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Aspects of Ecology of *Clarias anguillaris* (Teleostei: Clariidae) in the Cross River, Nigeria

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Abstract

The life history of *Clarias anguillaris* was studied over 24 months in the upper, middle and lower reaches of the 200 km length of Cross River, Nigeria. The influence of spatial and seasonal variables on the distribution and abundance, reproduction, diet and size was determined from catch samples over 24 months in the 200 km length of the Cross River, Nigeria. Fish occurred unevenly in the three reaches and over the dry and wet seasons, with peak abundances during the early and late rains and lower values in the upper reach than in the middle and lower reaches. Night catches were higher than day catches, with males being more common than females. The peak breeding period was June - July. The fish were omnivorous with trophic flexibility being related to food availability.Mean allometric coefficients in the three reaches indicated an isometric growth pattern. The condition of the fish was the same in the three reaches but declined during dry season and improved during early and late rains. Fish was therefore in better condition during the rainy season and was not affected by spatial changes.

Keywords: distribution, abundance, fecundity, diet habit, length-weight relationship, condition factor, sex ratio, spatial variables, seasonal variables**.**

Cross River'da (Nijerya) *Clarias anguillaris* (Teleostei: Clariidae) Biyoekolojisinin Belirlenmesi

Özet

Nijerya'daki 200 km uzunluğundaki Cross Nehrinde *Clarias anguillaris*'in yaşam hikayesi araştırıldı. Mevsimsel değişkenlerin; dağılım, üreme, besin ve büyüklük üzerindeki etkisi Cross River'da 24 aylık sürede av örneklerinden tespit edildi. Balıklar, kuru ve nemli mevsimlerde nehrin menbası, orta kesimi ve mansabında eşit bir dağılım göstermediği tespit edildi. En yüksek bolluk, erken ve geç yağmurlarda olurken daha düşük değerler orta kısım ve mansaptan ziyade menbada görüldü. Erkek sayısı, dişilerden fazla (1:0,6) olduğu gibi, gece avları, gündüz avlarından daha yüksekti. Üreme dönemi Haziran– emmuz'da olduğu belirlendi. Balıklar, besinin yararlanırlığına bağlı olarak trofik esnekliği olan omnivor balıklardı. Üç yerdeki ortalama allometri katsayıları, izometrik bir büyüme modelinin olduğunu belirtti. Balıkların kondisyonu üç istasyonda da aynı olmakla beraber kuru mevsim boyunca azaldı ve erken ve geç yağmurlarda iyileşti. Bu nedenle balıklar yağmurlu mevsim boyunca kondisyonları gelişti ve çevresel değişikliklerden etkilenmediler.

Anahtar Kelimeler: dağılım, bolluk, fekondite, besindüzen alışkanlığı, boy–ağırlık ilişkisi, kondisyon faktörü, cinsiyet oranı.

Introduction

Clariid catfishes occur in most freshwater bodies of South East Asia and Africa where they constitute a significant component of the catches. The highest generic diversity is found on the African continent where some 14 genera have been reported (Teugels, 1986) against two in South East Asia. In both continents, Clariidae are of great economic importance as food fish and vital in the sustainability of aquaculture (Venden Bossiche and Bernacsek, 1990). Their aquaculture attributes include; ability to withstand handling stress, disease resistance, high growth rate, yield potential, fecundity and palatability. *Clarias anguillaris* and *Clarias gariepinus* are the two species most readily acceptable in Nigeria, because they grow to large sizes. There is acute reduction of these species in inland waters in Nigerian natural water bodies because of the over-exploitative nature of indigenous fishers that destroys the habitat and fisheries resources (Viser, 1970). Effort by Nigerian government to conserve and propagate these species through fisheries regulation and fish breeding is being hindered because of the little information available (Fagbenro *et al.*, 1993) on the ecology of these species in Nigerian waters. Most of these research works are limited to the reproductive biology of *C. gariepinus.* No work had been undertaken on the ecology of *C. anguillaris* in Nigeria. This paper therefore provides information on the ecological influence of spatial and seasonal variables on the distribution and abundance, growth, diet and reproduction of *C. anguillaris* in a floodplain river of South Eastern Nigeria. These data will form the basis for management strategy of the species in Cross River.

Material and Methods

The study site is the Cross River, a floodplain river located at the South Eastern part of Nigeria (Figure 1) on Latitude 4º25'–7º00' N, longitude 7º15'–90º30' E. It is bounded in the south by the Atlantic Ocean, East by the Republic of Cameroun, the Nigerian states of Benue in the North, Ebonyi and Abia in the West and Akwa Ibom; South West. Climate of the study area is defined by dry season and wet season. Three sampling sites were selected along the length of the river, with one sampling site randomly selected each time from each of the following reaches; upriver (reach I), middle river (reach II) and down river (reach III) Upriver was located 200 km from the river source with rocky, gravel and sandy substratum. The shoreline was covered with savannah grassland and has wood and paper industries located close to the source. The middle river had a rocky substratum and shoreline sparsely shaded by forest and savannah grassland. Downriver had a muddy substratum and opens up into the Cross River estuary, with shoreline thickly shaded with rainforest.

