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The Reproductive Biology of *Auchenoglanis biscutatus* and *Protopterus annectens* from Lower River Benue Wadata, Makurdi-Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Data on the reproductive biology of *Auchenoglanis biscutatus and Protopterus annectens* were collected between april 2019 to march 2020. Reproductive parameters including sex ratio was determined as number of males by number of females, gonadosomatic index as total gonad weight by body weight and expressed in percentage while fecundity was obtained via volumetric and gravimetric methods. There was a slight dominance of males over females of both species (1.1:1) with more immature individuals caught within the study period. Higher GSI, gonad length and gonad weight (0.87±0.06, 15.94±0.89 and 3.01±0.19) were recorded in *Auchenoglanis biscutatus*

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during dry season while GSI and gonad weight (4.06±0.62, 5.63±0.45) of *Protopterus annectens* and number of mature fishes (0.35) were higher during rainy season. The relative fecundity for *Auchenoglanis biscutatus* investigated had no significant difference in both seasons (7.99±0.94, 8.22±0.78) while the relative fecundity for *Protopterus annectentens* differed significantly among the wet and dry seasons (3.43±0.94, 0.48±0.22). The relative fecundity of *Protopterus annectens* (11.59±2.04) was higher than that of *Auchenoglanis biscutatus* (8.04±0.75).it was concluded that the study of the sex ratio indicates that males were higher than females.

Keywords: Reproductive biology; seasons and indices.

1. INTRODUCTION

Increase in human population and the attendant increase in demand for animal protein has continued to raise the demand for and consumption of fish and fish products worldwide. Freshwater fishery has an important bearing on the lives of many African communities primarily as an important source of dietary protein and secondarily as a source of subsistence income. Fish provides a good source of high quality protein and contains many vitamins and minerals. Scientific knowledge and understanding of key population characteristics such as feeding and reproduction of fish are very necessary in the assessment and formulation of prudent management policies for fish stocks [1] (Novaese and Carvalho 2012).

According to Umaru et al., [2] domestication and culture of commercially important fish species remains the key to mitigating further decline and possible extinction of these fishes. One of the important aspects of fish that needs to be focused for a successful domestication program includes the aspect of the biology of the fish. Okafor et al., [3] opined that most commercially important fish species have not been successfully cultured on a commercial scale due to insufficient knowledge of the biology of these fishes; hence, in order to cultivate any of these fish species successfully in captivity, a good knowledge of their biology is important.

Reproduction in fishes is one of the fundamental biological processes that enable survival and continuity of species in the aquatic environment. Reproductive patterns of fish, according to Pauly [4], differ when factors such as habitats, geographical zone and species are considered, which are influenced by environmental and biotic factors. These reproductive parameters include sex ratio, stage of maturity, gonad index (GI), gonadosomatic index (GSI), and fecundity. Knowledge on the reproductive patterns of fishes as well as growth and mortality characteristics will define the regenerative capacity of a population. Gonad maturation stages have become increasingly important in fish production, especially in induced spawning and hybridization in addition to determine the stock that is, mature, and the size or age at first maturity. This work seek to determine the reproductive parameters of *Auchenoglanis biscutatus* and *Protopterus annectens* in Lower River Benue at Wadata-Makurdi.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted at the lower River Benue axis at Wadata landing site in Makurdi. Makurdi is the capital of Benue State in Nigeria, is located at Longitude 7°43°N and Latitude 8°32°E (Fig. 1). The town is divided into the North and the South bank by the River Benue. The samples were collected for further analysis at the general purpose Laboratory Department of Fisheries and Aquaculture Joseph Sarwuan Tarka University Makurdi.

2.2 Fish Collection

Fish were collected from April 2019 to March 2020, fish samples were collected from Wadata landing site between 08:00 to 09:00 hours.

2.3 Fish Measurement

This was done with the aid of measuring board, measuring rule, weighing balance, pair of divider and thread of varying lengths. Measured in centimeters (cm) and grams (g), recorded on data collection sheets for each sample separately. Validation of the two species was done by comparing the values of the body proportions obtained with standard keys by De Vos [5] and Pauly et al. [6].

