THE BIOLOGY OF THE WEST AFRICAN CLARIID, *Clarias macromystax* GUNTHER, 1864 (OSTEICHTHYES: CLARIIDAE) IN A NIGERIAN RIVER BASIN

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ABSTRACT

The biology of the West African clariid, Clarias macromystax, was studied in Anambra river basin, Nigeria. The clariid occurred more abundantly and frequently in forest floodplain ponds than in other habitats, and was totally absent in the river systems. Length ranged from 9.7 to 30.2 cm TL and weight from 9 to 168 g; females were heavier, but not longer, than males. The b-values (2.4190-2.5209) of the total length-weight relationships exhibited negative allometric function. Mean relative condition, K_n, was better in females than males but showed a definite cycle in both sexes. Over 50% of both sexes were mature at 15.1-20.0 cm TL in their first year of life. Fecundity ranged from 2.136×10^3 to 37.250×10^3 (mean $14.942 \times 10^3 \pm 11.248 \times 10^3$) and correlated highly and positively with length, body weight and ovary weight. Ovary weight was the best predictor of fecundity. Communal spawning involving C. macromystax and C. agboyiensis occurred. Feeding was carried out throughout the day with higher feeding intensity at night. Food of primary importance were Caridina niloticus, Sudanonautes africanus, Odonata naiad, terrestrial Orthoptera, formicoid Hymenoptera, Dytiscidae, Oreochromis niloticus, Parachanna obscura, fruits and seeds, plant detritus and mud. Diet breadth was season-dependent. The clariid fed by foraging, shoveling and surface feeding. E. clarias, Procamallanus laevichonchus and a larval spiruroid parasitized various organs. C. macromystax is a new host record for these helminth parasites.

Keywords: *Clarias macromystax,* Abundance, Reproduction, Food, Parasites, Anambra river basin, Nigeria.

INTRODUCTION

Eleven *Clarias* species – *C. agboyiensis, C. buettikoferi, C. dialonensis, C. ebriensis, C. laeviceps, C. lamottei, C. longior, C. maclaremi, C. macromystax, C. salae* and *C. submarginatus* -- are endemic in the coastal forested areas of West Africa and each of them has very restricted distribution. For example, *C. macromystax* is restricted to the coastal basins from Benin to Nigeria. *C. macromystax, C. agboyiensis* and *C. ebriensis* occur in the guinean zone of Nigeria, but *C. macromystax* also inhabits the soudanean zone. Except for species of the subgenera *Dinotopteroides* and *Clarias*, there appears to be a marked tendency for increased speciation of species of other genera of *Clarias* in the waters of forest areas (Sydenham, 1980). *C. macromystax* is the least abundant of clariids of the subgenera *Clarioides* and *Anguilloclarias*, which occur in the Anambra river basin (Ezenwaji, 1992, 1993). The clariid is usually abundant in some floodplain ponds where it is cultured semi-intensively. Like other clariids, its flesh is very tasty and it contributes to the protein intake of the riverine people.

There is remarkable paucity of information on all aspects of the biology of *C. macromystax*. The purpose of this contribution is to fill this information gap and to investigate the distribution, abundance, population structure, reproduction, food and parasites of *C. macromystax* in the Anambra river basin, southeastern Nigeria.

MATERIALS AND METHODS

Samples of *C. macromystax* were collected from Nsugbe, Otuocha, Oroma-etiti, Enugwu-otu, Ogurugu and Ugwuoba in the Anambra river basin (Ezenwaji, 2002). Collections were made in these sampling locations from June, 1983 to September 1985, June to September 1986, January to May 1987 and May to December 1997 with 200 baited hook (No. 17) and line, 10 fishing baskets and 30 hoop fyke traps. Each sampling location was divided into four major habitats – forest floodplain pond (ffp), grassland floodplain pond (gfp), marshy area (m) and river (r). Each of the four sets of 200 lines set overnight (18.00 – 07.00 h) in each sampling location was taken as a unit of effort used to determine distribution and abundance of the clariid.

Standard (snout to end of caudal peduncle) and total lengths (SL and TL, to the nearest centimeter) and body weight (to the nearest gram) of each *C. macromystax* were measured and the sex of fish above 9.0 cm TL was determined by examining the genital papilla (pointed in males) and/or the gonads microscopically. The total length-standard length,

Table 1: Abundance and percentage frequency of occurrence (%FO) of *C. macromystax* (n = 255) using experimental gear (200 baited hook and line)

	No. and %FO in habitats (values in parentheses show weight (kg))								
	ffp[a]		gfp[b]		r		m[c]		Location total
Location	**No.**	**%FO**	**No.**	**%FO**	**No.**	**%FO**	**No.**	**%FO**	
Nsugbe	25(1.4)	96	9(0.5)	33	0(0)	0	0(0)	0	34[i](1.9)
Oroma-etiti	27(1.5)	100	16(0.9)	83	0[d](0)	0[d]	8(0.4)	39	51[h](2.8)
Otuocha	13(0.7)	50	7(0.4)	29	0[e](0)	0[e]	0(0)	0	20[j](1.1)
Enugwu-otu	21(1.2)	100	5(0.3)	28	0(0)	0	0(0)	0	26[g](3.9)
Ogurugu	31(1.7)	100	29(1.6)	100	0(0)	0	11(0.6)	56	71[g](3.9)
Ugwuoba	28(1.6)	100	16(0.9)	80	0[f](0)	0[f]	9(0.5)	45	53[h](3.0)
Habitat Total	145(8.1)		82(4.6)		0(0)		28(1.5)		255(14.2)
% Habitat total[+]	56.9[k](57.0)		32.2[l](32.4)		0(0)		11.0[m](10.6)		
Habitat %FO		91		59		0		23	