Fish samples for all assessments in each site were randomly collected twice every month, in the day (24:^{00}-06:^{00} hours and night (08:^{30}-12:^{00} hours) and during wet and dry seasons, from randomly selected artisanal fishermen whose fishing gears were mainly seine net (10-34 mm stretched mesh size) and gill net (22-76 mm stretched mesh size). Fish samples were preserved in 10% formalin prior to laboratory examination. In the laboratory, data obtained from each fish included; length, weight, sex, fecundity and food records. Standard length (SL) and total length (TL) were measured to the nearest 0.1cm and weighed (wt) to the nearest 0.1 g. Samples were identified using FAO Species Identification Sheet (Fischer and Bianchi, 1984) and sexed by visual observation.

Specimens for diet studies were dissected and their guts removed immediately after capture and stored in formaldehyde solution (4%) until the contents were analysed. Gut analysis was later carried out, food items identified to the lowest possible taxon and analysed quantitatively for percentage composition by number (N) and frequency of occurrence (FO). Diet breath, estimates the diet

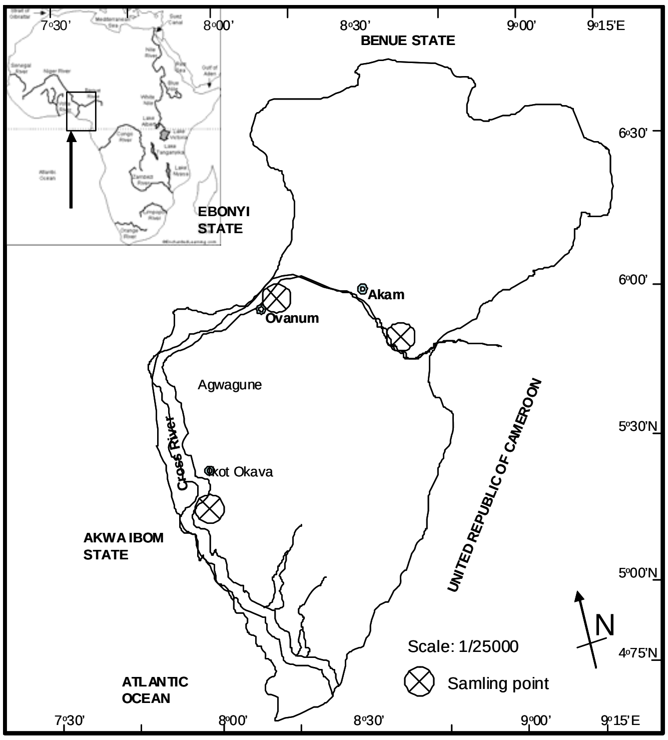

Figure 1. Map of Cross River State showing study area.

spectrum that was calculated using the diversity index of Shannon- Wiener (H); H = -∑pi ln pi where, pi is the proportion by the number of food type i, Food richness; expressed using Margalef's index: d= (S–1)/logN) where d= Margalef's index, S is the number of species and N is the number of individuals and Gut Repletion Index (GRI) which is the percentage of non-empty stomach was estimated for samples from each reach.

Analysis of fecundity was limited to the peak spawning period (May-July) and only ripe female fish (494) were used for the estimation. Ovaries were excised from body cavity of each fish and preserved in Gilson fluid. Eggs in a l-gram sub-sample were counted. Counting was done for five similar sub samples. The mean number of eggs in the five sub samples gave the number of eggs per gram of weight. Fecundity was calculated by multiplying the total weight of eggs by the number of eggs per gram weight. Relative fecundity (RF) = No. of eggs per unit length (cm). Fecundity- length and fecundity- weight was determined using the expression by King (1991): $F = ax^b$, F = absolute fecundity, x = independent variables (body weight, total length and condition index). a = constant, b = allometric coefficient both of which were evaluated by least squares regression analysis using log transformed data; log F = log a + b log xi. Length at first maturity was worked out by plotting the percentage of mature fish against their lengths. Length at which 50% of the females were mature was considered length at first maturity. It was calculated by an equation generated from the graph and confirmed by eyeballing. Gonad cycle was determined from changes in gonad weight, as shown by Gonado-somatic Index (GDI) calculated by expressing the gonad weight as percentage of body weight.

Length-weight relationship (LWR) of fish was estimated from the equation $W = aL^b$, W = weight of fish in grams, L = total length of fish in centimetres, '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: $K = (W/L^3)*100$, K= condition factor, W = total weight (g) and L =total length (cm).

