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Length-Weight and Length-Length Relationships of *Heterotis niloticus* (Cuvier, 1829) and *Raiamas senegalensis* (Steindachner, 1870)

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Abstract

The sustainable exploitation of freshwater fish species of commercial value is inevitable for fishery to continuously play its role in the social and economic growth of Nigeria. *Heterotis niloticus* and *Raiamas senegalensis* are two commercially available species in Lake Alau. The length-weight relationship (LWR) and length-length relationship (LLR) of these species were investigated to determine their growth patterns and state of wellbeing. Fish samples were collected from fishermen landings weekly for four months. The morphometric indices such as Total Length (TL), Standard Length (SL) and Body Weight (BW) were assessed using standard methods. A total of 1583 specimens comprising 602 *H. niloticus* (51.61% males and 48.39% females) and 981 *R. Senegalensis* (56.57% males and 43.43% females) were collected. TL ranged from 10.2 to 42.8 cm; 15.5 to 41.6 cm, SL 9.5 to 39.9 cm; 14.0 to 39.9 cm and weighed between 128.50 and 420.14 g; 123.05 and 401.8 cm for *H. niloticus* and *R. senegalensis*, respectively. The growth coefficient (b) ranged between 3.127 and 3.340 for *H. niloticus* and 2.592 and 3.193 for *R. senegalensis*. This indicates positive allometric growth pattern for the two-species investigated. The LLR varied from 1.511 to 2.148 and 1.506 to 1.820 for *H. niloticus* and *R. senegalensis,* with mean condition factor of 2.04 ± 1.76 (*H. niloticus)* and 1.97 ± 1.98 (*R. senegalensis*). This study therefore concludes that Lake Alau is favourable to good growth, reproduction, and survival of these species.

Keywords: Growth patterns; Length-weight; Morphometric; Lake Alau

Introduction

Inland tropical water has rich biodiversity which plays significant role in the economy, culture, tradition and food habits of Nigerians. About 316 recorded freshwater bony fish species belonging to 50 families have been reported in Nigeria [1]. *Heterotis niloticus* and *Raimas senegalensis* constituted some of the most dominant fish species in these waterbodies. These fresh water species inhabit from muddy to clean water and may be found in lakes, streams, rivers, canals and ponds, occurring mainly in shallow waters. They are bottom and column feeders, feeding on aquatic algae and higher plants as well as insects, crustaceans and rotifers. Recently, there is a report of acute reduction in the number of these species in inland waters in Nigeria because of over-exploitation by indigenous fishers who destroy the habitat and fishery resources [2].

Length-weight and length-length relationships are used extensively in fishery research and management [3]. According to Akinsanya et al. [4], the emanating need to culture fishes for protein consumption for the rapidly growing population in Nigeria has made it necessary to intensify studies on the length frequency of the African freshwater fishes. It is equally necessary to provide and increase the knowledge of the stock available. The length-weight relationship is one of the standard methods that yield valid biological information. It establishes the mathematical relationship between the two variables (length and weight) so that the unknown variable can be readily computed from the known variable. Length and weight data are essential for estimating growth rates, age structure [5], for calculating the standing stocks biomass [6], condition indices [7] and several other aspects of fish population dynamics [8].

Length-length relationships (LLRs) are also important in fishery management for comparative growth studies [9]. Length-length relationships are still scarce for most tropical and sub-tropical fish species [6,10,11], although LLRs are readily available for most European and North American freshwater and marine fishes [12-14]. The condition factor (CF) is an index reflecting interactions between biotic and abiotic factor on the physiological condition of fishes. It shows the welfare of the population during the various stages of the life cycle [15]. Length-weight relationship (LWR) and length-length relationship (LLR) of fishes can indicate species status in an environment and characterize patterns of growth [16,17]. Despite the various studies on this subject for marine and freshwater fishes in Nigeria [18-29], there is paucity of information on length-weight relationships and length-length relationships of these commercially important fishes from Lake Alau. The present study therefore aims at providing scientific background on the LWR and LLR of *Heterotis niloticus* and *Raimas senegalensis* in Lake Alau, Nigeria.

