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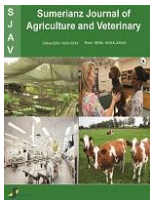

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# Morphometric Characters of African Bonytongue, *Heterotis Niloticus* (Cuvier, 1829) From Lake Alau, Maiduguri, Nigeria

**Olanrewaju A. Nurudeen***
Federal College of Freshwater Fisheries Technology, P.M.B. 1060, Maiduguri, Nigeria
Email: arogidigbaonline@yahoo.com

**Agbelege O. Olusegun**
Federal College of Freshwater Fisheries Technology, P.M.B. 1060, Maiduguri, Nigeria

**Grema F. Alkali**
Federal College of Freshwater Fisheries Technology, P.M.B. 1060, Maiduguri, Nigeria

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## Abstract

This study reports the length–weight relationships and morphometric characters of *Heterotis niloticus* in Lake Alau, Maiduguri, Nigeria. Monthly sampling was carried out and 104 (78 males and 26 females) fresh specimens were collected from fishers' catches between August 2019 and January 2020. Fish morphometric features of each sample were measured and weighed using standard method. Length-Weight Relationships (LWR, b >3 or <3 – allometric; b =3 – isometric), and Fulton's condition factor (K=100W/L) were assessed using standard procedures. 17 characters were studied in percentage of standard length. Data were analysed using descriptive statistics and ANOVA at α0.05. Fish sampled had total length ranging from 40.00cm to 80.50cm and weight between 700.00g and 1500.00g. The coefficient b of the LWRs indicated negative allometric growth (b < 3.0) for males (2.27), females (1.07) and combined sex (1.51). Also, the mean K of all the sampled population varied from 0.992±0.30 to 1.043±0.09. Males were in better condition than females (P>0.05) between sex. Coefficient of variation values revealed a low intra-group variation (CV < 33%) for all characters. Mean size of all the parameters show higher values in females compared to males. Different morphometric characters such as total length, pre-anal length, anal length, pre-pelvic length, pectoral fin length, pre-dorsal fin length, dorsal fin length, caudal and body depth show significant positive increase with standard length.

**Keywords:** Morphology; Length relationships; Allometry; *Heterotis niloticus*; Lake alau.

## 1. Introduction

The African bonytongue, *Heterotis niloticus* is a large fish that is widespread in rivers and lake system in many parts of Africa. It attracts high economic value due to its high protein content and hardy flesh [1], hence, the fish is highly sourced and cherished as a very important component in the diet of Nigerians. Despite this enormous importance and value, the species is suffering the combined effects of heavy exploitation and environmental degradation [2]. It is no doubt that several factors including urbanization, increasing population and industrialization have increased pressures on resource base leading to declining benefits. The conservation of freshwater fisheries has however been recognized as an important consideration throughout the World. According to Begg, *et al.* [3], Knowledge of fish stock structure is essential for effective fishery management.

Morphometric characters have been commonly used as markers in fisheries biology for stock identification [4, 5]. They are important for identifying fish species and their habitat as well as ecological criteria in any water body. It is common to use morphometric measurements to identify and classify fishes [6]. Also, King [7], report that morphometric relationships between various body parts of fish can be used to assess the well-being of individuals and to determine possible difference between separate unit stocks of the same species. In general, fish demonstrate greater variances in morphological traits both within and between populations than other vertebrates and are more susceptible to environmentally induced morphological variations. Nayman [8] considered morphological systematic as easiest and authentic methods for the identification of specimen.

Morphological systematic is a vigorous tool in fishery biology investigations and stock structure assessments [9]. Patterns of morphometric variation in fish are indicative of differences in growth and maturation rates because body form is a product of ontogeny [10]. According to Akin-Oriola, *et al.* [11], information on morphometric and meristic features is necessary for assessment of the fishery to ensure sustainability and also form the basis for their inclusion in a regional food security programme. As well, various authors including Yakubu and Okunsebor [12], Hossain, *et al.* [13], Turan, *et al.* [14] and Begg, *et al.* [3] have referred to the morphological differences in fish as a result of adaptation to its new environment. It is therefore important to document morphometric characteristic to provide basic information needed for identifying stock, describing their spatial distribution and measuring discreteness and relationship among stocks [15]. Systematic knowledge on the growth, abundance and distribution of *H. niloticus* is lacking especially in Lake Alau. This study therefore aimed at examining morphometric relationships of *H. niloticus* from Lake Alau.

