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Biological Assessment of Target Species in the Mid Cross River Flood System, South Eastern Nigeria: Implications for Fishery Modelling, Conservation and Policy

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Abstract: *The length-weight relationship and condition factor of target species were determined in mid-Cross River basin, South-Eastern Nigeria. These target species are known for their nutritional and economical values. These species are readily available and affordable for the common poor and vulnerable (aged, women and children) in the society who require these renewable natural resources as a vital, rich and cheap source of alternative animal protein. A total of 465 fish samples were analyzed. Data were collected monthly over a period six months. The length-weight relationship and condition factors were determined by mathematical and statistical method in FISAT II software. The length-weight relationship value of Chrysichthys nigrodigitatus was given as 'a' value was -1.280 and 'b' value was 2.572 which shows negative allometric growth pattern while 'r' value was 0.706. The correlation coefficients were all positive and significant. The length-weight relationship for Heterobranchus bidorsalis showed that the intercept 'a' is at 0.121 with the slope 'b' of 1.543, and the correlation coefficient 'r' of 0.848. The value of 'b' reveals that the fish has a negative allometric growth pattern. The regression coefficient 'b' for the length-weight relationship was 1.420 showing that the fishes exhibit negative allometric growth pattern in the rivers while the regression coefficient 'r' is 0.856 which is close to unity indicating a good relationship between the length and weight of Clarias gariepinus. The overall condition factor value obtained in this study (K = 1.46) showed that C. nigrodigitatus were in good health condition. The size compositions of the population of the fish in the study showed that the fish have potential for growth and nutritional status. The monthly condition factor of H. bidorsalis showed that the highest condition factor of 3.55 was in observed in August while the lowest condition value of 1.87 was noted July. The average condition factor for the four months was 2.66. The condition factor 'K' of C. gariepinus ranges from 1.00 to 1.80 with the highest observed in the month of June and the lowest observed in the month of August.*

Key words: *length-weight relationship and condition factor, Chrysichthys nigrodigitatus, Heterobranchus bidorsalis, Clarias gariepinus.*

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I. Introduction

Fish provides an excellent source of protein in the diet of many families in tropical Africa and contributes to the economy and development of any nation if properly managed for sustainability [1]. Captured fisheries involve the harvesting of naturally existing stocks of wild fish. This can be done either by small scale/artisanal fishers or by industrial/commercial trawlers. Artisanal fishing activities constitute the traditional occupation of communities possessing water sources. Water bodies are among the important natural resources bequeathed to Nigeria by nature [2]. The hunting, catching and marketing of edible fresh water and ocean fishes largely dominate fishing industry in Nigeria. Basically, Fish-supply in Nigeria is either from capture fisheries, fish-farming or importation [2]; [3].Of all the animal protein foods produced and consumed in Nigeria, fish is of prime importance as it has remained a major source of protein, which is rich in essential amino acids for both rural and urban poor households. The accessible knowledge about species biometric parameters will create a set of vital tools to contribute not only the sustainable exploration of the fishing resources, but also the regional development policy options, allowing to assess and foresee the possible effects on the aquatic ecosystem .Length and weight are two fundamental components in the study of the biological assessment of fish species at individual and population levels. Length-weight relationship is an important model in the biological and ecological study of fish. It is highly important in stock assessments, in the prediction of the weight of fish from a given length. It is used in the studies of populations' structures, reproduction, recruitment patterns and condition factor as well as providing information on growth, mortality patterns. Effective management and conservation of any fishery requires considerable knowledge regarding population parameters such as length weight, age and growth, mortality and recruitment of the exploited stock [4]; [5]. Three economically important species of catfish were selected, thus their length-weight relationship (LWR) and condition factor were studied with the main objectives of providing the much needed information about each fishery for rational management, conservation of these limited but renewable natural resources, permit future comparison studies among populations of same species using models and also evidence for policymaking by the stakeholders of the fisheries.

