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RECRUITMENT, EXPLOITATION, RELATIVE YIELD PER RECRUIT AND MORTALITY OF *Synodontis schall* (BLOCH AND SCHNEIDER, 1801) IN LOWER RIVER BENUE AT MAKURDI

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Abstract: The recruitment, exploitation, relative-yield per recruit and mortality of *Synodontis schall* in River Benue were estimated using the length frequencies collected from January, 2009 to December, 2010. Fishing Mortalities (F) of 2.203, 2.355 and 2.360 in the females, males and combined sexes were found to be higher than natural mortalities (M) of 1.235, 1.227 and 1.045 in the females, males and combined sexes respectively. The total mortalities were 3.438, 3.582 and 3.405 in the females, males and combined sexes respectively. Exploitation ratios of 0.64, 0.66 and 0.69 for the females, males and combined sexes were high and exceeded the 0.5 optimal values for sustainable yield. Using the reference points of E_{max}, $E_{0.1}$ and $E_{0.5}$, current exploitation rates suggest unsustainable stocks for this species in river Benue. Recruitment was continuous with two pulses, the first one at the beginning of the year and the second one in the middle of the year. The current exploitation rates suggest growth overfishing with selective mortality towards smaller fish sizes, therefore, the protection of the immature fish will be the key factor to preserve the spawning stock.

Keywords: Exploitation; Mortality; Recruitment, Relative-yield per recruit, *Synodontis schall*.
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INTRODUCTION

The genus *Synodontis* is the most common of the three genera of the Mochokidae family. It is among the most preferred fish in Northern Nigeria (Reed *et al*., 1967) owing to their abundance in artisanal fisheries. The genus consists of 23 species in Nigerian waters (Idodo–Umeh, 2003). *Synodontis* species only occur in Africa; they are present in River Nile, and restricted to water systems within the tropics (Willoughby, 1974). The genus is commercially important in the inland waters of West Africa and in River Benue at Makurdi. *S. schall* (Bloch and Schneider, 1801) is one of the species that is available in the fish markets throughout the year. Recruitment is the entrance of young fish into the exploited fishing area to become liable to contact with fishing gears (Gulland, 1983). It also refers to the addition of new fish to the vulnerable population by growth from among smaller size individuals (Ricker, 1975). Recruitment is the major source of variability in fish population, the mean age of fish at recruitment generally depends on the type of mesh size of the gear used in fishing (Ricker, 1975). Knowledge of recruitment is necessary for proper management of a fishery. It is necessary to know the sizes or age which fish get encountered with the fishing gears so that the amount of fishing catch can be controlled. The exploitation rate is an index which estimates the level of utilization of a fishery. It assesses if a stock is overfished or not, on the assumption that optimal value E (opt.) is equal to 0.5. The use of E or 0.5 as optimal value for the exploitation rate is based on the assumption

that the sustainable yield is optimal when F = M (Gulland, 1971; Pauly, 1983).

Mortality strictly refers to the number of fish which die during a year or season. Natural mortality (M) means deaths from all causes except man's fishing. These include predation, diseases, pollution, accidents, senility, lack of oxygen and food, overcrowding, wrong handling techniques etc. Fishing mortality (F) means deaths from fishing activities of man. Despite the commercial importance of *S.schall* in River Benue at Makurdi, no study has been carried out on the recruitment, exploitation, relative-yield-per recruit and mortality of the species. This paper therefore aims at determining the recruitment, exploitation, relative- yield- per recruit and mortality of the species in River Benue at Makurdi.

EXPERIMENTAL

The study was carried out in the Lower Benue River at Makurdi, Nigeria. The Lower Benue River is the portion of the Benue River that is contained within the Benue and Kogi States of Nigeria (Reid and Sydenhan, 1979). River Benue originates from the Adamawa Mountains of Cameroun and flows west across East-Central Nigeria (Nedeco, 1959). It is the largest tributary of the Niger which it joins at Lokoja in Kogi State, Nigeria. The River has extensive alluvial plain stretching for many kilometers, which covers a distance of approximately 187 kilometers. The extensive flood plain forms breeding grounds for many fish species (Beadle, 1974). The highest water levels are in August to September and the Lowest are in March to April.

Sampling Method: *S. schall* were purchased from fish sellers at Wadata Market, Makurdi, which is one of the landing sites on the bank of River Benue. They were procured fortnightly for 24 months and transported to the Biology Laboratory in Benue State University for identification and measurements. Identification was done using the keys of Reed *et al*. (1967) Holden and Reed (1972), Babatunde and Raji (1998) and Idodo-Umeh (2003).