[+] **Figures in the % habitat total row and location total column with the same letter are not significantly different, P = 0.05;* [a] *Forest floodplain pond;* [b] *Grassland floodplain pond;* [c] *Marshy area;* [d] *Ezechi river;* [e] *Anambra river,* [f] *Ezu river*

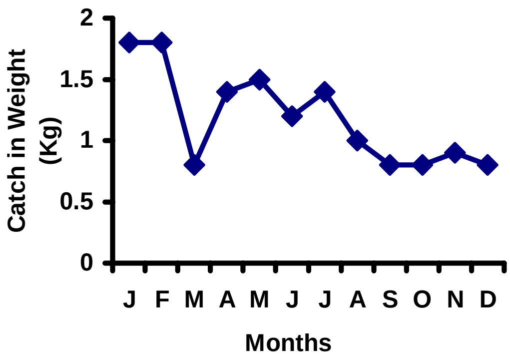

Figure 1: Changes in the monthly abundance of *C. macromystax* in the Anambra river basin

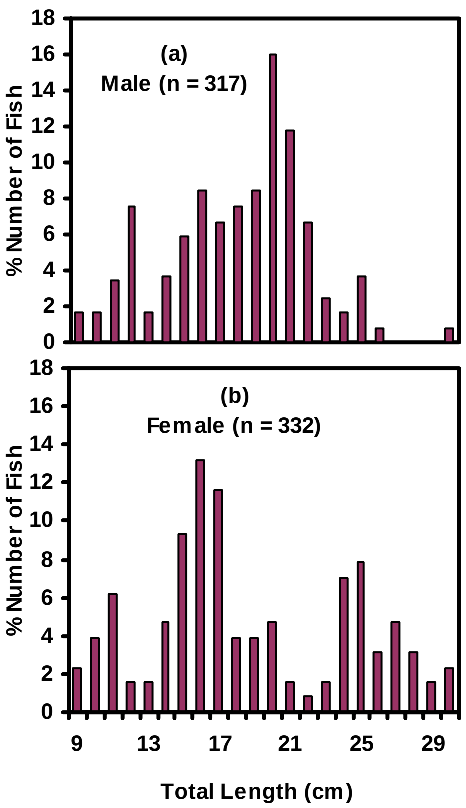

Figure 2: Length - frequency distribution of male (a) and female (b) *C. macromystax* in the Anambra river basin

and length-weight, relationships were determined using the power curves, $TL=aSL^b$ and $W = aTL^b$ respectively. Relative condition factor (K_n) was estimated as $K_n = W/aTL^b$ (Le Cren, 1951).

The gonad maturity stages for this clariid were delimited as in Ezenwaji (2002) as follows: I – immature, II – developing; III – mature; IV – ripe; V – running; VI – spent. Gonad stages IV and V in the male were indistinguishable from stage III, so the three stages were grouped under stage III. Thus, four stages were recognized in the male. Size at maturity was determined as the size at which 50% of individuals were in gonad stage III. Absolute fecundity, defined as the number of ripening oocytes in the female ovaries prior to the next spawning period (Bagenal, 1978), was determined by counting all ripe oocytes in both ovaries. Regression analyses of fecundity (F) on SL, TL, body weight (W_b) and ovary weight (W_o), and of gonadosomatic index (GSI) on F were performed using the least squares method. Observations on spawning aggregation, migration and actual spawning were made from elevated platforms along the banks and on spawning grounds.

The relative volume of food in each fish stomach was determined irrespective of fish size. The degree of stomach fullness was estimated by an arbitrary 0 – 16 point scale as follows: 16 points for full, 12 for ¾ full, 8 for ½ full, 4 for ¼ full, 2 for 1/8 full, 1 for traces of food and 0 for empty stomach. Stomach fullness of 22 specimens caught at night (19.30 – 05.00 h) and 30 caught during the day (08.00-17.00 h) were used to evaluate diel-feeding activity. The vacuity index was calculated as the number of empty stomachs divided by the total number of stomachs examined multiplied by 100. Stomach contents were sorted into species/groups and analyzed for dry weight and relative frequency (Hyslop, 1980). The latter was calculated as the frequency of each food category expressed as a percentage of the sum of the frequencies of all food items (King, 1988) as

