Size, Length-Weight Relationships, Reproduction And Trophic Biology Of *Chrysichthys nigrodigitatus* And *Chrysichthys auratus* (Siluriformes: Bagridae) In A Natural West African Lake

Inyang, N. M. and Ezenwaji, H. M. G.
Fisheries & Hydrobiology Research Unit, Department of Zoology,
University of Nigeria, P.O. Box 3140, Nsukka, Nigeria.

Corresponding author: Ezenwaji, H. M. G., Fisheries & Hydrobiology Research Unit, Department of Zoology, University of Nigeria, P.O. Box 3140, Nsukka, Nigeria.

Abstract

Size, length-weight relationships, reproduction and trophic biology of *Chrysichthys auratus* and *C. nigrodigitatus* were investigated from May, 1990 to July, 1991 as part of the bio-limnological study programme of Agulu lake. *C. auratus* was more abundant and significantly longer (SL) than *C. nigrodigitatus*. As an assemblage, the population of *Chrysichthys* species exhibited isometric length-weight relationship (LWR) (b = 3.109±0.281) thus obeying the 'cube' law. Fecundity ranged between 625 and 2184 oocytes (mean 1163±461 oocytes) in *C. auratus* and between 733 and 1988 oocytes (mean 1261±384 oocytes) in *C. nigrodigitatus*. Mean exponent ($\bar{b}$ = 1.765±0.382) of the length-fecundity relationship (LFR) is less than 3 indicating that the *Chrysichthys* species exhibit substantial fish size – egg size changes. The mean weight exponent ($\bar{b}$ = 0.56±0.23) of the weight-fecundity relationship (WFR) is significantly different from 1 showing that fecundity does not relate linearly with weight. Standard length (SL) is the best predictor of fecundity in *C. auratus* while in *C. nigrodigitatus* it is body weight (B_w). Breeding in *C. auratus* occurred between April and September. The diameter of ripe oocytes was 2.04 ± 0.32 mm in *C. auratus* and 2.1±0.36 mm in *C. nigrodigitatus*. The species fed on both plant and animal materials with the animal component dominating [56.8% and 62.1% percentage frequency of occurrence (%FO); 53.6% and 42.6% volumetric index (VI) for *C. auratus* and *C. nigrodigitatus* respectively]. The high Spearman's rank coefficient (r = 0.75) and the Raabe's factor (R = 59.0%, %FO; 56.8%, VI) show strong similarity and overlap in the food types of the two species. Similarly, Raabe's factor (R = 62.7%) indicates trophic niche overlap between the small- [8 – 14 cm standard length (SL)] and large-sized (≥ 15 cm SL) individuals of *C. auratus*.

Key words: Size, morphometric relationships, reproduction, food, *Chrysichthys* species

Introduction

Chrysichthys species are widespread and common in Afro-tropical waters from Senegal and Nile southwards (Skelton, 1988). In these areas, they are much cherished as food and are good aquaculture candidates which adapt easily to various culture systems (Ezenwa, 1982; Erondu, 1990). The species constitute significant portions of fishers' catch in lake, river and lagoon fisheries in Nigeria (Fagade and Adebisi, 1979). In Agulu lake fishery, *Chrysichthys auratus* (Geoffroy Saint-Hilaire, 1809) and *C. nigrodigitatus* (Lacepede, 1803) form 36% by weight of the catch (Nnadozie, 2003).

Available information on aspects of the biology of *Chrysichthys* species in Nigeria indicate that they perform differently in different ecosystems (Imevbore, 1970; Fagade and Adebisi, 1979; Ikusemiju and Olaniyan, 1977; Sturm, 1984; Nwadiaro and Okorie, 1986, 1987; Erondu, 1990). Thus, for a fuller understanding of particular species, there is the need for the species to be studied in different ecosystems in which they occur to ensure proper utilization, management, conservation and culture of the species in a particular system.

Apart from the report of Nwadiaro and Okorie (1986, 1987) in Oguta lake, there is a dearth of information on aspects of the biology of *Chrysichthys* species in a natural lacustrine habitat in southeastern Nigeria. The present work, which is part of a larger study on the hydrobiology of Agulu lake, examines the size, length-weight relationships, reproduction and trophic biology of *C. auratus* and *C. nigrodigitatus*.