Materials and Methods

Description of the study site

Lake Alau is situated en route of River Ngadda, along Bama road in Borno State, Nigeria. It is 22 Km from Maiduguri lying at a Latitude: 11° 44' North, and at Longitude: 13°10' East. The total area of the lake is about 56 Km^2 with a maximum depth of 9m. It has a distinct tropical savannah climate with a marked monsoonal effect with an

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average rainfall of 600 mm, humidity 49.0% and average atmospheric temperature ranging from a minimum of 28°C in wet season to a maximum of 48°C in dry season [30,31]. The reservoir is characterized with loamy soil and a total storage capacity of 54,600 ha. The reservoir is a means of livelihood to rural populations who live nearby especially from Maiduguri and Konduga town. A large number of fishes including some commercially important species are fished by both small and large scale fishers throughout the year.

Sample collection and laboratory activities

Regular weekly samples were obtained from fishermen's catch at their landing site during August 2015 to January 2016. All sampled fishes were identified to species level using standard keys [1,32]. Total specimens were brought to the Wet laboratory, National Institute for Freshwater Fisheries Research (NIFFR), Maiduguri Zonal Office for further analysis. After blotting the specimens to remove excess water, total length (TL) and standard length (SL) of each fish were measured and body weight (BW) determined following Kareem et al. [18]. The sex of each specimen was identified by examination of the gonads.

Determination of length-weight and length-length relationships

The relationship between the length and the weight of the fish was estimated using the equation $W = aL^b$ [33] and logarithmically transformed into log $W = loga + blogL$ Where; W is the weight of the fish, L is the total length of the fish, a is the constant or intercept and b is the length exponent or slope. The determination coefficient (r^2) was used as an indicator of the quality of the linear regression [34]. The null hypothesis that b = 3 was tested using two tailed t test as described by Zar [35]. The t-test analysis was carried out for the length and weight data of each species to confirm the significance of the relationship at P<0.05 [34]. The length-length relationship (LLR) was estimated as $TL = aSL^b$ and its log-log form $log\ (TL) = log\ (a) + blog\ (SL)$. Goodness of fit was determined using the coefficient of determination (r^2) and the null hypothesis that b = 1 was tested using two tailed t test.

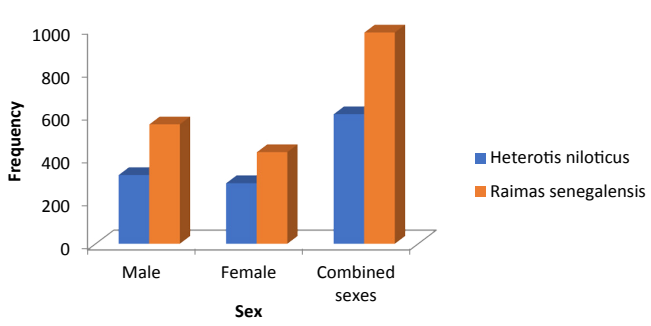

Figure 1: Sample size and composition of *Heterotis niloticus* and *Raimas senegalensis* collected from Lake Alau.

Statistical analysis

All the statistical analyses were considered at significance level of 5% (p<0.05). The Statistical Package for Social Sciences (SPSS, version 17) and Microsoft Office Excel software were deployed in this study. Tables and graphs were plotted with the use of MS Words and Excel 2007.

Results and Discussion

The sample size and sex distribution for the two-species investigated are shown in Figure 1. A total of 1583 specimens comprise of Six hundred and two (602) *Heterotis niloticus* and Nine hundred and eighty-one (981) *Raimas senegalensis* were collected and used for the length-weight and length- length relationship calculations. In *H. niloticus*, 320 (51.61%) were males and 282 (48.39%) were females while *R. Senegalensis* consists of 555 (56.57%) males and 426 (43.43%) females. The observed sex distribution among the species showed preponderance of males over females in their population. The sex ratio recorded in this study is in compliance with the works of Achakzai et al. [36] in Manchar Lake, Kashyap et al. [37] in Gomti River and Lawal et al. [38] in Epe Lagoon.

The result of the length-weight analysis for *H. niloticus* and *R. senegalensis* collected from Lake Alau was presented in Tables 1 and 2. The standard and total length range for *H. niloticus* is 9.50 to 39.90 cm and 10.20 to 42.80 cm, respectively. The mean standard length

Sex	Total length (cm)			Standard length (cm)		
	Minimum	Maximum	Mean ± SD	Minimum	Maximum	Mean ± SD
H. niloticus						
Male	19.80	42.80	27.21 ± 5.06	16.80	39.90	25.79 ± 5.21
Female	10.20	38.10	26.74 ± 4.96	9.50	36.50	25.39 ± 4.81
Combined sex	10.20	42.80	26.99 ± 5.01	9.50	39.90	25.61 ± 5.03
R. senegalensis						
Male	17.80	38.20	28.56 ± 4.88	16.50	36.50	26.15 ± 4.88
Female	15.50	41.60	27.02 ± 4.70	14.0	39.90	25.57 ± 4.71
Combined sex	15.50	41.60	27.32 ± 4.81	14.00	39.90	25.90 ± 4.81
SD= Standard deviation, cm = centimeter.						

