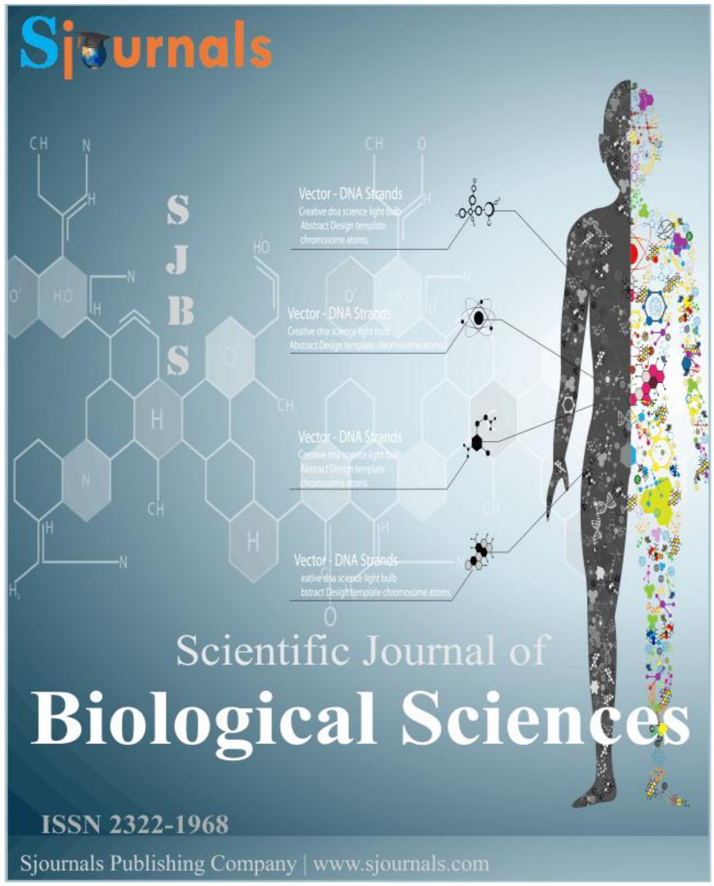
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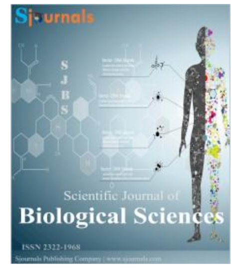

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Original article

Aspect of reproductive biology of the cassava croaker, *Pseudotolithus senegalensis* (valenciennes, 1833) of Ivory coast continental shelf

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A B S T R A C T

From January to December 2014, some aspects of *Pseudotolithus senegalensis* reproductive biology in Ivory coast were investigated and focused on sex ratio, gonadosomatic and liver-somatic index, size at first maturity, stages of gonadal development and fecundity. A total of 696 fish with body length of 12 to 36 cm standard length (SL) and body weight of 25. 2 to 675.1 g were used for this study. The sex ratio of *P. senegalensis* was 1: 0.5 (male to female). The females were more than the males ($x^2_{0,05}$ (1) = 51.36; p< 0,05). Males and females reach first maturity at 19.01 and 22.28 cm SL respectively. The monthly variations of the gonadosomatic index (GSI), hepatosomatic index (HIS) and the condition factor (K) indicated two periods of reproduction. The long period and the short period were respectively from March to June and from September to November. The hepatic reserves seem to be mobilized to ensure the energetic cost of the reproduction. The absolute Fecundity was ranged from 78612 to 140946 eggs and was positively correlated with standard length and weight. Fecundity-length and fecundity-weight relationships showed positive correlations. The fecundity-length and fecundity-weight relationships were determined by regression analysis with the regression equation F= 12.820xSL–321.70 (r=0.99) for fecundity-length and F= 0.27xTW – 46.66 (r=0.98) for fecundity-weigth relationship.

