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THE LENGTH-WEIGHT RELATIONSHIP, CONDITION FACTOR AND REPRODUCTIVE BIOLOGY OF *Pseudotolithus (P) senegalensis* (Valenciennes, 1833) (croakers), IN TOMBO WESTERN RURAL DISTRICT OF SIERRA LEONE

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ABSTRACT

The length–weight relationship (LWR), condition factor (K), sex ratio, gonadosomatic index (GSI) and hepatosomatic index (HSI) of 412 specimens of *Pseudotolithus senegalensis* (Valenciennes, 1833) from Tombo, a coastal fishing community in the western rural district of Sierra Leone were studied for twelve months. Samples used for the study were collected from the catches of artisanal fishers and measurements of length and weight of samples were done *in situ* using the facilities of the Ministry of Fisheries and Marine Resources. Samples for the reproductive study were preserved in an ice box and taken to the laboratory of the Department of Aquaculture and Fisheries Management, Njala University, Sierra Leone for analysis. The parameters "a" and "b" of the length-weight relationship were estimated using the equation described by Ricker ($W = aL^b$) while the condition factor was calculated using Fulton`s equation ($K = W100/L^3$). The reproductive biology of the fish was estimated using Gonadosomatic index (*GSI*) and Hepatosomatic index (*HSI*). The combined LWR for both sexes showed that **a, b** and **r** values were – 2.57, 3.35 and 0.899, respectively. The **r** – values obtained show a strong linear relationship between the length and weight of the species. The length-weight relationship indicated allometric growth for *P. senegalensis* in the study area. The condition factor (K) varied from 0.64 – 1.0; this may be attributed to environmental conditions of the water. The species clearly exhibited a positive allometric growth pattern ($t\alpha$ (2), 0.05, 411> 1.965). The sex ratio of males to females was 1:1.15 and was not significantly different from the expected 1:1 ratio. Estimation of GSI and HSI was carried out from December, 2010 to May, 2011 to determine the spawning behaviour of *P. senegalensis*. The mean GSI obtained indicated that March and April, respectively are the two peak spawning period for the species. Gonadosomatic index ranged between 1.1% and 2.8% for the females. The results of this study revealed that *P. senegalensis* does not have obligatory spawning month but exhibit multiple spawning behaviour. The length-weight relationships and condition factor of the study indicated that the fish were thriving very well in the coastal water of Sierra Leone. Sustainable management of the species, therefore, requires that the environment be protected against anthropogenic pollution and imposition of closed fishing season especially during the two peak spawning period is recommended to enable the species recruit effectively.

Key words: Length-weight, *Pseudotolithus senegalensis*, Condition factor, reproductive biology, Tombo, Sierra Leone

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INTRODUCTION

The croakers, drums and meagres are the most important sciaenid species in Sierra Leone. *Pseudotolithus senegalensis* (croakers) are found along the West African Coast from Senegal to Gabon [1]. They occur in the warm water above the base of the thermocline [1] and are primarily marine but also occur seasonally in brackish water areas. It inhabits mud, sandy and rocky bottoms from the shoreline to 70-m depth. The smaller and younger ones prefer shallow waters and move to mid-waters when bottom temperature falls below 18°C. *Pseudotolithus senegalensis* (Valenciennes, 1833) occurs in similar habitats as *Pseudotolithus* (fonticulus) *elongatus*. The two species are jointly harvested by artisanal and industrial fisheries, using set gillnets, beach seines, long lines and bottom trawls. *P. senegalensis* and *P. typus* form approximately 30% of catch of the trawl fishery on the continental shelf [2].

These fish species are of considerable economic importance and contribute significantly to national food security and provide employment and revenue to the larger proportion of the Sierra Leone population. Sierra Leone government provides certain incentives in the form of exemption of custom duties and internal taxes to promote certain activities including exploitation of its fishery resources. These incentives are, however, not without negative consequences on its fishery sector. Available data from scientific analysis and resource surveys conducted on Sierra Leone waters revealed that the demersal`s fish resources are fully if not over exploited [3]. As such, a rational management of these resources requires an in-depth knowledge of its biology and ecology. Knowledge on their biology is important for management and sustainable exploitation of the stock. In the context of a multispecies and multi fleet, the knowledge of the state of exploitation of a given resource is important and necessary for proper management of that population [4].