Table 1: Total length and standard length distribution of *Heterotis niloticus* collected from Lake Alau.

Sex	*R. senegalensis*			*H. niloticus*		
	Min	Max	Mean ± SD	Min	Max	Mean ± SD
Male	123.05	389.05	280.17 ± 50.53	201.05	401.08	277.22 ± 52.89
Female	123.05	401.08	276.94 ± 51.15	128.50	420.14	274.80 ± 52.32
Combined sex	123.05	401.08	278.77 ± 50.80	128.50	420.14	275.74 ± 51.45
SD= standard deviation, cm = centimeter, g = grams.						

Table 2: Weight distribution of *R. senegalensis* and *H. niloticus* collected from Lake Alau.

Sex	a	b	sb	r^2
H. niloticus				
Male	0.830	3.340	0.161	0.774
Female	0.752	3.127	0.430	0. 851
Combined sexes	0.798	3.205	0.736	0.702
R. senegalensis				
Male	0.534	3.193	0.183	0.827
Female	0.682	2.592	0.252	0.771
Combined sexes	0.625	2.829	0.150	0.802
a = intercept, b = slope, sb = standard error of the slope, r^2 = correlation coefficient.				

Table 3: Regression coefficient for length-weight relationships of *H. niloticus* and *R. senegalensis* collected from Lake Alau.

Sex	a	b	sb	r^2
H. niloticus				
Male	0.525	2.148	0.017	0.790
Female	0.774	1.511	0.011	0.881
Combined sexes	0.601	1.802	0.010	0.813
R. senegalensis				
Male	0.481	1.506	0.224	0.406
Female	0.675	1.820	0.270	0.354
Combined sexes	0.578	1.697	0.007	0.385
a = intercept, b = slope, sb = standard error of the slope, r^2 = correlation coefficient.				

Table 4: Length-length relationships (LLR) between total length (TL) and standard length (SL) of *H. niloticus* and *R. senegalensis*.

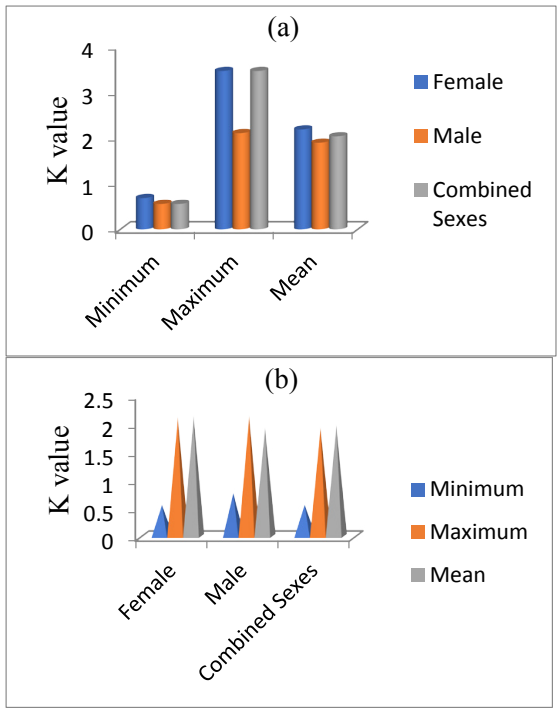

Figure 2: Condition factor of (a) *H. niloticus* and (b) *R. senegalensis* in Lake Alau.

ranged from 25.39 ± 4.81 cm to 25.79 ± 5.21 cm while total length varied between 26.74 ± 4.96 cm and 27.21 ± 5.06 cm. However, the weight varied between 128.50 g to 420.14 g with mean varying from 274.80 ± 52.32 g to 277.22 ± 52.89 g. This result showed that males were longer but females were heavier in *H. niloticus* population. This is in conformity with Le Cren [39] who reported that females are heavier than males of the same length probably because of differences in fatness and gonadal development.