Statistical Analysis

Data collected were collated and analysed using descriptive statistics (mean, standard deviation and percentage). Statistical comparison of data between and within zones was carried out using analysis of variance (ANOVA) and line graphs using excel statistical package (2007). Sex ratio of the fish was studied using Chi-square test (X^2) and values were tested using 95% confidence level. Correlation analysis was used to ascertain the significance of these relationships. The variability in data was evaluated using the coefficient of variation (CV) and the F – ratio test. The exponents (b) of LWR were tested for departure from isometry (b=3) using t – statistics.

Results

Distribution of *C. anguillaris* was uneven (D = 0.65, P<0.001) through space and time as shown by the Kolmogorov-Simirnov goodness of fit D test (Table 1). The highest number and weight were recorded in the Lower reach, while the least were in the Upper reach; and difference between the reaches was significant for numbers (F= 3.36, P<0.05) and weight (F= 4.5, P<0.05). Field observation and their occurrence in the net during capture showed that both the young fish (< 10cm) and adult (> 10cm) occurred mostly in the deep layers of low velocity areas of the river. However, it was observed that they make lateral movements to the shallow parts of the banks mainly for feeding.

Monthly variation in the abundance of catfish revealed that peak abundance was biphasic for the juvenile fish and uniphasic for the adult. The phases occurred in reach I and II (Figure 2A-C) in the early rainy months (May-July) and late wet months (November-January) for the adult fish and only in late wet months (November-January) for the juvenile fish. While the adult fish in reach III exhibited the same pattern as those in other reaches, the juvenile fish showed a slightly extended peak between November and March. Generally, juvenile fish was significantly higher (P<0.001) in the early dry months (November-January).

Males were more common than females as male: female sex ratio (1:0.6) of *C. anguillaris* over the entire study period showed highly significant (Chi-square, P<0.001) monthly variation from the expected sex ratio of 1:1 with males more numerous in all months of sampling except in the month of November (Table 2).

Maturity curve plotted for the fish showed that 50% of the males matured at 14.8cm total length (TL) and females at length 15.7cm (Figure 3). GSI varied from 2.5 to 9.4 in female fish and from 1.5 to 4.5 in male fish and were higher in the wet season than dry (Table 3). Monthly changes in the GSI of *C. anguillaris* females and males in consecutive months revealed that both values were very low during September to February and the highest in May (Figure 4).

Table 4 showed that absolute fecundity varied from 5515 and 65,800 while mean fecundity from 7511 ± 2923 eggs for fish with SL = 14.8cm and weight 102.4g (Upper reach) to 39803 ± 9352 for fish SL = 45.9cm and weight = 625.5g (Lower reach). Figures 5A and B showed positive and linear relationship between total length, body weight and fecundity indicating that fecundity increase as body size increased. r^2 value was 0.739 for total

Table 1. Distribution of relative abundance of *C. anguillaris* in the three sampling stations

Stations	Upper River	Middle River	Lower River	D	P
Abundance (N = 1500)	206	554	740	0.6541	<0.001
Biomass (g) ($3.6 \times 10^{5)}$	0.2×10^5	1.2×10^5	2.2×10^5	0.5422	<0.001