II. Materials and Methods

Study area

The Cross River is a major component of the inland waters of south-eastern Nigeria, and its role to the fishery of the area is quite significant. The Cross River originates from the Cameroon high mountains and flows through Ebonyi State and Cross River State into the Atlantic Ocean. The river (Figure 1) lies in an area between 5°57″–5°30′20″ N and 7°58″–5°30′20″ E [6]. The approximate surface area of the Cross River is 3,900,000 ha [7]. The rainy season and the dry season are the two main seasons of the area. The latter occurs between October/November and March, while the former is from April to September/October. During the rainy season, water level increases dramatically in the river. The rise in water levels of the river is brought about by direct precipitation within the catchment areas as well as by inflow from the Afikpo and Cross River flood plains. The inundated soils are sandy with good water retention capacity. During the dry season, water is remains in the main river channel and in few flood plain pools. The fishing communities of the mid Cross river basin are Oziza, Ndibe, Uwana and Enoma.

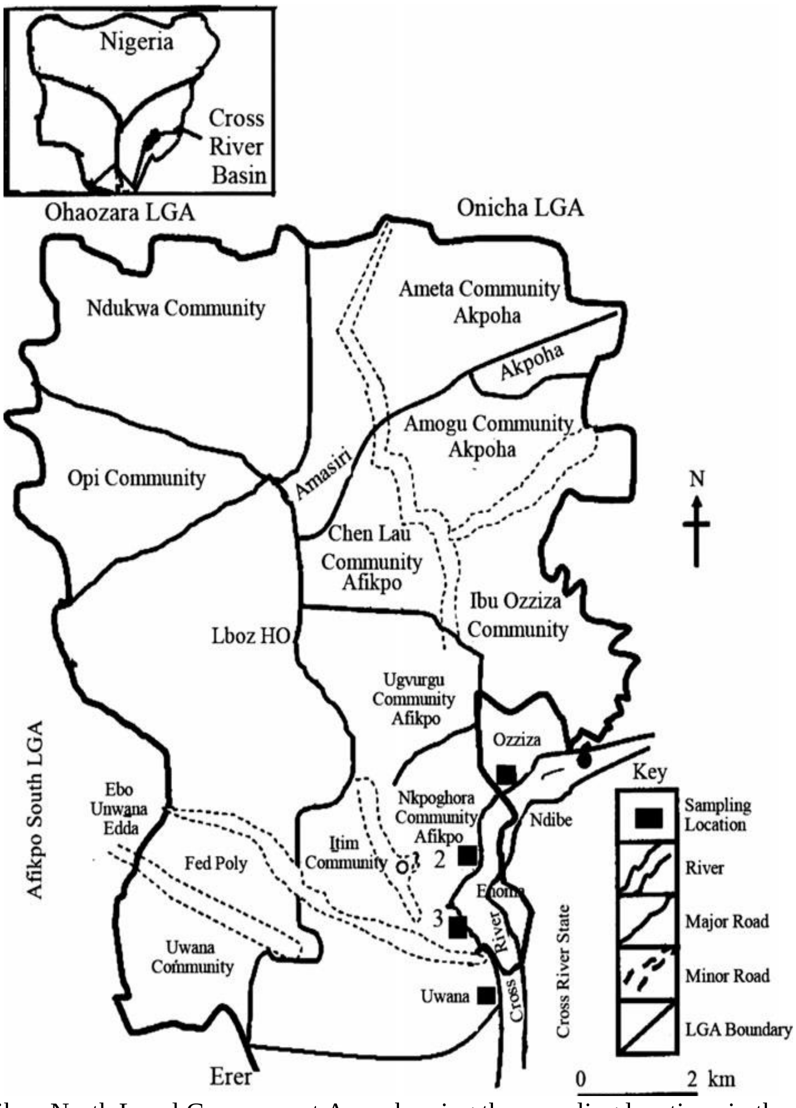

Fig 1. Map of Afikpo North Local Government Area showing the sampling locations in the Cross River basin [6].

Study population

For the fishery assessment of target communities, fish samples were collected from four communities which include; Oziza, Akpoha, Ndibe and Unwana from April-September 2019. A total of 170 *C. nigrodigitatus*, 145 fish specimens of *H. bidorsalis* and 150 *C. gariepinus* were purchased from every other local fishermen as the fishes were landed at the fish port of the target communities using locally available crafts and fishing gears which include canoes, cast nets, gill nets, lift nets, fishing baskets, hook and lines.

