scale of gonad maturity stages given by Fontana (1969). Gonadal stages were examined macroscopically and classified as follow:

Stage I: Immature; Stage II: Early maturing; Stage III: Developing; Stage IV: Developed/Pre spawing; Stage V: Spawing; Stage VI: Spent. The number of males and females in the different stages of gonadal development were counted and recorded.

### 2.6. Size at first maturation

Size at first maturation was obtained through the relative frequency of adult females (maturating, mature, and spent) by size class as follows:

$$F = \frac{1}{1 + e^{a+b\times L}} \times 100 \quad (1)$$

Where, F= frequency of adult females for each length class interval; L = pivotal point of each length class interval; a and b are parametres. The parametres a and b were estimated by least squares of the linearised form of the previous function:

$$-Ln[(1/F)-1] = a + b \times L \quad (2)$$

The size at first maturation ($L_{50}$) as the length in which 50% of the individuals joined the reproductive population was estimated as:

$$L_{50} = -a/b$$

Where, a and b are the same parameters of the previous equation (2).

### 2.7. Length-weight relationship

Methods to estimate the length-weight relationship of fishes are described by Quinn and Deriso (1999). The length-weight relationship was estimated by using the equation:

$$W = aL^{b}$$

Where W= weight in grams, L= length in centimetres , a is a scaling constant and b the allometric growth parameter.

The parametres *a* and *b* in that formula were estimated through logarithmic transformation in the form, Log *W* = Log *a* + *b* Log LF, where *W* is the total body weight of fish (g), LF is the fork length of fish (cm), 'Log *a*' is the intercept on the Y-axis and '*b'* is the growth exponent or regression coefficient. The value of *b* gives information on the kind of growth of fish: if $b = 3$ (the growth is isometric) and the growth is allometric if $b \neq 3$ (negative allometric if $b < 3$ and positive allometric if $b > 3$).

## 3. Results

### 3.1. Sex ratios

A total of 400 males and 331 females were observed out of 731 samples examined. In this study, the sex ratio was 1: 0.82 (male to female) there were more males than females. The male to female ratio was significantly different ($\chi_{0.05}(1) = 6.51$, $P < 0.05$) from the expected 1:1 distribution (Table 1).

**Table 1**
Sex ratio distribution in relation with months.

| Month | Male | Female | Sex ratio | $\chi^2_{(0,05,\ 1)}$ | Probability |
|---|---|---|---|---|---|
| | LF [mean±SD(n)] | LF [mean±SD(n)] | M: F | | |
| January | 12.49±0.59 (44) | 13.10±0.43 (8) | 1 : 0.18 | 24.92 | 0.000001* |
| February | 12.86±1.56 (8) | 16.15±2.25 (62) | 1 : 0.98 | 0.01 | 0.926 |
| March | 1363±1.00 (66) | 15.38±2.80 (51) | 1 : 4.25 | 24.14 | 0.000001* |
| April | 14.68±1.51 (12) | 15.91±2.85(22) | 1 : 0.96 | 0.96 | 0.326 |
| May | 14.46±1.31 (23) | 15.82±1.49 (22) | 1 : 0.59 | 3.81 | 0.051 |
| June | 15.13±2.12 (37) | 15.38±1.73 (12) | 1 : 1.50 | 0.80 | 0.371 |
| July | 14.75±3.09 (38) | 15.69±2.63 (15) | 1 : 0.39 | 2.13 | 0.144 |
| August | 14.88±1.05 (24) | 15.27±0.81 (18) | 1 : 0.75 | 3.85 | 0.05 |
| September | 13.68±1.45 (36) | 13.23±1.26 (24) | 1 : 0.67 | 8.00 | 0.005* |
| October | 12.43±2.25 (24) | 13.28±2.22 (30) | 1 : 1.25 | 0.67 | 0.414 |
| November | 13.06±1.84 (56) | 13.68±1.81 (18) | 1 : 0.64 | 4.35 | 0.037* |
| December | 11.88±1.45 (32) | 12.40±2.27 (28) | 1 : 0.88 | 0.27 | 0.606 |
| Total | 13.44±1.96 (400) | 14.76±2.51 (331) | 1 : 0.83 | 6.51 | 0.011* |

*sex-ratio significantly different from the theoretical sex-ratio 1:1, p<0.05, M=Male, F=Female, LF=Folk length, SD= Standard deviation.

