STUDY ON LENGTH-WEIGHT RELATIONSHIPS AND REPRODUCTIVE BIOLOGY OF SYNODONTIS NIGRITA (VALENCIENES, 1840) IN KANGIMI RESERVOIR, KADUNA STATE, NIGERIA.

1Dambo, A. and 2Solomon, S.G.
1Department of Biological Sciences, Ahmadu Bello University, Zaria, Nigeria.
2Department of Fisheries and Aquaculture, University of Agriculture, Makurdi, Nigeria
*Corresponding author’s email: damboabrak@yahoo.com

ABSTRACT
The length-weight relationships and reproductive biology of Synodontis nigrita was studied. Fish specimens were collected from fishermen catch at the landing site. Estimated exponent (b) varied between 1.949 and 2.845 (2.3092±0.08). Correlation (0.915±0.01) between length and weight indicated a strong positive relationship. There were more females than males in the fish species, the difference was not significant (P>0.05). Male fish recorded gonadosomatic index range from 0.253±0.03 to 2.715±0.15 and 0.410±0.05 to 5.352±0.72 for females. The gonadosomatic index of the male fish was not significantly different from that of the female. Rainy months gonadosomatic index were significantly higher than the dry months (P<0.05). The fish was observed to exhibit negative allometric growth. The species investigated recorded higher values of GSI in the wet season indicating the breeding period of the fish.

Key words: LWR, Sex Ratio, Synodontis nigrita

INTRODUCTION
Fish is an important source of dietary protein. Synodontis nigrita is commonly called upside-down catfish is a common freshwater fish in Nigeria. The body is dark to grey-brown in colour (Idodo-Umesh, 2003) with small dark spots on the body and fins (Olaosebikan and Raji, 2013).

In fisheries management, one important tool used is length weight relationship (LWR) estimate of fish. The length–weight relationship of fish is an important fishery management tool (Abowei, 2010). Estimate of LWR is useful in fish stock assessment and proper management of a fishery (Andreu-Soler et al., 2006). Standard measures of LWR determination for fish species render the results more reliable when making comparisons between populations (Kara and Bayhan, 2008). Parameter b of the LWR describes the growth pattern of fish species. Literature is available which indicate isometric and allometric growth pattern can be exhibited by freshwater fish species (Abowei, 2010; Ibrahim, 2012; Usman et al., 2014).

Sex ratio indicates the proportion of male and female in a population and in nature the ratio is expected to be 1:1. In the culture and reproduction of fish species inhabiting fresh water one important consideration should be sex ratio (Mekkawy and Hassan, 2011). Study on sex ratio of fish species in rivers, lakes or reservoirs have been conducted (Oboh et al., 2013; Shinkafi et al., 2013; Akombo et al. (2016).

Reproductive biology is an important factor that influences the dynamics of a given population. Spawning is one of the most significant phases of the reproductive cycle. It comprises ovulation and oviposition in the female and spermatiation and sperm release in the male (Agarwal, 2008).

Knowledge of some reproductive traits such as sexual dimorphism, egg size, fecundity and spawning time are fundamental to understanding how these traits should be adopted to maximize reproductive success in a particular environment (Mazzoni et al., 2005). Information on fish reproduction is also important in aquaculture. Lack of documented information on the length-weight relationships and reproductive biology of this species in the reservoir made the study imperative. The information is key to proper management of the fishery.

MATERIALS AND METHODS

Study Area
Kangimi reservoir was the study area (Figure 1). It is located between latitude 10°42′30″N and longitude 7°42′30″E. River Kangimi was impounded mainly for potable water supply to Kaduna metropolis and irrigation. Fishermen from nearby villages catch fish from the reservoir.

