Full Length Research Paper

Biological assessment of *Oreochromis niloticus* (Pisces: Cichlidae; Linne, 1958) in a tropical floodplain river

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Biological assessment of *Oreochromis niloticus* was conducted monthly between January, 2004 and December, 2006 in 3 zones [(Zone I: upper Cross River (savanna wetlands) Zone II: middle Cross River (savanna/forest wetlands) and Zone III: lower Cross River (forest wetlands)] along 200 km length of the inland wetlands of Cross River, Nigeria. Major items in the diet of *O. niloticus* were algae and plant 38 and 20.4% (Zone I), 21.7 and 18.0% (Zone II), 20.2 and 26.9% (Zone III), respectively. Diet breadth ranged from 0.820 - 0.913. Food richness and Gut Repletion Index were 12 and 100%, respectively. Sex ratio was 1: 1 (Zone1), 1:0.78 (Zone II) and 1: 0.89 (Zone III). Mean allometric coefficients (b) of the length-weight relationship were 2.194 ± 0.215 (Zone I), 2.935 ± 0.333 (Zone II) and 3.03 ± 0.202 (Zone III). Fecundity varied from 70 eggs for fish (total length (TL) = 11.00cm and weight (W) = 37.9 g) to 502 eggs (TL = 25.8cm and W = 198.8g) in Zone I, 60 eggs (TL = 13.3cm and W = 19.8g) to 709 egg (TL = 26.5, W= 317.0) in Zone II and 110 eggs (TL = 13.7cm, W = 24.0g) to 811 eggs (TL = 22.8cm, W = 278.8g) in Zone III. Relationship exists between fecundity and body size. Mean condition index ranged from 0.770 ± 0.128 minimum for males at Zone I to 1.188 ± 0.157 maximum also for males at Zone III. Therefore, male *O. niloticus* were in better condition than females and the forest wetlands of Cross River (Zone III) offered more favourable living conditions for the species than the savanna wetlands (Zone I and II).

Key words: Biological assessment, Cross River, inland wetlands, *Oreochromis niloticus*

INTRODUCTION

The nile tilapia, *Oreochromis niloticus* (Pisces: Cichlidae), is important in the ecology of tropical waters as well as in the resources of aquatic systems of the sub-tropical region. It is the most popular species of the bony fish in Africa (Omotosho et al., 1990). This is attributed to the many positive aquacultural qualities including tolerance to poor water quality, wide range of food, fast growth, firm flesh and mild flavour (Fagade, 1971; Fryer and Iles, 1972; Avtallion, 1982; Ugwumba, 1988). The annual potential fish yield from the inland wetlands of Nigeria in1995 was estimated to be 1.5 million metric tones (mt)

as against the actual exploited production of 486,000 mt in the same year (Welcome, 1976). Thus culturable fishery resources including *O. niloticus* distributed in the Nigerian inland water mass offer a promising potential in the Nigerian fishery scenario which can be further improved by a thorough knowledge of the biological attributes of these species.

Biological assessment studies can be useful to establish the relative wellbeing of a fish population (Moreau et al 1986), differentiate taxonomic units (Bolger and Connolly 1989), conduct fish stock size assessment and discrimination (Holden and Raitt, 1974), for rational utilization of stocks (Leone, 1967), enable protection of new recruits and prediction of recruitment viability (King and Udo, 1998).

