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Research Article
Sex Ratio and Allometry of *Synodontis melanoptera* and *Hydrocynus forskalii* in a Man-made Lake, Nigeria

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Abstract

Background and Objective: Sex ratio and allometry provide key information necessary for assessing reproductive potential and estimating stock size in fish populations. Sustainable management of dwindling commercially important fish stock in Nigerian inland water depend on adequate knowledge of the biological status of such fish species. Therefore, sex ratio and allometry of *Synodontis melanoptera* and *Hydrocynus forskalii* from Lake Alau, were investigated to enhance their production. **Materials and Methods:** A total of 512 fish samples comprising 252 *S. melanoptera* and 260 *H. forskalii* were randomly collected from fishers catch weekly for a period of 3 months. Length and weight were individually measured following standard procedure and sexes were separated after dissection. Length-weight relationship was estimated according to linear regression model $W = aL^b$ and condition factor determined using the equation $K = 100.W/L^3$. **Results:** The mean length and weight for *S. melanoptera* and *H. forskalii* were 11.49±2.71 cm; 36.06±21.76 g and 11.91±3.53 cm; 29.52±15.44 g, respectively. The growth coefficient 'b' ranged from 2.802-3.177 for *S. melanoptera* and 2.230-2.707 for *H. forskalii*. While, the mean condition factors varied from 1.81±0.83-2.49±1.83 for *S. melanoptera* and 1.24±1.04-2.03±2.14 for *H. forskalii*. The sex ratio was 1:1.03 in *S. melanoptera* and 1:1 in *H. forskalii*, male:female, respectively. **Conclusion:** The growth of both species was allometric and the condition factors indicate a good state of well-being in the reservoir.

Key words: Length-weight relationship, condition factor, sex ratio, lake alau

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Nigeria is endowed with a coastline of 853 km and over 14 million ha of inland waters within extensive river systems, lakes, flood plains and reservoirs scattered over the entire land surface area[1] of over 4,212,500 ha. Also, the inland water of Nigeria has in the past thirty year increased tremendously as a result of construction of large, medium to small reservoirs purposely for hydro-electric power generation, irrigation and urban water supply thus increasing potential for fisheries development for food security and poverty alleviation[2].

Lake Alau is a man-made lake impounded in 1987 after damming of the River Ngadda. It is in the Sahel Savannah vegetation zone of north-eastern Nigeria. Bankole *et al.*[3] identified ten fish species belonging to 8 families and reported annual fish catch of 471.1 Mt at low water level to 584.9 Mt at high water level. *Hydrocynus forskalii* and *Synodontis* spp. are among the commercially important species exploited for food and ornamental purpose in this reservoir.

Synodontis melanoptera (Mochokidae) form part of the commercial catches in northern Nigeria and, according to Reed *et al.*[4] they are available throughout the year. Also, *Hydrocynus forskali*, (Characidae) is among the most commercially exploited fishes for human consumption in Lake Alau[5]. Recently, there are great concerns over the status of this lake due to habitat modification, obnoxious fishing practices and other anthropogenic threat which may physiologically and morphologically impact the fish resources. The depletion of wild fish stocks is globally acknowledged[6] and attributed to population growth, overfishing, destructive fishing methods and practices, pollution, ecological change, environmental degradation and climate change. Hence, there is need for management measures to prevent biological and commercial extinction and also to optimize the benefits derived from the fishery over an indefinite period.

Biological parameters such as length-weight relationship, condition factor and sex composition are used to predict the potential yield and determine the appropriate size at capture for optimum yield[7]. Length-weight relationship is an important fishery resource management tool that provide proper guide for exploitation and management of fish population[8]. It is useful tool for fisheries research as it allows the conversion of growth-in-length equations to growth-in-weight for biomass estimation, determination of the condition and differences in life histories of fish species[9]. Estimation of the general well being of fish is based on the hypothesis that heavier individuals of a given length are in better condition than less weightier fish[10]. Condition factors have also been used as index of growth and feeding intensity and provide information on the physiological state of the fish in relation to its welfare. Knowledge of sex ratio provides information on sexual viability, segregation and aggregation of sexes according to their feeding, breeding or migratory behaviour[11]. Babu and Neelakantan[12] posited that sex composition of catch helps to understand if any difference exists in fishing between males and females and the possible bearing this will have on the fishable stock.