Some scientific investigations have been carried out on the status of the population and reproductive biology of *P. senegalensis*. Such investigations include the effects of long-term exploitation of demersal`s fish populations off the coast of Sierra Leone, West Africa by Coutin and Payne [5]; the growth, maturity and mortality of the sciaenidae of the tropical West Africa and those on biological data of West African croakers [6,7]. The reproductive biology and production characteristics of three croaker species of the Guinea coast were studied by Zuyev and Giragosov [8]. The dynamics of *P. typus* in the Gulf of Guinea was studied and it was discovered that the fishing effort targeting the sciaenids is well over the sustainable level [9].

Information on the reproductive biology of *P. senegalensis* in the coastal waters of Sierra Leone is very scanty. Therefore, this present study seeks to document information on the length-weight relationship of *P. senegalensis*. Knowledge of length-weight relationship helps in estimating the standing stock or biomass thereby establishing the yield by converting one variable into another as is often done during field studies, calculating condition indices, comparing the ontogeny of fish population from different regions and in trophic studies [10, 11].

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It also aims to determine the spawning behavior of the species using gonad development stages, Gonadosomatic Index (GSI) and Hepatosomatic Index (HSI) of specimens collected directly from artisanal fishermen at Tombo – Western fishing district of Sierra Leone.

MATERIALS AND METHODS

Study Area

The study was carried out at the Tombo fish landing sites within the Yawribay Proposed Marine Protected Area (YPMPA) of Sierra Leone. On average, the two fish landing site is 52 km away from Freetown. Tombo is among the largest fishing communities in the Western Area Fishing district of Sierra Leone. The study area is located south of Freetown and it lies between latitudes 7˚52' and 8˚20' N and longitudes 12˚45' and 13˚10'W. The total area is about 29,505 hectares characterized by intertidal mud sediments [12].

The climate of the study area is tropical with two well-defined seasons; the dry season (November to April) and the rainy season (May to October). The heaviest rainfall occurs in July, August, and September with average annual rainfall of approximately 122.7inches (311.6cm). Mean monthly temperatures are 27.0^{o}C and 28.6^{o}C for the rainy season and dry season, respectively. Within the continental shelf area, mean monthly temperatures range from 26^{o}C to 27^{o}C during the rainy season and 28^{o}C to 29^{o}C during the dry season.

The heaviest rains occur in July and August and the mean monthly amount of rainfall reaches its maximum in July and August [13]. The dry season (November to April) is dominated by the north east trade winds from the north while the monsoon or rain bearing winds dominate during the rainy season (May to October).

Sources of data

Length and weight relationship determination

Monthly samples were collected at Tombo fish landing sites. Fish specimens for the study were collected from artisanal fishers and middle men at the landing sites. Sampling of landed catches was done once in a month for a period of six months. The fishers used a wide range of fishing gear such as hooks and line, long line, cast nets, gillnets, seine nets and traps.

During the sampling period, the total lengths of fish samples were measured using an improvised measuring board made from wood to the nearest 0.5cm. To reduce bias, samples were collected at random from different boats of artisanal fishers. Corresponding weights of each fish were also measured using an electronic balance scale to the nearest 0.5g. Data on length and weight frequencies were recorded into excel data sheet for statistical analysis. Furthermore, sub-samples of 10 female fish were drawn at random every month from each site and preserved in a cooling box using ice cubes. The preserved samples were taken to the laboratory for detailed studies on the reproductive biology.

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Laboratory analysis

Sub-samples taken to the laboratory were treated individually to determine the sex and weight of gonad and liver. In the laboratory, standard length of each sub-sample was measured to the nearest 0.5cm using a measuring board and the gutted weight of corresponding sample measured to the nearest 0.5g. Specimens were dissected and the gonads were carefully removed with the aid of forceps after dissection. The gonad and the liver were weighed separately to the nearest 0.5g. The sexes of dissected specimens were identified by examination of the gonads. The proportion of the two sexes relative to one another was used to calculate the sex ratio.