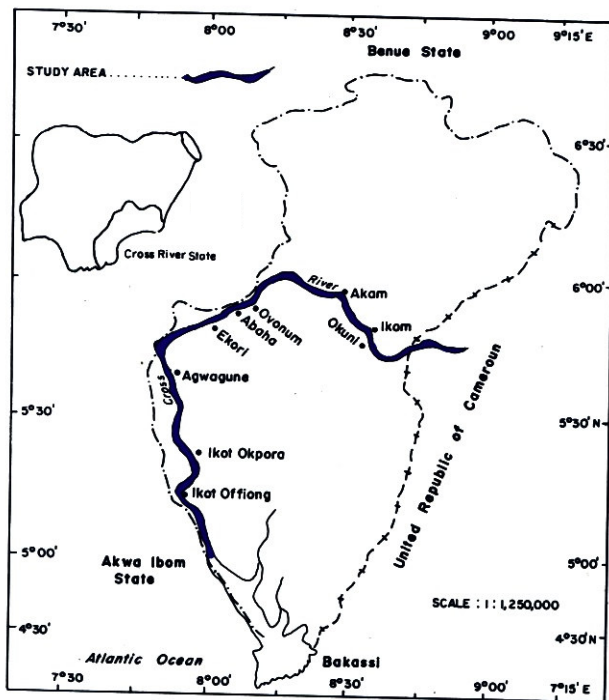*Corresponding author. E-mail: benbeff06@yahoo.com

Figure 1. Map of Cross River State showing study area.

At present there is no biological data of these species in the inland wetlands of Cross River, Nigeria. In this investtigation the biological characteristics including sex ratio, fecundity, length-weight relationship, condition factor and diet habit were considered.

MATERIALS AND METHODS

The study area (Figure 1) was Cross River; a floodplain river located at the South-Eastern part of Nigeria (Latitude 4º25´- 7º00´N; Longitude 7º15´- 9º30´). The climate of Cross River is largely tropical- humid with dry and wet seasons. The area was classified into 3 zones using vegetation cover as criteria. (Zone I = upper Cross River (savanna wetlands), Zone II = Middle Cross River (forest-savanna wetlands) and Zone III = lower Cross River (forest wetlands). Monthly fish samples, for studies, were randomly collected between January 2004 and December 2006 from artisanal catches along the 3 zones in the 200 km length of Cross River. Fishing gears used include gillnet, cast net, beach seine, hook and line and traps. Samples were identified using FAO Identification Sheet Fischer and Bianchi (1984) and sexes determined according to Trewavas (1986), by examining the genital papilla located immediately behind the anus. In males the genital papilla has only one opening the (urinary pore of the ureter) through which both milt and urine pass. In females the eggs exit through a separate oviduct and only urine passes through the urinary pore. Placing a drop of dye (methylene blue) on the genital region helps to highlight the papilla and its openings. Fish were measured for total length (TL) and standard length (SL) to the nearest 0.1 cm weighed (total weight) to the nearest 0.1 g.

Ripe female fish (494) were used for fecundity estimation. Absolute fecundity was estimated using total number of eggs in the ovaries of the fish prior to spawning (Baganal, 1978) and calculated by multiplying total weight of eggs by number of eggs per gram weight. Length-weight relationship was estimated from the equation $W = aL^b$ (Pauly, 1984) and was logarithmically transformed into log $W = \log a + b \log L$. W = weight of fish in grams, L = total length of fish in centimeters, a is proportionality constant and b is the allometric coefficient both estimated by method of least squares.

Fulton's condition factor (CF) was determined using the expression by Ricker (1975): $K = W100 / L^3$ where K=condition factor, W = total weight and L = total length.

Specimen for diet studies were fixed immediately after capture in 10% formalin and later gut analysis carried out using numerical and frequency of occurrence methods (Hynes, 1950; Borutsky et al., 1961), Food Richness, Diet breath and Gut Repletion Index (Hynes, 1950; Hyslop, 1980). Diet Breadth was calculated using the Simpsons Diversity Index (Begon et al., 1986) Food Richness is the number of food items in the diet.

$$D = 1 - \frac{\sum_{i=i}^{3} ni \ (ni - 1)}{n \ (n-1)}$$

n = Number of individuals in a sample from a population, and D = Simpsons Index

Linear regression was employed to determine the type of relationship between any given pair of variables and their linear equations. Correlation analysis was used to ascertain the significance of this relationship. Variability in data was evaluated using the coefficient of variation and the F ratio test (Lewontin, 1966). The exponents (b) were tested for departure from isometry (b = 3) using t statistics (Pauly, 1984; Enin, 1994). Data were analyzed using descriptive statistics (mean, standard deviation and percentage). Comparison of data from zones was carried out using analysis of variance (ANOVA) (Steal and Torrie, 1980) and line graphs using the Statistical Package for the Social Sciences (SPSS, 1999).

