Asian Journal of Advances in Agricultural Research

6(1): 1-8, 2018; Article no.AJAAR.39241
ISSN: 2456-8864

Length-weight Relationship, Condition Factor and Length Frequency Distribution of the Tongue Sole *Cynoglossus senegalensis* from Akpa Yafe River, Bakassi, Cross River State, Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Author ANN managed the analyses and literature searches of the study. Author EVO designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJAAR/2018/39241
Editor(s):
(1) Wuyi Liu, Professor, Department of Science & Technology Research, Fuyang Normal College (West), Anhui Province, China.
Reviewers:
(1) Javier E. Contreras-Reyes, Instituto de Fomento Pesquero, Chile.
(2) Abdullah Ekrem Kahraman, Istanbul University, Turkey.
(3) Bryan Matthias, University of Minnesota, USA.
Complete Peer review History: http://prh.sdiarticle3.com/review-history/23642

Original Research Article

Received 29th December 2017
Accepted 5th March 2018
Published 15th March 2018

ABSTRACT

The length-weight parameters, condition factor and length frequency distribution of the tongue sole, *Cynoglossus senegalensis* (Kaup, 1858) from Akpa Yafe River, Nigeria, were estimated. A total of 292 freshly caught samples were collected between November 2014 and October 2015 from the catches of the artisanal fisheries at Ikang beach, Bakassi L.G.A., Cross River State. Results showed a negative allometric growth indicating that the fish gets slimmer as it grows larger. A significant linear relationship is given by the equation: $W = .0.0413TL^{2.3861}$ and Log W = 2.3861TL - 1.3841(r^2 = 0.7700, P < 0.05, n = 292, d.f. = 290). Mean monthly condition factor of *C. senegalensis* was highest (0.419 ± 0.01) in May and lowest (0.277 ± 0.02) in November. The

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length frequency distribution showed that the highest length frequency was in length class 57.1-60.0 cm (47) and the lowest (1) in 33.1- 36.0 cm, 36.1- 39.0 cm, 39.1 – 42.0 cm, 81.1 – 84.0cm, and 87.1 – 90.0 cm length class. These important findings would be useful for fishery biologists and fishery managers in evaluating the population dynamics, stock assessment and sustainable management of *C. senegalensis* from Akpa Yafe river and other similar water bodies.

Keywords: Length-weight relationship; condition factor; length frequency distribution; tongue sole; Cynoglossus senegalensis; Akpa Yafe River.

1. INTRODUCTION

Length-weight relationships and condition factor of fishes are important tools in fisheries science. Length-weight relationship (LWR) is an important growth index used as a sustainable management tool by fishery biologists. Length-weight relationship (LWR) is useful in fisheries science in the following areas; estimation of average weight of fish at a given length group [1], growth rate estimation [2], estimation of length and age structures [3], conversion of growth in-length equations to growth-in-weight in stock assessment models [4], estimation of biomass from length frequency distributions [5]. Information on length-weight relationship (LWR) are also used in comparing morphological aspects and life history of fish populations inhabiting different water bodies [6]. Condition factor is another important tool that is vastly used in fisheries science by fish biologists, fishery managers and aquaculturists. The relevance of condition factor in fisheries science is widely related to health status, growth and feeding intensity in various fish species [7]. According to Contreras-Reyes [8], interpretation of condition factor in fish is based on the hypothesis that heavier fish of a given length are in better condition. Variations in condition factor values is an indication of the degree of food source availability, state of sexual maturity and suitability of a specific water body for healthy growth of fish [9]. Condition factor is useful in understanding the life cycle, management of fish species and maintaining the equilibrium in the ecosystem [10]. Length frequency of fishes are also very useful in different aspects of fisheries science. It provides deep knowledge on the structure of natural fish population size [2]. In gear selectivity evaluation, length frequency distribution is the first step used in evaluating different gears used in the same water [11]. The tonguesole fish (*Cynoglossus senegalensis*) commonly known as “Ukpek” by the Efik and Ibibio tribes in Nigeria belongs to the Cynoglossidae family. *C. senegalensis* is one of the most valued and important food fish for the Akpa Yafe river inhabitants due to its taste and meat quality. This species has a flat body without a pelvic fin and both eyes on the left side of the body. According to Udo et al., [12], a major feature of this species is the presence of a long hook on the snout over hanging the mouth. *C. senegalensis* is a tropical species found within the geographical range (22°N 18°S and 18°W 14°E) and also in subtropical oceans within the depth of 10-110 m [13-15]. In Akpa Yafe River, information of some aspect of the biology of *C. senegalensis* which could be useful in the sustainable management of this species has not been documented. Therefore, the aim of this study is to determine the length-weight relationship, condition factor and length frequency distribution of *C. senegalensis* from Akpa Yafe, Baksaai, Nigeria.