Table 2: The sex ratio of *C. macromystax* in Anambra river basin

Month	Overall Number collected M	Overall Number collected F	Sex ratio (M:F)	In gonad stages III-V Number collected M	In gonad stages III-V Number collected F	Sex ratio (M:F)	On spawning run Number collected M	On spawning run Number collected F	Sex ratio (M:F)
January	32	26	1:0.8	6	16	1:2.7	-	-	-
February	29	24	1:0.8	11	6	1:0.5	-	-	-
March	15	20	1:1.3	4	10	1:2.5	-	-	-
April	22	22	1:1.0	16	14	1:0.9	-	-	-
May	33	39	1:1.2	27	32	1:1.2	-	-	-
June	37	51	1:1.4	29	44	1:1.5	14	19	1:1.4
July	29	38	1:1.3	4	14	1:3.5	2	5	1:2.5
August	21	34	1:1.6	4	10	1:2.5	2	2	1:1
September	14	18	1:1.3	6	1	1:0.2	-	-	-
October	24	19	1:0.8	9	4	1:0.4	-	-	-
November	31	28	1:0.9	5	6	1:1.2	-	-	-
December	30	33	1:1.1	8	10	1:1.3	-	-	-
Total	317	352	1:1.1	129	167	1:1.3	18	26	1:1.4

Table 3: TL – SL (a), SL – weight (b) and TL-weight (c) relationships of male, female and both sexes of *C. macromystax*

a)		SL (cm)			TL-SL relationships		
Sex	**n**	**Min.**	**Max.**	**Mean (S.D)**	**a**	**b**	**r^2**
Male	49	8.5	26.9	15.7± 1.6	1.1905	0.9813	0.997
Female	55	8.4	26.7	15.4± 5.8	1.2066	0.9800	0.997
Both sexes	104	8.4	26.9	15.5± 4.7	1.2060	0.9786	0.997

b)		SL (cm)			SL-weight relationships		
Sex	**n**	**Min.**	**Max.**	**Mean (S.D)**	**a**	**b**	**r^2**
Male	49	8.5	26.9	15.7± 1.6	0.0598	2.3678	0.947
Female	55	8.4	26.7	15.4± 5.8	0.0496	2.4804	0.969
Both sexes	104	8.4	26.9	15.5± 4.7	0.0545	2.4246	0.956

c)		TL (cm)			TL-weight relationships		
Sex	**n**	**Min.**	**Max.**	**Mean (S.D)**	**a**	**b**	**r^2**
Male	49	9.9	30.2	18.8± 1.2	0.0386	2.4190	0.955
Female	55	9.7	30.1	18.3± 6.2	0.0317	2.5209	0.964
Both sexes	104	9.7	30.2	18.5± 5.3	0.0345	2.4751	0.957

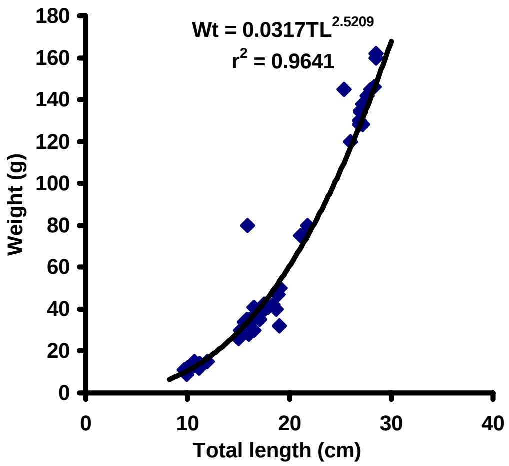

Figure 3: Length-weight relationship of female *C. macromytax* in Anambra river basin

follows: $\% RF = 100(ai / \sum_{i=1}^{n} A)$ where ai = the frequency of item a_i, and A = the frequency of the n^{th} item. The dietary importance of each food item was then expressed as an index of food significance (IFS) as follows: $IFS = \% RF \times \% W_t / \sum (\% RF \times \% W_t) \times 100$.

Food items with IFS ≥ 1.5% were considered primary, whereas those with IFS ≥ 0.01% but <1.5% were secondary food items. IFS data were used to compute diet breadth based on Shannon-Wiener function $(\overline{H})$ derived from the equation:

$$\overline{H}_{(IFS)} = -\sum_{i=1}^{s} (ni/N)\log_e(ni/N)$$

where n_i = the IFS of each food item, and N = the total IFS of all food items.

Food richness was defined as the number of food items in the diet with IFS ≥ 0.01%.

The helminth parasites were investigated by examining the external and internal organs. Further treatment of the parasites was as in Ezenwaji and Inyang (1998).

Data for the same month in different years were pooled. Abundance data were tested for normality and analyzed using a two-way ANOVA. Relative condition and food composition were analyzed

Table 4: Size at maturity of *C. macromystax* in Anambra river basin

Length group (cm TL)	Male		Female	
	Sample size (breeding)	% Breeding	Sample size (breeding)	% Breeding
<10.0	24(0)	-	19(0)	-
10.1 – 15.0	19(5)	26.3	13(3)	23.1
15.1 – 20.0	39(26)	66.7	34(23)	67.6
20.1 – 25.0	11(9)	81.8	22(20)	90.9
25.1 – 30.0	7(7)	100	9(8)	88.9

** Percentage of males and females in breeding condition (gonad stages III – V) by size groups are shown.*

Table 5: Regression equations for the relationships between fecundity and total length, standard length, body weight and ovary weight ($F = aL^b$, $F = \alpha + \beta X$ and GSI and fecundity ($GSI = aF^b$) in *C. macromystax*

Variable	Unit	a	b	r^2	p
(a) Fecundity					
Total length	cm	0.049	3.983	0.855	<0.001
	mm	5.66×10^{-6}	3.965	0.853	<0.001
Standard length	cm	0.135	3.812	0.860	<0.001
	mm	2.1×10^{-5}	3.812	0.859	<0.001
Body weight	g	46.035	1.260	0.822	<0.001
	g	-3998.709	208.996	0.775	<0.001
Ovary weight	g	933.149	0.987	0.995	<0.001
	g	536.767	861.281	0.993	<0.001
(b) GSI					
Fecundity		0.545	0.36	0.55	<0.001

