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RESEARCH ARTICLE

Relative growth and morphometry of otolith sagittae of *Pseudotolithus senegalensis* (Val.) along the coastline of Cameroon

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Abstract. *Pseudotolithus senegalensis* is among the most important commercial fishes in Cameroon. However, data on the life history of *P. senegalensis* are limited. This study analyzed the length-weight relationship (LWR) and condition factor of the fish, the relationship between the length and weight of fish and the length and weight of otolith sagittae. The fish (123) were collected for a period of three months (March-May) from the coastline region of Down Beach, Limbé, Cameroon. There was a significant ($P<0.05$) positive allometric relationship between the length and weight of the fish. However, no significant ($P>0.05$) relationship between the length class frequency of males and females was noted. Relationships between fish length and weight and otolith length and weight were described by linear regression models and significant correlations were obtained for all relationships. The highest correlation ($r^2 = 0.55$) was between otolith length and fish weight and the lowest correlation ($r^2 = 0.14$) was between otolith weight and fish weight. The results of this study demonstrate that fish length and weight and otolith dimensions have a positive allometric relationship; therefore, they could be a useful instrument for the assessment and evaluation of fish growth in stock and fisheries management.

Keywords: fish length, morphometry, otolith, *Pseudotolithus senegalensis*, Cameroon.

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Introduction

Artisanal and industrial fisheries are crucial to human life. For instance, fishing is a source of income and contributes tremendously to a country's growth development product. In many parts of the world, fish are cheap sources of animal protein and approximately 16% of the animal protein consumed globally is from fish (Cardoso et al. 2013, Cardoso et al. 2020). Fish is present in many diets and delicacies in Cameroon, and about 3.2 million metric tons of fish are expected to be consumed annually by 2026 (Studies, Planning, Cooperation and Statistics Division, 2021). Fishery provides jobs to fishers, traders, marketers, and processors, which is why the demand for fish has impacted local production and fishing.

The fish communities of commercial importance, mainly exploited by artisanal and industrial fisheries

in Cameroon, include the coastal (suprathermoclinal) sciaenid community, the shallow community (superthermoclinal) sparid community, and the deep water (subthermoclinal) sparid sub-community (FAO 2016). The most important Scianidae in Cameroon are croackers and drums, among which there is the genus Pseudotolithus with *Pseudotolithus elongates*, *P. typus*, *P. senegalensis*, and the boe drum, *Pteroscion peli* (FAO 2016). These species are distributed widely along the coast of tropical West Africa from Senegal to Angola (Edwards et al. 2001).

Pseudotolithus sp. is one of the major components of landed fish species (Djama and Pitcher 1989). Recently, the cited authors studied the mortality and growth of *P. elongatus* and *P. typus*, which are prerequisites for rational exploitation. However, studies also revealed that since 1983, there has been a decline in catch per unit effort from the stock, and the size of fish in the harvested population is progressively decreasing and is now less than 80 cm (Gbarguidi 2000). The population of this fish is probably decreasing because of overfishing to meet high consumer demand (Narges et al. 2011). It is, therefore, necessary to evaluate some valuable parameters reflecting their life history to ascertain which measures to take to manage the fishery properly. However, understanding the variation of some features (fish and organ sizes) is necessary for growth prediction.

Morphometric sizes (length and weight) of fish and otolith dimensions are critical for decision-makers as they provide baseline information for estimating growth rates and ages (Costa et al. 2018). Otolith morphometrics also reflect crucial patterns in teleost fishes (Tuset et al. 2008). However, alteration or variation may occur among species and individuals due to factors such as the environment and fish physiology. Generally, studies of fish otolith morphometry are scarce in many parts of the world, including in Africa and Cameroon. Studies on the morphometry of the length or weight of *P. senegalensis* have not been reported in Cameroon to date.

In contrast, fish are abundant along this region's coastline. The study by Djama and Pitcher (1989) is the only one that provides important information on the biology and ecology (growth and mortality) of *P. senegalensis* in Cameroon. Up-to-date information on the relationship between otolith dimensions and fish length and weight is needed to enhance regional knowledge of *P. senegalensis*, and otolith analysis may be of great importance in assessing the age of this fish.