RESULT

Diet habit

Trophic spectra of 370 samples of *O. niloticus* examined are shown Table 1. Though there was similarity in the ingested food objects between zones, the percentage occurrence of the food items varied. In Zone I, algae and plant remains formed the major food items in the diet with percentage frequencies of 3 and 20.4% respectively; followed by *Eichhornia* (9.8%), *Nymphaea* (8.5%) and annelid worms (7.8%). Algae and plant remains were also dominated the ingested food in stratum II but at 21.7 and 18.0%, respectively, followed by *Nymphaea* (12%), annelid worms (10.9%), *Eicchornia* (9.6%), *Pensetum purpureum* (9.0%), *Pistia* (8.3%) and *Lemna* (7.0%). Zone III had plant remains (26.9%) and algae (20.2%) as dominant items followed by annelid worms (11.4%) *Nymphaea* (11.4%), *Eicchornia* (8.6%), *Pensetum purpureum* (7.8%) and *Lemna* (7.7%).

Diet breadth ranged from 0.820-0.913, Food Richness and Gut Repletion Index were 12 and 100%, respectively, with no significant difference between zones (p>0.05).

Table 1. Trophic spectra of *O. niloticus* in the inland wetlands of Cross River.

Food item	Zone I		Zone II		Zone III	
	Frequency of occurrence (%)	Numerical (%)	Frequency of occurrence (%)	Numerical (%)	Frequency of occurrence (%)	Numerical (%)
Algae						
Spyrogyra	16.0	17.3	9.9	9.6	11.6	11.5
Chlamydomonas	9.0	9.9	4.9	5.1	5.5	4.5
Oscillatoria	5.1	5.9	2.0	2.1	1.2	1.1
Senedesmus	7.9	7.9	4.9	3.4	6.7	4.9
Free Floating						
Macrophytes						
Pistia	2.9	3.5	8.3	2.3	7.6	6.9
Azolla	3.0	3.3	3.4	3.4	4.4	3.7
Lemna	4.6	4.5	7.0	7.7	3.9	3.8
Eichhornia	9.8	8.4	9.6	8.6	3.6	1.1
Rooted macrophytes						
Nymphaea	8.5	9.5	12.0	11.4	13.9	13.2
Pensetum purpureum	5.0	5.7	9.0	7.8	8.0	7.4
Plant Remains	20.4	17.3	18.0	26.9	22.2	29.3
Annelid worms	7.8	7.4	10.9	11.4	11.4	9.2
Food richness	12		12		12	
Diet breath	0.913		0.875		0.820	
Gut Repletion Index (GRI)	100%		100%		100%	

Sex ratio

Result of the 2007 specimen of *O. niloticus* examined for sex ratio in Cross River inland wetlands as pooled from all three zones was approximately 1:0.97. The sex ratio varied with season and zone. Mean sex ratio was 1: 1 (Zone I), 1:0.78 (Zone II) and 1: 0.89 (Zone III) with a general trend of increased male dominance from January-June followed by decreases from July-December.

Length-weight relationship (LWR)

Variations in the LWR of *O. niloticus* in the 3 Zones showed remarkable differences (Figure 2; F = 4.284 P< 0.05). The overall pattern of the LWR was;

Wt = -1.320 Lt $^{2.194}$ Zone I
Wt = -2.486Lt $^{2.935}$ Zone II
Wt = -2.354 Lt $^{3.039}$ Zone III

Wt = total weight. Lt = standard length; and r = correlation.