Fish specimen collection and Identification
Fish samples were collected from Goro and Kangimi. Synodontis nigrita from fishermen catch. The fishermen used traps and gill nets with stretched mesh size ranging from 1.00cm to 5.00cm. Sample was collected once monthly. The duration of sampling was June, 2015 to May, 2016. Text by Reed et al. (1967); Idodo-Umesh (2003); Olaosebikan and Raji (2013) was used to identify fish.
Sex determination, Length and Weight Measurement

Sex of fish was determined based on the possession of a genital papilla by the male using a binocular dissecting microscope. The sex of some specimens was done by dissecting the abdomen, open ventrally from the anus to the pectoral fin, with a scalpel or knife to examine the gonad. The sex ratio (male: female) was calculated as:

\[ \text{Sex Ratio} = \frac{\text{No. of males}}{\text{No. of females}} \]

Total length of the fish was measured from the tip of the snout to the end of the caudal fin. Both length measurement was done with a meter rule and recorded in centimeter. Body weight was measured with Ohaus sensitive electric balance (Model: SE3001F) to the nearest gramme. The weight of the gonads was measured.

The total length was related with body weight of fish using the equation:

\[ W = aL^b \] in logarithmic form: \( \log W = \log a + b \log L \).

Where: \( W = \) fish weight in grams, \( L = \) total length of fish in centimeter, \( a = \) intercept, and \( b = \) slope, geometric growth pattern value (Froese, 2006).

Gonado somatic index

The spawning period was calculated as: \( \text{GSI} = \frac{\text{Weight of gonad}}{\text{Weight of fish} \times 100} \) (Hirpo, 2012).

DATA ANALYSIS

The mean and standard error of body weight, total length and gonadosomatic index determined. Least squares regression analysis was used to estimate the values of intercept \( (a) \) and slope \( (b) \) for length-weight relationship. Chi-square was employed to test whether there is significant difference in the observed from the expected 1:1 sex ratio at 95% probability. Student’s t-test was used to test for significant difference in the sexual and seasonal of GSI. Variation observed in the mean values of GSI was tested to determine significant difference using Analysis of Variance (ANOVA) at 0.05 levels. Duncan Multiple Range Test (DMRT) was introduced to rank the means when the difference is significant.

RESULTS

Table 1 presents the length weight relationship of the fish. Estimated exponent \( (b) \) in \( S. \ nigrita \) was lowest \((1.949)\) in August and highest \((2.845)\) in January with mean of \( 2.3092 \pm 0.08 \). The mean \((0.915 \pm 0.01)\) correlation coefficient \( (r) \) determined indicated a strong positive relationship. The proportion of males to females indicate there was no significant difference \((P>0.05)\) in all the months (Table 2). Length exponent \( b \) of \( LWR \) that equal 3 is indicative of isometric growth, values less than 3 show negative allometric and more than 3 exhibit positive allometric growth. The parameter \( b \) estimate suggests negative allometric growth in \( S. \ nigrita \) \((2.3092)\). Fish with negative allometric growth suggests their length increase faster than the width (Dutta and Banerjee, 2016). The negative allometric growth observed in the present work is consistent with negative allometric \( b \) value \( 2.73 \) for \( S. \ schall \), \( 2.79 \) for \( S. \ clarias \) and \( 2.86 \) for \( S. \ membranaceus \) from the lower Nun River, Niger Delta (Hart and Abowei, 2007). According to Bagenal and Tesch, 1978 the length exponent in most species of fish is from 2.0 to 4.0. The geometric growth pattern of \( S. \ nigrita \) is within the range of 2.0 to 4.0. The strong positive correlation coefficient \( (r) \) for the length-weight relationship of \( S. \ nigrita \) indicates...
increase in length with increase in body weight. Hart and Abowei, 2007 also reported positive correlation coefficient between the length and weight of *S. schall*, *S. clarias*, *S. membranaceus*. The variation observed in $b$ value estimate in this work and those of other study may be due to difference in environmental factors imposed by local weather conditions. Oliva-Paterna et al. (2009) suggested that sex, method of preservation, stage of gonad development and size of specimens included in the analysis may have an effect on length–weight relationship in fish.