Materials and Methods

The study area was the six-armed, medium-sized Agulu lake located between 6° 01' and 6° 10'N and longitude 6° 35' and 7° 03'E (Fig. 1). The lake ultimately discharges into the River Niger at Atani through the Idemili river. It has three permanent surface water sources namely Idemili Omelagha, Utokoloafo and Egbulumawolo streams.

The climate of the study area shows distinct rainy (April-September/October) and dry (October/November-March) seasons. Seasonal fluctuations in water depth (Z_{max} 11.5-13.4 m) are moderate. The increase during the rains results mainly from run off from the catchment area into arm I. The lake surface area also fluctuates seasonally (ca 10 - 13 ha); the longest distance (that is, from arm I to arm VI) is 1.3 km. Maximum depth recorded (11.5 m) was in arm VI. The average depth is 4.7 m. Water surface temperature ranges from 24 – 32° C (Emejulu et al., 1992).

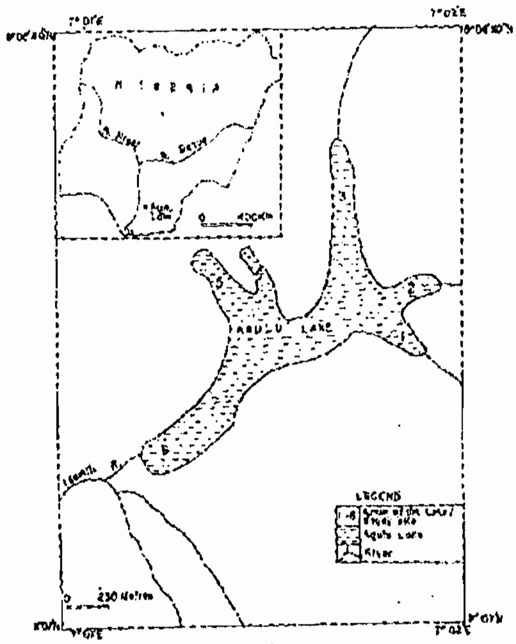

FIG. 1 : AGULU LAKE

The mean annual rainfall is 215 cm.

The lake lies within the tropical rainforest region and lake riparian vegetation of macrophytes, sedges and grasses is dense and is dominated by *Raphia hookeri* (Mann & Wendl) and *Elaeis guineensis* (Jacq). The zooplankton is dominated by cladocerans (Jeje, 1982), copepods and rotifers. The benthos at mid-lake is made up mainly of dipteran insects, particularly *Chaoborus* and *Chironomus* species. The West African broad-nosed crocodile, *Osteolaemus tetraspis*, is the most conspicuous reptile in the lake. It subsists on fish. In the shore areas, the abundant emergent/submerged vegetation and coarse materials are excellent habitats for freshwater gastropod molluscs, especially *Bulinus* spp., *Biomphalaria pfeiffery* (Krauss) and *Lymnaea* *natalensis* (Krauss), transmitting schistosome parasites of human and veterinary importance (Emejulu *et al.*, 1994The diversity of natural fish food organisms makes Agulu lake a very conducive breeding ground for many fish species, particularly *Heterotis niloticus*, *Mormyrus rume*, *Heterobranchus longifilis* and Chrysichthys species.

The *C. nigrodigitatus* and *C. auratus* used in this study were collected monthly from Agulu lake between May, 1990 and July, 1991 inclusive using cast net, seine net, set gill net, long line and local bamboo traps. The last three fishing gears were set in the evening (16.00 – 18.00 h) and hauled in the morning (07.00 – 10.00 h). Seine net and cast net were used at different locations in the lake during the day (10.00 – 16.00 h).

The standard and fork lengths (SL and FL, cm) and body and gonad weights (B_w and G_w, g) of each catfish were measured and the sex determined by examination of the gonads. The parameters of the length-weight relationships (LWR) were determined separately for both sexes of each species, the immature individuals and all individuals combined. These different estimates were considered separate "populations" (King, 1996 a, b). The coefficient of variation (CV) was determined as: $CV = \{100 \times S / \bar{X}\}$ %, where S=standard deviation and $\bar{X}$ = population mean.