There was significant relationship between length and weight in the three Zones (Zone I: r = 0.953, Zone II: r = 0.934, Zone III: r = 0.963). The monthly variations in the parameters of the LWR for combined male and female for the 3 Zone is shown in Figure 1. Annual mean proportionality constant (a) for *O. niloticus* in the 3 zones were
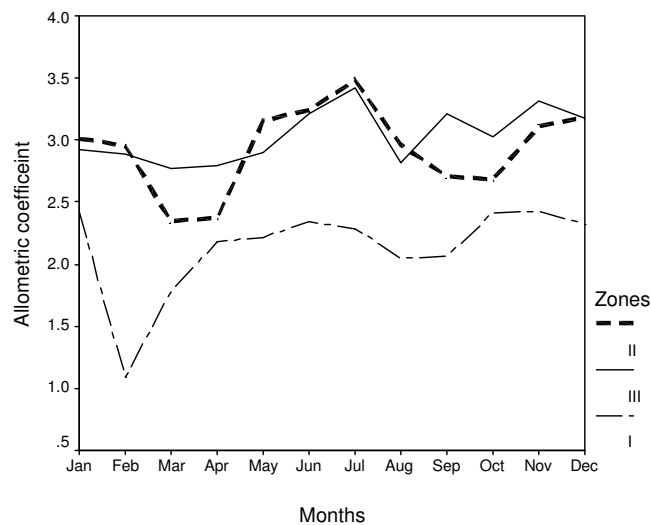

Figure 2. Monthly mean variation in the parameter of length - weight relationship of *O. niloticus* (both male and female pooled) in the 3 zones of Cross River State (2004- 2006).

1.320 ± 0.341 (Zone I), 1 2486 ± 0.392 (Zone II) and 2.353 ± 0.409 (Zone III) with coefficient of variability (cv) range from 27.3 – 31.6%. Mean allometric coefficients (b) were 2.194 ± 0.215 (Zone I), 2.935 ± 0.333 (Zone II) and 3.03 ± 0.202 (Zone III) and significantly deviated from the cube value (t = 4.127 P < 0.05) for Zone I. Zone II and III
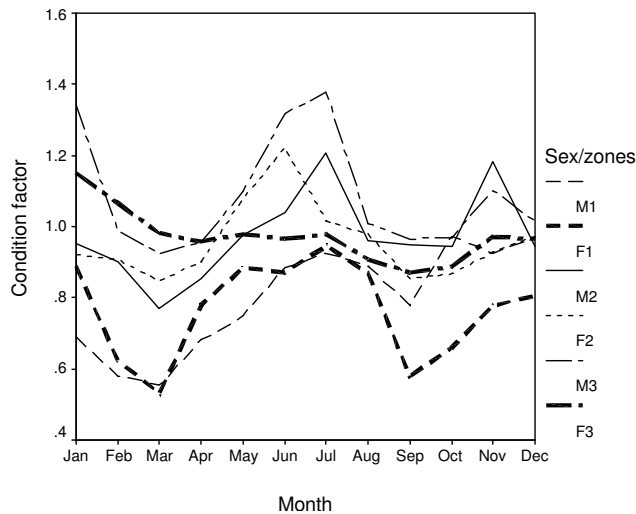
Figure 3. Monthly mean Variations in the condition factor of male and female O. niloticus in the three zones of Cross River Inland Wetlands (2004 – 2006).

showing no significant deviation from cube value [t = 1.127 P > 0.05 (Zone II), t = 2.012, P > 0.05 (Zone III)]. Mean value of b (allometric coefficient) for *O. niloticus* in the fishing seasons of Cross River inland waters were significantly different from cube value (b = 3) for Zone I (F = 9.9, P< 0.05) but did not show significant difference in Zone II and III (P > 0.050).