D = Kolmogorov – Smirnov goodness of fit statistics

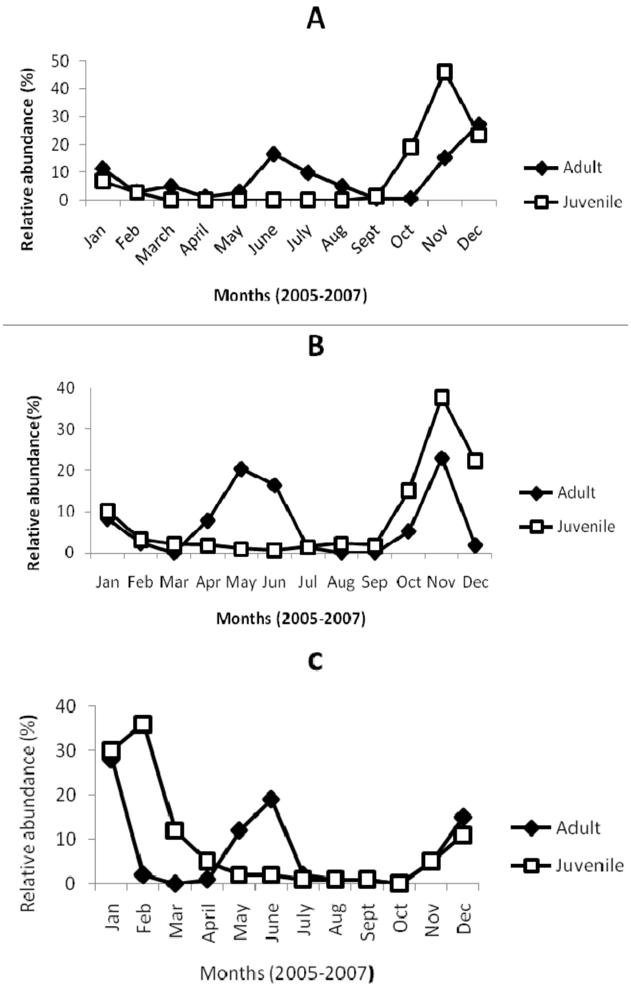

Figure 2. Percentage monthly abundance of adult and juvenile *C. anguillaris* in inland wetlands of Cross River.
A: Reach I, **B**: Reach II, **C**: Reach III.

Table 2. Mean monthly variation in the sex ratio (Male : Female) of *C. anguillaris* in the Cross River

Month	Total Sample	Male	Female	Sex Ratio	Chi - square
Jan	22	18	4	1: 0.3	6.00*
Feb	18	12	6	1: 0.5	2.45
March	10	6	4	1: 0.7	4.14*
April	10	7	3	1: 0.4	1.45
May	68	50	18	1: 0.4	27.5**
June	112	82	30	1: 0.5	17.25**
July	96	59	37	1: 0.6	8.64**
Aug	21	15	6	1: 0.4	17.24**
Sept	12	9	3	1: 0.3	19.41**
Oct	4	4	0	-	4.00*
Nov	86	31	55	1: 1.7	4.30*
Dec	30	20	10	1: 0.5	6.45*
Overall	493	313	180	1: 0.58	31.02**

* P<= 0.05 and ** P < 0.001

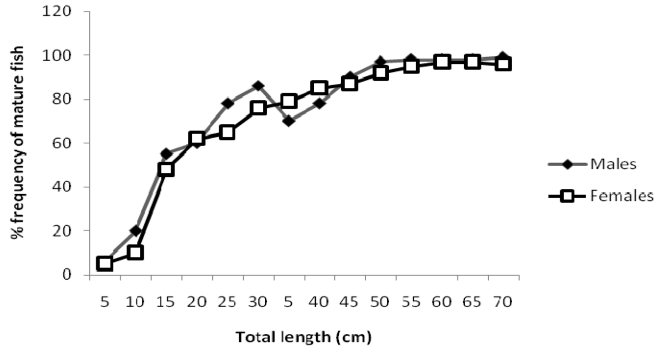

Figure 3. Percentage occurrence of mature male-and female *C. anguillaris* at different lengths.

Table 3. Mean ± SD of seasonal variation in the GSI of male and female fish

Season	Sample size	Wet season	Dry season	P
GSI (Male)	149	4.5 ± 1.2	1.5 ± 0.8	P < 0.05
GSI (Female)	167	9.5 ± 2.8	2.5 ± 0.4	P < 0.05

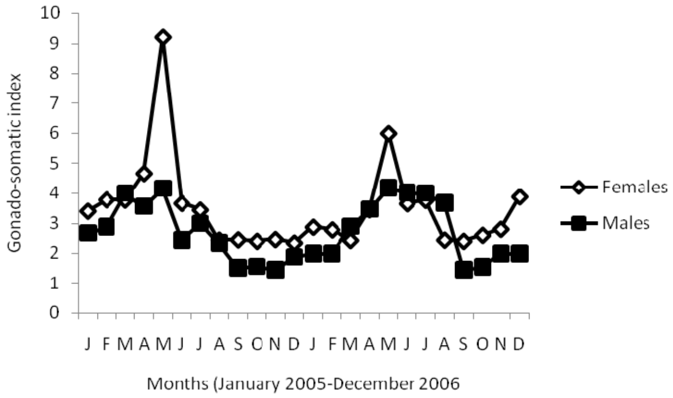

Figure 4. Mean ± SD of Gonado-somatic Index (GSI) of male (145) and female (151) *C. anguillaris* in Cross River.

Table 4. Mean ± SD of standard length, Body weight and absolute fecundity of fish in the sapling sites

Sampling site	Sample size (n)	Standard length (cm)	Body weight (g)	Absolute fecundity
I	163	14.8±5.4	102.4±34.5	7511±2923
II	142	16.7±6.7	138.4±75.2	9123±4563
III	155	18.7±10.8	324.9±298.6	39803±9352

length/fecundity and 0.705 for body weight/fecundity.