*Corresponding Author

# 2. Materials and Methods

## 2.1. Study Area

Lake Alau, the largest man-made reservoir in Borno State, Nigeria located between Latitude 11°39'84"–11°40'02"N and Longitude 13°39'92"–13°40'12" E [16]. It was created in 1987 by damming river Ngadda about 22 km from Maiduguri, along Bama road and has a total surface area of 56 $km^2$. The annual inflow into Lake Alau was about 329,000 cubic meters of water [17]. Lake Alau has a mean depth of 9.5 m, temperature of 28.6 °C, pH of 7.28, total alkalinity of 38.4 mg/l and characterized with loamy soil [18]. It sustains a thriving artisanal fisheries industry and serves as a source of water for domestic and industrial use.

## 2.2. Fish Sampling and Collection

One hundred and four live samples of *Heterotis niloticus* were collected monthly from artisanal fishers and middlemen at the landing sites for six months (August, 2019 to January, 2020). Basically, these specimens were collected in early hours (0700 and 0900 h) and late in the evening (1700 and 1800 h). The specimens were transported to Wet laboratory of National Institute for Freshwater Fisheries Research (NIFFR), Maiduguri Zonal Office for further analysis.

## 2.3. Weight-Length Relationship and Condition Factor

Length and Weight of all samples collected were measured and weighed in fresh condition following Olanrewaju [19]. These data were used to find the relative condition factor [20] and the weight-length relationship (WLR), making use of Equation 1:

$W = aLt^b$ ……. (1)

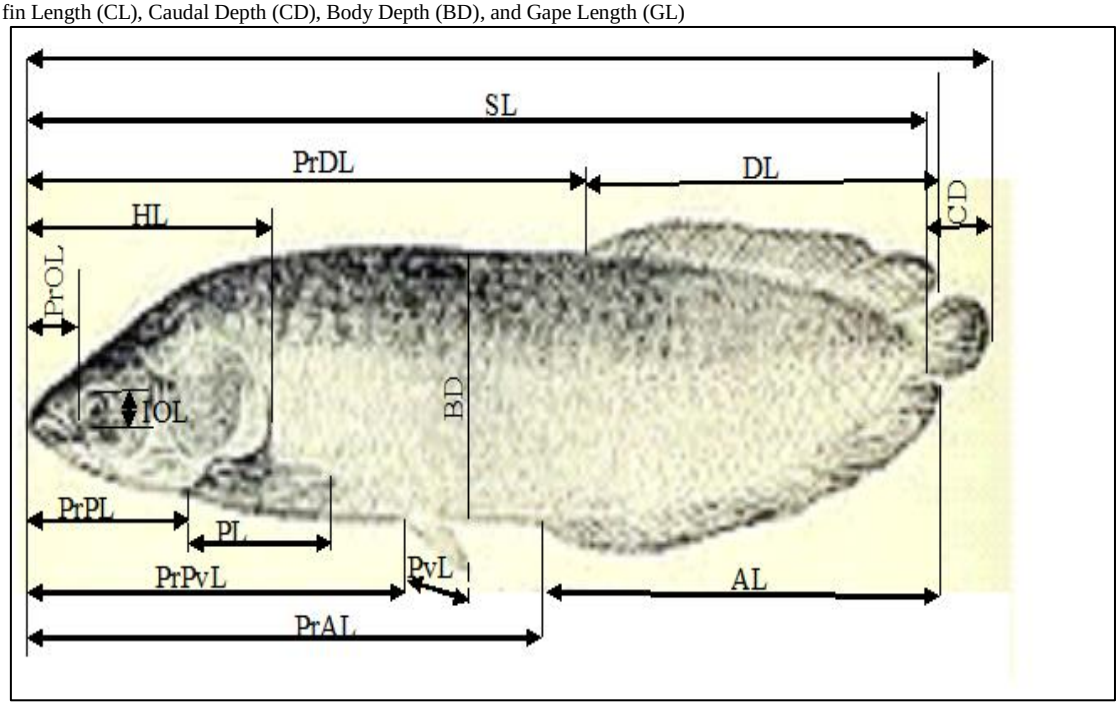
Where W stands for total weight in grams, Lt for total length in centimeters and **a** and **b** are constants. Both of these constants were estimated by a linear regression of Equation 2 transformed:

$W = \log a + b \times \log L$ ……. (2)

## 2.4. Assessment of Morphometric Characteristics

Specimens were measured for morphometric characters to the nearest centimeter (0.1 cm) using a divider and a wooden measuring board [21]. Seventeen morphometric characters (Figure 1) were recorded for each fish following the standard procedure of Vasave and Saxena [22]. Each sample was sorted into sexes by dissecting the abdomen and observing the gonads immediately after morphometric data had been taken.