Therefore, this study aims to evaluate the length-weight relationship (LWR) of *P. senegalensis* and to assess possible length differences between sexes and to evaluate the relationship between otolith sagittal dimensions and the length and weight of *P. senegalensis*.

Materials and methods

Fish specimens (123) were collected at random monthly for three months from local fishers landing at a commercial fish market near the Down Beach, Limbé (4°00'20,6''N 9°11'57,6''E) situated on the northern coastline of Cameroon. Fishing was conducted with gillnets at 15–50 m depths. All specimens were identified using FAO (2016) guidelines. Measurements of total length (TL, ± 1mm), standard length (SL, ± 1 mm), and total weight (W, ± 1g) were also recorded. The sex of the fish was determined by examining the gonads with a magnifying glass, and classification was done according to the method in Brown-Peterson (2011). Fish otoliths were extracted, rinsed with saline solution, dried, measured with a caliper, and weighed on an analytical balance (10^{-6} g). Otolith length was taken from the tip of the rostrum to the posterior margin.

Data were subjected to tests of normality and homoscedasticity of variance. The LWR used the model equation as follows: $W_t = aTL^b$. Data were transformed into logarithms to determine a and *b*; a corresponds to the coefficient and *b* the allometric coefficient (Froese 2006). Student *t*-test was used to test the hypothesis that the calculated value was equal to 3. The condition factor expresses the physiological condition estimated with equation $K=W\ TL^{-b}$, where

Table 1
Distribution of total length (TL) of individuals in different size classes of *P. senegalensis* based on sex

Total length of fish (mm)	Number of male	Number of female
141-160	10	5
161-180	16	4
181-200	14	9
201-220	20	4
221-240	21	7
241-260	7	2
261-280	1	2
281-300	0	1

K is the allometric condition factor, and b is the coefficient of the LWR equation. The relationships between otolith length (OL), otolith weight (OWt) and total length (TL), standard length (SL), and total weight (W) were determined using the least squares method in linear regressions of decimal logarithms of parameters (X-Y): OL vs TL, OL vs SL, WT vs OWt. All analyses were computed with Past, and regression models were done in Excel (Microsoft 365); statistical significance was considered when $P<0.05$.

Results

The study focused on examining the total and standard lengths of *P. senegalensis* in 123 fish specimens. The fish examined had a sex ratio of (2.3:1) with male dominance over female. The total length range of the fish was 145–296 mm with a mean of 205.26 ± 32.87, and the standard length range was 110–240 mm with a mean of 165.78 ± 31.45 mm (Table1). The weight range of the fish was 22–171 g with a mean of 76.53 ± 37.02 g.

The study revealed that the LWR of pooled data with equation $W = 1.991\ TL \times 0.173$ ($r^2 = 0.283$, n = 123) was significant ($P < 0.05$). The coefficient estimate demonstrated highly significant positive allometric growth with $b < 3$ ($P < 0.001$) and a condition factor of 0.9.

The study also documented the relationship between otolith dimensions and fish sizes to assess their impact on fish growth (Table 2). Otolith length, for instance, showed a variation between 3 and 15 mm, with a mean of 9.16 ± 2.92 mm and weight from 0.12 to 0.60 g and a mean of 0.28 ± 0.086 g for all the fish samples examined (n = 123).

The relationship between the OL vs TL and OL vs SL was studied using a regression model, and the results showed statistical differences (Table 3). The range of the coefficients obtained for OL vs TL were 0.61–1.35; the equation was $TL = -1.33\ OL^{0.98}$ ($r^2 = 0.183$, n = 123). However, the fish showed positive

Table 2
Morphometric measurements (mean ± S.E) of *P. senegalensis* (n = 123). TL - total length; SL - standard length; W - total weight; OL - otolith length; OW - otolith width

Morphometric variables	n	Mean ± SD	Minimum	Maximum
TL (mm)	123	205.26 ± 32.87	145	296
SL (mm)	123	165.78 ± 31.45	110	240
WT (g)	123	76.53 ± 37.02	22	171
OL (mm)	123	9.16 ± 2.92	3	15
OW (mm)	123	0.28 ± 0.086	0.12	0.6

Table 3
Relationships (x - y) between *P. senegalensis* sizes and otolith sagitta measurements. Number of specimens (*n*), coefficients of determination (r^2), and parameters of power equations: a and *b*, regression parameters; CI, 95% confidence interval; TL - total length; SL - standard length; W - total weight; OL - otolith length; OW - otolith width. Values are significant at P < 0.05