Data Analysis

The relationship between the length (L) and weight (W) of fish was expressed by the equation given by Gayanilo and Pauly [14].

$W = aL^b$

$\ln W = \ln a + b \ln L$

Where

W = Weight of fish in (g)

L = Total length (TL) of fish in (cm)

a = Constant (intercept)

b = slope (change in weight per unit change in length)

The "**a**" and "**b**" values were obtained from a linear regression of the length and weight of the fish measured.

The exponent `b` provides information on fish growth. When b=3, increase in weight is isometric and when the value of b is other than 3, weight increase is allometric, (positive allometric if b>3, negative allometric if b<3). The null hypothesis of the isometric growth (H_0: b =3) was tested by t – test, using the statistic: $ts = (b-3)/S_b$, where S_b is the standard error of the slope, for $\alpha=0.05$ for testing significant differences among slopes (b) between two regressions for the same species [15].

Length in exponent 3 expressed as a percentage was used to calculate the condition factor estimated from the relation below;

$K = 100\ W/L^3$

Where,

K = Condition factor

W = Weight of fish (g)

L = Length of fish (cm)

The weight of each fish and of its gonad was used to determine the gonadosomatic index (GSI) following Ekanem *et al*. [16].

$$GSI = \frac{\text{weight of gonad}}{\text{Weight of gutted fish}} \times 100$$

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Hepatosomatic index (HSI) was also calculated [16] using the relationship below.

$$HSI = \frac{\text{Weight of liver}}{\text{Weight of gutted fish}} \times 100$$

RESULTS

The total length of *P. senegalensis* ranged from 24.3 to 54 cm (π = 36.5 cm) and the total weight between 112 and 1000 g (π = 360.5g). Table 1presents the results of the length – weight relationship and condition factor obtained for the species. Sex ratio of male to female was (1:1.15); fish length ranged from 24.3cm (minimum) to 54cm (maximum) (45.2 ± 2.90) while the weight ranged from 112g (minimum) to 1000g (maximum). The mean monthly condition factor recorded for the fish was 0.98 as shown in Table 1. The results of student's t - test to analyze the significance of variation in the estimates of 'b' for *P. senegalensis* was calculated as ts = (b-3)/S_b, (3.35-3.0) / 0.143 = 2.448. The regression exponent values obtained for *P. senegalensis* was significantly different (P<0.05) from 3 indicating positive allometric growth (tα (2),0.05,411> 1.965).