**Figure-1.** Schematic illustration showing morphometric characters measured in *Heterotis niloticus*. Total Length (TL), Standard Length (SL), Head Length (HL), Pre-Orbital Length (PrOL), Inter-Orbital Length (IOL), Pre-Dorsal Length (PrDL), Pre-Pectoral Length (PrPL), Pre-Pelvic Length (PrPvL), Pre-Anal Length (PrAL), Dorsal fin Length (DL), Pectoral fin Length (PL), Pelvic fin Length (PvL), Anal fin Length (AL), Caudal fin Length (CL), Caudal Depth (CD), Body Depth (BD), and Gape Length (GL)




## 2.5. Statistical Analysis

Data generated for morphometric and growth pattern estimation were determined by descriptive statistics, multiple linear regression and ANOVA at $\alpha_{0.05}$. The coefficient of variation (CV%) was computed as: CV% = 100 x S.D./X, where S.D. is the standard deviation and X is the mean of the measurements of morphometric characters for each sex. The Statistical Package for Social Sciences (SPSS, version 20) and Microsoft Office Excel software were deployed in this study.

# 3. Results and Discussion

## 3.1. Length and Weight Distribution

The length and weight distribution of *Heterotis niloticus* in this study is as presented in Table 1. Mean standard length obtained for female (49.63±11.48 cm) were slightly higher than male (47.84±3.73 cm) and combined sex (48.21±6.02). However, body weight is higher in male (1146.66±212.03 g) as compared to female (1130.00±294.58 g) and combined sex (1143.26±227.83 g.). The length and weight data of all specimens collected revealed that females were longer while males were heavier in *Heterotis niloticus* population from Lake Alau. This result contradicts the findings of Olanrewaju, *et al.* [23] who report longer males and weighty females in *H. niloticus* samples used in their study. This variation could mean that these studies were conducted at different time of the year on the same Lake Alau.

**Table-1.** Summary of Standard Length and Weight of *Heterotis niloticus*

| Sex | Standard Length (cm) | | |
|---|---|---|---|
| | Min | Max | Mean±SD |
| Male | 41.00 | 59.00 | 47.84±3.73 |
| Female | 40.00 | 80.50 | 49.63±11.48 |
| Combined Sex | 40.00 | 80.50 | 48.21±6.02 |
| *Weight (g)* | | | |
| Male | 800.00 | 1500.00 | 1146.66±212.03 |
| Female | 700.00 | 1500.00 | 1130.00±294.58 |
| Combined Sex | 700.00 | 1500.00 | 1143.26±227.83 |

**Legend:** *Min* minimum, *Max* maximum, *SD* standard deviation

Sample sizes (*n*), regression parameters and coefficients of determination (*r*) of *Heterotis nioticus* are given in Table 2. The total number of *Heterotis niloticus* specimens assessed throughout the study was 104; out of which 78 (75.0 %) specimens were males and 26 (25.0 %) were females. Thus, males were most abundant than females (1♀: 3♂) in the sampled population, an indication of male dominating population. This finding of sex ratio in *H. niloticus* agrees to the result of an earlier study by Olanrewaju, *et al.* [23] that reported a skewed sex ratio of 1: 1.88 (♀: ♂) in favour of males.

## 3.2. Weight-Length Relationship and Condition Factor

The calculated growth coefficient '*b*' values for the Length-weight relationships were found as 2.27, 1.07 and 1.51 for males, females and combined sexes respectively. The values of correlation coefficient '*r*' computed are 0.839 (male), 0.562 (female), and 0.645 (combined sexes). Analysis of the LWR suggested that males and females *H. niloticus* showed a non-isometric or negative allometric growth pattern in the study area. This result is similar to those reported by Olanrewaju, *et al.* [23] from Lake Alau, but differed considerably from those of Ezekiel and Abowei [24] who reported positive allometric growth patterns with '*b*' value of 3.17 for *H. niloticus* in Amassoma flood plains. The difference in these results as presumed by Nehemia, *et al.* [25] may be due to differences in ecological condition. The correlation coefficient values in the study indicates high degree of correlation (P<0.001) between standard length and weight i.e., body weight increased with increase in body length, but the rate of increase in weight is less than the rate of increase in length.