Good record of literature on length-weight relationship and condition factors of freshwater teleost from Nigeria water bodies[8,10,13,14] are pre-ponderance. However, only a few authors have reported the growth patterns and general well-being of fishes in Lake Alau[15,16]. Hence, sex ratio, length-weight relationship and state of well-being of *Synodontis melanoptera* and *Hydrocynus forskalii* in Lake Alau, Nigeria were investigated.

MATERIALS AND METHODS

Study area: Lake Alau is situated about 19 km from Maiduguri, Borno state, northeast Nigeria between Latitude 11°39'84''-11°40'02''N and Longitude 13°39'92''-13°40'12''E (Fig. 1). It is about of 354 m, above sea level, with a surface area of about 56 km^2 and a total storage capacity[17] of 54,600 ha. It was built in the late 80's primarily for provision of potable water.

Fish sample collection: Live specimens of *Synodontis melanoptera* (Boulenger, 1902) and *Hydrocynus forskalii* (Cuvier, 1819) were obtained (September-December, 2015) with the help of artisanal fishers and transported in oxygenated open tanks to the laboratory within 2 h of capture. Species identification was performed with the aid of reference materials[2,4,18]. Fish samples were weighed to the nearest 0.1 g using weighing balance after blot drying with a piece of clean moist hand towel. Total length (TL) and Standard length (SL) of each fish were measured to the nearest 0.1 cm using measuring board. The total length (TL) of the fish was measured from the tip of the anterior part of the mouth to the caudal fin while standard length was measured from the tip of the snout to the caudal peduncle. Fish were dissected to determine their sexes on the basis of gonads.

Estimation of length-weight relationships and condition factor: The LWR of fish was estimated by using the equation[19]:

$$W = \alpha L^b$$

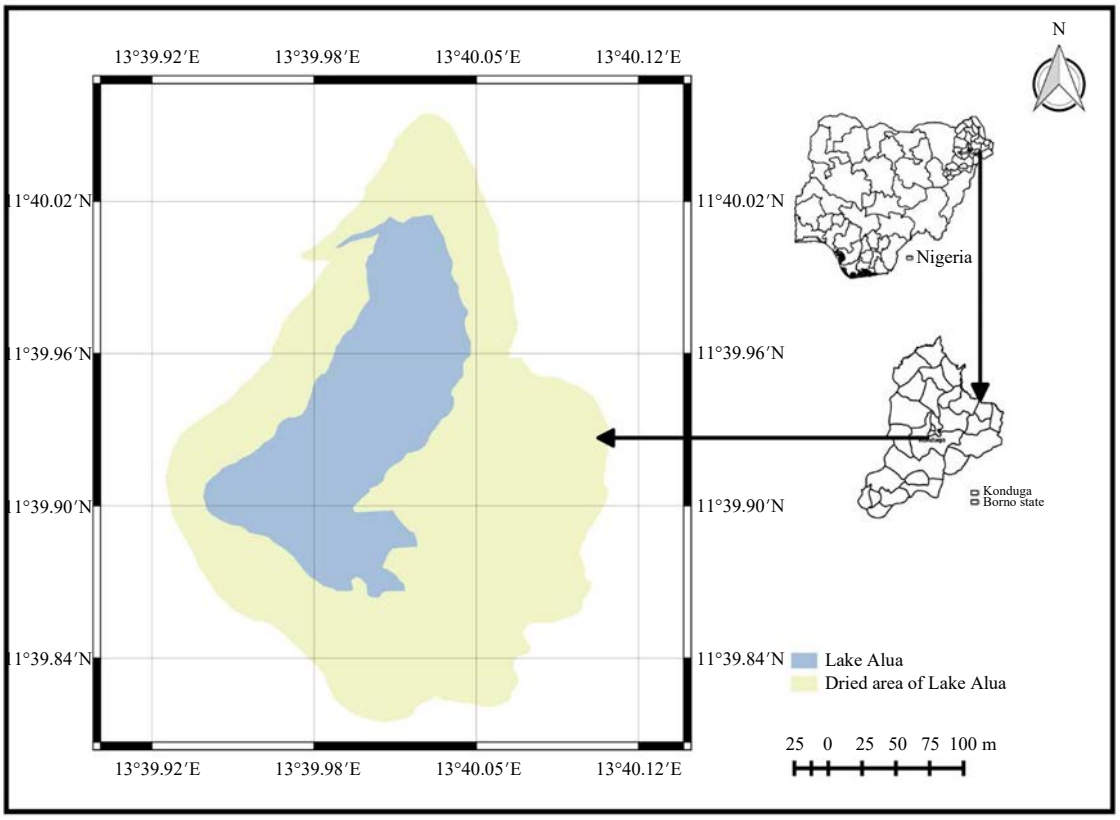

Fig. 1: Map of Lake Alau, Maiduguri, Nigeria

Where:

W = Weight (g)
L = Standard length (cm)
α = Scaling constant (intercept)
b = Allometric growth coefficient (slope)

After logarithmic transformation of this relation ($\log_{10} W = \log_{10} a + b \log_{10} L$), parameters a and b were determined via least squares linear regression[20].

Fulton's condition factor was calculated from the expression[21]:

$$K = 100W/L$$

Where:

K = Condition factor
W = Whole body weight (g)
L = Standard length (cm)

Statistical analysis: All the statistical analyses were considered at significance level of 5% ($p<0.05$). Chi-square (χ^2) test was used to test deviations from the expected sex ratio (1:1). Descriptive statistics such as chart, graph and table were also used.

RESULTS

Figure 2 present sample sizes and sex distribution for the two species investigated. A total of 512 fish samples composed of 252 *Synodontis melanoptera* and 260 *Hydrocynus forskalii* were collected during the study period. This result revealed 128 males and 124 females (χ^2 = 0.21, df = 1, $p<0.05$) for *S. melanoptera* while *H. forskalii* is having 130 males and 130 females ($\chi^2 = 0.00$, df = 1, $p>0.05$).

The length-weight frequency distribution of *S. melanoptera* and *H. forskalii* sampled from Lake Alau is shown in Table 1. The standard length of *S. melanoptera* sampled ranged from 5.90-22.50 cm while the weight ranged from 7.22-97.10 g. The largest male fish weighed 85.9 g, while the largest female fish weighed 97.1 g. Also for *H. forskalii*, the least standard length was 4.90 cm (7.22 g BW) in male while the largest was 30.1 cm SL (81.2 g BW) in female. The mean length range for *S. melanoptera* and *H. forskalii* are

Table 1: Length and weight distribution of *S. melanoptera* and *H. forskalii* captured from Lake Alau

		Standard length (cm)			Body weight (g)		
Species	Sex	Min.	Max.	Mean±SD	Min.	Max.	Mean±SD
S. melanoptera	Male	5.90	22.50	11.33±3.02	7.22	85.90	37.10±21.54
	Female	6.50	19.20	11.65±2.34	8.10	97.10	34.98±22.03
	Combined sex	5.90	22.50	11.49±2.71	7.22	97.10	36.06±21.76
H. forskalii	Male	4.90	28.50	10.81±2.22	7.22	82.00	27.15±13.49
	Female	4.30	30.13	13.01±4.20	6.80	81.20	31.88±16.89
	Combined sex	4.30	30.13	11.91±3.53	6.80	82.00	29.52±15.44

SD: Standard deviation, cm: Centimeter, g: Grams, Min: Minimum, Max: Maximum

Table 2: Regression coefficient for length-weight relationships of *S. melanoptera* and *H. forskalii* captured from Lake Alau

Species	Sex	a	b	sb	r^2
S. melanoptera	Male	-2.324	2.802	0.523	0.623
	Female	-1.492	3.177	0.594	0.811
	Combined sexes	-1.728	3.049	0.398	0.586
H. forskalii	Male	0.733	2.707	0.129	0.882
	Female	0.837	2.540	0.328	0.773
	Combined sexes	0.618	2.230	0.132	0.622

a: Intercept, b: Slope, sb: Standard of the slope, r^2: Correlation coefficient

Table 3: Condition factor of *S. melanoptera* and *H. forskalii* captured from Lake Alau