Length-Weight Measurements: The standard lengths (SL) of the fish samples were measured using a measuring board. The anterior tip of the fish was placed against a stop at the beginning of the measuring scale with its mouth closed. SL was taken as the length from the tip of the fish's mouth to the hidden base of the tail fin rays and this was measured to the nearest 0.1 centimeter. The total weight (TWT) was measured using a digital electronic weighing balance (Adam AFP 4100 L). This was read to the nearest 0.1 gram.

Sex Determination: The different sexes of *Synodontis* species can be identified only after dissection. Thus the fish were dissected and the gonads inspected using the keys of Nikolsky (1963). In the young males, testes were thin, thread like with very small projections, whitish in colour and extend to about 1/3 of the abdominal cavity. In adult males, the testes were creamy in colour with very conspicuous granules. The young females had thin, pink to white tubular structures occupying about 1/5 of the abdominal cavity. In adult females, that were about to spawn eggs were readily discernable in the ovaries which increased in size and filled most of the abdominal cavity (Bagenal and Tesch, 1978; Halim and Guma'a, 1989).

Mortality Calculation: Mortality was calculated by following methods-

i. **Natural Mortality (M):** Natural mortality (M) was estimated using Pauly's formula of (Pauly, 1980).

$$\mathbf{Log_{10}M = -0.0066 - 0.279}$$
$$\mathbf{Log_{10}L_{\infty} + 0.6543LogK + 0.463Log_{10}T}$$

Where,

L_{∞} = asymptotic length in cm

K is based on Von Bertalanffy parameters,

T = the mean environmental temperature taken as 27.6 in this study.

ii. **Total Mortality (Z):** Total Mortality (Z) was evaluated on FiSAT II from the lengths of fish samples using the Beverton and Holt model Z.

$$\mathbf{Z = K [L_{\infty} - L_{mean}]/[L_{mean} - L']}$$

Where Z= Beverton and Holt function,

K = curvature parameter of the VBGF,

L_{∞} = asymptotic length of fish,

L_{mean} = mean length of fish samples

L' = cut off or lower limit of the smallest length class.

iii. **Fishing Mortality (F):** Fishing Mortality (F) was calculated from

Fishing Mortality $\mathbf{F = Z - M}$

Fishing Exploitation $\mathbf{E = F/Z}$

The fraction of total mortality (Z) caused by fishing mortality (F).

Relative–Yield-Per Recruit

The relative-yield-per recruit (Y/R)' and relative-biomass-per recruit (B'/R) were estimated by applying the model of Beverton and Holt (1966) using the current growth parameters obtained from the Walford plots as modified by Pauly and Soriano (1986) which is incorporated into the FiSAT software package (Gayanilo *et al*., 2005).

Recruitment Pattern: This was calculated from the Fish Stock Assessment Tools (FiSAT II, 1996) of the FAO-ICLARM using the growth parameters: L_∞, K, (C, WP) and t_o obtained from the Length frequency data and the Walford and Ricker plots.

RESULTS AND DISCUSSION

From the exploitation and mortality rates and yield per recruit (Y/R) of *S.schall* in river Benue, From the table it evident that fishing mortality (F) is much higher than natural mortality (M) (Table 1). This means that *S.schall* in this river die more as a result of fishing activities than natural causes. All the values of the exploitation ratio for both males and females were high and above 0.5 which point to high fishing pressures on the stocks in the river. Consequently, the yield per recruit for this species is very low as shown in the table and figures 1-3 below.

Table 1. Exploitation, Mortality and Yield per Recruit of *S.schall* in River Benue at Makurdi

Parameter	Sex		
	Female	Male	Combined Sex
Number	306	329	635
Length (cm)	6.6–30.4	6.1–21.5	6.1 – 30.4
M (1/yr)	1.235	1.227	1.045
F (1/yr)	2.203	2.355	2.360
Z (1/yr)	3.438	3.582	3.405
E (1/yr)	0.64	0.66	0.69
(R/Y)	E_{max} = 0.363	E_{max} = 0.363	E_{max} = 0.357
(R/Y)	E_{50} = 0.236	E_{50} = 0.236	E_{50} = 0.231
(R/Y)	E_{10} = 0.254	E_{10} = 0.254	E_{10} = 0.260

Figures 1,2 and 3 below shows the relative yield per recruit (Y/R) and biomass per recruit (B'/R) of *S.schall* in River Benue at Makurdi. The descending curves show the decrease in biomass per recruit as fishing mortality increased, while the ascending curves illustrate the small increase in yield when F was increased beyond F 0.1. *S.schall* females had E_{max} = 0.363, $E_{0.1}$ = 0.254 and E_{50} = 0.236; the males had E_{max} = 0.363, $E_{0.1}$ = 0.254 and E_{50} = 0.236 and combined sexes had E_{max} = 0.357, $E_{0.1}$ =0.260 and E_{50} = 0.231. This result shows that the yield per recruit and biomass per recruit are quite low. Figure 4 below shows the recruitment of *S.schall* in River Benue for one year. The FiSAT II plot of the percentage recruitment of *S.shall* into the fishery in River Benue showed continuous recruitment from January to November, with two peaks, a minor one in January and February and a major one from May to July.