Data collection methods

The samplings were made by random samples of the catch of the commercial artisanal fishers. The fish samples were collected from four sampling locations, Enohia, Ozizza, Ndibe and Uwana in the Cross River basin at Afikpo, Southeastern Nigeria (Fig. 1). The catches were made by the local fishermen using gill nets, cast nets, lift nets, fishing baskets and traps. The samples were sorted and identified to species level using the guides of [8]. Fish samples were preserved in 100% ethanol as voucher specimens. Total length (TL) measurements were made to the nearest 0.1cm with a meter rule measuring board. Weight measurements were made with a FEJ-1500A electronic compact weighing balance to the nearest 0.1g.

Data Analysis

Use of FiSAT II: The data obtained in the fishery assessment study is presented using simple frequency distribution table and charts. The correlation between the length and weight are determined using (FAO-ICLARM Stock Assessment Tool) FiSAT II software [9]. The condition factor was calculated using the mean weight and length and statistical difference was measured at 0.05 level of significance.

The Length - weight relationship (LWR) was estimated by using the equation:

$W = a L^b$

Where W = Weight (g), L = Standard length (cm), a = Constant, b = Growth exponent.

Fulton's condition factor was computed according to [10] as:

$K = {}^{100W}/_{L^3}$

Where K = Condition Factor, W = Total body weight (g), L = Standard Length (cm)

III. Results

Sex ratio

C. nigrodigitatus, *H. bidorsalis* and *C. gariepinus* were collected from the four sampling areas of Mid Cross River Basin between the sampling periods of April-September 2019. One hundred and fifty (150) specimens of *C. nigrodigitatus* were sampled. Total number of male samples was fifty two (52) and ninety eight (98) were females with the sex ratio of 1:1.9. One hundred and six (106) samples of *H. bidorsalis* were sampled for this study, with 49 male samples and 57 female samples. The sex ratio of males to females was 1:1.2. The total number of samples for *C. gariepinus* was 133. The total number of male sampled was 64 while the total number of female sampled was 69 and overall sex ratio was 1:1.07.

Totallength Frequency Distribution

The lowest and the highest lengths recorded were 16cm TL and 71cm TL respectively with mean value of 45.3±5.11cmTL. The highest frequency distribution of total length for *C. nigrodigitatus* was recorded in the interval of 25-40cm TL while the interval of 70-85cm TL showed the lowest frequency distribution as indicated in Fig.2a.

Total length of *H. bidorsalis* ranged from 11.2-38cm TL (mean 22.8±2.11cm TL).The result of length frequency distribution revealed that the length ranges of 20-25cm TL had the highest frequency while the lowest frequency was seen in the length class of 35-40cmTL (Fig. 2b).The total length of *C. gariepinus* was between 16.9 and 37.5cm TL (mean27.1±6.67cm TL. Length frequency distribution showed that length class of 25-30cm TL had the highest frequency while the lowest frequency was recorded in the length class of 15-20cm TL (Fig. 2c).