Relationship	n	a	*b*	r^2	±CI (a)	±CI (b)	P value
TL vs OL	123	-1.33	0.98	0.19	2.19	0.61	< 0.001
SL vs OL	123	1.79	0.45	0.33	1.6	0.34	< 0.001
W vs OL	123	0.032	0.49	0.55	0.11	0.41	< 0.001
W vs OW	123	-0.935	0.197	0.14	1,09	0.11	< 0.001

allometric growth for OL vs W ($W = 0.032\ OL^{0.49}$, r^2 =0.55, n = 123, CI (b) = 0.41 – 0.57, P < 0.05), which aligns with the prevailing assumption that there is a pattern of otolith length increment growth with increasing fish weight. Furthermore, the relationship between the OW vs W showed a significant positive allometric growth pattern of increasing otolith weight with increasing fish weight ($W = -0.94\ OW^{0.197}$, r^2 = 0.55, n=123, CI (b) = 0.11-0.28, P < 0.05).

Discussion

This preliminary study of the LWR and otolith dimensions of *P. senegalensis* is one of the first attempts in the Central African region to understand the impact of the size and weight of fish on otoliths and possible fish age. Spatiotemporal factors generally influence the study of fish growth patterns, thus permitting a better understanding of stock variability (Sossoukpe et al. 2013).

The significant correlation observed in the present study between the total length and weight, and TL vs OL and OL vs W demonstrates that the tool used for analysis is good enough for predicting fish growth from otolith measurements. This agrees with studies documenting the use of this model for fishery stock population assessments (Onay and Ceylan 2022); the cited authors also demonstrated a positive, strong relationship between TL vs OL and OL vs OW in both sexes in *Symphodus cinereus*.

Fish fitness is a function of changes in environmental factors such as temperature, salinity, conductivity, dissolved oxygen, and turbidity (Javor et al. 2011). The LWR in the current study showed positive, significant allometric growth in the pooled data. This could be attributed to the fact that variation may be due to environmental factors such as temperature that could positively affect length (Mendoça et al. 2022).

However, the condition factor to which the fish in this study was exposed is less than 1, indicating that environmental conditions could be more favorable for optimal fish growth. This could be an indication that intrinsic and extrinsic parameters influenced fish fitness. Factors such as structure in size and gonadal maturity might be responsible for the change in the LWR in fish sexes. However, in the current study, there were no significant growth differences in length between male and female fish. This may indicate that both sexes were found in the gill net and fishing was not selective; moreover, juvenile and adult fish were both targeted as commercial-sized fish.

Studies of fish otoliths are not restricted to ichthyology but may also be useful in disciplines including stratigraphy, archaeology, paleontology, and zoography (Tuset et al. 2008). Otolith morphometrics and shape are reported to be correlated with the length and weight of fishes (Eroglu and Sen 2009). The assumption is that as fishes grow, otolith sizes increase. In this study, this relationship was expected to be similar to other reported findings regarding the relationship between otolith size and somatic growth in other fish species (Dehghani et al. 2016, Mendoça et al. 2022).

Our study demonstrated significant relationships between OL vs TL, OL vs SL, OL vs W, and OW vs

W. Therefore, our results indicate a strong relationship between otolith and fish size, which could be crucial in standardizing fish age reading investigations. In other studies, morphometric relationships between otolith sagitta dimensions and fish length and weight were determined, which helped estimate the size and age of the prey consumed (Javor et al. 2011). The determining coefficient of OL vs TL demonstrated that otolith size could be a good indicator of fish size.

Conclusion

This study demonstrated that otolith and body length and weight are practical quantitative values that can be used for assessing *P. senegalensis* growth parameters along the coastline of Cameroon. This study serves as a baseline and reference point that may support further studied data for the evaluation of life history parameters and may be inherent body composition of this fish in the region. However, the lack of similar studies on this fish in the region limits the possibility of making direct comparisons with the results presented here. Therefore, we recommend further studies be performed on this topic, but also studies on the relationship between the length/weight of fish and fish age since these are necessary for determining fish growth rates that could shed light on habitats and the food conditions of fishes.

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