Gonad maturation stages based on macroscopic evaluation were according to a 4 – stage classification scheme modified from Hilge (1977): I – immature; II- maturing/ripening; III – ripe; IV – spent. Absolute fecundity, defined as the number of ripe oocytes in the female prior to the next spawning period (Bagenal, 1978), was estimated by direct counting of the oocytes in both ovaries fixed in Gilson's fluid. Regression analyses of fecundity on SL, FL, B_w and G_w were performed using the least square method. Oocyte diameters of both *Chrysichthys* species were measured with an ocular micrometer.

Stomach contents were sorted into categories and analyzed by frequency of occurrence and volumetric methods (Hyslop, 1980). Spearman's rank coefficient (r) (Fritz, 1974) and Raabe's factor (R) (Hellawell, 1978) were used to compare the similarity and food preferences of the two species, and of the small (8 – 14 cm SL) and large- (> 15 cm SL) sized individuals. The percentage frequency of occurrence (%FO) of a particular food item in the stomach was used in Spearman's rank analysis. In Raabe's coefficient factor, both the %FO and volumetric index (VI) were used in comparing the two species, whereas only the %FO was used for the size groups of *C. auratus*. Raabe's factor (R) was calculated as: $R = \sum \min(a, b, c \ldots n)$, where min (a, b, c ...n) = minimum percentage of the food type common to both species and size groups.

Fulton's condition factor (K) was determined for each fish as follows: $K = 100 \times B_w/L^3$, where B_w = body weight of fish (g), and L = standard length of fish (cm). The Z statistic was employed in the analysis of sex ratio.

Results

Abundance, size range and population structure: Out of 205 specimens of *Chrysichthys* species collected, 134 (65.4%) were *C. auratus*, while 71 (34.6%) were *C. nigrodigitatus*.

The length of *C. auratus* ranged from 6.2 to 26.6 cm SL (mean 16.5±5.91 cm SL) with a weight range of 8.0 – 140 g (mean 52.8±29.6 g).The length frequency distribution (Fig. 2a)

Table 1: Length-weight relationships and related statistics of *Chrysichthys* species in Agulu lake

Species	Sex/group	N	Standard length (cm) Mean	S.D.	Min.	Max.	LWR a	b	r^2
C. auratus	M	44	11.93	2.26	8.7	17.2	0.035	2.934	0.918
	F	49	11.32	1091	7.0	15.5	0.055	2.781	0.884
	I	15	7.20	0.73	6.2	7.9	0.017	3.28	0.618
	C	108	11.48	2.19	6.2	17.2	0.038	2.91	0.9
C. nigrodigitatus	M	21	12.69	2.0	9.8	16.9	0.005	3.656	0.947
	F	24	11.77	1.71	9.3	16.5	0.018	3.196	0.911
	I	10	7.78	0.85	6.8	8.8	0.034	2.928	0.969
	C	55	11.89	2.30	6.8	16.9	0.018	3.183	0.953

M = male; F = female; I = immature; C = all individuals combined

Table 2: Percentage of male and female *C. auratus* at different stages of gonad maturation in Agulu lake.

Months	Male I	II	III	IV	Female I	II	III	IV
May	16.0	13.8	53.2	17.0	13.0	15.0	54.0	18.0
June	11.1	38.4	40.4	10.1	11.9	40.6	41.6	5.9
July	12.0	15.0	46.0	27.0	19.0	19.0	50.0	12.0
August⁺								
September	48.5	51.5	-	-	47.2	45.4	7.4	-
October	67.0	33.0	-	-	77.2	22.8	-	-
November	47.0	53.0	-	-	38.0	62.0	-	-
December	49.0	51.0	-	-	40.0	60.0	-	-
January⁺								
February⁺								
March	45.5	54.5	-	-	55.5	44.5	-	-
April	13.7	41.2	45.1	-	19.2	50.5	30.3	-

+ Samples with ≤ 3 individuals were not included in the analysis.