Length-weight equation models established for both the sexes of *C. anguillaris* and in the three reaches are given separately, in Table 5. The regression models fitted for length and weight of male and female yielded significant results, however, the value of the regression coefficient or allometric coefficient (b) for male and female was approximately '3' (i.e. did not vary significantly from '3', t= 24.8, P>0.05 for male; t= 48.5, P>0.05 for female) depicting isometry. The growth in length and gain in weight of the fishes were well correlated. There was a significant correlation between length and weight at the three reaches with 61.2–70.5% of the variation of the body weight being accounted for by changes in length. Mean condition factor ranged from 0.640 ± 0.12 minimum for males in the Upper reach to 1.35 ± 0.11 maximum also for males at the Lower reach with no significant (P>0.05) difference between reaches and sexes. However, there was significant monthly variation in the condition factor with both sexes recording the highest condition factor between June

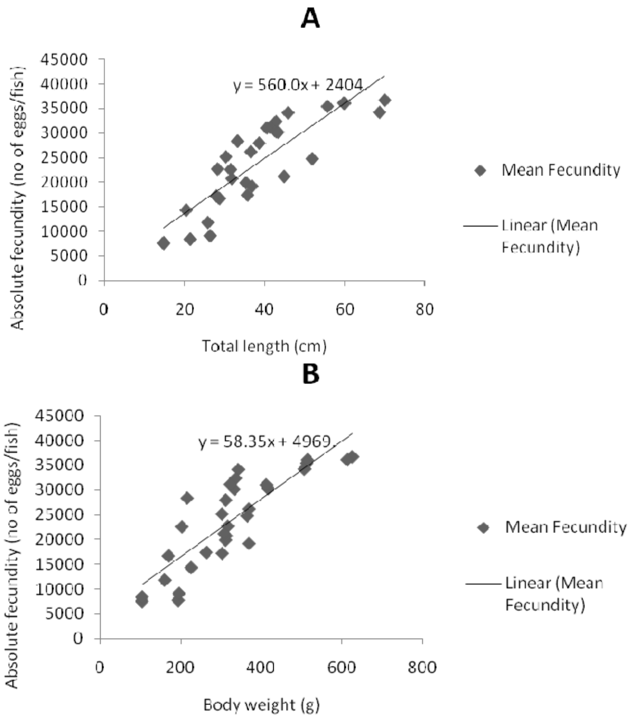

Figure 5. Fecundity-length and weight relationship of *C. anguillaris*. A: Fecundity-length relationship. B: Fecundity- weight relationship.

Table 5. Regression models for different variables of length-weight relationships of *C. anguillaris*

V	M	Vr	r^2	P
Length-weight (I)	$Wt=-1.903\ Lt^{2.53}$	L: 8.8-34.7cm W: 102.4-504.3g	0.776	< 0.05
Length-weight (II)	$Wt=-2.610\ Lt^{2.87}$	L: 9.6-38.8cm W: 122.1-611.6g	0.873	< 0.05
Length-weight (III)	$Wt=-2.828\ Lt^{2.89}$	L: 8.9.9-45.9cm W: 136.6-625.5g	0.987	< 0.05
Length-weight (M)	$Wt=-2.520\ Lt^{3.14}$	L: 8.8-45.9cm W: 125.4-625.5g	0.922	< 0.05
Length-weight (F)	$Wt=-1.496\ Lt^{2.5}$	L: 9.5-40.6cm W:102.4-544.g	0.789	< 0.05

I: Upper reach, II: Middle reach, III: Lower reach, M: male, F: female, V: Variable, M: Model, r^2: Regression coefficient, Significant P= 0.05

and July and between November and January. Least values were obtained from February to April and August to October (Figure 6).

The most frequent food item found in the African catfish in all the reaches were fish prey and fish remains constituting 64.3 percent of the diet in the wet season and less than 20 percent in the dry season (Table 6). Among the habitual prey; insects, Crustaceans, worms and rotifers occur most frequently during the dry season constituting 40% of the diet. Plant materials were also common only during dry season. Indices of the diet composition showed that Gut Repletion Index (GRI) was 100% in both wet and dry season and 75 percent and 100 percent in the day and night respectively. In addition, the least prey diversity was found in dry season diet (H =2.4 and 1.2 for wet and dry seasons respectively). Diel pattern in the consumption of food items by *C. anguillaris* showed twelve food types ingested during the night while eight types were taken during the day (Table 7). Occurrence of all items except plant materials was significantly higher (P<0.05) in the night catches than the day.