Sex ratio is calculated to indicate the proportion of male and female in a given ecological system. There were more males than females. The proportion of males and females did not differ significantly. This indicates that there was equal distribution of males and females in all the months. The migratory behavior of the male in search of mate, couple with condition of the environment and error during sampling might have been the reason for the deviation from 1:1 ratio observed.

Work by other researchers has indicated female dominance over male. Adebiyi (2012) documented sex ratio 1: 1.11 (male to female) in *Brachydeuterus auritus* from Lagos coast. Oboh et al. (2013) observed sex ratio of 1:1.35 (male to female) for *Synodontis schall* from Jamieson River, Nigeria. The sex ratio differed significantly (P<0.001) from the expected 1:1 ratio.

Mean monthly gonadosomatic index in *S. nigrita* is presented in Table 3. The mean values of gonadosomatic index in males fluctuated from $0.253\pm0.03$ (February) to $2.715\pm0.15$ (July) and from $0.410\pm0.05$ (December) to $5.352\pm0.72$ (June) for females. The monthly gonadosomatic index values variation in males and females was significant at P<0.05. The gonadosomatic index of the male fish was not significantly different from that of the female. The mean gonadosomatic index for males, females and combined sex in the rainy season was significantly higher than the dry season (P<0.05) Table 4.

High GSI indicate breeding and was considered the spawning period. Fish with low GSI were collected during the dry season.

The month of June to October marked the breeding period of *S. nigrita*. The maximum GSI value for male was observed in July. The female fish GSI was at the peak in June. Males GSI ($0.253 – 2.715$) is lower than that of the females ($0.410 – 5.352$). The month of June to October marked the breeding period of *S. nigrita*. The maximum GSI value for male was observed in July. The female fish GSI was at the peak in June. Males GSI (1.51) is lower than that of the females (2.02). The species investigated recorded higher values of GSI in the wet season. This implies that the species in the rainy months deployed huge energy to produce reproductive cells. Generation of energy for the process of reproduction is supported by the increase of nutrients. All the specimens recorded higher GSI values in the rainy months. It means that the fish invest more energy towards gamete production in rainy season. Run-off water during the rainy season introduces nutrients in the reservoir thereby stimulating the important process of primary production which serves as the base for trophic energy transfer.

Gonadosomatic index in this study was observed to be high in the wet season is similar to Oboh et al. (2013) who noted male and female specimens of *Synodontis schall* from Jamieson River, Nigeria start breeding activities at the onset of the rains. Furthermore, Olele and Etim (2011) suggest that fish with heavy gonad were collected from in rainy season. Females were observed to have GSI that is higher than males. This fact agrees with the finding of Shinkafi et al. (2013) who reported the GSI of female *Distichodus rostratus* in River Rima was higher than that of the male.
### TABLE 1: LENGTH-WEIGHT RELATIONSHIP OF SYNODONTIS NIGRITA FROM KANGIMI RESERVOIR