Species	Sex	Minimum	Maximum	Mean±SD
	Male	0.29	3.18	2.49±1.83
S. melanoptera	Female	0.51	2.50	1.81±0.83
	Combined sexes	0.29	3.18	2.13±2.14
	Male	0.25	1.82	1.24±1.04
H. forskalii	Female	0.57	2.39	2.03±2.14
	Combined sexes	0.25	1.82	1.56±1.63

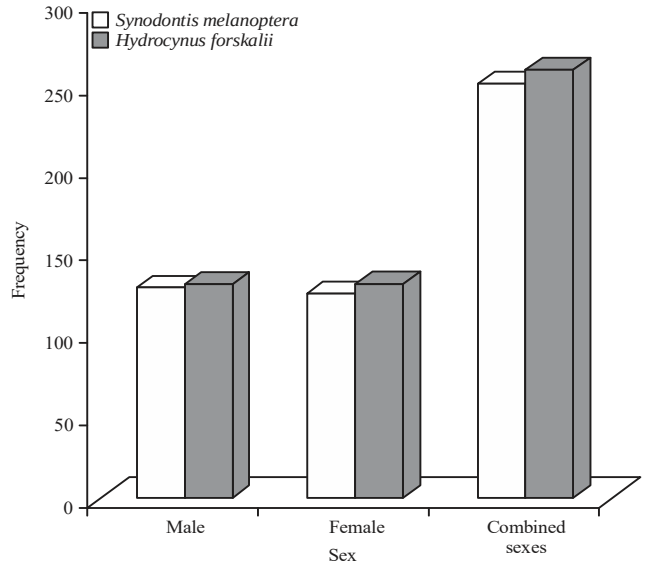

Fig. 2: Sample size and sex distribution of *Synodontis melanoptera* and *Hydrocynus forskalii* collected from Lake Alau

11.33±3.02-11.65±2.34 and 10.81±2.22-13.01±4.20 cm, respectively while the mean weight range were 34.98±22.03-37.10±21.54 and 27.15±13.49-31.88±16.89 g for *S. melanoptera* and *H. forskalii*, respectively.

Estimates of a and b for the length-weight relationship, the coefficient of the regression (r^2) and standard error of b for *S. melanoptera* and *H. forskalii* were tabulated in Table 2. In *S. melanoptera*, the exponent b values varied between 2. 802 for male and 3. 177 for female, while combined sexes had 3.049. The correlation coefficients (r^2) of the fish ranged between 0.586 and 0.811. The calculated allometric coefficient b for *H. forskalii* ranged from a minimum of 2.230 for combined sexes, to a maximum of 2.707 for male. However, the lowest value r^2 (0.622) was obtained in combined sexes while the highest (0.882) was recorded in male. The values of intercept ranged from -1.492 (female) to -2.324 (male) in *S. melanoptera* while log "a" value for *H. forskalii* was varied between 0.618 (combined sex) and 0.837 (female), respectively.

The results of analysis for condition factor of *S. melanoptera* and *H. forskalii* was presented in Table 3. The condition index value for *S. melanoptera* ranges from 0.29-3.18 in male to 0.51-2.50 in female. Also, the mean condition factor value varied from 1.81±0.83 in females to 2.49±1.83 in males. In *H. forskalii*, K-values were maximum in females (2.39) and minimum in male (0.25). The mean condition factors for male, female and combined sexes were 1.24±1.04, 2.03±2.14 and 1.56±1.63, respectively.

DISCUSSION

Growth is defined as the change in size with reference to time. According to Pauly[19], weight of a fish is expressed as a function of length. Establishment of a relationship between weight and length is essential for the calculation of production and biomass of a fish population[9]. The sample size depicted in *Hydrocynus forskalii* and *Synodontis melanoptera* in this study is comparable to those recorded in Dadin-Kowa dam[22], Idah area of River Niger[23], Ogudu Creek[24] and Lake Onah[25]. The sex ratio was in favour of female in *S. melanoptera* (1♂:1.03♀) while *H. forskalii* have equal sex distribution (1♂:1♀). This result however show no significant difference ($p>0.05$) from the expected ratio of 1:1 in both species. Similar ratio of 1:1.07 and 1:1 for the *Synodontis resupinatus* and *Synodontis rabbianus* were reported by Aliko *et al.*[26] and Offem *et al.*[7], respectively.