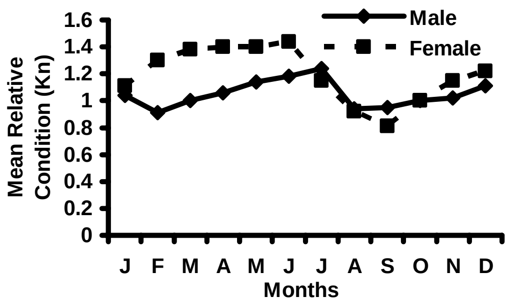

Figure 4: The mean monthly relative condition of C. macromystax in Anambra river basin (95 % confidence limits are indicated).

with Student's t-test, whereas sex ratio was analyzed using χ^2 test. Terminology of infection statistics (Margolis *et al.,* 1982) as modified by Bush *et al.* (1997) was employed in the analysis of parasite data. Differences were considered significant at 5% level of probability.

RESULTS

Distribution and Abundance: *C. macromystax* was caught, but unevenly distributed, in the locations (Table 1). Its distribution in the habitats showed that the clariid preferred ffps, with a habitat frequency of occurrence of 91%, and was totally absent from the rivers.

The number of the clariid in Ogurugu was significantly higher than in other locations (P < 0.05), followed by Ugwuoba and Oroma-etiti, which were not different from one another (P > 0.05) (Table 1). Within the habitats, the clariid was most abundant in ffps. Peak catches occurred in January and February and from April to July, whereas low catches occurred from September to December and in March (Figure 1).

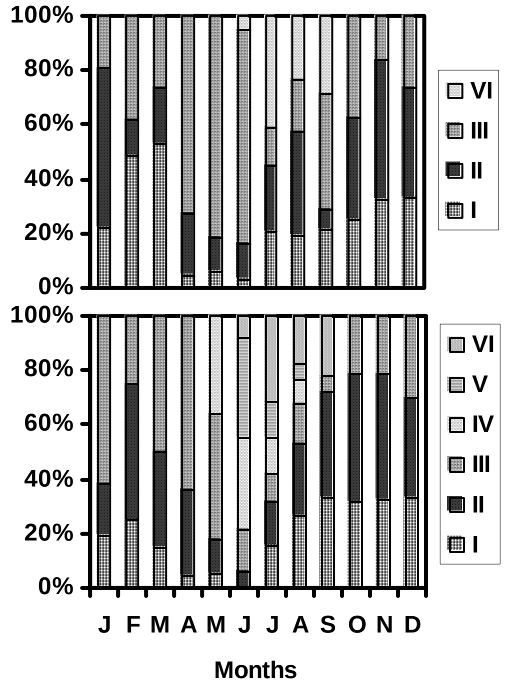

Figure 5: The monthly percentage distribution of male (a) and female (b) *C. macromystax* with gonads in different stages of maturity. Stages III - V are grouped under III in males

Size Range and Population Structure: The length of *C. macromystax* ranged from 9.7 to 30.2 cm TL. Males (range 9.9 – 30.2 cm TL, mean 18.8 ± 1.2 cm TL) were not longer than females (range 9.7 - 30.1 cm TL, mean 18.3 ± 6.3 cm TL) (P > 0.05), but females (range 9 – 162 g, mean 60.1 ± 50.3 g) were heavier than males (range 10 – 168 g, mean 50.0 ± 28.5 g) (P < 0.05). Both sexes had two modes but while the females had one big mode at 16 cm TL and a small one at 25 cm TL, males had the big mode at 20 cm TL and the small one at 12 cm TL (Figure 2). Females were clearly dominant from 24 – 30 cm TL. The monthly overall sex ratio (M, 317:F, 352; X^2 =1.83) and the ratio on spawning run (M, 18 : F, 26; χ^2 = 1.45) (Table 2) did not differ significantly from 1:1 sex ratio (P>0.05), but the ratio in gonad stages III – V (M, 129:F, 167; χ^2 = 4.88) differed significantly.

Within the months females were dominant in August in overall, in January, March, June to August in gonad stages III – V and in July during spawning run. Males were predominant in February and September to October in gonad stages III-V.

Table 6: The tropic spectrum and index of food significance (IFS) of the diet of *C. macromystax* in Anambra river basin

