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Assessment of the growth parameters and mortalities of two species of catfish, *Synodontis membranaceus* (Geoffroy saint-hilaire, 1809) and *Synodontis gambiensis* (Günther, 1864) in River Benue at Makurdi, Nigeria

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Abstract
The growth parameters and mortalities of *Synodontis membranaceus* and *Synodontis gambiensis* in river Benue at Makurdi were studied over a 24 month period from January, 2009 to December, 2010. A total number of 106 specimens of *S.membranaceus* comprising 47 females and 59 males and 109 specimens of *S.gambiensis* comprising 53 females and 56 males were used for the study. The asymptotic length (L_∞) calculated for the two species were 23.50, 23.70 and 23.00cm in the females, males and combined sexes in *S.gambiensis* and 37.04,28.25 and 35.10 cm in *S.membranaceus* females, males and combined sexes respectively. The growth rate (K) was found to be (0.310–0.640) in *S.membranaceus* and (0.500 – 0.571) in *S.gambiensis*. Growth performance indices (Ø') for the two species were 2.212, 2.374 and 2.445 in *S.gambiensis* females, males and combined sexes and 2.562, 2.689 and 2.869 in the females, males and combined sexes of *S.membranaceus* respectively. Natural Mortality (M) was found to be 1.1774, 1.3070, and 1.2444 in the females, males and combined sexes in *S.gambiensis* and 0.9846, 1.3340 and 0.8312 in *S.membranaceus* females, males and combined sexes respectively. Fishing Mortality (F) was higher than natural mortality (M) except in *S.gambiensis* females as follows, 1.0096, 2.1540 and 1.3376 in the females, males and combined sexes and 3.0934,1.9850 and 2.2108 in *S.membranaceus* females, males and combined sexes respectively. Total mortality (Z) was observed to be 2.187, 3.461 and 2.582 in *S.gambiensis* females, males and combined sexes and 4.078, 3.319 and 3.042 in *S.membranaceus* females, males and combined sexes respectively. Mean Exploitation ratios for the species were high and exceeded the 0.5 optimal values for sustainable yield. These were *S.gambiensis* (0.53) and *S.membranaceus* (0.70). The survival rate of *S.gambiensis* in the River was found to be much lower than that of *S.membranaceus* (0.556 in *S.gambiensis* as against 1.482 in *S.membranaceus* respectively). 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: Growth parameters, Mortalities, *Synodontis membranaceus*, *Synodontis gambiensis*, River Benue.

1. Introduction
Synodontis membranaceus is one of the species of the genus *Synodontis*. Teugels, (1996) [46] reported that this species was endemic to Africa. It is one of the most important commercial fish species in the artisanal fisheries in Nigeria (Reed *et al*., 1967) [42]. In River Benue it is not common throughout the year but it is one of the species that attains the biggest size. Because of their relatively large sizes they are generally preferred by fishermen and consumers and command a higher market value. *S.membranaceus* is potentially suitable for culture (Owolabi 2005) [37], though up to now no information exists on their culture (Owolabi, 2008) [38]. They are popular aquarium species (Teugels, 1996 [46]; Owolabi, 2008 [38]) as they exhibit the habit of swimming upside down. The studies carried out on *S. membranaceus* include those of Bishai and Gideiri (1965) [13] on feeding and reproduction in River Nile at Khartoun, Willoughby (1974) [50] on orientation and Swimming, and Owolabi (2005) [37] on other aspects of the biology of the fish in Jebba Lake, Nigeria. There is paucity of published work on the species in lower River Benue. Akombo *et al*., (2011) [6] worked on its Morphometric and growth pattern.
Synodontis gambiensis is another species of the genus that is found in River Benue. Published works on this species are very few. Ofori-Danson (1992) [32] studied some aspects of the ecology of the freshwater catfish *Synodotis* in Kpong Headpond (Ghana). He encountered five species of which *Synodontis shall* and *Synodontis gambiensis* were the most important.

Araoye (2009) [7] reported that *S.gambiensis* was common in Asa Lake, Ilorin, Nigeria. Achinonye-Nzeh and Isimaikaiye (2010) [10] observed that *S.gambiensis* was one of the sparsely populated species in the newly constructed reservoir at the University of Ilorin, Ilorin, Nigeria. Odiko *et al*., (2010) [31] found only eight (8) specimens throughout their 24 months of study in Ovia River in Edo state, Nigeria. Published works on the biology of this species in this area are not available.