2. MATERIALS AND METHODS

2.1 Description of Study Area

Akpa Yafe River which is a tributary of Cross River lies approximately between latitude 4.683˚N and longitude 8.517˚E. The river forms a natural boundary between Cameroon and Nigeria by the Eastern flanks of Bakassi and Akpabuyo Local Government Areas of Cross River State, Nigeria. Its basin covers an area of 54,000 km^3 with 40,000 km^3 in Southern Nigeria and 14,000 km^3 in the Cameroon. Akpa Yafe River takes its rise from the Atlantic Ocean. The major occupation of the river inhabitant include; fishing, farming, petty trading, boat making, palm wine tapping etc. The river is rich in both fin fishes and shell fishes of economic value including, Silver catfish (*Chrysichthys nigrodigitatus*), African Catfish (*Clarias gariepinus*, *Heterobranchus longifilis*), Ecomog (*Heterotis niloticus*), the grey mullet (*Mugil cephalus*), the blue crab (*Callinectes amnicola*) etc.

2.2 Collection and Identification of *C. senegalensis* from Akpa Yafe River, Nigeria

A total of 292 freshly caught samples of *C. senegalensis* were collected between November 2014 and October 2015 from the catches of the artisanal fisheries at Ikang beach, Bakassi L.G.A., which is a major landing point of the artisanal fisheries of the Akpa Yafe River. The fishers caught the experimental fish with a wide range of fishing gear such as gill net, cast net, hook and line, long line and traps. Samples collected were immediately transported in ice-packed containers to the Fisheries and Aquaculture laboratory, Institute of Oceanography, University of Calabar, for further analysis. Identification of *C. senegalensis* was based on photo cards and identification key given by Fischer [16] and Schneider [17].

2.3 Measurements of Biometric Parameters of *C. senegalensis* from Akpa Yafe River, Nigeria

The following biometric parameters were measured for each specimen: Total length (TL, cm) and Total weight (TW, g). Total length was measured to the nearest 0.1 cm from the tip of the mouth to the end of the caudal peduncle. Total weight was taken to the nearest 0.1 g using Metlar-2000D electronic weighing balance [18] and [19].

2.4 Length-Weight Relationship of *C. senegalensis* from Akpa Yafe River, Nigeria

The length- weight relationship of *C. senegalensis* from Akpa Yafe River was estimated using the equation: given by Froese [20] as follows:

$$W = aL^b$$

Where W is the total weight (TW, g), a is the intercept, L is the total length (TL, cm) and b is the slope. The parameters a (intercept) and b (slope) were estimated by linear regression based on logarithms using the linear regression routine of Microsoft Office Excel in PC windows (2007) as follows:

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

where W = total weight (TW, g) and L = total length (TL,cm)

Departure from isometry (i.e. b = 3) for the exponents (b) of the length-weight relationship was tested using a t-statistic function given in according to Pauly [20].

$$t = \frac{\text{s.d. (x)}}{\text{s.d. (y)}} \cdot \frac{/ b - 3 /}{\sqrt[2]{1 - r^2}} \cdot \sqrt[2]{n - 2}$$

Where s.d. (x) is the standard deviation of the Log L values, and s.d. (y) is the standard deviation of Log W values, n is the number of samples used in the computation, b is the estimated exponent of the LWR and r^2 is the correlation coefficient of the relationship. If t calculated is greater than the tabled value of t for the degree of freedom, n – 2, it implies that the value of b is different from 3 [21].

2.5 Condition Factor (CF) of *C. senegalensis* from Akpa Yafe River, Nigeria

The Fulton's condition factor (CF) was calculated as follows: $CF = 100W/L^3$

where CF is the condition factor, W is the total body weight (TW, g), L is the total length (TL, cm) and 3 is a constant.