1. Introduction

Some important aspects of fish reproductive biology are fecundity, Gonadosomatic index, Sex ratio which gives information necessary for successful fisheries management and recruitment in natural water bodies and aquaculture of fish species (Adebiyi, 2012). Studies on fecundity of fish species are pertinent and useful for systematics in racial studies related to total population estimation and productivity (Adebiyi, 2012). Ivorian coast contains many economically important fish species like *Pseudotolithus senegalensis* (Valenciennes, 1833) which is one ivorian coast demersal resources (Troadec, 1971). It forms part of the trawl fishery catch in the ivorian coast and belongs to family Sciaenidae and inhabits soft muddy sandy bottoms at depth between 15-70 m (Seret, 2011).

Pseudotolithus senegalensis is a very common species along the African west coast (distribution recorded from Morocco to Angola). These are a highly valued food-fish in Ivory Coast (Troadec, 1971) and contribute in 9 % of proportion to the fishery trawler of the ivorian continental shelf. Despite its wide geographical distribution and its commercial and recreational value, few biological studies of the Sciaenidae family have been conducted in Africa. Research has been carried out on the dietary of some economically important fish species which include *Pseudotolithus senegalensis* and *Pseudotolithus typus* (Anyanwu and Kusemiju, 1990; Nunoo et al., 2013). Information on the reproduction of *P. senegalensis* has been given by several researchers in Africa (Troadec, 1971; Sun, 1975). These studies have given much information on many aspects of biology of *Pseudotolithus senegalensis*.

The aim of this study was to investigate the sex ratio, gonadosomatic index, hepatosomatic index, condition’s factor, stages of gonadal development and fecundity which are some aspect of the reproductive biology of *Pseudotolithus senegalensis* off the ivorian coast, Ivory Coast. It is hoped that the information obtained from this study will contribute to our knowledge of the reproductive biology of *P. senegalensis* in Ivory coast.

2. Materials and methods

2.1. Study area and sampling sites

The ivorian continental shelf covers an area of 11000 km^2 and extending to about 550 km. According to Soro et al. (1991), it is influenced by two marines seasons: The cold season from December to January and from July to September, the warm season extending from February to June and October to November. The period from July to October corresponds to the major upwelling whilst a minor upwelling is usually observed between January and February (Colin, 1988). The specimens of the Cassava croaker, *P. senegalensis* were collected from commercial catches at the fishing harbour from the industrial bottom trawlers and artisanal.

2.2. Collection specimens and sampling

Specimens were collected from January to December 2014. A total of 696 specimens of *P. senegalensis* collected during the study period. The samples were transported to the research laboratory and preserved in a deep freezer at -20°C until examination and analysis.

2.3. Morphometric measurements

Specimens were brought out of the deep freezer and allowed to thaw and body length and weight were measured. Total and standard lengths were measured using a one-meter measuring board graduated in cm. The fish was wiped with a dry napkin before weighing and body weight and ovary weight were measured using a weighing balance (Sartorius model).

2.4. Sex ratio

Each specimen was dissected and the gonads were removed. The sex of each specimen was identified by examination of the gonads. The proportion of two sexes relative to one another was used to calculate the sex ratio

2.5. Stages of gonadal development

Gonadal stages were examined macroscopically and classified according to Fontana & Le Guen (1969) as follows: Stage I, immature; Stage II, developing; Stage III, mature; Stage IV, ripe; Stage V, egg-laying; Stage VI, spent. The number of males and females in the different stages of gonadal development were counted and recorded.

2.6. Gonadosomatic index

The gonadosomatic index (GSI) was calculated for each gonad (Wootton, 1990) from the equation:

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

Where, Wg= gonad weight (g); We= eviscerate weight (g)

2.7. Hepatosomatic index

The hepatosomatic index was calculated according to (Lambert and Dutil, 1997; Pardoe et al., 2008).

$$HSI = \frac{W_l}{We} \times 100$$

Where, W_l= liver weight (g); We= eviscerate weight (g)

2.8. Relative growth condition factor

Relative growth condition factor (Kn, coefficient of condition), which measures physiological well-being of the fish (Wotton, 1994) was estimated using the formula as following:

$$K = \frac{W_t}{SL^3} \times 10^3$$

Where, Wt = total weight (g); SL = Standard length (cm)

2.9. Size at first sexual maturity

Size at first maturation was obtained through equation:

$$P = \frac{1}{1 + e^{-(a + b\,SL)}}$$

Where, P= frequency of adult individual; LS= Standard length (cm); a and b are parameters.