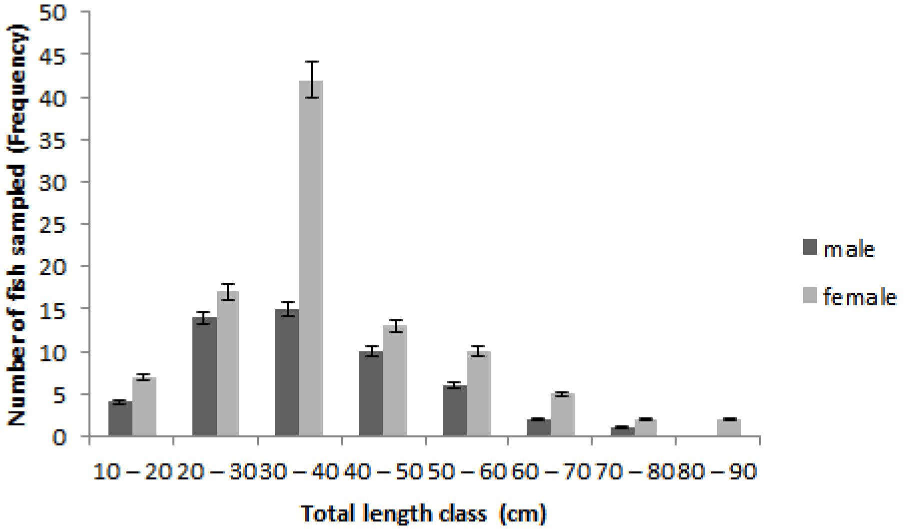

Fig. 2a: Total length frequency distribution of *C. nigrodigitatus*

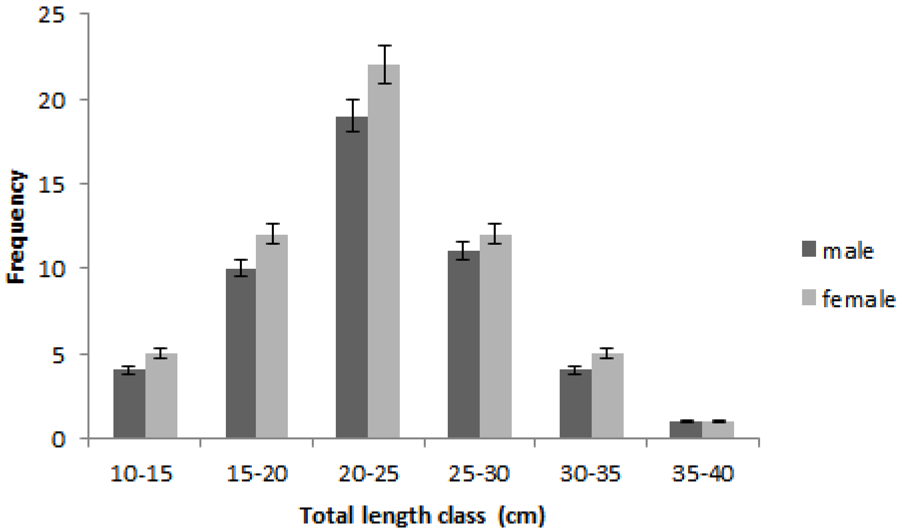

Fig. 2b: Total length frequency distribution of *H. bidorsalis*

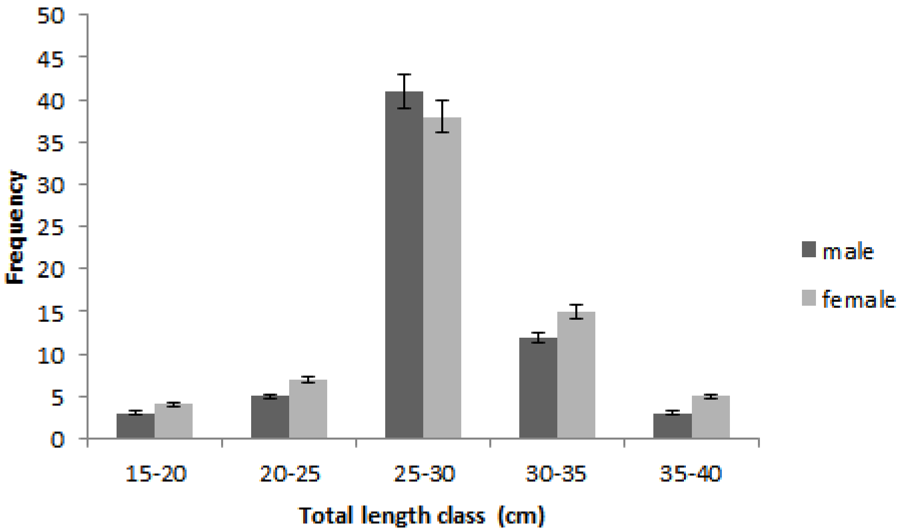

Fig. 2c: Total length frequency distribution of *C. gariepinus*

Total weight Frequency Distribution

The lowest and the highest weights recorded were 450.4g and 4445.2g respectively with the mean value of 840.4±20.9g. The highest frequency distribution of *C. nigrodigitatus* was recorded in the weight interval of 450-1000g while the interval of 3000-4000g showed the lowest frequency distribution as showed in Fig.3a.The weight distribution of *H. bidorsalis* showed that the weight ranged from 108.3 to 547.6g and with a mean value of 315.2±41.1g. The highest frequency was recorded in weight class 350-400g while the lowest frequency was seen in weight class 500-550g (Fig. 3b). The overall weight of *C. gariepinus* was between 124.5g and 410.4g. The mean weight of the sampled population was 235.5±67.7g. The weight frequency distribution showed that the highest frequency was within the weight class of 250-300 g, while the lowest frequency was within the weight class of 100-150g (Fig. 3c).