2.4 Reproductive Parameters

2.4.1 Sex ratio determination

The sex of each specimen obtained during the sampling period was determined. This was done by visual observation of the external features. Females were recognized by round inflammation around the genital aperture and the distended aperture, slightly sticky skin, and, by the presence of testes in the case of males. The number of the identifiable males and females of the samples for each sampling period was recorded and used to determine the sex ratio. Sex ratio was calculated using the formula:

Sex ratio =number of males / number of females [7]

2.4.2 Gonadosomatic Index (GSI)

The body weights of the samples with their corresponding gonad weights was taken and used to calculate the gonadosomatic index (GSI). This was determined as:

GSI = W/B x 100 [8].

Where

W=weight of the gonads
B = weight of the fish (g)

2.5 Fecundity Estimation and Oocyte/Egg Diameter

This is the number of eggs in the ovaries that was matured during a particular spawning season.

Ripe eggs were removed from gravid fish, weighed and preserved in Gilson's fluid. The preserved ovaries were washed several times in distilled water to get rid of the preservative, then eggs were separated from the ovaries, placed on filter paper to remove excess water. Clumped eggs were carefully separated and air dried at room temperature. The diameters were determined using an electronic microscope. Volumetric and gravimetric methods were employed to estimate the number of eggs in each of the gravid fish.

2.6 Statistical Analysis

All the data obtained on gonads were subjected to independent sample t-test to determine the mean values. This was done at p<0.05.

3. RESULTS

3.1 Reproductive Indices

Fig. 1 showed mean gonad weight of *Auchenoglanis biscutatus* and *Protopterus annectens* from Lower River Benue.The result indicated that *Auchenoglanis biscutatus* female gonad was heavier than the male, same in the case of *Protopterus annectens,* the female gonad was heavier than the male, and in general the gonads of P*rotopterus annectens* were higher than that of *Auchenoglanis bisctatus*.

Table 1 explained the mean reproductive indices of *Auchenoglanis biscutatus* and *Protopterus annectens* from Lower River Benue, this showed all parameters differs significantly at (p<0.05) with the sex ratio for both species as Male:Female (1.1:1) and the maturity ratio for both species showed the immature fishes were more than the matured fishes during the study period.

Table 2 showed mean seasonal reproductive indices of *Auchenoglanis biscutatus* from Lower River Benue, which revealed that all Gonad length, Gonad weight and GSI differs significantly across the two seasons and the maturity ratio also showed the immature fishes were more than the matured fishes for both seasons.

Table 1. Some reproductive indices of selected fishes from Lower River Benue

Parameters	Auchenoglanis	Protopterus	P-Value
Gonad Length	11.87 ± 0.60^{b}	17.62 ± 0.44^{a}	0.00
Gonad Weight	2.13 ± 0.13^{b}	4.31 ± 0.27^{a}	0.00
GSI	0.66 ± 0.04^{b}	2.35 ± 0.32^{a}	0.00
Sex Ratio (Male: Female)	1.1 : 1	1.1 : 1	
Maturity Ratio(Matured : Immature)	0.23 : 1	0.24 : 1	

means in the same row with different superscripts differ significantly
a and b shows whether the two means are significant or not

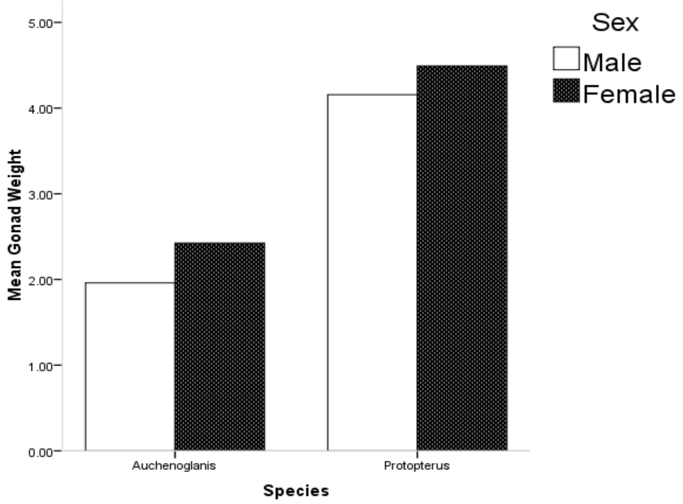

Fig. 1. Mean gonad weight of *Auchenoglanis biscutatus and Protopterus annectens* from lower river Benue at Wadata

Table 2. Seasonal reproductive indices of *Auchenoglanis biscutatus* from lower river Benue