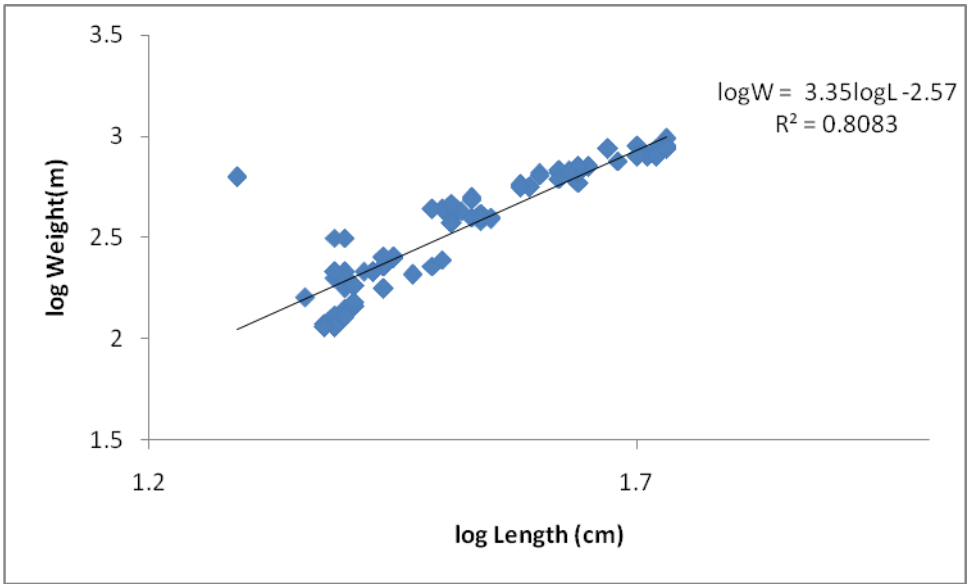

Figure 1: Length-Weight Relationship for *Pseudotolithus senegalensis*

The results for the regression of length and weight are represented in Figure 1 above. There is a linear relationship between the length and the weight as indicated by the high 'r'. The r^2 determined for the species is 0.8083 at $W = -2.57L^{3.35}$.

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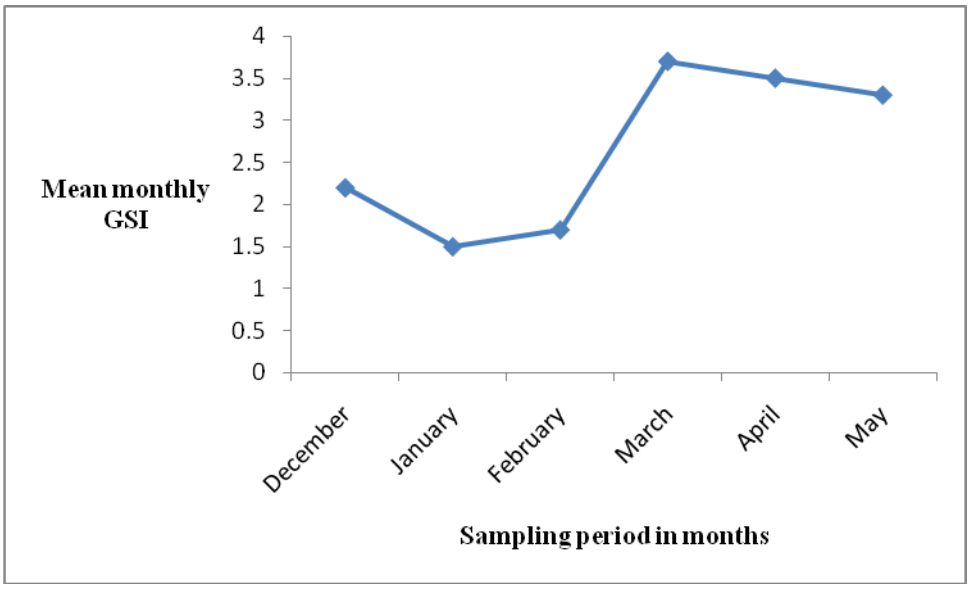

Figure 2: Mean monthly Gonadosomatic index (GSI) for *Pseudotolithus senegalensis*