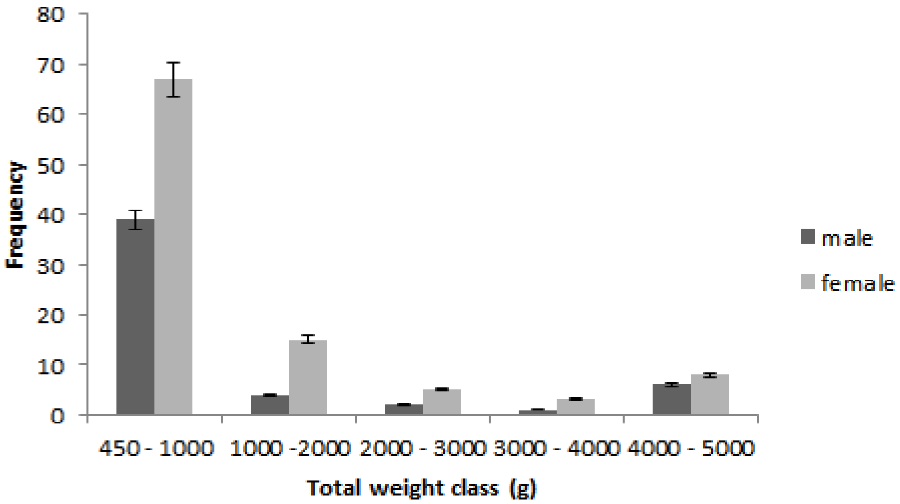

Fig. 3a: Total weight frequency distribution of *C. nigrodigitatus*

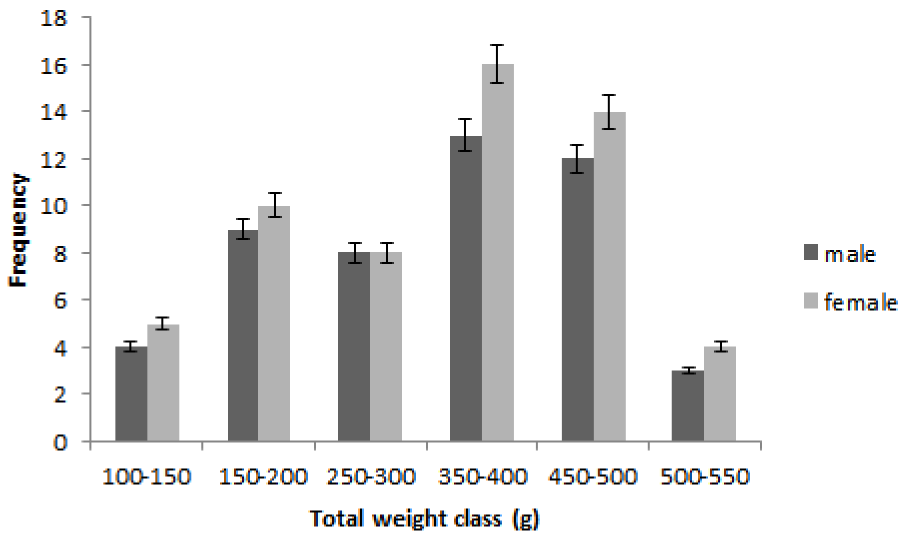

Fig. 3b: Total weight frequency distribution of *H. bidorsalis*

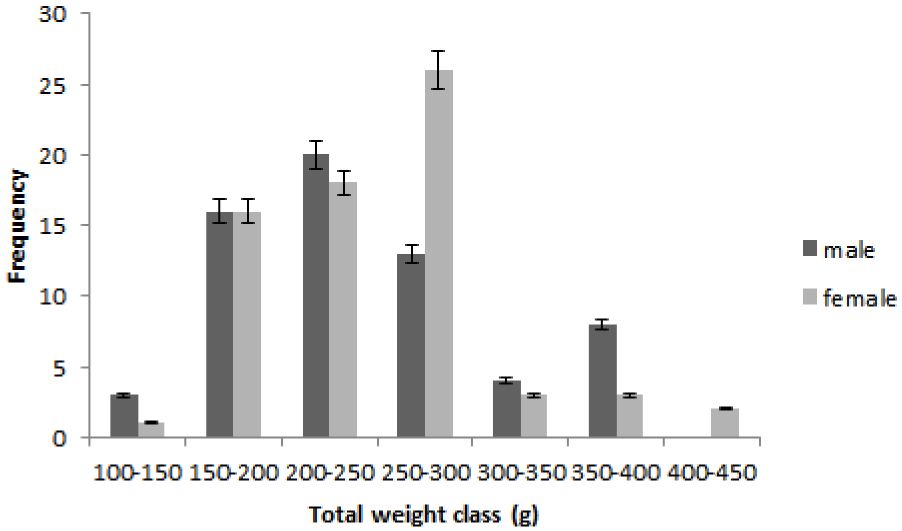

Fig. 3c: Total weight frequency distribution of *C. gariepinus*

Length-weight relationship

Length-weight relationship of target species of the mid Cross River basin is shown in Table 1. The length-weight relationship of *C. nigrodigitatus* showed that 'a' value was -1.280 and 'b' value was 2.572 and the value of r = 0.706 (Fig. 4). The length-weight relationship of *H. bidorsalis* from the graph showed that the intercept 'a' is at 0.121 with the slope 'b' of 1.543, and the correlation coefficient 'r' of 0.848 (Fig. 5). The length- Weight relationship of *C. gariepinus* showed a regression coefficient 'b' of 1.420, correlation coefficient 'r' of 0.856 and intercept of 0.322 (Fig. 6).

Table 1: Length Weight Relationship of target fish species

Parameters/Fish species	*C. nigrodigitatus*	*H. bidorsalis*	*C. gariepinus*
Number of Observation	170	145	150
Intercept (a)	-1.280	0.121	0.322
Standard deviation of 'a'	0.331	0.148	0.110
Confidence Interval of intercept	-1.930	-0.175	0.110
	-0.634	0.410	0.532
Slope (b)	2.572	1.543	1.420
Standard deviation of 'b'	0.212	0.095	0.075
Confidence Interval of slope	2.153	1.360	1.270
	2.981	1.729	1.565
Correlation coef. (r)	0.706	0.848	0.856
r^2	0.500	0.720	0.730
Confidence Interval of r	0.6154	0.783	0.800
	0.7783	0.894	0.896
Growth pattern	Negative allometry	Negative allometry	Negative allometry