### 3.2. Gonadosomatic index

The gonadosomatic index (GSI) of *B. auritus* males ranged from 0.06 % to 5.01% (mean 1.28 % ± 1.04). The gonadosomatic index of females ranged from 0.003 % to 9.297 % (mean 1.80 % ± 1.67). High gonadosomatic indices were observed in February -July with a peak in April (2.89 % ± 1.11) for males and in March (4.40 % ± 3.00) for females (Fig. 1).

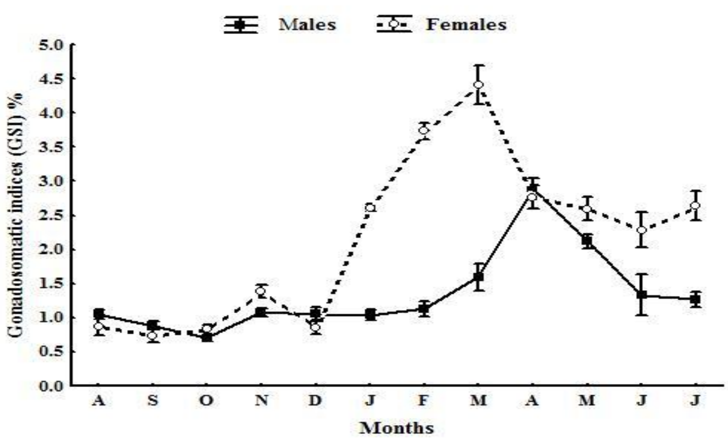



**Fig. 1.** Monthly Gonadosomatic indices of *B. auritus* from Côte d'Ivoire marine fishery.

### 3.3. Condition factor

The condition factor, K for males were ranged from 0.95 to 2.12 (mean = 1.69 ± 0.01) was significantly lower than that of females ranged from 0.90 to 3.02 (mean = 1.78 ± 0.01). The condition factor for the combined sexes ranged from 0.9 to 3.02 with a mean value of 1.73 ± 0.01 (Fig. 2).

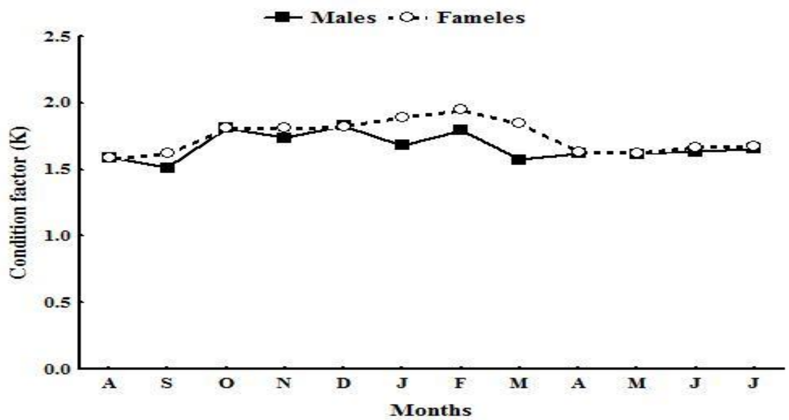



**Fig. 2.** Monthly Condition factor of *B. auritus* from Côte d'Ivoire marine fishery.

### 3.4. Length at first maturity

Length at first maturity ($L_{50}$) is the length at which 50 % of the fish have reached maturity. Fig. 3 presents a cumulative plot of number of mature specimens versus total length for both sexes in *B. auritus*. The corresponding values for $L_{50}$ are as follows: Male, 12.93 cm (n = 400) and Female, 12.71 cm (n = 331). The length at first maturity ($L_{50}$) of males was slightly higher than females. The smallest male found in the sample to have reached maturity measured 11. 3 cm, while the corresponding size for females was 11.6 cm.