| Month   | N  | Min. | Max.   | Mean±SE | Min. | Max.   | Mean±SE | $LWR$ | $a$          | $b$   | $r$          | Growth Pattern |
|---------|----|------|--------|---------|------|--------|---------|-------|--------------|-------|--------------|----------------|
| June    | 64 | 35.6 | 255.6  | 107.33±6.13 | 13.3 | 30.3   | 20.36±0.50 | -0.649| 2.029        | 0.921 | NA           |
| July    | 48 | 27.3 | 333.6  | 118.47±10.47| 11.8 | 27.5   | 19.38±0.68 | -0.923| 2.296        | 0.903 | NA           |
| August  | 41 | 35.3 | 482.6  | 189.52±20.79 | 10.0 | 36.2   | 21.67±1.15 | -0.377| 1.949        | 0.916 | NA           |
| September | 43 | 37.2 | 373.3  | 122.76±10.17 | 10.3 | 35.7   | 19.34±0.74 | -0.512| 1.997        | 0.942 | NA           |
| October | 43 | 46.2 | 426.7  | 155.45±0.87 | 12.6 | 36.1   | 23.11±0.87 | -0.850| 2.246        | 0.933 | NA           |
| November | 33 | 51.7 | 343.8  | 137.79±11.12 | 15.1 | 32.7   | 23.61±0.71 | -0.738| 2.070        | 0.884 | NA           |
| December | 38 | 40.8 | 397.6  | 144.49±12.13 | 14.7 | 37.2   | 23.82±0.75 | -1.455| 2.609        | 0.961 | NA           |
| January | 20 | 46.3 | 393.5  | 153.71±22.47 | 15.2 | 34.4   | 24.24±1.12 | -1.811| 2.845        | 0.937 | NA           |
| February | 40 | 21.8 | 432.5  | 139.21±13.03 | 15.8 | 36.1   | 22.91±0.75 | -0.943| 2.238        | 0.889 | NA           |
| March   | 26 | 51.7 | 391.4  | 181.5±18.92 | 18.3 | 36.2   | 26.69±1.01 | -1.502| 2.591        | 0.918 | NA           |
| April   | 39 | 52.4 | 394.3  | 150.25±14.01 | 14.3 | 30.9   | 22.61±0.84 | -0.709| 2.187        | 0.897 | NA           |
| May     | 38 | 50.8 | 376.8  | 149.00±12.36 | 16.2 | 32.5   | 25.02±0.62 | -1.571| 2.654        | 0.881 | NA           |
| Total   |    |      |        | 145.79±6.87 | 14.7 | 37.2   | 22.73±0.64 | -1.003±0.13| 2.309±0.08 | 0.915±0.01| NA |

SE = Standard Error; NA = Negative Allometric

_FUDMA Journal of Sciences (FJS) Vol. 5 No. 3, September, 2021, pp 367 - 374_
TABLE 2: MONTHLY SEX RATIO OF *SYNODONTIS NIGRITA* FROM KANGIMI RESERVOIR

| Month  | N  | Males | Females | Ratio | Chi sq | P-value |
|--------|----|-------|---------|-------|--------|---------|
| June   | 42 | 22    | 20      | 1:0.90| 0.095  | 0.758   |
| July   | 18 | 7     | 11      | 1:1.57| 0.889  | 0.346   |
| August | 19 | 6     | 13      | 1:2.16| 2.579  | 0.108   |
| September | 16 | 6     | 10      | 1:1.66| 1.000  | 0.317   |
| October | 30 | 17    | 13      | 1:0.76| 0.533  | 0.465   |
| November | 24 | 10    | 14      | 1:1.40| 0.667  | 0.414   |
| December | 33 | 18    | 15      | 1:0.83| 0.273  | 0.602   |
| January | 12 | 5     | 7       | 1:1.40| 0.333  | 0.564   |
| February | 31 | 11    | 20      | 1:1.81| 2.613  | 0.106   |
| March  | 20 | 12    | 8       | 1:0.66| 0.800  | 0.371   |
| April  | 26 | 10    | 16      | 1:1.60| 1.385  | 0.239   |
| May    | 16 | 9     | 7       | 1:0.77| 0.250  | 0.617   |
| Total  | 287| 133   | 154     | 1:1.16|        |         |