This work was therefore aimed at determining the growth parameters and mortalities of *Synodontis membranaceus* and *Synodontis gambiensis* in River Benue at Makurdi, Nigeria.

2. Materials and methods

2.1 Study Area

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 [43]). River Benue originates from the Adamawa Mountains of Cameroun and flows west across East-Central Nigeria (Nedeco, 1959 [29]). 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 [11]). The highest water levels are in August to September and the Lowest are in March to April.

2.2 Sampling method:

The *S. membranaceus* and *S.gambiensis* specimens were purchased from the fishermen at the landing site in Wadata Market, Makurdi, which is one of the landing sites on the bank of River Benue. The fishes were caught by the fishermen on the river using different types of gears such as gill nets, cast nets, hooks and traps. The fishes were procured fortnightly for 24 months (from January, 2009 to December, 2010) 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) [42], Babatunde and Raji (1998) [8] and Idodo-Umeh (2003) [22].

2.3 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 AFP4100L model). This was read to the nearest 0.1 gramme.

2.4 Sex Determination

The different sexes of *Synodontis* species can only be identified after dissection. Thus the fishes were dissected and the gonads were inspected using the keys of Nikolsky (1963) [30]. In the young males, testes were thin, thread like with very small projections, whitish in color and extend to about 1/3 of the abdominal cavity. In adult males, the testes were creamy in color 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 [9]; Halim and Guma'a, 1989 [15]).

2.5 Length-at-Age

The length at age was calculated using the Von Bertallanffy's growth model in the LSA/FiSAT computer programmes.

The Von Bertalanffy's growth model of (1957) described growth curves as expressed by the formula:

$$L(t) = L_\infty(1-e^{-k(t-to)})$$

WhereL(t) = length at age t

L_∞ = asymtotic or maximum attainable length, assuming fish growth is indefinite.

k = rate at which the asymtotic length is approached.

t_o = a time in the growth history of fish at which the fish would be zero sized.

e = exponential and

t = age in years.

The Ford Walford plots were obtained by plotting $L_t + \Delta t$ against L_t, where Δt are changes in lengths separated by a year interval and L_t is length at age. The value of L_t at the point of interception of the regression line with the 45^0 line gives the $L\infty$ (Ricker, 1975) [41].

From the $L\infty$, five values were obtained by successive addition of 1 to the $L\infty$ twice and subtraction of 1 twice from it. Trial plots of ($L\infty$ -L_t) against age were done using the method of Ricker (1975) [41], where the line of best fit was selected by eye to obtain the true $L\infty$.

The gradient $Log_e\ L\infty + Kt_0$, is the intercept, then

$$t_0 = \frac{(\text{Y–intercept} - \text{Loge } L_\infty)}{K}$$

K is the gradient of the line of best fit from the trial plots of Log_e ($L\infty$ - Lt) against age.

By these the Von-Bertalanffy growth parameters $L\infty$, K and t_o were obtained.

2.6 Growth Performance Index

The growth performance index Ø' was calculated using the formula of Pauly and Munro (1984).

$$Ø' = \text{Log}K + 2\text{Log}L\infty.$$

Where, K and $L\infty$ are parameters of VBGF.

2.7 Mortality

i. Natural Mortality (M)

Natural mortality (M) was estimated using Pauly's empirical formula of (Pauly, 1980) [40].

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

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

Z= Beverton and Holt function, K = curvature parameter of the VBGF, $L\infty$ = asymptotic length of fish, L_{mean} = mean length of fish samples and L' = cut off or lower limit of the smallest length class.

iii. Fishing Mortality (F)
Fishing Mortality (F) was calculated from F = Z – M, and the Exploitation from E = F/Z i.e. the fraction of total mortality (Z) caused by fishing mortality (F).