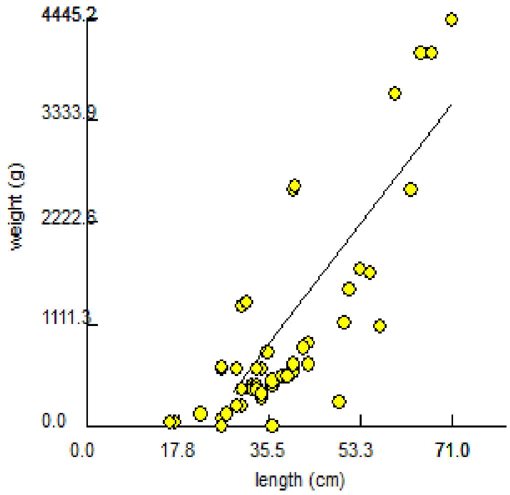

Fig.4: Length-weight relationship of *C. nigrodigitatus*

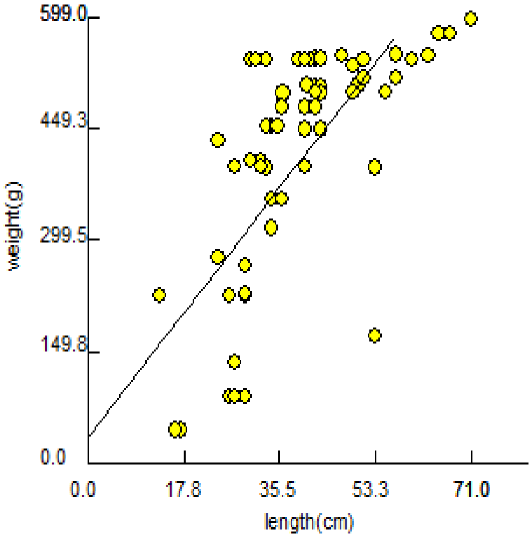

Fig 5: Length-weight relationship of *H. bidorsalis*

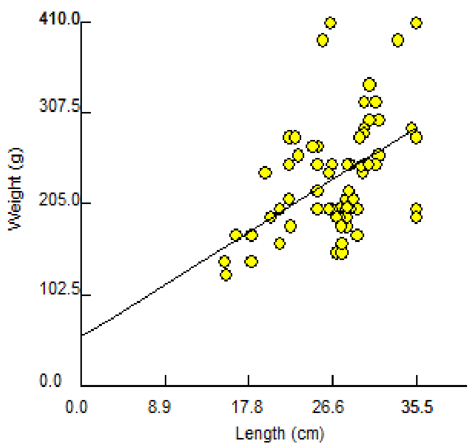

Fig. 6: Length-weight relationships of *C. gariepinus*

Condition Factor

Monthly condition factor values of target species of the mid Cross River basin are as seen in Table 2. Monthly variations in condition factor of *C. nigrodigitatus* were shown. It is observed that higher values were detected in July (1.68) and August (1.45), meanwhile lower ones were found in September (1.31) and June (1.39). The overall condition factor value is 1.46. These indicates that the fish are in good health condition and that there were plenty of food to support both somatic and gonadal development of the fish within the period of this sampling (April - September) 2019. The monthly condition factor of *H. bidorsalis* showed that the highest condition factor of 3.55 was in observed in August while the lowest condition value of 1.87 was recorded in July. Then the average condition factor for the four months was 2.41. The monthly mean condition factor of *C. gariepinus* ranged between 1.00 and 1.80. The highest mean condition factor of the sampled population was recorded in the month of June while the lowest mean condition factor was recorded in the month of August with overall condition factor of 1.24.

Table 2: Overall Monthly Condition Factor Value of target fish species

Months	K-**Value**		
	C. nigrodigitatus	*H. bidorsalis*	*C. gariepinus*
April	1.44	1.67	1.77
May	1.48	2.11	1.11
June	1.39	2.34	1.80
July	1.68	1.87	1.02
August	1.45	3.55	1.00
September	1.31	2.89	1.15
Overall	1.46	2.41	1.24

IV. Discussion

The population structure, length, weight and their relationship are very vital in any fishery production providing information on stock composition, size increment, growth patterns and well-being of the fish [11]. It can also be used to estimate the status of a particular species, because such estimation is relevant for its management [12]. The chi-square analysis showed variation ($P<0.05$) in the monthly sex ratio of the three catfish sampled in this study. In the population of one hundred and fifty (150) fish samples of *C. nigrodigitatus,* 35% were males while 65% were females with the ratio of 1:2, respectively. This is an indication that the female *C. nigrodigitatus* has higher population abundance than the male counterparts. This is not in consistence to the work of [13] where they observed that the