**Table-2.** Length-weight relationships of *Heterotis niloticus*

| Sexes | n | Equation | a | b | r | Sig. level |
|---|---|---|---|---|---|---|
| Male | 78 | y = 2.273x – 0.763 | 0.763 | 2.273 | 0.839 | P<0.001 |
| Female | 26 | y = 1.076x + 1.279 | 1.279 | 1.076 | 0.562 | P<0.001 |
| Combined Sexes | 104 | Y = 1.513x + 0.506 | 0.506 | 1.513 | 0.645 | P<0.001 |

Legend: *n* sample size, *a* intercept, *b* slope, *r* correlation coefficient, *Sig*. significant

Table 3 shows condition factor (*K*) of *Heterotis niloticus* in Lake Alau during the period of investigation. The *K* value obtained in male ranged from 0.73 to 1.21 with a mean of 1.043±0.09. In female, it was ranged from 0.290 to 1.250 with a corresponding mean of 0.992±0.30. In case of combined sexes, the mean *K* was 1.034±0.14 with a range of 0.290 to 1.250. The mean condition factor (K) for *H. niloticus* is greater than 1 and this shows that the fish is above average condition within the Lake. The K value recorded in this study agrees with the values reported by Olanrewaju, *et al.* [23] and Ezekiel and Abowei [24] for *H. niloticus* in Lake Alau and Amassoma flood plain, respectively.

**Table-3.** Fulton's Condition Factor of *Heterotis niloticus*

| Sexes | Mean | Minimum | Maximum |
|---|---|---|---|
| Male | 1.043±0.09 | 0.730 | 1.218 |
| Female | 0.992±0.30 | 0.290 | 1.250 |
| Combined Sex | 1.034±0.14 | 0.290 | 1.250 |

## 3.3. Morphometric Characters

The descriptive statistical results of all the selected morphometric traits of males and females *H. niloticus* is as shown in Table 4. The coefficients of variation (CV) of male population were relatively high in pre- orbital length (25.42 %) and gape length (32.85 %). Female however, had high CV values in standard length (28.09 %), total length (27.11 %), dorsal fin length (32.77 %) and head length (28.70 %). The least value observed in male population was 6.72 % for pre- pelvic length while female recorded 9.35 % for caudal depth. It is discovered that mean sizes of all selected traits were higher in females as compared to those of males throughout the sampling period. The results on various morphometric characters of *Heterotis niloticus* between sexes showed that the females grow larger in size than males. This same observation of sexual dimorphism based on morphometric features has been reported in *Parachanna obscura* by Olanrewaju [19] in Eleyele Reservoir and Odo, *et al.* [26] in Anambra River.

Table 5 evinced the results of linear relationship of various morphometric characters and standard length. All the morphometric characters measured in relation to standard length show marked values ($p<0.05$) of regression coefficient ($b$) except gape length and pre-orbital length in male and female respectively. Linear relationships have been observed between all the independent and dependent characters in both sexes. In female, total length, dorsal length and pre-dorsal length showed high positive correlation with standard length, with '*r*' value of 0.998, 0.977 and 0.718, respectively. However, the degree of association between the pre-anal length and standard length is positive with '*r*' value of 0.818 in male. Also, linear relationships have been observed between all the independent and dependent characters in both sexes. In similar studies, several authors including Azua, *et al.* [27], Vatandoust, *et al.* [28], Vasave and Saxena [22], Idowu, *et al.* [29], Negi and Negi [30] reported narrow range in the majority of morphometric characters of the species studied. Esmaeili, *et al.* [31] and Verep, *et al.* [32] also obtain strong correlation between total length and other parameters in *Alburnoides qanati* and *Barbus tauricus*, respectively.

**Table-4.** Descriptive statistical results of all the selected morphometric traits of males and females *Heterotis niloticus*