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

$$LS_{50} = -\frac{a}{b}$$

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

2.10. Fecundity

The fecundity is defined as the number of developing oocytes per female in a reproduction season. Fecundity was determined from specimens having ovaries with the late vitellogenesis stage of oocytes (Stage IV). The number of developing oocytes was estimated by the volumetric method. Using this method, fecundity is determined as the product of gonad volum and oocyte density. Oocyte density is the number of oocytes per volum of ovarian tissue, and it is determined by counting the number of oocytes (Vo) in a volum sample of ovarian tissue. After the ovaries volum determined (V_{ovary}), 3 subsamples of know volum are extracted from ovaries total volum. The accuracy and precision of fecundity estimation should be evaluated, especially regarding the number of subsample. As a rule-of-thumb, a sufficient number of subsamples is reached when the CV of the number of oocytes per unit volume is less than 5 % (Kjesbu, 1989). Each subsample volume are determined (Vi), it's homogenize and repeatedly sucking in and out of a Pasteur pipette, to identify and count all the vitellogenic oocytes. Oocytes can be counted using a microscope.

$$F = \frac{[\sum_i \frac{V_o}{V_i}]}{n} \times V_{ovary}$$

The relationship between fecundity and some morphometric measurements were determined by relating total fecundity (F) data to standard length (LS), total weight (TW) using the following formula:

$$F = a \times SL^b \quad F = a \times TW^b$$

Where F= Fecundity, a= Regression constant, b= Regression constant.

2.11. Statistical analyses

Data were analyzed using Analysis of variance (ANOVA) and chi-square analysis. The sex ratio was tested for the expected 1: 1 ratio by using chi-square analysis. The ANOVA test was used for length and weight mean comparisons between male and females.

3. Results and discussion

3.1. Sex ratio

A total of 458 males and 238 females were observed out of 696 samples examined. The sex ratio was 1: 0.52 (male to female). The difference in sex ratio was significant ($p < 0.05$).

3.2. Size range and population structure

Total lengths of *Pseudotolithus senegalensis* ranged from 12.0 to 36.0 cm. The difference in fish length between males (ranges 12 cm – 35.4cm SL, mean 19.24 cm ± 3.72 cm SL, N = 458) and females (12.5 cm – 36 cm, mean 19.76 cm ± 4.80 cm, N = 238) is not significant ($P > 0.05$).

3.3. Size at first sexual maturity

The length at first maturity for males of Pseudotolithus senegalensis was 19.01 cm SL (Fig 1) whereas in females it was 22.08 cm SL.

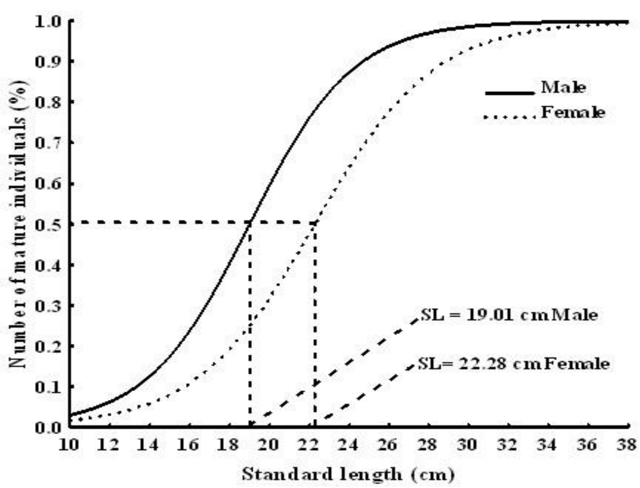

Fig. 1. Cumulative plot percentage of mature of *Pseudotolithus senegalensis* from January to December 2014; shown separately for males and females.