Discussion

The spatial and seasonal variation in the distribution and abundance of *Clarias anguillaris* observed in this study, as indicated by the Kolmogorov- Smirnov goodness of fit D test, support

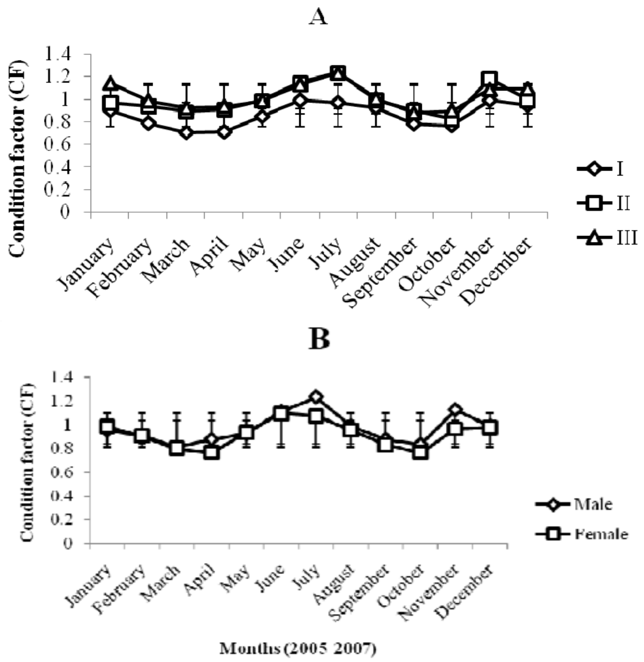

Figure 6. Mean ± SD of condition factor of *C. anguillaris* (male and female, N= 245) from Cross River Inland wetlands.
A: Reaches, B: Sexes, I: Upper reach, II: Middle, III: Lower reach

Table 6. Seasonal changes of frequency of occurrence and composition by number of food items in the stomach of the clarid catfish *C. anguillaris* in the Cross River

Food items	% Frequency of Occurrence			% Composition by Number		
	W	D	X^2	W	D	X^2
Annelid worms	6.1	2.7	4.7*	5.1	3.4	1.2
Nematode worm	5.0		6.2*	4.8	5.4*	4.8
Insecta						
Adult	6.6	22.2	12.5*	6.2	31.1	12.5*
Stages	10.5	5.2	5.1*	9.2	23.5	10.4*
Crustecean						
Bivalves	3.2	11.4	6.9*	4.5	24.3	14.5*
Gastropods	5.2	32.0	14.8*	6.7	23.3	11.4*
Decapods	7.4	30.8	11.6*	9.7	42.4	16.6*
Fish						
Whole adult fish	10.9			17.9		12.2*
Fish juveniles	23.7	8.8	9.8*	18.8	12.3	2.3
Plant materials	1.8	31.8	23.2*			
Food richness		12			9	
Diet breath (H)		2.4			1.2	
Gut repletion index		100%			100%	

Significant at *P = 0.05, W: wet season, D= dry season

the idea that various fish communities show non-random patterns in composition over time and space (Kilgour and Barton, 1999). The occurrence of the highest number and biomass in the Lower reach of Cross River confirmed earlier findings (Aluko and Shaba, 1999; Merron, 1993.) that this species is common in habitats that are turbid, muddy and forest swamps in nature. Sydenham (1975) further explained that preference for muddy forest swamps and pools is to enable catfish to survive in them during dry season using their accessory breathing organs to take in atmospheric oxygen. Diel pattern of the fish abundance, in this study, with higher night catches than day had been reported (Bruton, 1979) and showed that the species are nocturnal. Lower dry season catches may be as a result of courtship, mating and resting during which the species withdraw to suitable and save grounds for spawning and becomes less unavailable for catch (Bruton, 1979). On the other hand, availability of abundant food during early rains and late wet season could also be an important factor responsible for increased fish abundance during

Table 7. Diel variations in the food habits of *C. anguillaris* in the Cross River

	Method Frequency of occurrence				Numerical			
	D	N	X^2	P	D	N	X^2	P
Annelid worms	8	34	12.4	>0.001	17	76	10.9	>0.001
Nematode worm	3	23	9.3	>0.001	13	56	12.2	>0.001
Insects								
Adult	92	201	179.2	<0.001	201	387	145.6	<0.001
Stages	103	243	198.5	<0.001	324	487	45.7	<0.001
Crustacean								
Bivalves	34	123	67	<0.001	98	223	139.8	<0.001
Gastropods	98	222	177.3	<0.001	190	432	173.6	<0.001
Decapods	-	302	-	-	-	-	-	-
Fish								
Whole adult fish	-	345	-	-	-	-	-	-
Fish juveniles	-	422	-	-	-	-	-	-
Rotifers	34	67	23.8	>0.001	87	98	11.4	>0.001
Plant materials	287	101	103.3	<0.001	569	189	187.6	<0.001
Food richness		8	12			8	12	
Diet breath (H)	0.98	2.02						
Gut repletion index	75%	100%				75%	100%	

X^2= Chi-Square test, D: Day, N: Night [Use same set-up approach as above. Ed]

this season (Wooton, 1979).