Food species/group	%RF	%Wt	IFS
Rotifera			
Keratella cochlearis	0.29	+	+
Annelida			
Libyorilus sp	0.44	1.34	0.22
Leeches	0.58	1.91	0.41
Arachnida			
Water mite	0.44	+	+
Crustacea			
Ostracoda	7.84	0.07	0.20
Bosmina longirostris	3.48	0.01	0.01
Daphnia sp	4.79	0.02	0.04
Thermocyclops sp	1.02	+	+
Caridina noloticus	1.89	4.30	2.99
Sudanonaues africanus	1.45	4.46	2.38
Insecta			
Povilla adusta	4.21	0.1	0.15
Odonata naiad	2.32	2.31	1.97
Terrestrial Orthoptera	3.05	16.48	18.50
Carixa sp	2.18	0.02	0.02
Gerris sp	0.58	0.01	+
Peidae	0.44	+	+
Trichoptera larvae	1.45	0.04	0.02
Chironomidae	14.66	0.15	0.81
Chaoborus larvae	0.73	+	+
Mosquito larvae and pupae	4.79	0.06	0.11
Formicoid Hymenoptera	4.21	4.80	7.44
Dytiscidae	7.40	5.25	14.30
Fish			
Oreochromis niloticus	2.76	25.71	26.12
Parachanna obcura	1.16	18.47	7.89
Phractolaemus ansorgi	0.16	0.72	0.04
Tilapia fry	1.16	3.18	1.36
Amphibia			
Tadpole	0.44	0.21	0.03
Algae			
Spirogyra sp	3.34	+	+
Zygnema sp	0.58	+	+
Microcystatis sp	0.29	+	+
Scenedemus sp	1.74	+	+
Navicula sp	1.02	+	+
Fruits and seeds	3.34	7.56	9.29
Plant detritus	7.11	1.17	3.06
Mud	5.08	0.84	1.57
Sand grains	3.63	0.80	1.07

Morphometric Relationships: The relationship between SL and TL (TL = aSL^b) of male, female and both sexes of *C. macromystax* (Table 3a) showed that their b-values were not different from 1 (P>0.05) and that their correlation coefficients were high, positive and significant (r = 0.998, P < 0.001). For the SL-weight (Table 3b) and TL-weight (Table 3c) (Figure 3) relationships, the intercept, a, and the b-values showed high homogeneity. The b-values revealed negative allometric LWR.

Relative Condition, K_n: The mean monthly relative condition (K_n) was 1.05 ± 0.10 (range 0.91 ± 0.04 – 1.24 ± 0.04) in the male, and 1.19 ± 0.21 (range 0.81 ± 0.11 – 1.44 ± 0.08) in the female (Figure 4). The mean K_n rose steadily from October to a peak in June after which it gradually fell to the lowest value in September. A definite cycle was, therefore, established. Generally, females were in better condition than the males.

Reproduction: The monthly percentage distribution of male and female gonad maturity stages (Figures 5a and b) showed that immature, developing and mature gonads occurred all the year round. The high numbers of immature individuals of both sexes from July to March showed that the clariid was recruited into the artisanal fishery during this period. Gonad recrudescence lasted seven months (October – April). At this time, ripe, running or spent individuals were totally absent. The breeding season was from May to September when ripe and running individuals were present in the population.

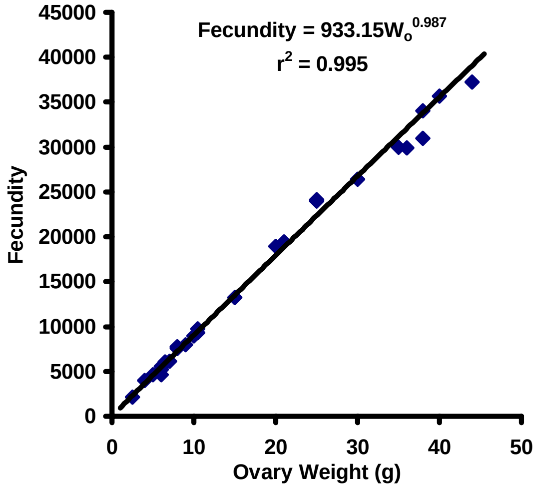

Figure 6: The fecundity - ovary weight relationship of *C. macromystax* in Anambra river basin

Over 50 % of both sexes were mature at 15.1 - 20.0 cm TL in their first year of life (Table 4). The smallest mature female and male were 13.8 cm TL and 13.1 cm TL respectively. The fecundity of 31 ripe female *C. macromystax* ranged from 2.136 x 10^3 to 37.250 x 10^3 (mean 14.942 X 10^3 ± 11.248 x 10^3). The regression equations for the relationships between fecundity and total length, standard length, body weight and