Parameters	Wet Season	Dry Season	P-Value
Gonad Length	7.79±0.41^{b}	15.94±0.89^{a}	0.00
Gonad Weight	1.24±0.11^{b}	3.01±0.19^{a}	0.00
GSI	0.48±0.05^{b}	0.87±0.06^{a}	0.00
Sex Ratio (Male: Female)	1 : 1	1 :1	
Maturity Ratio (Matured : Immature)	0.40 : 1	0.09	

means in the same row with different superscripts differ signific
a and b shows whether the two means are significant or not

Table 3. Seasonal reproductive indices of *Protopterus annectens* from lower river Benue

Parameters	Wet Season	Dry Season	P-Value
Gonad Length	15.74±0.58^{b}	19.49±0.59^{a}	0.00
Gonad Weight	5.63±0.45^{a}	3.00±0.21^{b}	0.00
GSI	4.06±0.62^{a}	0.83±0.06^{b}	0.00
Sex Ratio (Male: Female)	1 : 1	1 : 1	
Maturity Ratio (Matured : Immature)	0.35 : 1	0.16 : 1	

means in the same row with different superscripts differ significantly
a and b shows whether the two means are significant or not

Table 4. Mean seasonal reproductive indices of female *Auchenoglanis biscutatus* from lower river Benue

Parameters	Wet Season	Dry Season	P-Value
Egg Diameter	2.38±0.17^{a}	2.37±0.13^{a}	0.97
Egg Circumference	7.48±0.53^{a}	7.44±0.41^{a}	0.97
Egg Surfaces	4.67±0.70^{a}	4.43±0.49^{a}	0.87
Relative Fecundity	7.99±0.94^{a}	8.22±0.78^{a}	0.91

means in the same row with different superscripts differ significantly
a and b shows whether the two means are significant or not

Table 3 showed mean seasonal reproductive indices of *Protopterus annectens* from Lower River Benue, the results revealed Gonad length, Gonad weight and GSI differs significantly in both wet and dry season and the immature fishes were more than the mature fishes for both seasons.

Table 4 explained the mean seasonal reproductive indices of female *Auchenoglanis biscutatus* which indicated that for Egg diameter there was no significant difference across the two seasons. For Egg circumference also there was no significance difference in both wet and dry seasons, it was the same with Egg surface across the two seasons where there was no significant difference and also Relative fecundity showed there was no significant difference in both the wet and dry season. However Egg diameter, Egg circumference and Egg surface were higher in wet season why Relative fecundity was higher in dry season.

Table 5 showed mean seasonal reproductive indices of female *Protopterus annectens* which indicated that Egg diameter showed no significant difference in both seasons, Egg circumference also showed no significant difference, Egg surfaces had no significant difference in both wet and dry seasons, however Relative fecundity differs significantly across the seasons at ($p<0.05$).

Table 6 showed mean reproductive indices of *Auchenoglanis biscutatus* and *Protopterus annectens* from Lower River Benue; the results indicated that all parameters differ significantly among the two species except for relative fecundity that had no significant difference.

3.2 Gonadosomatic Index

Fig. 2 showed gonadosomatic indices of *Auchenoglanis biscutatus* male was high in dry season with (0.8) compare to (0.6) wet season while in *Protopterus annectens* male, the GSI was high in wet season with (4.0) compare to dry season (1.00). For female *Auchenoglanis biscutatus*, GSI was low in wet season (0.2) compare to dry season (0.8) while for female *Protopterus annectens,* the GSI was high in wet season (4.00) compare to dry season (0.7).

Fig. 3 showed the mean relative fecundity and length relationships of *Auchenoglanis biscutatus* which indicated that the lowest number of mean relative fecundity of 4.32kg was found in fishes that ranged 30.1-40cm and the highest was relative fecundity of 9.87kg was found in fishes ranged of 20.1-30.0cm.

Fig. 4 showed mean egg diameter and relative fecundity of *Auchenoglanis biscutatus* that indicated there was no known trend.

Fig. 5 showed the mean relative fecundity and length relationship of *Protopterus annecten* that showed that the least mean relative fecundity of 7.85kg was found in fishes ranged of 10-20.0cm and the highest mean relative fecundity of 22.92kg found in fishes ranged of 20.1-30.0cm. However, this also showed that almost all the relative fecundity increases with increase in the length of the fish.

Fig. 6 showed mean egg diameter and relative fecundity of *Protopterus annectens* that indicated there was no known trend.