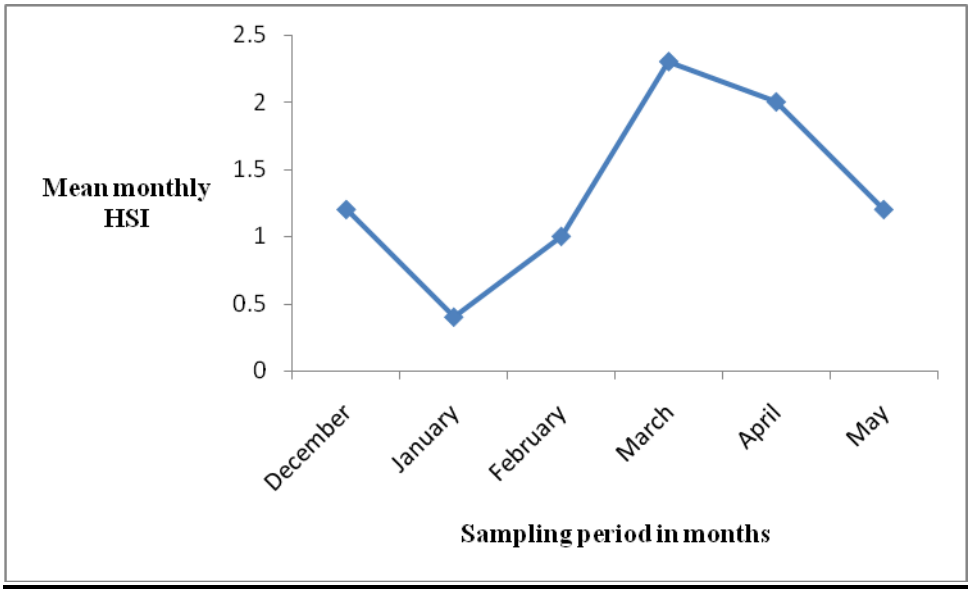

Figure 3: Mean monthly hepatosomatic index (HSI) for *Pseudotolithus senegalensis*

Figure 2 and 3 showed the Gonadosomatic index (GSI) and Hapatosomatic index (HSI) of the fish. Mean monthly Gonadosomatic index and Hepatosomatic index was at peak in March and low in January of the sampling period. It was apparent from the results that gonadal development peaks in March, which is the beginning of the onset of the rainy season and decreases progressively. The rainy season is obviously the best period

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for most fishes to spawn because of the high abundance of food materials for the fry and fingerlings.

The mean monthly condition factor for *P. senegalensis* studied is presented in Figure 4. Mean monthly condition factor was higher in March and April than in other months as shown in Figure 4. The fish appeared to enter into maturation phase during the month of March and April as could be seen from the results of GSI and HSI.

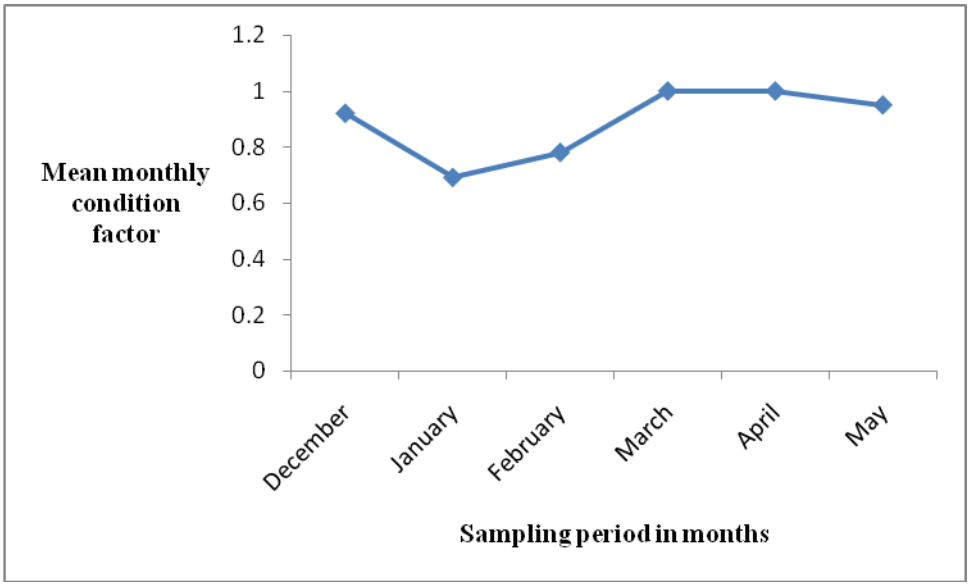

Figure 4: The mean monthly condition factor of *P. senegalensis*

DISCUSSION

In this study growth of fish showed positive allometry as t–test departure from 3 which is the value of isometric growth showed significant difference P<0.05 (tα(2),0.05,411> 1.965). The `r` value of 0.899 showed correlation between length and weight. Allometric growth has been observed in other species such as 2.84 for female *Clarias gariepinus* and 3.289 for *Barilius ngawa* [17, 18]. The occurrence of absolute isometric growth (b = 3) in nature is occasional [19, 20]. According to Hile [21] and Martin [22], the value of 'b' usually ranges between 2.5 and 4.0. Allen [23] suggested that the value of 'b' remains constant for ideal fish.