Condition factor (CF)

For the combined sexes K values ranged from 0.554 – 0.936 with annual mean of 0.784 ± 0.115 (Zone I), 0.808 – 1.131 with annual mean of 0.960 ± 0.093 (Zone II) and 0.929 – 1.246 with annual mean of 1.0444 ± 0.093 (Zone III). Condition factor for separate male and female sexes of *O. niloticus* in the three zones are shown in Figure 3. Annual mean condition index ranged from 0.770 ± 0.128 minimum for males at Zone I to 1.188 ± 0.157 maximum also for males at Zone III. Highest condition factor of 1.205 and 1.367 were recorded for male *O. niloticus* in Zone II and III, respectively, in July (the peak of the rising flood) and 0.974 in Zone I in October. Female *O. niloticus* peak Condition Factor of 1.151 was recorded in January (Zone III), 1.223 in June (Zone II) and 0.946 in July (Zone I). However there was no significant inter-sexual (F=1.08, p > 0.05) and inter-seasonal (F = 0.97, p > 0.05) differences in condition factor from expected value (1.0).

Fecundity

Fecundity varies with individual fish from 70 eggs for fish (total length (TL) = 11.00 cm and weight (W) = 37.9 g) to

502 eggs (TL = 25.8 cm and W = 198.8 g) in Zone I, 60 eggs (TL = 13.3 cm and W = 19.8 g) to 709 egg (TL = 26.5, W= 317.0) in Zone II and 110 eggs (TL = 13.7 cm, W = 24.0g) to 811 eggs (TL = 22.8 cm, W = 278.8 g) in Zone III. There was a significant relationship between fecundity and total length (r = 0.884, P < 0.001) and between fecundity and body weight (r = 0.985, P < 0.001) according to the exponential equation:

$$F = 2.079\,L^{2.649} \text{ and } F = 24.322\,W^{0.572}$$

F = Relative fecundity, r = correlation coefficient, L = standard length. The smallest sexually mature fish in Zone I was 13.5 cm while 14.0 cm in Zone II and 15.4 cm in Zone III.

Breeding season

Seasonal variation in fecundity showed that for all the three zones fecundity increased from January and peaked in August and started decreasing to the least in December. Sexually matured females of *O. niloticus* were more predominant in the months of July and August.

DISCUSSION

Variation in the biological characteristics of O. *niloticus* with the zones and seasons is an evidence of hetero-geneity in the habitat type between different zones of the study area (Welcome, 1985; Cowx and Welcome, 1998). Dominance of algae, macrophytes, plant remains and annelid worms in the diet of *O. niloticus* at different percentages of occurrence in the three zones revealed the species as a primary consumer that lives as an herbi-vore and a planktivore. High value of Diet Breadth (0.88 ± 0.55) depicts wide food spectrum; an ecological advan-tage which enables the fish to switch from one food item to another depending on availability. This agrees with earlier findings by Crozier (1985); Brown (1986) and Ugwumba (1988) that the feeding habit of *O. niloticus* overlaps, utilizing various materials found in the environ-ment. Gut repletion index of 100% in all the zones indicates very high feeding intensity for this species which explains their high rate of success in this river.

Observation that sex ratio of *O. niloticus* in the study area as pooled from all three zones was 1:0.97 male: female ratio was close to that (1:0.75) obtained by Omotosho et al. (1990) for *Tilapia zilli* and *Sarotherodon niloticus* in Oba Reservoir, Ibadan, Nigeria and 1:1 obtained by Gomez-Marquez et al. (2003) in Coateteko lake. Nikolsky (1963) cited that the sex ratio varies considerably from species to species but majority of cases it is close to one and may vary from year to year in the same population. It is important to stand out the fact

that *O. niloticus* populations in the study area with more males than females could be favourable to the fishery because it can serve as a regulatory mechanism for the sex ratio. This may be due to the fact that the gears are not set close to breeding ground (Fryer and Iles (1972) or as pointed out by Nikolsky (1963) that in African water bodies, it is common that in the populations of fish the males dominate because they generally present more growth than females without this representing a risk situation for the fishery. Seasonal variation in the sex ratio observed was probably because once fertilization of the eggs was completed, males possibly emigrate from spawning areas towards feeding grounds located in shallow part (where they are captured) while females go towards submerged vegetation and rocky areas to carry out the incubation and protection of offspring.