2.6 Length - Frequency Distribution of *C. senegalensis* from Akpa Yafe River, Nigeria

The data obtained for the length measurement of 292 samples of *C. senegalensis* from Akpa Yafe river were grouped into 20 length classes of 30.1- 33.0 cm, 33.1- 36.0 cm, 36.1- 39.0 cm, 39.1 – 42.0 cm, 42.1 – 45.0 cm, 45.1 – 48.0 cm, 48.1 -51.0 cm, 51.1 – 54.0 cm, 54.1 – 57.0 cm, 57.1 – 60.0 cm, 60.1 – 63.0 cm, 63.1 – 66.0 cm, 66.1 – 69.0 cm, 69.1 – 72.0 cm, 72.1 – 75.0 cm, 75.1 – 78.0 cm, 78.1 – 81.0 cm, 81.1 – 84.0cm, 84.1 – 87.0 cm and 87.1 – 90.0 cm length classes for subsequent analysis.

3. RESULTS

3.1 Length - Weight Relationship of *C. senegalensis* from Akpa Yafe River, Nigeria

Length-weight relationship of *C. senegalensis* from Akpa Yafe river (Fig. 1) was estimated for 292 samples. The normal plot of total weight (TW, g) against total length (TL, cm) for pooled

sex of *C. senegalensis* is shown in Fig. 1. A significant linear relationship was established, given by the equation: $W = .0.0413TL^{2.3861}$ (r^2 = 0.7700, t-Test, P < 0.05, d.f. = 290), and the length-weight parameters was estimated as: a = 0.0413 and b = 2.3961. t-statistic showed that the value of b = 2.3961 is significantly different from 3 and hence, the weight growth for *C. senegalensis* departs significantly from isometric condition of b=3.

3.2 Mean Monthly Condition Factor of *C. senegalensis* from Akpa Yafe River, Nigeria

Results obtained for mean monthly condition factor of *C. senegalensis* from Akpa Yafe river (Table 1) showed that the highest value (0.419 ± 0.01) was obtained in May, followed by 0.403 ± 0.02 obtained in June and least (0.277 ± 0.02) in November. Fig. 2 shows the monthly variation in condition factor for *C. senegalensis* from Akpa Yafe river.

3.3 Length – frequency Distribution of *C. senegalensis* from Akpa Yafe River, Nigeria

The length frequency distribution of *C. senegalensis* from Akpa Yafe River (Fig. 3) showed that 30.1- 33.0 cm length class had a frequency of 2, 33.1- 36.0 cm (1), 36.1- 39.0 cm (1), 39.1 – 42.0 cm (1), 42.1 – 45.0 cm (10), 45.1 – 48.0 cm (22), 48.1 -51.0 cm (24), 51.1 – 54.0 cm (18), 54.1 – 57.0 cm (20), 57.1 – 60.0 cm (49), 60.1 – 63.0 cm (39), 63.1 – 66.0 cm (33), 66.1 – 69.0 cm (19), 69.1 – 72.0 cm (22), 72.1 – 75.0 cm (18), 75.1 – 78.0 cm (5), 78.1 – 81.0 cm (6), 81.1 – 84.0 cm (1), 84.1 – 87.0 cm (2) and 87.1 – 90.0 cm (1).

Table 1. Mean monthly condition factor of *C. senegalensis* from Akpa Yafe River, Nigeria

Months	No. of fish collected	Mean ± SE
January	20	0.384 ± 0.02
February	22	0.311 ± 0.01
March	6	0.315 ± 0.04
April	8	0.339± 0.03
May	32	0.419 ± 0.01
June	32	0.403 ± 0.02
July	32	0.311 ± 0.02
August	32	0.322 ± 0.01
September	32	0.358 ±0.02
October	35	0.352± 0.01
November	13	0.277 ± 0.02
December	28	0.368 ± 0.01
Total	**292**	

4. DISCUSSION

Data obtained from length-weight relationship are very reliable in evaluating growth patterns and relative well-being of fishes. According to Nash et al. [7], values of regression coefficient from length-weight relationship (LWR) shows the growth pattern (isometric or allometric growth pattern) in fish which is observed to vary between stocks of same species. The exponent (b = 2.3961) of the length-weight relationship of *C. senegalensis* were significantly different