Males were longer and heavier than females in *S. melanoptera* and conversely in *H. forskalii*. This is in agreement with Le Cren[27], who reported that females are heavier than males of the same length probably because of difference in fatness and gonadal development. This finding was in tandem with the report of Olanrewaju *et al.*[15], who documented superior body weight in male *Raiamas senegalensis* from Lake Alau. The highest 'b' value was arrived at in females of *S. melanoptera* followed by combined sexes and males. The exponential value of 3.177 in females implies that the females gain weight at a faster rate in relation to its length. On the other hand, the 'b' value of *H. forskali* was 2.707, 2.540 and 2.230 in males, females and combined sexes, respectively. However, the growth exponential values, "b" in combined sexes of *S. melanoptera* and *H. forskalii* showed a positive allometric ($b>3$) and negative allometric growth ($b<3$), respectively. The regression coefficients 'b' value of 3.177 in *S. melanoptera* deviates significantly from the isometric value of '3', suggested that the fish is heavier in relation to its length. The negative allometry in *H. forskalii* indicates that the fish get thinner as they grow[28]. This finding is consistent with the work of Olanrewaju *et al.*[15], who reported calculated 'b' values of 3.205 (positive allometric) and 2.829 (negative allometric) for *Heterotisniloticus* and *Raiamas senegalensis*, respectively, in Lake Alau. Kalu *et al.*[16] reported similar negative allometric growth pattern in *Clarias gariepinus* (2.99) and *Tilapia zilli* (2.96) from Lake Alau. Similar findings in *Synodontis schall* were reported by Offem *et al.*[7], from cross river inland wetland, where the positive allometry (3.1) was evident. However, Achionye-Nzeh[29] documented positive allometric growth in *Hydrocynus forskalii* from a reservoir in Ilorin, Nigeria.

Sex-wise analysis of condition factor (Kn) in *Synodontis melanoptera* revealed that the mean Kn values in males (2.49 ± 1.83) was higher than that of females (1.81 ± 0.83). In *H. forskalii*, the mean values were 1.24 ± 1.04 and 2.03 ± 2.14 in males and females, respectively. According to Le Cren[27], Kn values greater than 1 indicated good general condition of the fish whereas values less than 1 denotes reverse condition. Adeyemi[23] however, reported higher Kn values in females of *Synodontis resupinatus* from Idah area of River Niger, Nigeria. Offem *et al.*[7] studied the condition of four *Synodontis* species in Cross river inland wetlands, Nigeria where they all show values below 1. High Kn values were recorded in *Synodontis ocellifer* (1.80) and *Hydrocynus brevis* (1.16) and low values in *Bagrus bayad* (0.59) by Nazeef and Abubakar[22]. Olanrewaju *et al.*[15] also made a similar observation in Lake Alau, Nigeria where Kn values was found to be high in *Heterotis niloticus* (3.47) and *Raiamas senegalensis* (2.14). High Kn values observed *S. melanoptera* and *H. forskali* in the present study suggest that the fish are in better condition.

CONCLUSION

In the current study, *S. melanoptera* and *H. forskalii* exhibited allometric growth. The correlation coefficients of the length-weight relationships indicated normal degree of positive correlation. The condition factor revealed that *S. melanoptera* and *H. forskalii* were in good physiological state of wellbeing in the lake. Further investigations on the bionomics of other fish species in this dam are advocated.

SIGNIFICANCE STATEMENT

Lake Alau supports a rich biodiversity and offering livelihood and nutritional security to both artisanal fishermen and the riparian community. *Synodontis melanoptera* (Boulenger, 1902) and *Hydrocynus forskalii* (Cuvier, 1819) constitute a delicacy for many low income earners as they are cherished for their taste and affordable price. However, these species has been less-studied from biology, ecology and conservation point of view. Studies on length-weight relationships of dominant and commercially important fishes are highly significant for management and conservation of populations in the lake. At present no published literature is available on length-weight relationships and well-being of these commercially important fishes from Lake Alau. The paucity of this information propelled this study, which is aimed at providing useful information for effective stock management on the lake.

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