Preponderance of the male specimens over the female in this study had been observed in populations of other catfishes (Bruton, 1979). He explained that male *Clarias* present more biomass by number and by weight than females without this representing a risk situation for the fishery. Ham (1981) suggested that sex disparity could be a result of the differential survival of certain environmental conditions. Fagade *et al.* (1984) described it as a mechanism for population regulation in fishes. Males could possibly emigrate from spawning areas towards feeding grounds located in shallow part (where they are captured) after fertilization of the eggs has ended (Ham, 1981). GSI has been used as indicator of the spawning period in teleosts (van der Waal, 1974). Peak of GSI for this species in April-May was confirmed by the largest frequency of the matured phases during this period; characterizing a single annual spawning, and synchronic ovarian development. By June/July, spawning is over as indicated by the decrease in GSI. This results support findings by de Graaf *et al*. (1995) that the final triggering of spawning in *Clarias* species is caused by a rise in water level due to rainfall, which commenced in the study area between April and June. These results indicated that for captive breeding programs gravid fishes are available in the wild during April-June. The status of the ovary of the fishes caught during October to January; revealed that most of the ovaries were spent. This shows that the most productive fishing period for the species in the Cross River was October-January because gravid fish are almost absent during the period, though the juveniles are abundant. However, with well regulated mesh size only the table sizes will be harvested. Although the length at first maturity obtained for the fish was 15.7cm, the minimum length recorded for specimens sampled was 8.8cm, indicating recruitment overfishing. Minimum length of fish with spent ovaries was 23.4cm. Hence closed and less intense fishing during April–September (period of abundance of gravid *C. anguillaris*), would help conservation of the natural stock of the fish, by allowing the fish to breed at least once in their lifetime.

Absolute fecundity between 5,515 and 65,800 eggs recorded in this study was comparatively low compared to observation from other Clariid catfishes. Gaigher (1977) recorded 70,000 eggs for *C. gariepinus* in Hardap dam, Namibia while 650,625 eggs were reported in *C. gariepinus* in Opa Reservoir, Nigeria (Abayomi and Arawomo, 1996). Peak season in fecundity of these species which coincides with onset of rains, and the rising flood have also been observed by van der Waal (1975). All explained that most tropical fishes are adopted to breed on the rising flood thus allowing the juveniles to take full advantage of the flooded banks for feeding while protected from predation (Aluko and Shaba, 1999).

The ranges of allometric coefficients of *C. anguillaris* obtained were within the limits given for fin fishes (Largler *et al*., 1977). The growth pattern was isometric (b = 3) implying that the population of *C. anguillaris* in the Cross River follows the cube law and therefore had homogenous groups. Hence, dynamics of the population of *C. anguillaris* in the area can be analysed using various conventional fish population dynamic models most of which assume isometry in fish growth. Aseasonality in the length – weight relationship parameter is an indication that biological phenomena such as foraging pattern, testicular anabolism (reproductive investment) and depletion during spawning have little impact on the length – weight functions (King, 1996).

Observed monthly fluctuation in the condition factor could be attributable to the influence of the breeding cycle. Our data show that condition factor is highly correlated with GSI. Higher condition factor obtained between June and July and low values between August and October had been reported (Rimmer and Merrick, 1983) and the results were attributed to spawning activities, which may have resulted from the accumulation of fats and ripe gonads carried by the mature adult females. The observation that 62% of the samples examined had condition factor above mean showed that the majority of fish in the population are in excellent condition.

Results of diet composition revealed *C. anguillaris* as omnivorous predatory fish. The diet spectra in which fish prey and insect were the most abundant could be closely marched with that obtained in *Clarias gariepinus* by Bruton (1979) in Lake Sibaya (South Africa) and Robbins (2004) in South Florida except that the authors observed increased preference for zooplankton with increasing size. There is considerable seasonal variation in the feeding activity correlated with flood regime. During the flood release of nutrients, rapid growth of vegetation and increased availability of other sources like; seeds, young shoots, leaves and mollusc form the bases for a particularly intense feeding activity (Robbins, 2004). The diet generally reflects the seasonal distribution of macro-invertebrates and fish prey in the environment as pointed out by Hyslop (1980). Presence of plant materials in the diet of this species had been reported (Hyslop, 1987) and was suggested that the frequent occurrence, especially during dry season, could be a survival strategy in times of scarcity of prey. Gut repletion index in this study is the percentage of non-empty stomach. Gut Repletion Index of one hundred percent indicates that the fish species is a regular feeder. High values of other indices (Food Richness and Diet breadth) showed that the species exhibits trophic flexibility, which is an ecological advantage that enabled the fish to switch from one food category to another in response to fluctuation in their abundance (Madu *et al.*, 1990). Diel pattern of feeding habit where *C. anguillaris* completely ignored fish prey during the daylight and feed mainly on invertebrates and plants was earlier observed by Bruton (1979). He attributed this behaviour to the inability of the catfish to catch prey fish in daylight due to the slow, methodical, predatory tactics of the species. Generally higher diet indices recorded for night catches, in this study, had been reported (Robbins, 2004), and it suggests that the species are more active at night.