3.4. Gonadosomatic index

The gonadosomatic index of P. senegalensis ranged from 0.07 to 0.76. The mean gonadosomatic index was 0.23 ± 0.53. High gonadosomatic indices were observed in April and October.

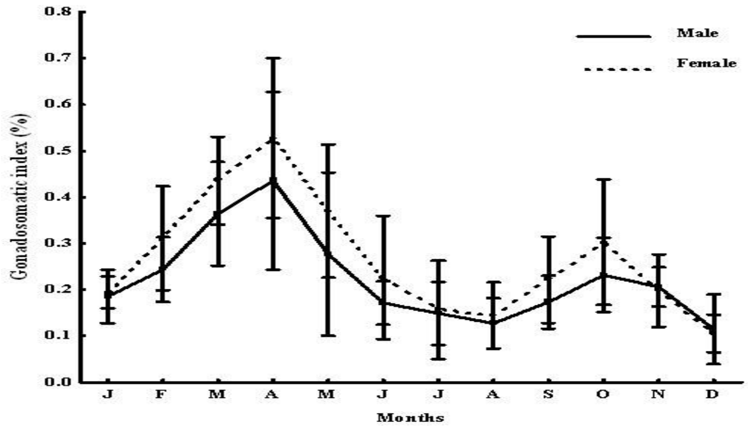

Fig. 2. Monthly changes in gonodosomatic index (GSI) of *Pseudotolithus senegalensis* females and males during one cycle.

3.5. Hepatosomatic index

The annual HSI cycle in *P senegalensis* begins with a decrease in liver weight in January to March just prior to maximum GSI levels in April, followed by an increase in July and September at the onset of mating (Fig. 3).

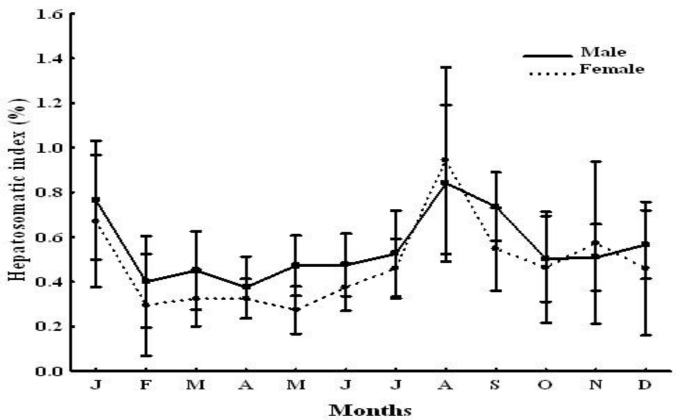

Fig. 3. Monthly changes in hepatosomatic index (HSI) of *Pseudotolithus senegalensis* females and males during one cycle.

3.6. Relative growth condition factor

The condition factor, K for males (mean = 1.57 ± 0.06; range = 1.43 – 1.74) was identical that of females (mean= 1.57 ± 0.16; range = 1.42 – 1.74). The condition factor for the combined sexes ranged from 1.42 to 1.74 with a mean value of 1.57 ± 0.16 (Fig. 4).

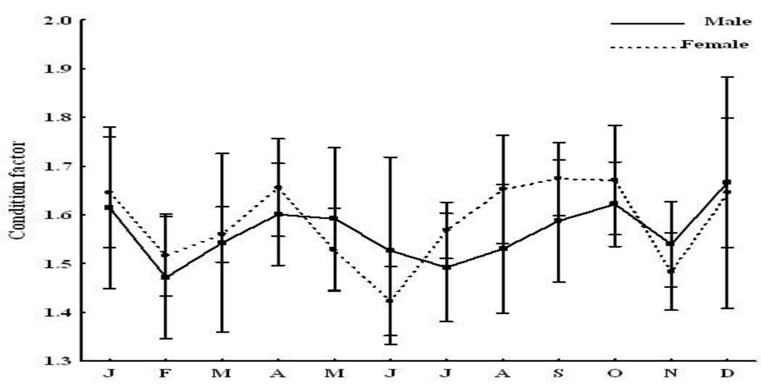

Fig. 4. Monthly changes in condition factor of *Pseudotolithus senegalensis* females and males during one cycle.