Table 5. Mean seasonal reproductive indices of female *Protopterus annectens* from lower river Benue

Parameters	Wet Season	Dry Season	P-Value
Egg Diameter	$1.64±0.16^a$	$1.99±0.08^a$	0.25
Egg Circumference	$5.16±0.50^a$	$6.24±0.26^a$	0.25
Egg Surfaces	$2.48±0.35^a$	$3.13±0.27^a$	0.32
Relative Fecundity	$3.43±0.94^a$	$0.48±0.22^b$	0.00

means in the same row with different superscripts differ significantly
a and b shows whether the two means are significant or not

Table 6. Some reproductive indices of selected female fishes from lower river Benue

Parameters	Auchenoglanis	Protopterus	P-Value
Egg Diameter	$2.38±0.13^a$	$1.73±0.13^b$	0.00
Egg Circumference	$7.47±0.42^a$	$5.42±0.39^b$	0.00
Egg Surfaces	$4.62±0.55^a$	$2.64±0.27^b$	0.00
Relative Fecundity	$8.04±0.75^a$	$11.59±2.04^a$	0.21

**means in the same row with different superscripts differ significantly*
a and b shows whether the two means are significant or not

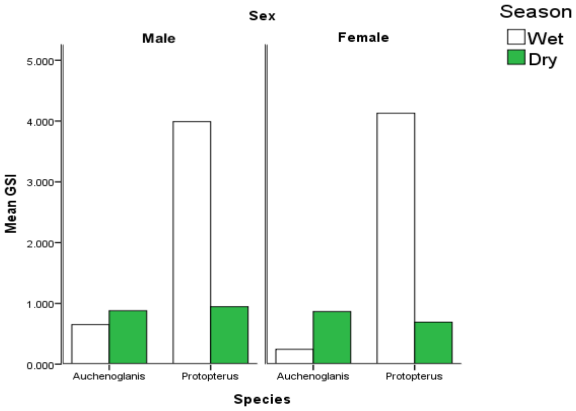

Fig. 2. Seasonal variation of the gonadosomatic indices of *Auchenoglanis biscutatus* and *Protopterus annectens* from lower river Benue

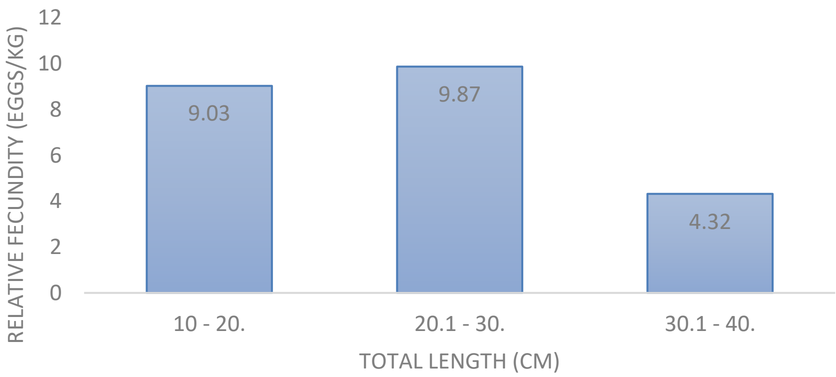

Fig. 3. Mean relative fecundity and length of *Auchenoglanis biscutatus* From lower river Benue at Wadata

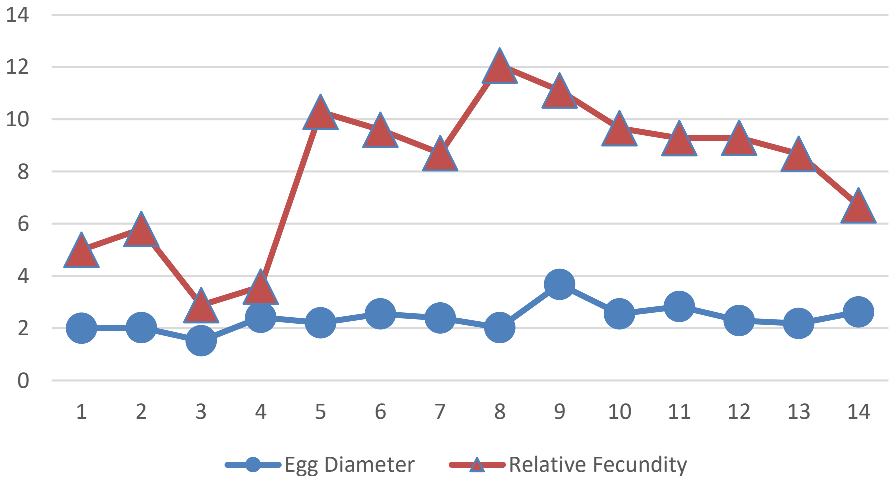

Fig. 4. Mean egg diameter and relative fecundity of *Auchenoglanis biscutatus* From lower river Benue at Wadata