Length – weight relationship gives information on the condition and growth patterns of fish. The change of *b* values depends primarily on the shape and fatness of the species although other factors may be responsible for the differences in the parameters of the length – weight relationship among seasons and years such as temperature, salinity, food, sex, time of year and stages of maturity [24].

The mean condition factor obtained for this study was 0.98 while the mean monthly condition factor ranged from 0.66 to 1.00 as shown in Figure 4. These results vary slightly from the condition factor (K) of between 0.77 – 0.81 reported for *Clarotes*

filamentosus in Lake Oguta and K – value ranging from 0.49 to 1.48 obtained for the same species in Adoni River [25, 26]. Certain factors are known to affect the wellbeing of fish [14]. These factors include data pulling, sorting into classes, sex, stages of maturity and state of the stomach [14]. Values of the condition factor may vary according to season and may be influenced by environmental conditions [25]. The growth conditions for the site where the research was carried out on the basis of the results obtained indicated that the equilibrium constant does not obey the cube law since it significantly deviates from 3. The value of the calculated allometric parameter 'b' was found to be more than 3, an indication that the fish were thriving very well in the coastal waters of Sierra Leone.

Gonadosomatic index was high in March – May, the highest gonadosomatic index obtained was in March (3.70) and this suggested that this could be the spawning period of *P. senegalensis*. March – May falls within the wet season and at this period, rainfall is high, water levels in the coastal waters increase and food availability is also high, thus providing favourable conditions for spawning to occur.

The hepatosomatic index recorded in this study showed similar pattern of occurrence as was observed for gonadosomatic index; highest hepatosomatic index was also recorded in March (2.80). Another period of high spawning activity occurred in April as shown in the result. The least spawning activity seemed to have occurred in January which had the lowest GSI value. The spawning period for *Pseudotolithus senegalensis* in the Cameroon is similar to that of *P. elongatus* in the Cross River estuary and that of *P. typus* of the Cameroon [27]. The only difference is the peak spawning period of *P senegalensis* and *P. typus*. They both have their first peak in March, April and May while the second peak is in November and December whereas *P. elongatus* has its first peak in December, January and February and the second peak in July and September [28]. The value of coefficient of correlation `r` estimated, indicated that the relationship between the length and weight of the species was significant. The sex ratio of the sampled fish as indicated in Table 1 showed that the female fish were more dominant especially in the months of March, April and May which is the peak spawning time. The female fish might have come close to the shore and other spawning grounds to spawn where they were caught by the artisanal fishermen.

The sex ratio observed for *P. senegalensis* in Tombo, Western rural district of Sierra Leone pointed to the fact that there were probably more females than males (1.15:1). This result was similar to what was obtained for *B. auritus* in Cape coast Ghana where the number of females exceeded that of the males [29]. The sex ratio of 1: 1.09 (male to female) obtained for trout sweet lips grunt *Plectorhynchus pictus* [30] was not different from what was obtained in this study.

The results of this preliminary study clearly showed that *P. senegalensis* does not have any obligatory month for spawning, but seems to exhibit multiple spawning behaviour. The spawning peaks appear to be from March - May and November – December, with March to May being the peak.

It is a well known fact that the length-Weight relationships and condition factor of fishes are important management tools and the results of these parameters in the western area fishing district of Sierra Leone have shown that the environment is suitable for the survival and reproduction of *P. senegalensis*. Since *P. senegalensis* is part of the commercially exploted species of Sierra Leone, it is important to have a record of their length and weight from different habitats for proper management decision. Sustainable management of the species also requires that the environment where the fish grows be protected against anthropogenic pollution. Imposition of closed fishing season especially during the two peak spawning period might be a sound recommendation for the species to recruit effectively.

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Table 1: Length-weight relationship and condition factor (K) for *Pseudotolithus senegalensis*

Sex ratio		N	a	b	R	Mean	Length cm			Weight (g)		
Male	Female					CF	Min	Max	Mean	Min	Max	Mean
1	1.15	412	-2.57	3.35	0.899	0.98	24.3	54	36.5	112	1000	360.5

CF - Condition Factor

Min – Minimum

Max - Maximum

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