3. Results
The total number of specimens used in this study was 106 specimens for *S.membranaceus* comprising 47 females and 59 males and 109 specimens for *S.gambiensis* comprising 53 females and 56. *S.membranaceus* had a combined length range of 7.9 – 28.8 cm with the mean of 17.01± 0.600 while *S.gambiensis* had the combined length range of 6.9 – 18.1cm with the mean of 12.19 ± 0.189 (Table 1).
From the results of the Walford plot analysis (Figs. 1-6 below) for the males, females and combined sexes, trial plots of natural logarithms of the difference between the asymptotic length (L_∞) and length-at-age (L_t) against age were carried out. Solutions of the following equations were used to determine the Von Bertalanffy growth parameters for the males, females and combined sexes.

$$Log_e (L_\infty - L_t) = Log_e L_\infty + Kt_0 - K_t$$

$$t_0 = \frac{Y - \text{axis intercept} - Log_e L_\infty}{K}$$

The growth rate (K) in both *S.membranaceus* males (0.640) and *S.gambiensis* males (0.571) was higher than in the females of both species (0.320) and (0.500) respectively. This means that the rate at which the males approach L_∞ is faster than the females.
The growth performance index (Ø) compares the growth performance of different species of fish.
S.gambiensis had the growth performance indices (Ø) of 2.212, 2.374 and 2.445 for the females, males and combined sexes while *S.membranaceus* had the growth performance indices (Ø) of 2.562 for the females, 2.689 for the males and 2.869 for the combined sexes. This means that the growth performance of *S.gambiensis* in the river is very poor while that of *S.membranaceus* is good.
The asymptotic lengths (L_∞) obtained from the Walford plots were 23.50cm, 23.70cm and 23.00 cm in the females, males and combined sexes respectively in *S.gambiensis* while in *S.membranaceus* the lengths were 37.04 cm, 28.25cm, and 35.10 cm in the females, males and combined sexes respectively (Table 2).
In this study, the largest sample in *S.gambiensis* was a male with the size of 18.1 cm and in *S.membranaceus* was a female with the size of 28.8 cm. Therefore, the values of the asymptotic lengths obtained in this study from the Walford plots are reasonable for these species in River Benue. It means that with favorable environmental conditions and less fishing pressure these species can grow to attain bigger sizes.
In the species studied, the hypothetical age at which length is zero (t_0) were all negative in *S.gambiensis* and *S.membranaceus* combined but positive in *S.membranaceus* males and females.
The values of $L_t – L_{t0}$ obtained from the Walford plots which represent the one year olds in *S.gambiensis* were all higher than the back-calculated values as shown in table 2 below (9.55, 9.90, and 9.50 cm as against 6.38, 6.43 and 8.61 cm in the females, males and combined sexes respectively. In the *S.membranaceus*, the back-calculated values were higher in the females and combined sexes (9.86 and 8.46 as against 8.90 and 6.70 cm respectively) and lower in the males (9.53 as against 12.70 cm, table 2).
The natural mortality (M) in *S.gambiensis* was 1.1774, 1.3070 and 1.2444 in the females, males and combined sexes respectively while in *S.membranaceus* the mortality was 0.986, 1.3340 and 0.8312 in the females, males and combined sexes respectively. Natural mortality (M) was higher in the males of both species than the females. The Fishing mortality (F) for all the species was higher than natural mortality (Table 2). The fishing mortality was 1.0096, 1.3070 and 1.2444 in the females, males and combined sexes of *S.gambiensis* while in *S.membranaceus* the mortality was 0.9846, 1.3340 and 0.8312 in the females, males and combined sexes respectively. The total mortality (Z) of all the species was generally high (Table 2). In *S.gambiensis* the mortality was 2.187, 3.461 and 2.582 in the females, males and combined sexes respectively while in *S.membranaceus* the total mortality (Z) was 4.078, 3.319 and 3.0420 in the females, males and combined sexes respectively. Total mortality (Z) in this case was highest in *S.membranaceus* females followed by *S.gambiensis* males.
Exploitation ratio (E) was found to be 0.46, o.62, 0.52 in the females, males and combined sexes *S.gambiensis* respectively with the mean of 0. 53. In *S.membranaceus*, the Exploitation ratio (E) was found to be 0.77, 0.60 and 0.73 in the females, males and combined sexes respectively with the mean of 0.70. The results of this study indicate that the exploitation rates of the two species of *Synodontis* under study are very high and exceed the 0.5 optimal values for sustainable yield.
As can be seen in table (2) with the high fishing and exploitation rates, the Survival rate (S) of these species in the river is very low. *S.gambiensis* has the survival rate of 0.389, 0.279 and 0.556 in the females, males and combined sexes respectively with the mean of 0.408 while *S.membranaceus* has 0.945, 1.466 and 1.482 in the females, males and combined sexes respectively with the mean of 1.298. This result shows that *S.membranaceus* has a higher survival rate in this river than *S.gambiensis*.