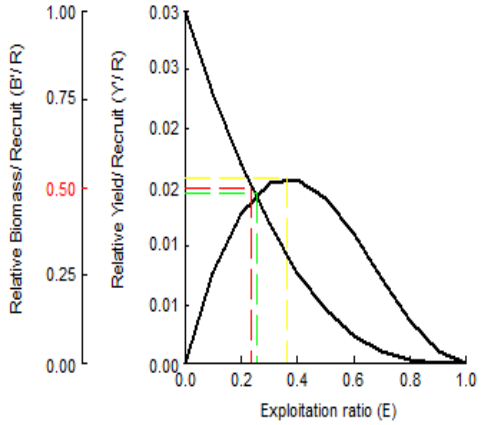

Figure 1. Relative Yield per Recruit and Biomass per Recruit of *S.schall* – Females

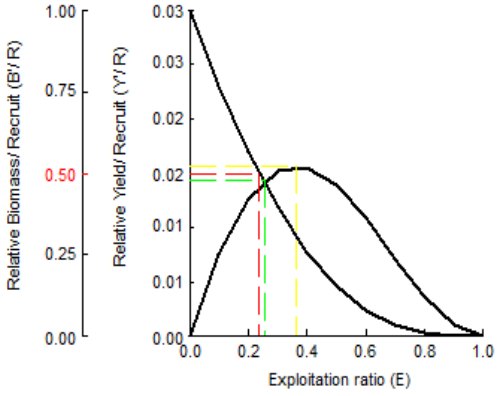

Figure 2. Relative Yield per Recruit and Biomass per Recruit of *S.schall* - Males

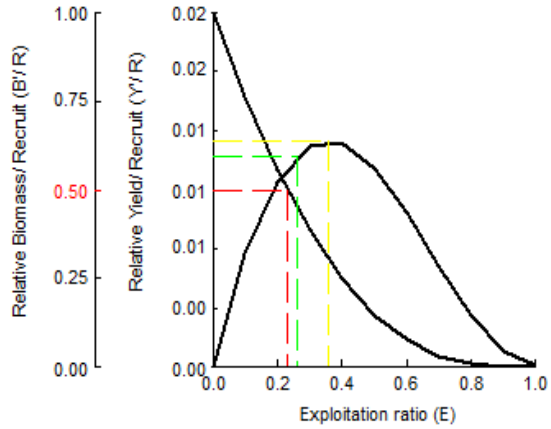

Figure 3. Relative Yield per Recruit and Biomass per Recruit of *S.schall* - Combined