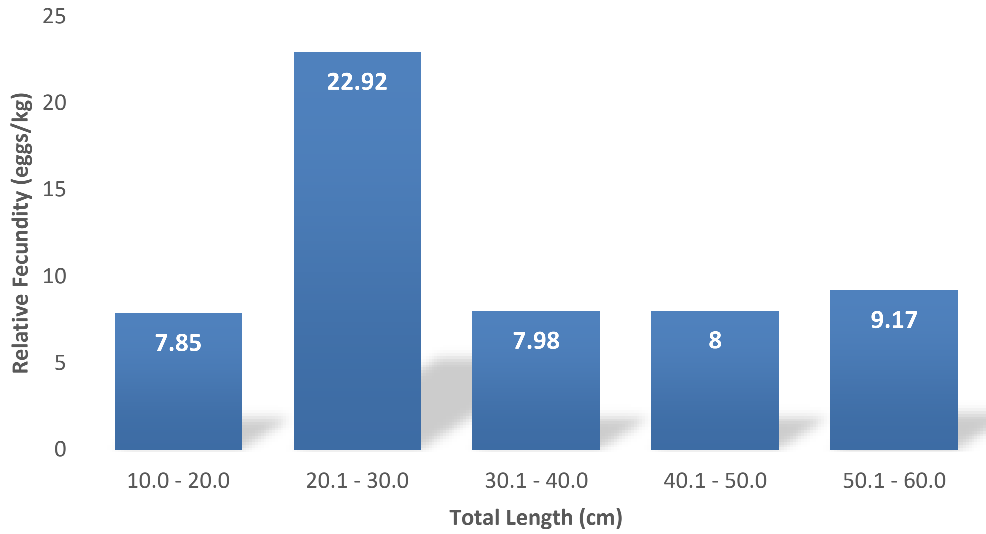

Fig. 5. Mean relative fecundity and length of *Protopterus annectens* from lower river Benue at Wadata

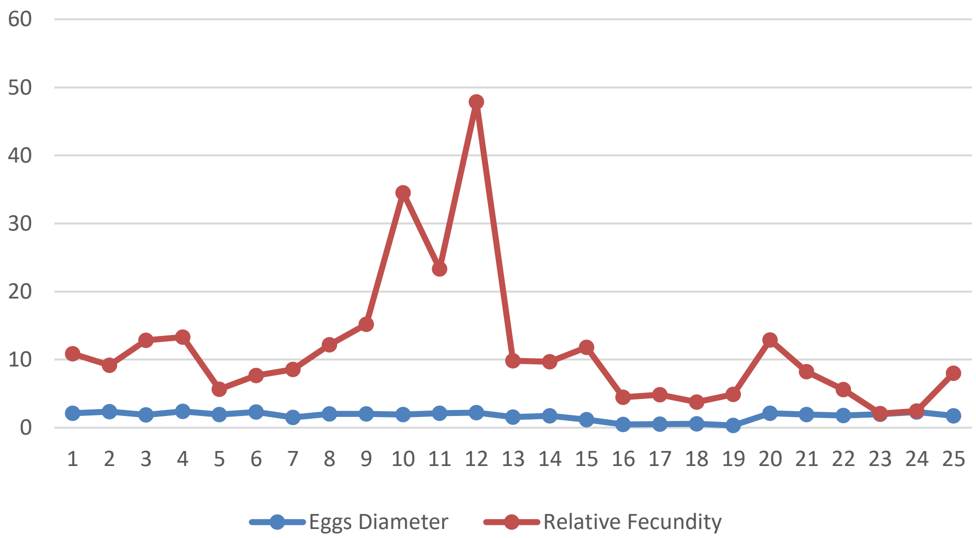

Fig. 6. Mean egg diameter and relative fecundity of *Protopterus annectens* from lower river Benue at Wadata

4. DISCUSSION

Gonadosomatic index (GSI) indicates gonadal development and maturity of fish [9]. The difference between male and female GSI suggests that energy invested in gamete production by male is probably less than that invested by females Partmar [10]. Generally, the results show that GSI of males were lower than those of the females. This could be due to physiological and hormone effects on the gonadal development of fish. The present study also showed that the GSI increase for both sexes of *Protopterus annectens* during rainy season. This could be due to spawning period and development gonads.