*Significant difference (P < 0.05)
### TABLE 3: MONTHLY GONADO SOMATIC INDEX (GSI) OF *SYNODONTIS NIGRITA* COLLECTED FROM KANGIMI RESERVOIR

| Month      | Male          | Female         | P-Value |
|------------|---------------|----------------|---------|
|            | Min. | Max. | Mean±SE | Min. | Max. | Mean±SE |
| June       | 0.288 | 7.219 | 2.170±0.25 | 0.806 | 14.74 | 5.352±0.71 |
| July       | 1.067 | 3.969 | 2.715±0.15 | 0.593 | 8.075 | 3.907±0.34 |
| August     | 1.856 | 3.763 | 2.328±0.13 | 1.595 | 6.383 | 3.512±0.35 |
| September  | 1.255 | 4.272 | 2.574±0.15 | 1.214 | 7.156 | 4.134±0.33 |
| October    | 1.071 | 4.394 | 2.177±0.16 | 0.498 | 3.82  | 1.925±0.21 |
| November   | 0.995 | 2.878 | 1.800±0.14 | 0.152 | 2.537 | 1.023±0.18 |
| December   | 0.147 | 1.887 | 0.628±0.11 | 0.160 | 0.838 | 0.410±0.05 |
| January    | 0.254 | 1.059 | 0.531±0.09 | 0.272 | 0.826 | 0.430±0.05 |
| February   | 0.042 | 0.477 | 0.253±0.03 | 0.118 | 1.828 | 0.416±0.07 |
| March      | 0.232 | 1.262 | 0.683±0.09 | 0.174 | 2.215 | 1.041±0.21 |
| April      | 0.306 | 2.517 | 1.123±0.17 | 0.288 | 1.364 | 0.705±0.06 |
| May        | 0.327 | 2.600 | 1.154±0.14 | 0.470 | 3.966 | 1.370±0.23 |
| Total      | 1.51±0.25 | 2.02±0.50 | 0.375  |

Means with different superscript in each column are significantly different (P<0.05); * = Significant difference (P < 0.05)
TABLE 4: COMPARISON OF SEASONAL GONADOSOMATIC INDEX (GSI) OF SYNODONTIS NIGRITA

| Season | Male±SE | Female±SE | Combined±SE |
|--------|---------|-----------|-------------|
| Dry    | 1.03±0.27 | 0.85±0.20 | 0.93±0.23 |
| Wet    | 2.17±0.27 | 3.66±0.65 | 2.96±0.43 |
| P-Value| 0.015*   | 0.001*    | 0.001*      |

Mean ± S.E.M; * = Significant difference (P < 0.05)

REFERENCES

Abowei, J.F.N. (2010). The Condition Factor, Length – Weight Relationship and Abundance of olisha africana (Block, 1795) from Nkoror River Niger Delta, Nigeria. Advance Journal of Food Science and Technology, 2(1): 6-11

Adebiyi, F.A. (2012). Aspects of reproductive biology of big eye grunt, Brachydeuterus auritus (Valenciennes, 1832). Nature and Science, 10(2): 19-24

Agarwal, N.K. (2008). Fish Reproduction. APH Publishing Corporation, New Delhi, 157p

Akombo, P. M, Akange, E. T. and Adeyemi, S.O. (2016). Some aspects of the biology of Synodontis (Cuvier, 1816) species in the lower river Benue, Makurdi, Benue state, Nigeria. International Journal of Fisheries and Aquatic Studies, 4(1): 238-242

Andreu-Soler A., Oliva-Paterna F. J., Torralva M. (2006). A review of length–weight relationships of fish from the Segura River basin (SE Iberian Peninsula). Journal of Applied Ichthyology, 22:295–296

Bagenal, T.B. and Tesch, F.W. (1978). Age and growth. In: Methods for assessment of fish production in fresh waters (T.B. Bagenal, ed). Blackwell Science Publications Limited, Oxford, pp101-136

Dutta, D. and Banerjee, S. (2016). Studies on length weight relationship, condition factor and hepatosomatic index of one stripe spiny eel Macrogogathus aral (Bloch and Schneider, 1801) in West Bengal. International Journal of Scientific and Research Publications, 6(8): 34-43

Froese, R. (2006). Cube law, Condition factor and Weight-length relationship, meta-analysis and recommendations. Journal of Applied Ichthyology 22: 241-253