Table 7: Monthly IFS of *C. macromystax* in Anambra river basin

	Months											
Food species/group	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Rotifera												
K. cochlearis	-	0.01	-	-	-	-	+	-	-	-	-	-
Annelida												
Libyodrilus sp	-	-	-	-	-	-	-	0.31	18.12	-	-	-
Leaches	3.77	-	-	-	-	-	-	-	-	5.15	4.42	5.44
Arachnida												
Water mite	-	-	-	0.02	-	-	-	-	-	-	-	-
Crustacea												
Ostracoda	0.08	0.21	0.03	0.02	0.07	0.01	0.22	0.36	0.05	0.11	0.11	0.07
B. longirostris	0.01	-	0.06	-	0.02	0.01	0.01	0.02	-	-	-	0.03
Daphnia sp	0.01	0.01	0.01	+	0.09	0.02	0.05	0.02	0.02	0.03	0.03	0.08
T. crassus	-	0.03	0.01	-	-	-	+	-	-	-	-	0.01
C. niloticus	-	-	38.37	5.26	2.89	-	-	2.63	9.71	2.14	2.14	5.27
S. africanus	2.43	36.21	3.40	2.34	7.71	-	-	-	3.24	-	-	21.05
Insecta												
Povilla adusta	0.10	0.18	-	0.46	-	-	0.10	0.22	0.02	0.07	0.03	0.25
Odonata naiad	1.22	-	-	-	-	0.75	2.24	1.92	2.43	4.98	0.71	1.76
Terrestrial Orthoptera	5.48	13.60	7.67	10.52	8.67	30.45	14.01	4.42	7.29	7.48	38.43	7.90
Corixa sp.	-	0.03	0.03	0.14	0.07	-	0.01	0.03	-	-	-	-
Gerris sp.	-	-	-	0.01	-	-	0.01	-	-	-	-	-
Pleidae	-	-	-	0.05	-	-	-	-	-	-	-	-
Trichoptera larvae	-	0.06	0.03	0.24	0.20	0.03	-	-	-	0.10	-	-
Chironomidae	0.09	0.73	0.39	0.14	0.49	0.70	0.39	0.62	0.25	0.50	0.52	0.77
Chaoborus sp	-	-	-	-	-	-	-	0.01	-	0.01	-	-
Mosquito larvae and pupae	0.03	0.15	0.09	0.05	0.13	0.14	0.06	0.02	0.02	0.22	0.03	0.09
Formicoid Hymonoptera	5.48	1.36	10.65	2.63	4.33	-	9.07	7.49	0.73	2.36	0.64	2.37
Dytistidae	8.76	7.24	1.02	8.43	5.78	16.90	14.55	11.10	2.91	4.48	2.57	3.16
Fish												
O. niloticus	41.37	25.69	-	-	65.41	-	9.53	59.63	54.99	56.41	48.39	14.91
P. obscura	-	-	24.70	67.93	-	43.58	28.90	1.59	-	-	-	-
P. ansorgi	-	-	7.67	-	-	-	-	-	-	-	-	-
Tilapia fry	-	7.55	-	-	-	-	-	0.27	-	-	-	-
Amphibia												
Tadpole	-	-	0.77	-	-	-	-	0.20	-	-	-	-
Algae												
Sprogyra sp.	+	+	+	-	-	+	+	+	+	+	+	+
Zyronema sp.	-	-	+	-	-	-	+	-	-	-	-	+
Microcystis sp.	-	-	+	-	-	-	-	-	+	-	-	-
Scenedemus sp.	-	-	-	-	-	-	+	+	-	-	-	-
Navicula sp	-	-	-	-	-	-	-	0.01	-	-	-	-
Fruits & seeds	24.33	-	-	-	-	4.14	16.91	5.70	-	6.64	-	22.80
Plant detritus	2.93	0.46	4.10	0.17	2.60	0.11	2.69	2.37	0.24	2.97	0.85	4.22
Mud	2.93	4.08	1.02	1.58	1.15	1.80	0.67	0.26	-	0.25	0.85	4.22
Sand grains	0.97	2.41	-	-	0.39	1.35	0.62	0.79	-	0.33	0.29	5.62
Food richness	17	18	18	17	16	14	18	23	14	18	15	19
Diet breadth	1.78	1.76	1.76	1.19	1.32	1.38	1.96	1.55	1.43	1.63	1.24	2.23
No. examined	14	14	15	16	14	17	31	30	13	16	17	15
No. with food	12	11	12	13	12	11	23	25	11	12	12	14

ovary weight ($F = aL^b$, $F = \alpha + \beta X$) showed that ovary weight had the best predictive value accounting for > 99.6 % of the variation in fecundity (Table 5a).

The GSI varied from 5 to 30.3 (mean 16.8 ± 6.0) and related exponentially to fecundity ($GSI = aF^b$) (Table 5b); the coefficient was high, positive and significant. Fecundity accounted for 74.2% of the variation in GSI.

The clariid spawned on the submerged grasses of adjacent areas of floodplain ponds from which it undertook short spawning run. It participated in communal spawning with *C. agboyiensis* on 17 July, 1997, 17 h after a heavy downpour which lasted almost two days.

Trophic Biology: Of the 212 *C. macromystax* (9.7 - 30.2 cm TL) stomachs examined, 44 (20.75 %) were empty and 168 (79.25 %) contained food. Only 28 (16.67 %) of the stomachs with food were full, whereas 140 (83.33 %) were partially filled. The mean vacuity index was 20.75 %. There were fuller stomachs during the night (19.30 – 05.00 h) than the day (08.00 – 17.00 h) indicating that the clariid fed more at night than during the day.

Generally, stomachs were less than half-full (Figure 7a). The mean stomach fullness index was 6.77 ± 1.09 (range 4.6 - 8.3); the index during the rains (6.92 ± 1.31) was not different from that in the dry season (6.62 ± 0.92) ($P < 0.05$). The mean percentage empty stomach was 20.3 ± 7.7 (range 6.7 – 35.3) indicating that stomachs generally contained food.