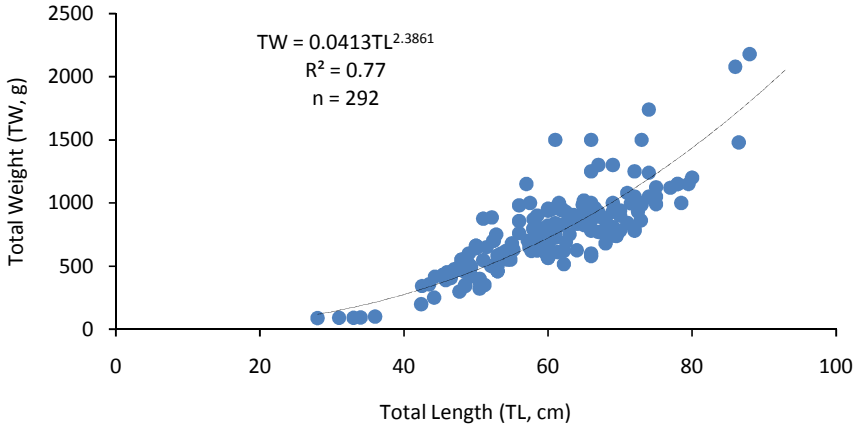

Fig. 1. Total Length (TL, cm) - Weight Relationship in Pooled sex of *C. senegalensis* from Akpa Yafe River, Nigeria (n=292)

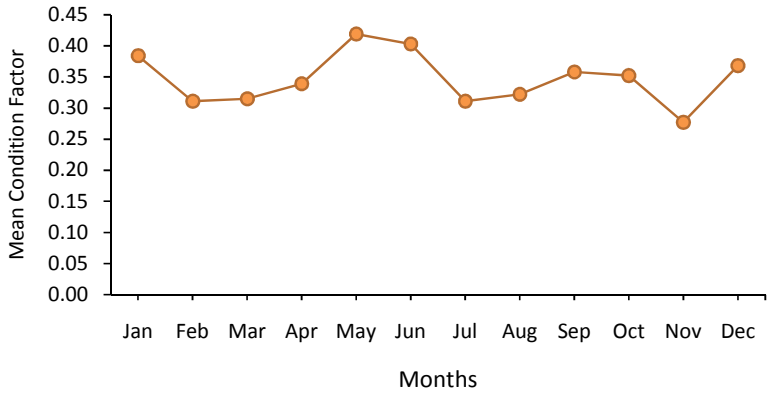

Fig. 2. Monthly variation in condition factor of *C. senegalensis* from Akpa Yafe River, Nigeria

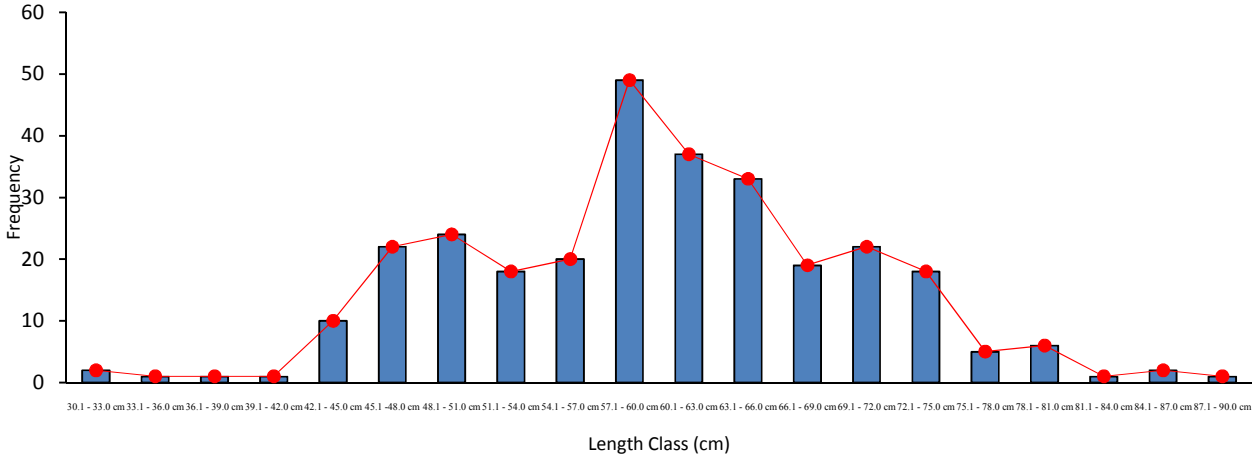

Fig. 3. Length–frequency distribution of *C. senegalensis* from Akpa Yafe River, Nigeria