Table 1: Size Distribution of the Two Species of Synodontis in lower River Benue

Species	Sex	No.	Length Range (cm)	Mean Length (cm) ± SE	Weight Range (g)	Mean Weight (g) ± SE
S.gambiensis	♀	53	9.3 – 17.7	12.45 ± 0.227	25.1 – 143.4	56.32 ± 3.25
	♂	56	6.9 – 18.1	11.94 ± 0.296	7.3 – 139.9	49.59 ± 3.58
	Combined	109	6.9 – 18.1	12.19 ± 0.189	7.3 – 143.4	52.86 ± 2.44
S.membranaceus		47	9.4 – 28.8	17.93 ± 0.941	21.43 – 663.6	202.00± 25.10
	♂	59	7.9 – 26.2	16.28 ± 0.769	15.2 – 485.9	151.4 ± 17.6
	Combined	106	7.9 – 28.8	17.01 ± 0.600	15.2 – 663.6	174.0 ± 14.9

Table 2 below shows the growth parameters and mortalities of these two species in River Benue at Makurdi.
♀= female, ♂ = male

Table 2: Growth parameters and mortalities of *Synodontis membranaceus* and *Synodontis gambiensis* in the lower river Benue at Makurdi.

Species	Sex	Growth Parameters							Mortality Coefficients			
		L_∞ (cm)	K (1/yr)	t_0 (cm)	L_t - L_{t0}(cm)	Back-calculated	Ø	S	M (1/yr)	F (1/yr)	Z (1/yr)	E (F/Z)
S.gambiensis	♀	23.50	0.500	-0.714	9.55	6.38	2.212	0.389	1.1774	1.0096	2.187	0.46
	♂	23.70	0.571	-0.464	9.90	6.43	2.374	0.279	1.3070	2.1540	3.461	0.62
	Comb.	23.00	0.523	-0.641	9.50	8.61	2.445	0.556	1.2444	1.3376	2.582	0.52
S.membranaceus	♀	37.04	0.320	0.344	8.90	9.86	2.562	0.945	0.9846	3.0934	4.078	0.77
	♂	28.25	0.640	0.890	12.70	9.53	2.689	1.466	1.3340	1.9850	3.319	0.60
	Comb.	35.10	0.310	-0.032	6.70	8.46	2.869	1.482	0.8312	2.2108	3.042	0.73

L_∞ = Asymptotic Length, K = Growth curvature, t_0 = length at time 0, L_t - L_{t0}= Change in length, Ø = Growth Performance Index, S=Survival Rate, M = Natural Mortality, F = Fishing Mortality, Z = Total Mortality, E= Exploitation Rate Ratio.

4. Discussion

The highest L_∞ of *S.gambiensis* was 23.70cm in the males and the maximum length of 18.1cm was also in a male. *S.membranaceus* had the L_∞ of 37.04cm in the females while the maximum length of 28.8cm was observed also in a female. The values of L_∞ in *S.gambiensis* and *S. membranaceus* were higher than the maximum length of the fishes obtained for the research. This means that these species have a tendency to grow more if the existing conditions in the river are favorable.

Araoye (1997) [7] computed the L_∞ of *S.schall* in Asa Lake from the observed, back calculated, and integrated methods as 50.4cm, 49.5cm and 50.0cm respectively. Abowei and Hart (2009) reported the L_∞ of *S.schall* to be 38.7cm, *S.clarias* 35.56cm and *S.membranaceus* 43.8cm from the Lower Nun River, Niger Delta. Midhat *et al*., (2012) [27] observed the L_∞ of 62.74 cm, 64.24 cm and 63.45cm for males, females and combined sexes respectively in *S.schall* in Egypt at Gizza.