Table 8: Seasonal variation in the IFS of *C. macromystax* in the Anambra river basin

Food species/group	Season: Dry	Rainy	P
Rotifera			
K. cochlearis	+	+	ns
Annelida			
Libyodrilus sp	+	0.38	
Leaches	3.32	-	
Arachnida			
Water mite	-	+	
Crustacea			
Ostracoda	0.10	0.22	<0.05
B. longirostris	0.01	0.03	<0.05
Daphnia sp	0.03	0.03	ns
T. crassus	+	+	ns
C. niloticus	4.02	1.82	<0.05
S. africanus	9.37	0.38	<0.05
Insecta			
Povilla adusta	0.10	0.14	ns
Odonata naiad	1.34	1.76	ns
Terrestrial Orthoptera	16.89	14.39	ns
Corixa sp.	+	0.04	<0.05
Gerris sp.	-	+	
Pleidae	-	+	
Trichoptera larvae	0.02	0.01	<0.05
Chironomidae	0.67	0.60	ns
Chaoborus sp	+	+	ns
Mosquito larvae and pupae	0.13	0.07	<0.05
Formicoid Hymonoptera	5.15	6.58	ns
Dytistidae	6.03	15.16	<0.05
Fish			
O. niloticus	36.39	29.11	<0.05
P. obscura	0.98	17.86	<0.05
P. ansorgi	0.30	-	
Tilapia fry	0.17	0.04	<0.05
Amphibia			
Tadpole	0.03	0.03	ns
Algae			
Sprogyra sp.	+	+	ns
Zyronema sp.	+	+	ns
Microcystis sp.	+	+	ns
Scenedemus sp.	-	+	
Navicula sp	-	+	
Fruits and seeds	7.42	7.50	ns
Plant detritus	3.62	2.33	<0.05
Mud	2.58	0.83	<0.05
Sand grains	1.34	0.68	<0.05
Food richness	23	23	
Diet breadth	2.11	2.03	
No. examined	91	121	
No. with food	73	95	

Thirty-six different food items were ingested (Figure 6). Of these, only six constituted primary food items. The dominant food groups, in order of importance, were insects, fish, fruits and seeds, crustaceans and plant detritus. Even though the diversity of insects in the diet was more than that of fish, the latter contributed to the diet in more months (9) than insects (3) (Table 7). Seven food items were ingested in all the months but only formicoid Hymenoptera was of primary importance. Food richness showed that the lowest number (5) of food items of primary importance occurred in June and November, whereas the highest (12) was in December. This latter month also had the highest diet breadth (2.23); the diet breadth of other months varied moderately.

The IFS of nine food items were higher in the dry season, and five during the rains (t-test, $P < 0.05$ in each case) (Table 8). Ten food items were of primary importance in the dry season, whereas nine were of primary importance during the rains. Quantitative food composition was the same in both rainy and dry season. Diet breadth was slightly season -dependent.

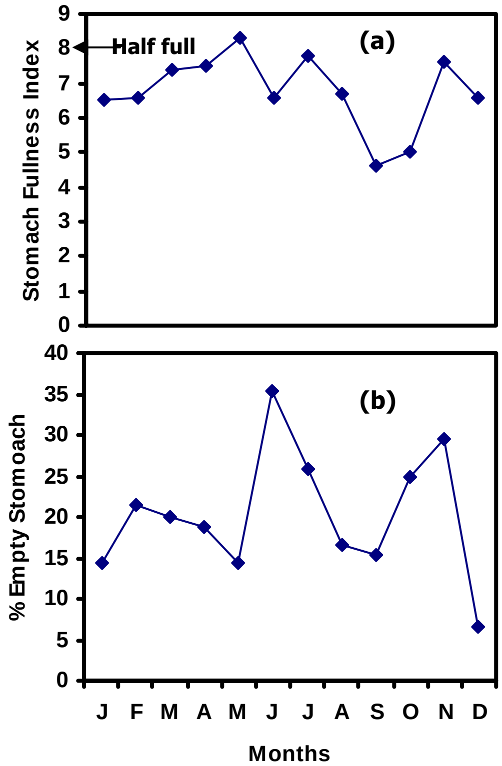

Figure 7: The monthly stomach fullness index (a) and percentage empty stomach (b) of *C. macromystax* in the Anambra river basin

C. macromystax fed by foraging, shoveling and surface feeding. Many food items of primary importance were ingested employing the latter method of feeding in this clariid.

Parasites: Three helminth parasites were recovered from the 164 *C. macromystax* examined. These were the metacercariae of *Euclinostomum clarias* Dubois (Digenea), *Procamallanus laevichonchus* (Wedl) and a larval

Table 9: The parasite spectrum and their overall prevalence (a) and the prevalence in relation to site in the host (b) in *C. macromystax* (n = 164) in Anambra river basin

	Parasite species	Sites in host	No. of fish infected	Total no. of parasites recovered	Prevalence	Mean intensity	Mean abundance
a)	**Parasite spectrum and their overall prevalence**						
	Euclinostomum clarias	Liver, gut mesentery, ovary and kidney	45	325	27.44	7.22	1.98
	Procamallanus laevichonchus	Stomach and rectum	5	9	3.05	1.8	0.05
	Larval spiruroid	Muscle, kidney and coelom	10	19	6.10	1.9	0.12
b)	**Prevalence in relation to sites in host**						
	E. clarias	Liver	29	248	17.68	8.55	1.57
		Gut mesentery	8	49	4.88	6.13	0.30
		Kidney	3	7	1.83	2.33	0.04
		Ovary	5	21	3.05	4.2	0.13
	P. laevichonchus	Stomach	4	6	2.44	1.5	0.04
	Larval spruriod (f. Physalopteridae)	Muscle	5	10	3.05	2.0	0.06
		Kidney	4	8	2.44	2.0	0.05
		coelom	1	1	0.61	1.0	0.01

spiruroid (f. Physalopteridae) (Nematoda) (Table 9a). *E. clarias* was the most prevalent and parasitized the liver, gut mesentery, ovary and kidney of the host. The liver was more heavily parasitized than other sites (Table 9b). The number of oocytes in parasitized ovaries was not different from that of non-parasitized ones ($P < 0.05$). In 45 hosts, seven (15.56 %) were simultaneously infected in the liver and gut mesentery by *E. clarias*, whereas one (2.22 %) was simultaneously infected in the liver and ovary. The prevalence, mean intensity and mean abundance of *E. clarias* and the larval spiruroid were significantly more in the dry than the rainy season ($P < 0.05$). The mean abundance of *E. clarias* and the larval spiruroid were not different between the sexes.