male specimens over the female were higher at the ratio of 1:0.15 for *C. nigrodigitatus* and 1:0.08 for *Chrysichthys walkerii* in Asejire Lake. This is important to stand out the fact that having less male and female *C. nigrodigitatus* in the Mid-Cross River Basin could be favourable to the fishery as it serves as a regulatory mechanism for the sex ratio. This may be due to the fact that the gears are set close to the breeding ground. The length frequency distribution of *C. nigrodigitatus* ranged from 16-71cmTL with the mean value of 38.16cm. The weight frequency distribution of *C. nigrodigitatus* showed that the lowest - highest weight range was 45.36 - 4445.18g, respectively whereas the mean value of the distribution was 1974.474g.

The results of this study showed that a total of 106 *H. bidorsalis* consisting of 57 were females while 49 were males. The sex ratio of males is to females was 1:1.16, the ratio of females was higher than the ratio of males. The chi-square analysis showed variation ($P<0.05$) in the monthly samples of *H. bidorsalis* used in this study. The result of length distribution among females and males revealed that the length ranges of 20-25cm had the highest number of females of 19 fishes and 17 fishes. The lowest number of female and male was 1 for both sexes at the length range of 35-40cm. The length distribution showed that the highest condition of 3.56 factors was recorded in the length range 25-30cm while the lowest condition factor was 1.04 at 10-15 length range. The weight distribution among the population of *H. bidorsalis* used in this study showed that the weight ranges from 100 to 550g, while the higher number of females falls at 350-400g and that of males was at 450-500g, while the lowest occurrence of females and males was 3 for each at 500-550g. There was a significant variation in the condition factor across groups. The highest condition factor was 3.46 of the weight range of 150-200g while the lowest condition factor 1.67 was observed at 350-400g. The result showed that there was significantly more female *C. gariepinus* in the sampled population than the male. The frequency distribution showed that a higher number of *C. gariepinus* of 38 females and 41 males was recorded in the length class of 25-30 while the least number of 4 for female and 3 for male was recorded in the length class of 15-20. For weight, a higher number of 26 females and 13 males fall within the weight class of 250-300 g, while the least number of 1 female and 3 males fall within the weight class of 100-150.