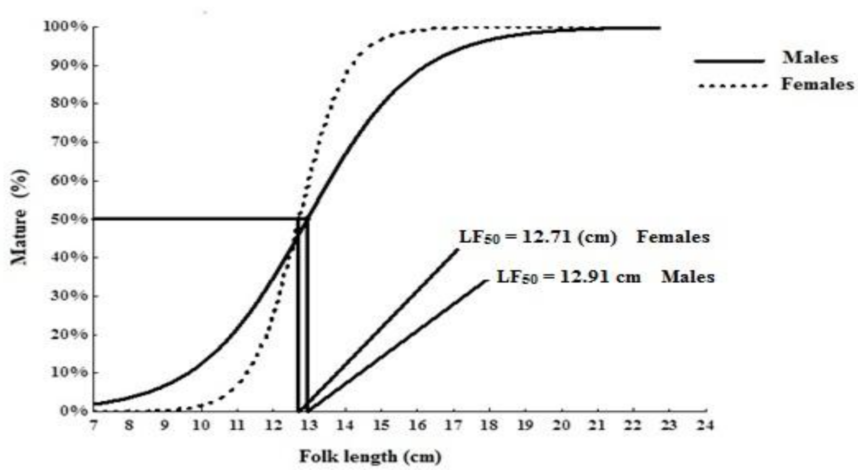


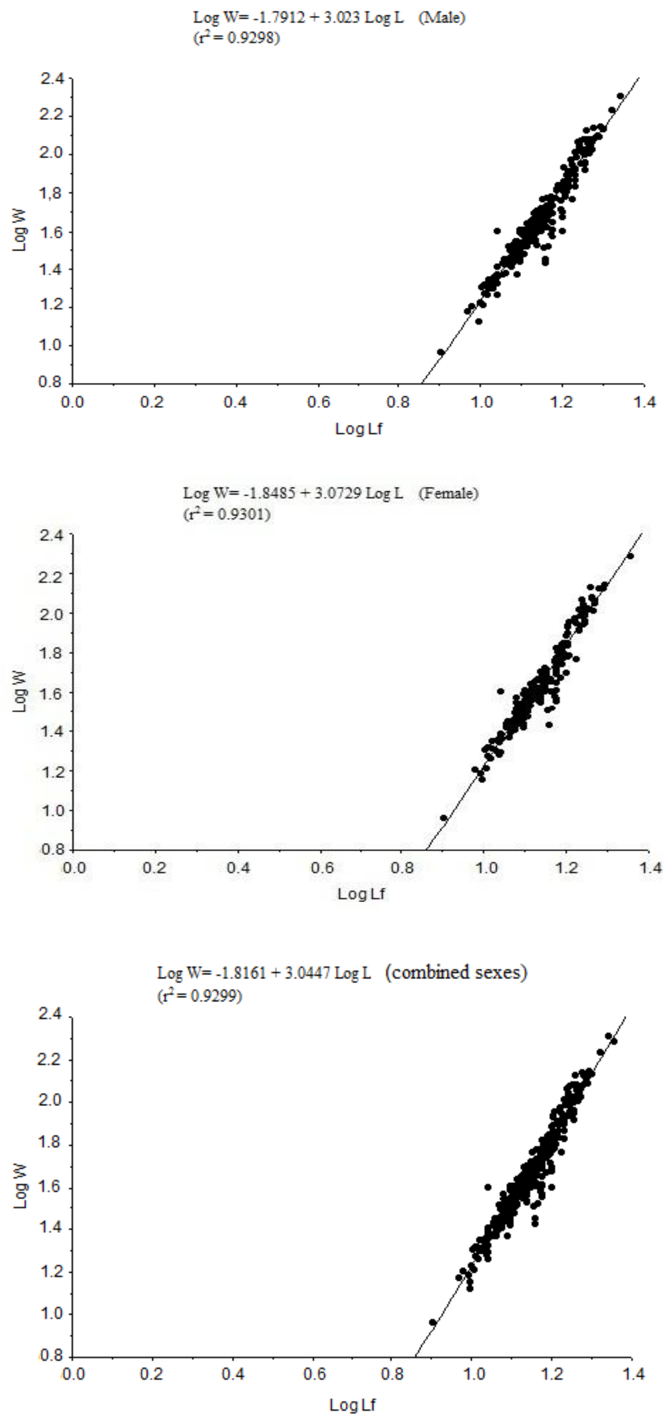

**Fig. 3.** Percentage of mature.

### 3.5. Fork length–weight relationship

Fork length and weight of *B. auritus* used to determinate the fork length–weight relationship, there were ranged from 8. 0 to 22.7 cm (mean = 14.03 ± 0. 8cm) and from 9.2 to 204.6 g (mean = 52.44 ± 1.1g), respectively. The constants of the length weight relationship were determined separately for each sex and for combined sexes (Fig. 4). The results were given by the following equation:

$$\text{Log } W = -1.7912 + 3.023 \text{ Log } L \ (r^2 = 0.93,\ r = 0.96,\ p < 0.05) \text{ (for males)}$$
$$\text{Log } W = -1.8485 + 3.073 \text{Log } L \ (r^2 = 0.93,\ r = 0.96,\ p < 0.05) \text{ (for females)}$$
$$\text{Log } W = -1.8161 + 3.045 \text{ Log } L \ (r^2 = 0.93,\ r = 0.96,\ p < 0.05) \text{ (for combined sexes).}$$