DISCUSSION

The total absence of *C. macromystax* from the river systems (Table 1) may be attributed to the hydrologic regime, unfavourable habitat and inability to disperse adequately, but it appears to be causally related to food supply and ichthyophagic predation pressure. In rivers, large, social hunting fish predators, such as *Clarias gariepinus* (Bruton, 1979), using juvenile *C. macromystax* as forage species (pers. obs), preclude the latter from the river habitat, as is the case, to a lesser extent, with *C. agboyiensis* and *C. albopunctatus* (Ezenwaji and Inyang, 1998; Ezenwaji, 1999). In addition, abundant food supply in the floodplain ponds probably offers little incentive for the clariid to migrate. In fact, most food of primary importance ingested by this clariid, such as terrestrial Orthoptera, formicoid Hymenoptera, fruits and seeds, plant detritus, Odonata nymph and fish, are either allochthonous from the dense overhanging vegetation in forest floodplain ponds or autochthonous but abundant in these habitats. This rich food supply promotes rapid growth and good recruitment; thus, over 89% of the *C. macromystax* of this study came from floodplain ponds, which are almost predator-free. The virtual restriction of *C. macromystax* in floodplain ponds, unlike *C. albopunctatus* present in all habitats (Ezenwaji, 1999), is probably the reason why it is the least abundant, and *C. albopunctatus* the most abundant, of the seven *Clarias* species of the Anambra river basin (Ezenwaji, 1986, 1992).

The 1:1 sex ratio in *C. macromystax* on spawning run (Table 2) appears to have some relationship with communal spawning observed in *Clarias* species of the Anambra river basin (Ezenwaji, 1992). The synchrony of endogenous and exogenous factors in these clariids and the pairing of the sexes prior to spawning suggest a 1:1 rule observed for the clariids on spawning run. In the situation of communal spawning and where sperms are released externally, the probability of hybridization becomes high. In fact, this may be responsible for the very high speciation of some clariids in forest coastal areas (Sydenham, 1980) and the observed difficulties in the precise identification of African *Clarias* species.

The food of *C. macromystax* is consistent with the food of other clariids of the subgenera *Clarioides, Anguilloclarias* and *Brevicephaloides* in its high content of insects (Jackson, 1961; Corbet, 1961; Welcomme, 1985; Bruton, 1979). Thus, terrestrial Orthoptera was the only food item of primary importance in all the months (Table 17). However, fish (*O. niloticus* and *P. obscura*) made the highest contribution energetically in most of the months. The dependence on food of allochthonous origin is probably why *C. macromystax* is much more abundant in forest floodplain ponds with overhanging canopies than in other habitats. The slightly higher diet breadth in the dry (2.11) than during the rains (2.03) indicates depressed resource abundance in the dry season. This is consistent with the optimal foraging theory (Schoener, 1971), which postulates that as diet breadth increases; resource abundance decreases, and vice versa. Studies in the topics, which also show lower resource abundance and higher diet breadth in the dry season are those of Zaret and Rand (1971), Welcomme (1979, 1985), Lowe-McConnell (1975) and King (1988). Conversely, the rainy season showed decreased diet breadth and increased resource abundance.

C. macromystax is a new host record for the helminth parasites reported in this study. The most important of these in terms of fisheries importance is *E. clarias* metacercariae, which parasitized the liver of *C. macromystx* much more than any other clariid of the basin (Ezenwaji and Ilozumba, 1992). As *E. clarias* has also been recovered from the body cavity of *Clarias angolensis* in Angola, recorded in *Clarias anguillaris* in Zaria (Shotter, 1980) and from many organs in *C. ebriensis, C. agboyiensis, C. albopunctatus* and *C. buthupogon* in the Anambra river basin (Ezenwaji and Ilozumba, 1982), it appears that the parasite may be more widely distributed in African *Clarias* species than was hitherto realized. This is the first report of the recovery of *E. clarias* in the liver, gut mesentery, kidney and ovary of *C. macromystax.* When infected with over 25 *E. clarias,* as in a 20.7 cm TL *C. macromystax,* the liver appeared diseased, the fish looked emaciated and metacercariae had escaped from their cysts and were free in the coelom. Unlike the nematode, *Philometra translucida,* which inhibits the eggs of *Pseudotolithus senegalensis, P. typus* and *P. elongatus* from growing to maturity and significantly lowers their fecundity (Anyanwu, 1983), *E. clarias* parasitizing the ovaries of clariids does not appear to be normal ovarian parasite. Consequently, the fecundity of *C. macromystax* is apparently unaffected.

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