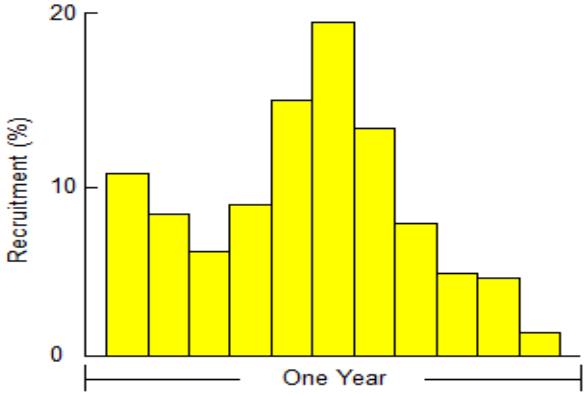

Figure 4. The Recruitment Pattern of *S.schall*

The results of this study suggest high mortality values for this species. High mortality values for this species have been reported by Abowei and Hart (2009) who observed the total mortality (Z) of 2.1 and the natural mortality (M) of 1.82 in *S. schall* from the Lower Nun River, Niger Delta. Fishing mortality (F) here was rather low, 0.30 in *S. schall*. Ogwueri *et al*., (2009) obtained the total mortality (Z) of 0.61-1.25 for some fish species of River Katsin-Ala, a tributary of River Benue. Uneke *et al*., (2010) reported the Z of 4.03, M of 2.77 and F of 1.26 in *Pellonula leonensis* in Anambra flood River system. Okechukwu (2011) observed the Z of 2.54, M of 0.88 and F of 1.66 in *Clarias gariepinus* in the Mid-Cross River Flood plain ecosystem. Midhat *et al*., (2012) on the other hand obtained low values of mortalities in *S.schall* from River Nile at Gizza. Total mortalities were 0.5165, 0.7552 and 0.5927 in the males, females and combined sexes respectively. Natural mortalities were 0.343, 0.332 and 0.347 in the males, females and combined sexes respectively. Fishing mortalities were 0.173, 0.423 and 0.246 for the males, females and combined sexes respectively. Total mortality (Z) was weighed heavily on the side of fish by Sparre *et al*., (1989) in which they attributed Z = 1.2yr^{-1} to heavy exploitation, Z = 0.9yr^{-1} to medium exploitation and Z = 0.6yr^{-1} to light exploitation. Therefore, the fish with the least Z are those which are probably difficult to catch due to gear selectivity or habitat choice of the fishes. This means that the gears that are used in river Benue are such that do not select juvenile fish from adult.

The exploitation rate giving maximum yield per recruit (E_{max}) using the knife-edge was estimated at 0.363, 0.363 and 0.357 in *S.schall* females, males and combined sexes respectively. These values are low compared to the values obtained in other places. The exploitation values of 0.64, 0.66 and 0.69 of the females, males and combined sexes are high and point to high fishing pressures on the stocks in the river. All the values are greater than the optimal value of 0.5 for sustainable yield indicating that the level giving maximum sustainable yield has been overshot. The high exploitation ratios observed in this study are similar with those observed in other places. Olaosebikan *et al*., (2006) estimated E as 0.73 and E_{max} as 0.454 for *Pararillia pellucid* in the upper arm of Jebba Reservoir. Lebo *et al*., (2010) observed the E of 0.73 with the predicted E_{max} of 0.59 in *Schibe mystus* in the Cross River. Okechukwu (2011) obtained the E of 0.66 with the E_{max} of 0.64 in *Clarias gariepinus* in the Mid-Cross River Floodplain ecosystem. Mahomoud *et al*., (2011) observed the exploitation ratios of 0.83 and 0.78 in the males and females of *Tilapia zilli* respectively in Lake Timsah, Egypt. These results show that many fish species in Africa are overexploited and if urgent measures are not taken to effectively manage the fishery, the fish populations will stand a risk of overexploitation.

The exploitation rate ($E_{0.1}$) at which the marginal increase in relative yield per recruit is 10% of its value at E=0, was estimated at

0.254, 0.254 and 0.260 in *S.schall* females, males and combined sexes respectively. The results obtained in this study were lower but not very far from those obtained elsewhere. Olaosebikan, *et al*., (2006) reported the $E_{0.1}$ of 0.360 for *P.pellucida* in the upper arm of Jebba Reservoir. Okechukwu (2011) obtained the $E_{0.1}$ of 0.50 for *Clarias gariepinus* in the Mid-Cross River Floodplain ecosystem. Maguza-Tembo *et al*., (2009) observed the $E_{0.1}$ values of 0.42 and 0.36 for *Engraulicypris sardella* in the Southeast and Southwest arms respectively of the Southern Lake in Malawi. The exploitation rate (E=0.5) which corresponds to 50% of the virgin relative biomass per recruit was estimated at 0.236, 0.236 and 0.231for *S.schall* females, males and combined sexes respectively. Olaosebikan *et al*., (2006) reported the $E_{0.5}$ of 0.293 for *P.pellucida* in the upper portion of Jebba Reservoir. Uneke *et al*., (2010) observed the $E_{0.5}$ of 0.331 for *Pellnula leonensis* in the Anambra flood River System. Recruitment in this species is continuous with two peaks, the first recruitment is in January/February and the second peak is from May-July. The first peak in January and February represents the recruitment of the juveniles that were bred the previous year while the May-July peak represents the recruitment of the adult breeding stock. These observations agree with the assertions of Rufli and Van Lissa (1982) and Pauly (1982) that they were characteristics of most tropical fish stocks with seasonal associations. *Synodontis* species spawn at the peak of the rainy season from June to September and most juveniles of the previous year are recruited into the fishery around October to January (Reed *et al*., 1967).

CONCLUSION

It can be concluded that *Synodontis schall* in River Benue with the exploitation ratios greater than 0.5 were higher than the values for sustainable yield for the exploitation of the fishery. These populations therefore stand a risk of overexploitation if urgent measures are not taken to effectively manage the fishery. Current exploitation rates in the river suggest growth overfishing since there is a selective mortality towards smaller fish sizes. This implies that juvenile individuals are the target of the fishery and the stock dynamics of these species in the river will be seriously affected. The protection of the immature fish is probably the key factor to preserve a spawning stock.

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