The different asymptotic lengths observed in the different localities even in the same species can only be explained by the different environmental conditions in those areas and high fishing pressure. Spare *et al*., (1992) [46] reported that growth of fishes differed from species to species and from stock to stock even within the same species as a result of different environmental conditions. King (1991) [20] had shown that the maximum size attained in fishes was generally location specific. Abowei and Hart (2007) [7] attributed the differences in the maximum size of *Chrysichthys nigrodigitatus* in the Lower Nun River to high fishing pressure, environmental pollution and degradation. Therefore the asymptotic length observed in this study in *S.membranaceus* which is lower than that observed by Abowei and Hart (2009) [8] from the Lower Nun River, Niger Delta may be as a result of the high fishing pressure as shown in the exploitation ratios in table 2.

In the species studied, the hypothetical age at which length is zero (t_0) were all negative in *S.gambiensis* and *S.membranaceus* combined and positive in *S.membranaceus* males and females. Gómez-Márquez *et al*., (2008) [17] observed a negative t_0 of -1.543 in *O.niloticus* from a tropical shallow Lake in Mexico. Abowei and Hart (2009) [8] reported negative t_0 values ranging from -0.20^{y-1} in *Brycynus dentex* to -1.05^{y-1} in *S.claris* in ten Finfish species from the Lower Nun River, Niger Delta. Okechukwu (2011) [34] obtained a negative t_0 of -3.93 for *Pellnula leonensis* in Mid-Cross River flood plain ecosystem. Gado (1999) [14] on the other hand reported positive t_0 values for the fishes of Hadeijia N'guru wetlands, North-Eastern Nigeria. Abowei and Hart (2007) [7] also reported positive t_0 values for the major cichlids and *Chrysichthys nigrodigitatus* from Umuoserche Lake and Nun River respectively. Sambo and Haruna (2012) [44] again reported positive t_0 values for the fishes of Adamu Ibrahim Lake, Kazaure, Jigawa state, Nigeria. These were *O.niloticus* 0.12 for males, 0.66 for females; *S.galilalaeus* 0.30 for males, 0.86 for females and *B.bayad* 0.50 for males, 0.85 for females. According to Pauly (1983) [39] t_0 values are usually negative. King (1997) [21] however reported that with negative t_0 values, juveniles tended to grow more quickly than the predicted growth curve for adults, and with positive t_0 values, juveniles grew more slowly. Schnute and Fournier (1980) [45] stated that L_∞, K and t_0 had no direct biological meaning and that values of L_∞ in particular were dependant on adequate sampling in the larger length classes.

Growth rate was highest in *S.membranaceus* males (0.633) and then *S.gambiensis* males (0.571). This means that the rate at which the males of these species approach L_∞ is similar and faster than the females. These findings are similar with the findings of Abowei and Hart (2009) [9] for the Fresh water fishes of the Reaches of the Lower Nun River. Growth rate was 0.64, 0.43 and 0.38 in *S.schall*, *S.clarias* and *S.membranaceus* respectively. In this case the growth rate of *S.membranaceus* was much lower than that in River Benue. Lebo *et al*., (2010) [23] obtained the growth rate of 0.33 y^{-1} for *Schilbe mystus* in the Cross River which is much lower than the values obtained in this river.

The growth performance index of fishes (Phi Prime Ø') compares the growth performance of different populations of fish species in the same or different environments. Growth performance indices of the two species were very good and ranged from 2.212 in *S.gambiensis* females to 2.869 in *S.membranaces* combined (Table 2). These findings were in conformity with those reported by many researchers on *Synodontis* species in other places. Gado (1999) [14] observed a growth performance index of 2.225 in the *Synodontis* species of the Hadejia-N'guru Wetlands. Abowei (2009) [1] reported the length performance index (Ø') of 2.63 in *Hemisynodontis membranaceus* from the fresh water reaches of Lower Nun River, Niger Delta. Abowei and Hart (2009) [8] observed the length performance indices of 2.71 in *S.schall*, 2.63 in *S.membranaceus*, and 3.23 in *S.clarias* from the Lower Nun River, Niger Delta. Midhat *et al*., (2012) [27] reported the growth performance indices in length of *S.schall* in River Nile at Gizza to be 2.689, 2.692 and 2.709 in the males, females and combined sexes respectively. Adedolapo (2007) [5] observed the performance indices of 2.62 and 2.51 in *Schilbe mystus* in Asejire and Oyan Lakes respectively. Monreau *et al*., (1986) [28] reported that environmental conditions like temperature and predation lead to faster growth towards small size with high K and low L_∞ or slow growth towards large size with low K and high L_∞. Faster growth rates are defensive mechanism against predators.