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References

Abayomi, O.S. and Arawomo, G.A.O. 1996. Sex ratio and fecundity of *C. gariepinus* in Opa Reservoir, Ile-Ife, Nigeria. In: Abstracts of annual conference of Fish Soc Nig (FISON), 2-8th November Lagos: 122-130.

Aluko, P.O. and Shaba, M. 1999. Intra- and inter-specific hybridization studies between exotic *Clarias gariepinus* and two indigenous Clariid species. Nigerian J. Genet., 14: 59–63.

Bruton, M.N. 1979a. The breeding biology and early development of *Clarias gariepinus* in Lake Sibaya, South Africa. Transactions of the Zoological Society of London 35: 1-45.

de Graaf, J.G., Galemoni, F. and Banzoussi, B. 1995. Recruitment control of Nile tilapia, *Oreochromis niloticus*, by the African catfish, *C. gariepinus.* Aquacult Res., 30: 25-36.

Fagade, S.O., Adebisi, A.A. and Atanda, A.N. 1984. The breeding cycle of *Clarias lazera*. Hydrobiologia, 100: 493-500.

Fagbenro, O.A. 1993. Studies on the biology and aquaculture potential of feral catfish *Heterobranchus bidorsalis* (Clariidae), Tropical Zoology, 6: 67–79.

Fischer, W. and Bianchi, G. 1984. Species Identification Sheets for Fishery Area. FAO, Rome, 34 pp.

Gaigher, L.G. 1977. Reproduction in the catfish (*Clarias gariepinus)* in the Opa dam, South West Africa. Madoqua, 10: 52–59.

Ham, R. 1981. The ecology of six native and two introduced fish species in Enoggera creek system, south east Queens, BSc (Hons) thesis, Griffith University, Brisbane, 157 pp.

Hyslop, E.J. 1980. Stomach content analysis, a review of methods and their application. Journal of Fish Biology 17: 411–429.

Hyslop, E.J. 1987. The growth and feeding habits of *Clarias anguillaris* during their first season in the floodplain pools of the Sokoto-Rima River Basin Nigeria Journal of. Fish Biology, 30(2): 183–192

Kilgour, B.W. and Barton, D.R. 1999. Association between stream fish and benthos across environmental gradients in southern Ontario, Canada. Freshwater Biol., 41: 553–566.

King, R.P. 1990. Some aspects of the reproductive strategy of *Ilisha africana* (Block 1795) (Teleostei: Clupeidae) in Iboe River estuary, Nigeria. Cybium, 15: 257–267.

King, R.P. 1996. The status and seasonality in the physico-chemical hydrology of a Nigerian rainforest Pond Jpn. J. Limn., 52(1): 1–12.

Lagler, K.F., Bardach, J.E., Miller, R.R. and Passion, D.R.M. 1977. Ichthyologia. Willey, New York: 506–520.

Madu, C.T., Fodike, E.B.C. and Ita, F. 1990. Food and feeding habits of hatchlings and the mudfish *Clarias gariepinus*. Journal of Aquatic Science, 5: 27-32.

Merron, G.S. 1993. Pack-hunting in two species of catfish, *Clarias gariepinus* and *C. ngamensis*, in the Okavango Delta, Botswana. Journal of Fish Biology, 43(4): 575–584.

Rimmer, M.A. and Merrick, J.R. 1983. A review of the reproduction and development in the fork-tailed catfishes (Ariidae). J. Limnol. Soc. Lond., 107: 41-50.

Robbins, H.R. 2004. Description: walking catfish-*Clarias batrachus*.US Geological Survey, Florida, 7 pp.

Sydenham, D.H.J. 1975. Observations on the fish populations of a Nigerian forest stream Revue de Zoologie Africaine, 89(2): 257-272.

Teugels, G.G. 1986. A systematic revision of the African species of the genus *Claries* (Pisces: Clariidae) Museum Resource Africa Centre, Belgium: 63-72.

van der Waal, B.C.W. 1974. Observations on the breeding habits of *Clarias gariepinus*. Journal of Fish Ecology, 6: 23-27.

van der Waal, B.C.W. 1975. Observations on the breeding habits of African catfish, *Clarias gariepinus* (Burchell). J. Fish Biol., 48: 6-10.

Venden Bossche, J.P. and Bernacsek, G.M. 1990. Source book for the inland fishery resources of Africa. 2. CIFA Technical Paper 18.2, FAO, Rome, 411 pp.

Varghese, T.J. 1961. Observations on the biology of *Racanda russelliana* (Gray). Indian Journal of Fisheries, 8: 96-100.

Viser, S.A. 1970. Kainji, a Nigerian man-made lake. Kainji Lake studies. Nigerian Institute of Social and Economic Research, Ibadan, 126 pp.