from 3, indicating that weight growth of *C. senegalensis* from Akpa Yafe river is allometric (negative). This species tend to become thinner with increasing length. Enin [22] explained that results from such analyses where b-values indicate allometric growth must be used with caution bearing in mind that the assumption of isometry in the models is violated. In most aquatic organisms like fish, deviation from isometry is commonly observed indicating that the fish change shape as they grow [23]. Abowei et al. [24] reported a positive allmetric growth (b=3.508) for *C. senegalensis* from Nkoro River in Niger Delta, Nigeria. Abowei and Hart [25] also reported a positive allometric growth (b=3.5001) for *C. senegalensis* from the lower Nun river, Niger Delta Nigeria. Sanyang et al. [26] obtained an isometric growth (b= 3.0000) for *C. senegalensis* from the Gambia. Ndome and Eteng [27] gave more reasons for variation in growth pattern to include season, gonad maturity, habitat, diet, sex, health, stomach fullness, preservation methods and annual differences in the environmental conditions. However, findings of this study for b-value (2.3961) which indicates a negative allometry agrees with that of Ndome and Eteng [27] who reported b-values of 1.8800 and 2.0000 for *C. browni* and *C. senegalensis* from the East Coast of Niger Delta, Nigeria. According to Koutrakis and Tsikliras [28], expected values of b for fish range between 2 and 4 and b-value obtained in this study (2.3960) was within this range. Similarly, findings of length-weight relationships in some marine flatfish species such as *Citharus linguatula* have also showed a negative allometry growth pattern [5]. This indicates that the length of *C. senegalensis* increases with a corresponding increase in weight. In fisheries science, condition factor commonly used in ascertaining the relative well-being of fish species. Condition factor is also used to evaluate the health status of water bodies. Condition factor could be influenced by several factors such as sex, food availability, age and environmental conditions. Low values of condition factor in fish may be due to poor environmental conditions, reduced availability of food and prey items [25]. The highest value of condition factor (0.419 ± 0.01) in this study was obtained in May, followed by 0.403 ± 0.02 obtained in June and least (0.277 ± 0.02) in November. This findings is within the range of 0.28 (June) and 0.36 (October) reported by Udo et al. [12] for the same species from the Cross River Estuary. Values of condition factor obtained in this study is lower than 1.52 ± 0.06 and 1.85 ± 0.02 reported by Ndome and Eteng [27] for *C. browni* and *C. senegalensis* from the East Coast of Niger Delta, Nigeria. Differences in values obtained for condition factor in this study compared to other studies for the same species may be attributed to spawning activities of *C. senegalensis* [24]. Also, Youson et al. [29] suggested that fish condition can be influenced by several extrinsic factors such as photoperiods and changes in temperature. Length-frequency distribution are useful analytical tools for managing and monitoring fisheries of any size. It is useful and important in the determination of growth and age in fish species [11]. The length composition of a fish population exhibits modes among species with short spawning season and a uniform and rapid growth, from which the modal length of the first few age groups can be easily determined [30]. In this study, the highest length frequency of *C. senegalensis* was obtained in length class 57.1-60.0 cm (47), followed by 60.1- 63.0 cm length class (37) while the least frequency (1) was obtained in 33.1- 36.0 cm, 36.1- 39.0 cm, 39.1 – 42.0 cm, 81.1 – 84.0cm, and 87.1 – 90.0 cm length class. Length frequency distribution is crucial in age and growth determination in fish [11]. According to Eyo and Awom [31], length composition of a fish population exhibits modes among species with a fast and uniform growth. To have a good mode characterization in length frequency analysis, the appropriate bin-size should be selected. Bin-size interval of 2 cm and 5 cm is recommended by Anderson and Neumann [32] for fish measuring up to 60 cm and 150 cm in length. According to Erzini [33], length bins between 1-2 cm generally gives a better mode characterization in length distributions. In this study, bin size of 2.9 cm helped in characterizing the mode of the length distribution of *C. senegalensis* in Akpa Yafe River. Length frequency distribution of *C. senegalensis* in this study showed a multimodal size distribution with length class 57.1 – 60.0 cm exhibiting the maximum peak, while smaller peaks were obtained in 48.1 – 51 cm and 69.1-72 cm length class.

5. CONCLUSION

Findings of this study has provided basic and crucial information on length-weight relationship, condition factor and length frequency distribution of *C. senegalensis* from Akpa Yafe river, Nigeria. These important findings would be useful for fishery biologists and fishery managers in evaluating the population dynamics, stock

assessment and sustainable management of *C. senegalensis*.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://prh.sdiarticle3.com/review-history/23642