| Morphometric character (cm) | Male | | | | Female | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean±SD | CV % | Min. | Max. | Mean±SD | CV % | Min. | Max. |
| SL | 47.92±3.61 | 7.53 | 41.00 | 59.00 | 49.94±14.03 | 28.09 | 40.00 | 80.50 |
| TL | 54.22±8.25 | 15.21 | 45.80 | 88.00 | 54.81±14.86 | 27.11 | 44.00 | 87.00 |
| PrOL | 2.91±0.74 | 25.42 | 2.00 | 4.50 | 3.34±0.74 | 22.15 | 2.10 | 4.20 |
| IOL | 1.61±0.20 | 12.42 | 1.20 | 2.00 | 1.65±0.26 | 15.75 | 1.30 | 2.00 |
| PrDL | 29.46±2.08 | 7.06 | 25.50 | 34.50 | 28.50±3.66 | 12.84 | 24.00 | 34.00 |
| PrPL | 9.59±0.81 | 8.44 | 8.00 | 11.00 | 9.35±1.03 | 11.01 | 8.00 | 10.50 |
| PrPvL | 20.67±1.39 | 6.72 | 17.40 | 23.10 | 19.65±2.59 | 13.18 | 16.50 | 23.20 |
| PrAL | 28.00±1.93 | 6.89 | 24.00 | 31.00 | 27.00±3.12 | 11.55 | 23.50 | 31.00 |
| DL | 18.73±3.90 | 20.82 | 8.40 | 33.00 | 19.22±6.30 | 32.77 | 15.00 | 33.00 |
| PL | 6.83±0.75 | 10.98 | 5.00 | 8.10 | 6.52±1.21 | 18.55 | 5.10 | 8.10 |
| PvL | 3.73±0.45 | 12.06 | 2.50 | 5.00 | 3.75±0.56 | 14.93 | 3.10 | 4.30 |
| AL | 19.41±1.40 | 7.21 | 17.00 | 22.00 | 18.75±2.01 | 10.72 | 16.30 | 21.50 |
| CL | 5.06±0.70 | 13.83 | 4.00 | 6.50 | 5.14±1.09 | 21.20 | 4.00 | 6.60 |
| CD | 2.77±0.25 | 9.02 | 2.00 | 3.20 | 2.78±0.26 | 9.35 | 2.41 | 3.10 |
| BD | 10.25±0.74 | 7.21 | 8.00 | 11.20 | 9.67±1.06 | 10.96 | 8.40 | 11.20 |
| HL | 11.85±2.10 | 17.72 | 10.10 | 19.50 | 12.02±3.45 | 28.70 | 10.00 | 19.40 |
| GL | 3.47±1.14 | 32.85 | 2.50 | 8.00 | 3.35±0.54 | 16.11 | 2.60 | 4.00 |

*Min* minimum, *Max* maximum

**Table-5.** Regression Analysis between standard length (dependent variable) and other morphometric characters (independent variables) in *Heterotis niloticus*

| Morphometric measurements (cm) | Male | | | Female | | |
|---|---|---|---|---|---|---|
| | a | b | r | a | b | r |
| TL | -0.590 | 1.382 | 0.664 | 0.087 | 0.972 | 0.998 |
| PrOL | -1.305 | 1.046 | 0.101 | 0.502 | 0.006 | 0.405 |
| IOL | -1.625 | 1.090 | 0.402 | -0.523 | 0.437 | 0.408 |
| PrDL | 0.232 | 0.739 | 0.246 | 0.676 | 0.459 | 0.718 |
| PrPL | -0.207 | 0.707 | 0.371 | 0.551 | 0.247 | 0.272 |
| PrPvL | 0.107 | 0.718 | 0.622 | 0.646 | 0.381 | 0.472 |
| PrAL | 0.030 | 0.843 | 0.818 | 0.771 | 0.389 | 0.640 |
| DL | -1.380 | 1.575 | 0.359 | -0.630 | 1.125 | 0.977 |
| PL | -1.071 | 1.133 | 0.527 | -0.256 | 0.631 | 0.632 |
| PvL | -1.105 | 0.997 | 0.375 | -0.040 | 0.362 | 0.317 |
| AL | 0.106 | 0.703 | 0.544 | 0.696 | 0.340 | 0.573 |
| CL | -1.450 | 1.281 | 0.496 | -0.460 | 0.689 | 0.614 |
| CD | -0.335 | 0.462 | 0.135 | -0.044 | 0.289 | 0.521 |
| BD | -0.001 | 0.602 | 0.361 | 0.339 | 0.381 | 0.684 |
| HL | -0.471 | 0.916 | 0.216 | 0.224 | 0.499 | 0.237 |
| GL | 0.140 | 0.230 | 0.016 | -0.051 | 0.339 | 0.241 |

**Legend:** *a* intercept, *b* slope, *r* correlation coefficient

# 4. Conclusion

The male *Heterotis niloticus* gained weight at faster rate in relation to its length when compared to females. The length-weight relationship of *H. niloticus* in both sexes show negative allometric pattern of growth in the studied habitat. However, the correlation coefficients of the length-weight relationships indicated high degree of positive correlation. The condition factor showed that *Heterotis niloticus* was in good physiological state of wellbeing in the lake. The study establishes clear sexual dimorphism in *H. niloticus* and also provide a general image of the relative growth of different body parts of taxonomic importance.

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