Results that *O. niloticus* showed negative allometry (2.19) in the length-weight relationship in Zone I is an indication that the population of the species in this zone had heterogenous groups with body weights varying differently with the cube of total length. On the other hand isometric growth shown by this same species in Zone II (2.9) and Zone III (3.04) was an indication that these zones have homogenous groups in their populations. This implies that the dynamics of populations of *O. niloticus* in Cross River can be analyzed using different conventional fish populations dynamic models most of which assume isometry. Significant inter-seasonal differences (p < 0.05) in the allometric coefficient (b) of *O. niloticus* in Zone I is an indication that biological phenolmenon e.g. feeding and spawning have much impact on length-weight relationship in the zones. However, seasonality in the length-weight parameter of the specimen in Zone II and III depicts little impact of biological phenomenon on breeding activity of the species in these parts of the river. The general trend of dimensional inequality exhibited by *O. niloticus* in Zone I compared to those of same species encountered at the other two zones may be regarded as one of the savanna grassland floodplain adaptations by the species.

Higher condition factor range recorded for male *O. niloticus* (0.554 – 1.376) in Zone III is an indication that male sex of these species were in better condition than the female sex and an evidence of greater food abundance at Zone III than other zones. Also, seasonality in the condition factor of these species may be attributed to the rich food supply in all seasons. Absence of inter-sexual and inter-seasonal differences in the condition factors in some zones showed that condition factor depends more on food availability than sex and season. The fact that 68% of the specimen examined had condition factors above the mean showed that *O. niloticus* population of the Cross River is in excellent condition.

Fecundity range (70 - 585 eggs) obtained per female *O. niloticus* was consistent with 104 to 709 eggs fecunddity range for *O. niloticus* reported by Gomeze-Marquez

et al. (2003) and 162 – 954 eggs for *Oreochromis aureus* by Palacios (1995) but lower than the 3706 eggs obtained for *Tilapia nilotica* by Fryer and Iles (1972), 2800 eggs for *T. nilotica* by Babiker and Ibrahim (1979) and 3960 for *Sarotherodon galilaeus* by Fagade et al. (1984). Low fecundity by *O. niloticus* in this study probably is a result of restrictions imposed by mouth-brooding habit of this species and limited space available for rearing the spawn in the mouth cavity (Babiker and Ibrahim, 1979). High relative abundance of *O. niloticus* in all the zones may be as a result of high parental care which guaranteed high survival rate of offsprings. Nutritional resources are known to play critical roles in regulating variations in fecundity (Wooton, 1973; Dajoz, 1977; Fagade et al., 1984; Bagenal, 1978; Nikolsky, 1963; Babiker and Ibrahim, 1979). Fish with high condition factor (good body condition) would be expected to have higher fecundity than those of low condition factor (bad body condition) (Baltz and Moyle, 1982). Hence higher fecundity in the species in Zone III than the other two zones is a manifestation of this reproductive trait. Peak season in the fecundity of these species coinciding with the rising flood (May - August) may be a natural phenomenon that ensures most fish spawn during this season so that the young follow the flood to areas of abundant food in the floodplains. In the receding flood (November- January) most females are spent hence only scanty eggs are noticed in them.

Conclusion

In this study, the knowledge on fish biological indices including sex ratio, diet habit, length-weight parameters, condition factor and fecundity has contributed greatly to the understanding of the fish population structure of the Cross River inland wetlands. The parameters as shown in this study can be used for studying growth and population dynamics of *O. niloticus* exploited from this river. Appropriate models can now be used for long or short term assessment of fish stock in the area.

ACKNOWLEDGEMENTS

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