3.7. Fecundity

The number of eggs in each mature ovary ranged from 78,612 eggs (in a fish of standard length 31.2 cm and body weight 462.7 g) to 140,946 eggs (in a fish of standard length 36.0 cm and body weight 675.1 g). Fecundity was positively correlated with length and body weight. The coefficient r was 0.99 and 0.98 for fecundity-length and fecundity-weight relationship.

In the study, there were more females than males. The male to female ratio was significantly different (P< 0.05) from the expected ratio of 1: 1. In the west of Africa, Troadec (1971) and Sun (1975) were observed in the population which is similar to the findings of this study. More male were observed in the population, which is similar to the findings of this study. High gonadosomatic index recorded for both male and female in the months of April and October. An increase in the average value of this index is indicative of a spawning event. This founding is similar to that reported for this specie (Troadec, 1971; Sun, 1975). *Pseudotolithus senegalensis* seems to spawn during the spring season as the GSI of females was the highest in April and October. The timing and duration of spawning in fishes is generally coincide with periods in which environmental conditions are favourable for larval survival and growth. In this periods adult spawning condition is optimal and their chance of survival is also high (Sadovy, 1996). In our study the spawning season started in April and finished in June for the high season, when to the early season it is started in October to November. This spawning period coincide white time when water temperature is rising in the Ivorian marine water (Morlière and Rébert, 1972).

As vitellogenessis proceeds in female of *P. senegalensis* GSI increases to a peak in May while HSI declines. The inverse relationship between the HIS and GSI values can be related to the use of liver reserves during gonad growth and maturation (Wallace and Selman, 1981). Weight of the liver in fish increases prior to reproduction, and is associated with the synthesis of lipids and proteins necessary for gonad development. Similar fluctuations in female HSI are reported for the Sciaenidae *Sciaena umbra* (Chakroun-Marzouk and Ktari, 2003). Seasonal variation in HSI of the *P. senegalensis* has been attributed to fluctuations in lipid content of the liver, which has been correlated with reproductive condition.

The length at first maturity of *Pseudotolithus senegalensis* suggests that male *P. senegalensis* attain maturity at a smaller size than females. Similar result was reported for this specie by Troadec (1971). The length at first maturity in this study is lower than the other estimate of size at maturity available for *Pseudotolithus senegalensis* (Troadec, 1971; Sun, 1975). The lower size at maturity for cassava croaker in this study could be related to the differences in environmental conditions, food availability, quality of food resources and/or fishing pressure could also influence this difference in size at maturity. Stock density, food, and water temperature may influence the growth of fish and further affect the age of first maturity (Tormosova, 1983). The smallest male found in the sample to have reached maturity measured 15.3 cm, while the corresponding size for females was 16.3 cm.

Information collected from fecundity studies of *P. senegalensis* implied that it is a mean fecund fish with 10^5 and 10^6 of eggs per female. Also, the relation of fecundity to length and weight of fish showed that there was a positive correlation between fecundity and length and fecundity and body weight of *P. senegalensis*.

4. Conclusion

The results of this study signified that the deviation in sex ratio from the 1:1 distribution which was in favor of females was not significantly different from the expected 1:1 distribution. High gonadosomatic indices recorded of April and October suggest the possible spawning period of *P. senegalensis* which coincided the spring. *P. senegalensis* may be considered as a low fecund fish when compared to other species of fish with millions of eggs. This information will contribute valuable knowledge needed for fisheries management and knowledge of *P. senegalensis* by increasing the knowledge of reproduction biology of *P. senegalensis.*

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