The values (*b*) of regression coefficient in the length–weight relationship equation calculated were 3.023 for males, 3.07 for females and 3.04 for males and females, with highly significant values of the coefficient of determination ($r^2$).




A

B

C

**Fig. 4.** Length-weight relationship of *B. auritus* for male (A) for female (B) and combined sexes (C).

### 3.6. Gonadal development stages

In this study, six stages of gonadal development were observed in male and female *B. auritus*. These Stage I (Immature); Stage II (Early maturing); Stage III (Developing); Stage IV (Developed / Pre spawning); Stage V (Spawning); Stage VI (Spent). Table 3 shows the macroscopic features of the stages of ovarian and testicular development of *B. auritus*. Percentage of gonadal maturity stages were follows: in females 8. 16 % of total fish were in developing stage (III); 18.12% were in developed stage (IV) and 37. 46% were in spawning stage (V).

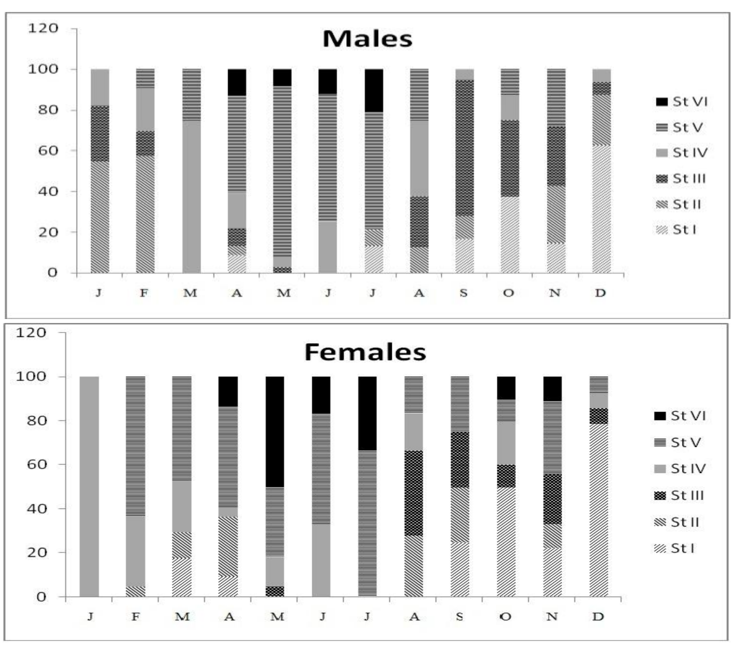
Therefore, 55.58% of fish were in the reproductive process. In males 20 % of total fish were developing stage (III); 13.75% were in developed stage (IV) and 25.75 % were in spawning. So 35. 5 % of the total fish were in the reproductive process.

**Table 3**
Stages of gonadal developments for males and females of *Brachydeuterus auritus* (adapted from Adebiyi, 2012).

| **Stage of gonadal development** | **Macroscopic features** | |
|---|---|---|
| | **Ovary** | **Testis** |
| Stage I (Immature) | Ovary was very small, thin, thread like pale in colour, occupying a small part of the body cavity. | Testis was thiny, slender translucent and pale in colour. |
| Stage II (Early maturing ) | ovary become slightly larger and increase in weight, translucent. | Testis became enlarge, flat, increase in weigth and volume, and creamy white in colour. |
| Stage III (Developing) | ovary was large, opaque and light yellow in colour, blood vessels were seen on the surface | Testis enlarge, increase in weight an volume, light pinkish and look more vascular. |
| Stage IV (Developed/Pre spawning ) | Ovary became more enlarge occupying almost entire body cavity, yellowish in colour and eggs were clearly visible. | Testy was enlarged, milky white. Milt release with a slight pressure. |
| Stage V (Spawning) | Ovary walls become thin almost transparent. Ripe eggs are visible through the ovarian wall and some ripe eggs are present in the oviduct. | Testy became flabby, thin and dull white in colour. |
| Stage VI (Spent) | Ovary was flaccid, sac like and reduced in volume. Ovary contains ripe unspawned darkned eggs and a large number of small ova. | Testis became flaccid empty with evidence of hemorraging (blooding). |