Hart, A. I. and Abowei, J. F. N. (2007). A study of the length – weight relationship, condition factor and age of ten fish species from the Lower Nun River, Niger Delta. African Journal of Applied Zoology & Environmental Biology, 9:13 – 19

Hirpo, L.A. (2012). Breeding Season and Condition Factor of Oreochromis niloticus (Pisces: Cichlidae) in Lake Babogaya, Ethiopia. International Journal of Agricultural Sciences, 2(3)116-120

Ibrahim, B. U. (2012). Length-weight relationship and condition factor of Hyperopisus bebe occidentalis (Mormyridae) in Kontagora reservoir, Niger state, Nigeria. Journal of Fisheries International, 7(1): 13-15

Idodo-Umeh, G. (2003). Freshwater fishes of Nigeria: Taxonomy, ecological notes, diet and utilization. Idodo Umeh Publishers Ltd, 243pp

Kara, A. and Bayhan., B. (2008). Length-weight and length-weight relationships of the bogue Boops boops (Linneaus, 1758) in Izmir Bay (Aegean Sea of Turkey. Belgian Journal of Zoology, 138 (2): 154-157

Mazzoni, R., Mendonca, R.S. and Caramaschi, E.P (2005). Reproductive biology of Astyanax janeiroensis (Osteichthyes, Characidae) from the Ulhhta River, Marica, RJ, Brazil. Brazilian Journal of Biology, 65 (4) : 643-649

Mekkawy, I.A.A. and Hassan, A.A. (2011). Some reproductive parameters of Synodontis schall (Bloch and Schneider, 1801) from River Nile, Egypt. Journal of Fisheries and Aquatic Sciences, 6(4): 456-471

Oboh, I. P., Ogbeibu, A. E. and Ogoanah, S.O. (2013). Gonadal development, fecundity and spawning pattern of Synodontis schall (Pisces: Mochokidae) from Jamieson River, Nigeria. Research and Reviews: Journal of Zoological Sciences, 1(2): 13-23

Olaosebikan, B.D and Raji, A. (2013). Field guide to Nigerian Freshwater Fishes. Revised Edition. Federal College of Freshwater Fisheries Technology, New Bussa, Nigeria, 144pp

Olele, N. F. and Etim, L. (2011). Some aspects of the biology of Synodontis nigrita (Curvier and Valenciennes, 1864) in Ohim Lake, Asaba, Nigeria. Journal of Agricultural and Biological Science, 6(1): 56-63

Oliva-Paterna F. J., Torralva M., Carvalho E. D. (2009). Length-weight relationships for twenty species collected in the Jurumirim reservoir (Paranapanema Basin, Brazil). Journal of Applied Ichthyology, 25:360-361

Reed, W., Burchard, J., Hopson, A.J., Jennes, J.H and Yaro, I. (1967). Fish and Fisheries of Northern Nigeria. Ministry of Agriculture, Northern Nigeria, 226pp

Olele, N.F and Etim, L. (2011). Some aspects of the biology of Synodontis nigrita (Curvier and Valenciennes, 1864) in Ohim Lake, Asaba, Nigeria. Journal of Agricultural and Biological Science, 6(1): 56-63
Shinkafi, B.A., Salim, A.M. and Yusuf, M.A. (2013). Some Aspects of the Biology of *Distichodus rostratus* (Gunther, 1864) in River Rima, North-western Nigeria. *Greener Journal of Biological Sciences, 3*(4): 136-145

Usman, A., Solomon, S.G. and Okayi, R.G. (2014). Aspects of the biology of some selected Fish Species from Lake Alau, Arid Zone Nigeria. *Nigerian Journal of Fisheries and Aquaculture, 2*(2): 18

©2021 This is an Open Access article distributed under the terms of the Creative Commons Attribution 4.0 International license viewed via https://creativecommons.org/licenses/by/4.0/which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is cited appropriately.