Adedolapo (2007) [5] showed that Phi Prime (Ø') were species specific parameters and gross dissimilarity of Ø' values for a number of stocks of the same species or related species are an indicator of unreliability in the accuracy of estimated growth parameters. Thus the similarity of Ø' related species in different tropical areas is an indication of the reliability of the computed growth parameters in this study. Gatabu (1992) [16] indicated that besides the genetic makeup which determines the growth potential of the species, overfishing, diet type and its utilization could affect the growth performance index of a particular species. Even though the growth performance is a function of L_∞, increase in L_∞ leads to increase in growth performance and vice versa.

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.

The results of this study suggest high mortality values for the two species. Natural mortality (M) was observed to be 1.1774, 1.3070 and 1.2444 in *S.gambiensis* females, males and combined sexes and 0.9846, 1.3340 and 0.8312 in *S.membranaceus* females, males and combined sexes respectively. Fishing mortality (F) was found to be 1.0096, 2.1540 and 1.3376 in the females, males and combined sexes of *S.gambiensis* and 3.0934, 1.9850 and 2.2108 in *S.membranaceus* females, males and combined sexes respectively. Total mortality (Z) was 2.187, 3.461 and 2.582 in *S.gambiensis* females, males and combined sexes and 4.078, 3.319 and 3.042 in *S.membranaceus* females, males and combined sexes respectively. These results are close to those obtained by Abowei and Hart (2009) [8] from the Lower Nun River, Niger Delta, though total mortality (Z) in *S.membranaceus* here is much higher. They observed the total mortality (Z) of 2.1 in *S.schall*, 2.1 in *S.clarias* and 1.5 in *S.membranaceus*, the natural mortality (M) of 1.82 in *S.schall*, 0.57 in *S.clarias* and 1.28 in *S. membranaceus*. Fishing mortality (F) here was rather low, 0.30 in *S.schall*, 0.67 in *S.clarias* and 0.22 in *S.membranaceus*. Ogwueri *et al*., (2009)[33] obtained the total mortality (Z) of 0.61-1.25 for some fish species of River Katsin-Ala. 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) [34] 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) [27] 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.

The total mortality (Z) was weighed heavily on the side of fish by Sparre *et al*., (1989) [46] 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 habit choice of the fishes. This means that the fishes in this river are heavily exploited as the total mortality of each species far exceeds the 1.2^{yr-1} mark (Table 2).

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[18]; Pauly, 1983) [39]. The exploitation rate (E) ranged between 0.46 in *S.gambiensis* females to 0.77 in *S.membranaceus* females (Table 2). The mean values for the species were S.gambiensis (0.53) and *S.membranaceus* (0.70). These values 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 mean E values obtained in this study for the species as given above for *S.membranaceus,* and *S.gambiensis* were much higher than the predicted values indicating that the *Synodontis* species in River Benue are experiencing excessive fishing pressure. This means that the *Synodontis* fishes of this river die more as a result of human exploitation than natural death. The high exploitation ratios observed in this study are similar with those observed in other places. Olaosebikan *et al*., (2006) [35] estimated E as 0.73for *Parailia pellucida* in the upper arm of Jebba Reservoir. Lebo *et al*., (2010) observed the E of 0.73in *Schilbe mystus* in the Cross River. Okechukwu (2011) [34] obtained the E of 0.66 in *Clarias gariepinus* in the Mid-Cross River Floodplain ecosystem. Mahomoud *et al*., (2011) [26] 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 most of the 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 and even extinction of some species.

5. Conclusion

The results of this study showed that the *Synodontis* species in River Benue with the high total mortalities and exploitation ratios of greater than 0.5 values are unsustainable for 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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