Fecundity is important in the estimation of stock size and stock discrimination of fish. It reveals useful information about the reproductive potential of fish. Ekamem [11] reported 28,086 eggs as absolute fecundity for species, while Offem et al. [12] did report 10,816 eggs; absolute and mean fecundity of 6,844-25,905 eggs and

4,522-20,321 eggs, respectively; which was high during April-June and fall sharply during August - September, which agrees with the findings of this study on *Auchenoglanis biscutatus* which showed the relative fecundity was higher in dry season (8.22±0.78) than wet season (7.99±0.94) but disagrees with the findings on *Protopterus annectens* which showed that the relative fecundity was higher in wet season (3.43±0.94) than dry season (0.48±0.22).

The result from this study also showed that *Protopterus annectens* had a higher relative fecundity during the period of study than *Auchenoglanis biscutatus.*

This could be due to the sizes and number of gravid fish caught, location, abundance of food, and physico-chemical parameters.

Adeyemi and Akombo [13] reported that low fecundity could be due to fishing intensity and possibly strong intra and inter specific food competition. Adeyemi [14] reported food and environmental factors apart from genetic factor to influence fecundity of fish. There was also increase in the number of eggs as the fish increase in size. The dissimilarities in the fecundity observed in this study could be due to the samples examined. Offem et al., [12] reported that the volume of eggs a fish can produce depended on space available in the body cavity that accommodate the eggs before spawning.

The mean egg diameter of the species ranged from 1.73±0.13 - 2.38±0.13 mm. These results is in disagreement with the findings of other researchers on *Synodontis* species.

Halim and Guma'a [15] observed the egg diameter of 0.6-0.9mm for *S. schall* from the White Nile. Araoye [16] observed the diameter of 0.80-1.omm (mean 0.99mm) for *S. schall* in Asa Lake, Ilorin. Laleye et al., [17] reported the diameter of 0.8-1.5mm for *S. nigrita* and 0.5-1.0mm for *S schall* from Oueme River. The difference in egg diameters in this study with the others could be as a result of the different methods used in determining the size. Another reason could be the nutritional demand of the fishes in the different localities.

However this study revealed there was no known trend for egg diameter and relative fecundity. The reason for this might be the order which they were captured as older fishes may be caught at some point and younger fishes at another point during the sampling period given that non-uniform trend.

Sex ratio provides information on the proportion of male to female in a given fish population, necessary for fish reproduction, stock size assessment, and the dominance of sex [18]. According to Laleye et al., [17], 1:1 is the ideal value of sex ratio. However, it may vary according to the year of captives, the season, the type of gear [17] and length group. Geographical location can also influence sex ratio (Wicconghby, 1997). In some cases, males may prevail in some population.

The results indicated the dominance of males over females. The reason for the male dominance could be that males move away from areas of spawning to where they are captured once fertilization of eggs is established while the females probably go towards submerged vegetation and other areas around the reservoir to evade predators and also continue brooding and protection of the offspring. Similar results were observed by Oso et al, [19] for two dominant fish species in Ado reservoir, Southwest Nigeria.

The findings from this study are in line with the works of Midhat et al., [20] who worked on Synodontis species in Egygt where they found that the number of males exceeded that of the females with the sex ratio of 1:0.83 (males 361, females 298). Offen et al. [21] observed in river Benue at Makudi, that Synodontis clarias and E. resupims had more males than female with the sex ratio of 1:2:1 and 8:1 respectively. The presence of more male than females according to Offen et al., [21,22] could be favourable to the fishery as it could serve as a regulatory mechanism for the sex ratio.

5. CONCLUSION AND RECOMMENDATION

It was concluded that the study of the sex ratio indicates that males were higher than females. The relative fecundity of *Protopterus annectens* was higher than that of *Auchenoglanis biscutatus* during the study period. Based on the findings of the study, I recommend that this fish should be cultivated by aquaculture industries.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Igbana T. M., Annune P. A., Obande R. A and Gbaaondo T. hereby declare that NO generative AI technologies such as Large Language Models

(ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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