Also in *R. senegalensis*, the standard length ranged from 16.5 to 36.5 cm for males and 14.0 to 39.90 cm for females while total length varied from 17.80 to 38.20 cm for males and 15.50 to 41.60 cm. However, the mean standard and total lengths were between 25.57 ± 4.71-26.15 ± 4.88 cm and 27.02 ± 4.70-28.56 ± 4.88 cm. The observed maximum body weight was 401.08 g, for a female and minimum of 123.05 g whereas; the mean body weights were between 276.94 ± 51.15 g in females and 280.17 ± 50.53 g in males.

The estimates of the regression parameters for males, females, and combined sexes of *H. niloticus* and *R. Senegalensis* are given in Table 3. The '*a*' values obtained for *H. niloticus* is 0.830 for males, 0.752 for females and 0.798 for combined sexes. The regression coefficients (*b*) values ranged from 3.340 for males, 3.127 for females to 3.205 for combined sexes. The result of calculated '*b*' value indicated positive allometric growth in both sexes of *H. niloticus* (b>3.0), which indicates that the fish grow as the cube of length. However, the relationship was highly significant (P<0.01) with coefficient of determination (r^2) ranged from 0.774 for male to 0.851 for female.

The intercept (*a*) values for *R. senegalensis* were 0.534 (male), 0.682 (female) and 0.625 (Combined sexes). The corresponding exponent '*b*' values were 3.193, 2.592 and 2.829 for male, female and combined sexes, respectively. The exponent '*b*' value of male gave a positive allometric growth while female and combined sexes exhibited negative allometric growth pattern.

The highest '*b*' value attained in female *R. senegalensis* implies that the females gain weight at a faster rate in relation to its length. The correlation coefficients values which ranged between 0.771 and 0.802 showed a high degree of positive correlation between the standard length and body weight. Similar findings in *Chrysichthys nigrodigitatus* were reported by Abowei and Ezekiel [40] from Amassoma river flood plains Nigeria, where the positive allometry was evident. Ezekiel and Abowei [19] also reported positive allometric growth in *Hepsetus odoe* from Bangladesh with b value 2.768 (males) and 2.667 (females). Shafi and Yousuf [41] reported positive allometric growth for males (3.07) and negative allometric for females (2.77) in *Schizothorax niger* from Dal lake. In contrast, Kashyap et al. [37] reported allometric growth for males and females from India with *b* value 2.95 (males) and 3.13 (females).

The regression analysis for length-length relationships (LLR) of *H. niloticus* and *R. senegalensis* is shown in Table 4. The regression coefficients (*b*) values for *H. niloticus* ranged from 1.511 (females) to 2.148 (males), whereas the '*a*' values ranged from 0.525 to 0.774 for males and females respectively. The determination coefficient (r^2) values varied from 0.790 in males to 0.881 in females. Similarly, the calculated linear regression for *R. senegalensis* indicates significant differences between the slopes of the L-L relationship within sexes. The regression coefficient *b* values varied between 1.506 for males and 1.820 for females. Hence, this result suggests that the species shows non-isometric growth pattern. However, the correlation coefficients for the species ranged from 0.354 in females to 0.406 in males. This is a clear indication that a weak correlation exist between the standard length and the total length of *R. senegalensis* from Lake Alau. The correlation of LLRs in the present study is similar to the findings of Adeyemi [42] for *Synodontis resupinatus* and Adeyemi [43] for *Synodontis robbianus* in the Idah, River Niger.

The condition factors (K) of these species ranged between 0.56 and 3.47 (Figure 2). A closer examination of the condition factors

revealed that females *H. niloticus* had the highest (3.47), followed by males *R. senegalensis* (2.14). The mean condition factor for both species (combined sexes) was 2.04 ± 1.76 (*H. niloticus)* and 1.97 ± 1.98 (*R. senegalensis*) [44,45]. The results indicate that fish species are doing well in the lake. This result was higher than the mean value (0.98) reported for *Heterotis niloticus* in Amassoma flood plain, Niger Delta, Nigeria by Ezekiel and Abowei [21]. It can be concluded that *H. niloticus* and *R. senegalensis* gain weight at a faster rate in relation to their length, an indication of good environmental condition.

Conclusion

In conclusion, this study has provided some basic information on the length-weight and length-weight relationships for *Heterotis niloticus* and *Raimas senegalensis* that will be helpful in similar studies. *H. niloticus* and *R. senegalensis* exhibited different growth patterns, and showed a strong association between length and weight. As no information on this subject currently exists about Lake Alau, the present results may contribute to this invaluable database. Further, it would be useful for fishery biologists and managers to impose adequate regulations for sustainable fishery management in this Lake.

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