### 3.7. Repartition of gonadal development stage

Monthly gonadal development and frequency of each developmental stage are shown in Fig.5. In males (Fig. 5 A), early active and growing stages were found from January to March; the mature stage (III) was reached in April (100%). From May to October, most males exhibited partially spawned gonads, indicating continuous spawning during this period.Spent and inactive stages dominated from July to late January. The macroscopic examination of the gonads showed that the species are immature between October and September (stages I and II). In November, the gonads were at the beginning of maturation (stage III) and maturation went on through December and January (stage IV) to reach in February and March stage V.




A

B

**Fig. 5.** Percentage of different maturation stages for males (A) and females (B) of *B. auritus*; St = Stage.

**4. Discussion**

The males were more than the females and the difference in sex ratio was significantly different from the expected 1:1 distribution. Asabere-Ameyaw (2001) reported the sex ratio of *Brachydeuterus auritus* of Cape coast Ghana, which was in contrast to the result obtained in this study; the females were more than the males. Samb (2003) in Senegal reported the opposite in sex ratio for *B. auritus* which indicate that the females outnumbered the males. However the sex ratio in Samb's study was not significantly different. According Ikusemiju *et al* (1979), in Nigeria the males were more than females. The sex ratio obtained in this study was similar with the sex ratio in Nigeria. The sex ratio in fish populations is governed by a number of factors such as differences in mortality or longevity between the sexes, and size dimorphism between sexes leading to differences in catchability between sexes.

According to Mellinger (2002), several hypotheses such as the migration for feeding, the difference of growth and the mortality rate by sexes could explain these results. The difference of growth rate between sexes and differential migration by sex could probably explain our results.

Gonadosomatic index was high in January - July; the highest gonadosomatic index was in March (9.30 ± 2.95) and this suggested that this could be the spawning period of *B. auritus*, July - September fall in the wet season. According Adebiyi (2012) in Nigeria, high gonadosomatic indices were recorded for *B. auritus* during the months of July, August and September, which suggested that these months are the spawning period of this fish. This was not in line with the results obtained for *B. auritus* in this study in where high gonadosomatic indices were recorded in January - July. The spawning periods of *B. auritus* in Sénégal were from October to March (Samb, 2003). This was in contrast with the results of this study. Spawning occurred throughout the year in Ghana (Asabere-Ameyaw, 2001). This was unlike the spawning period observed in this study.

The coefficient b of the length-weight relationship for male, for female and combined sexes fish are very close to 3, reflecting isometry. According to Adebiyi (2012) for *B. auritus* studied in Nigeria, negative allometric growth was observed with a b value of 2.68. This was in contrast to the result obtained in this study. The length-weight relationship indicated that *B. auritus* had negative isometric growth, which indicated that growth body length was proportionate to growth in body weight. Samb (2003) in Senegal, point out that male *B. Auritus* had positive allometric growth (b = 3.115) and the females had negative allometric growth (b = 2.908). This is unlike the results obtained for this study, where both male and *B. auritus* female had negative allometric growth. A similar result as observed in this study was obtained for *B. auritus*, in Congo which had isometric growth (b = 3.08) (Fontana and Bouchereau, 1976).

The results of the condition factor indicated that *B. auritus* were in good condition. In Nigeria, the condition factor of *B. Auritus* ranged between 0.76 - 3.20 for males while in females, it ranged from 0.75 to 3.07 for females (Adebiyi, 2013). The males had higher condition factor than the females. This was in contrast with the results obtained for *B. auritus* in this study were females had higher condition factor than the males. This difference is due to the different ecological conditions.

The size at first maturity of males was slightly higher than females (12.93 cm versus 12.71cm). According to Asabere-Ameyam (2001) females reach their first sexual maturity before males that (15.1cm, females and 14.8 cm, males). This was in contrast to the results obtained in this study. These differences in length at first sexual maturity may be attributed to differences in genetical and environmental conditions such as food supply, population density and changes in temperature.

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