Length- weight relationship and condition factor are an important indicator in studying the well-being of fishes. Length and weight relationship are essential for proper exploitation and management of the population of fish species [14]. When the values of b equal 3, the growth is called isometric, if it is less than 3 is referred to as negative allometric growth and when more than 3 it is called positive allometric growth The length-weight relationship of *C. nigrodigitatus* is considered to be of major interest, since apart from predicting the average weight of the fish at a given length, it is equally employed in assessing the wellbeing of the fish population in a given water body. The correlation coefficients were all positive and highly significant. *C. nigrodigitatus* exhibited negative allometric growth pattern. This result is not in accordance with the growth pattern within the same species reported in a population of *C. nigrodigitatus,* from three locations by [15] where the growth pattern indicated isometric growth. The value of 'b' 1.5428 shows that *H. bidorsalis* has a negative allometric growth pattern. The growth patterns in fish are affected by several factors such as seasonality, nature of the habitat, sex, food availability, sample size [16] and or habitat suitability [17].In the length-weight relationship of *C. gariepinus*, the regression coefficient ('b') and Correlation coefficient ('r') values obtained in this study were 1.41 and 0.85 respectively. Regression Coefficient 'b' larger or smaller than 3.0, shows an allometric growth. When value 'b' is greater than 3, it is said to have a positive allometric growth. However, 'b' value less than 3 shows a negative allometric growth. The 'b' value showed that the sampled population exhibits negative allometric growth pattern. These therefore mean that the fishes do not maintain dimensional equality. That is to say that there is no proportional increase in weight of the fishes as length increases. However, the correlation coefficient obtained in this study (0.85) is close to unity (1) which signifies a good relationship between the length and weight of *C. gariepinus* [18]. This growth pattern could be attributed to the alterations in the growth patterns of the fishes due to changes in their environment resulting from anthropogenic activities carried out in the rivers. This is similar to [19] which reported a 'b' value of 1.59 for combined sexes in Ebonyi river but is in contrast with [20] which reported a 'b' value of 3.3 showing a positive allometric growth. From the length weight parameters, fishes are affected by factors such as season, habitat, different population, sex, diet, etc. [21].

Condition factor or Pandora index (K) expresses the well-being of fish species in numerical terms. Condition factor can be influenced by both biotic and abiotic factors such as feeding regime and state of gonadal development. In this study all target species had condition factor value (K) greater than 1 indicative that the target species were in good condition. The overall condition factors (K=1.46) obtained in this study for *C. nigrodigitatus* were in similar to those obtained from the study in Num River by [22], the overall condition factor obtained from combined male and female sexes were 2.16.The two populations were in good condition.The condition factor observed in this study for *H. bidorsalis* is in line with the observation of [23],who reported values 1.57-3.83. [24] reported values (0.56 and1.62) in contrast with this present study. Differences in condition factor could be as a result of pollution and or anthropogenic activities (sawmilling, sewage disposal and presence of industrial effluents) [25]. The condition factors 1.00 to 1.80 obtained in this study for *C. gariepinus* were in contrast to that of other studies. [19] recorded condition factors of 0.58 to 1.74 for both sexes of*C. gariepinus*. The condition factors were relatively higher than the values (0.65-0.70) reported by [2]. The condition factors obtained in this study shows the fishes are in good condition in their environment however not in optimum growth. Therefore, adequate sustainable management practices are needed to conserve these three important economic viable catfish species.

V. Conclusion

In conclusion, the study population of these target species showed negative allometric growth pattern, this implies the species did not increase in weight faster than the cube of their total lengths in mid-Cross River basin. The values for condition factor indicate that the species are in good condition; this might be attributed to availability of food and favourable ecological conditions in the river. However due to the open access fisheries of this tropical river basin, management strategies (selecting the optimum mesh size which release small fish, allow each fish to produced eggs at least once in its life, curbing excess anthropogenic activities which leads to pollution) geared towards their sustainability should be implemented.

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