Table 3: Length-fecundity relationships (a) and weight-fecundity relationships (b) of *Chrysichthys* species in Agulu lake.

(a) Species	Length range	Fecundity (F) Min.	Max.	Mean (S.D)	Length-fecundity relationships a	b	r
C. auratus	8.7-15.5 cm SL	625	2184	1163±461	25.507	1.532	0.631
C. auratus	10.9-18.5 cm FL	625	2184	1163±461	29.191	1.349	0.566
C. nigrodigitatus	10.2-14.6 cm SL	733	1988	1261±384	6.832	2.077	0.864
C. nigrodigitatus	12.5-17.8 cm FL	733	1988	1261±384	4.213	2.102	0.864
(b) Species	**Weight range**	**Fecundity (F) Min.**	**Max.**	**Mean (S.D)**	**Weight -fecundity relationships a**	**b**	**r**
C. auratus	23.4-130.2 g Bw	625	2184	1163±461	145 735	0.505	0.623
C. auratus	2.8-19.0 g Gw	625	2184	1163±461	691.29	0.289	0.374
C. nigrodigitatus	40.0-100.0gBw	733	1988	1261±384	40.557	0.834	0.899
C. nigrodigitatus	5.2-13.5 g Gw	733	1988	1261±384	359.721	0.617	0.812

showed two modes at 12 and 15 cm SL. There was no significant difference in the ratio of male (44) to female (49) (Z = 0.5784, P>0.05). *C. nigrodigitatus* ranged from 6.4 to 20.3 cm SL (mean 10.5±5.91 cm SL),

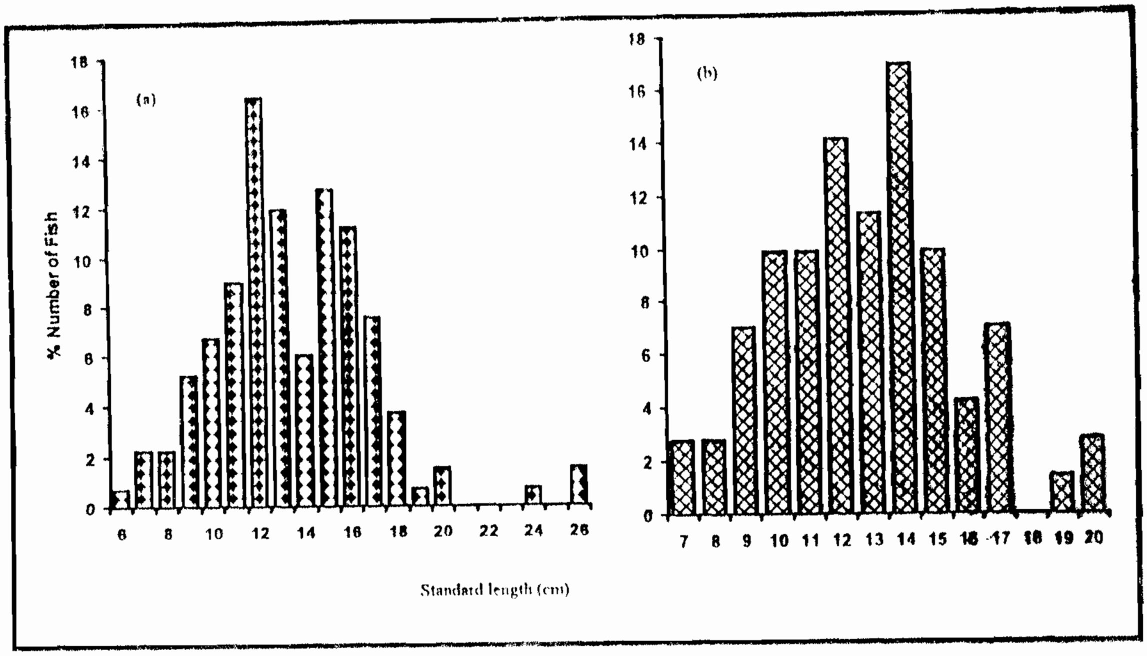

Fig. 2: Length frequency distribution of *C. auratus* (a) and *C. nigrodigitatus* (b) in Agulu lake.

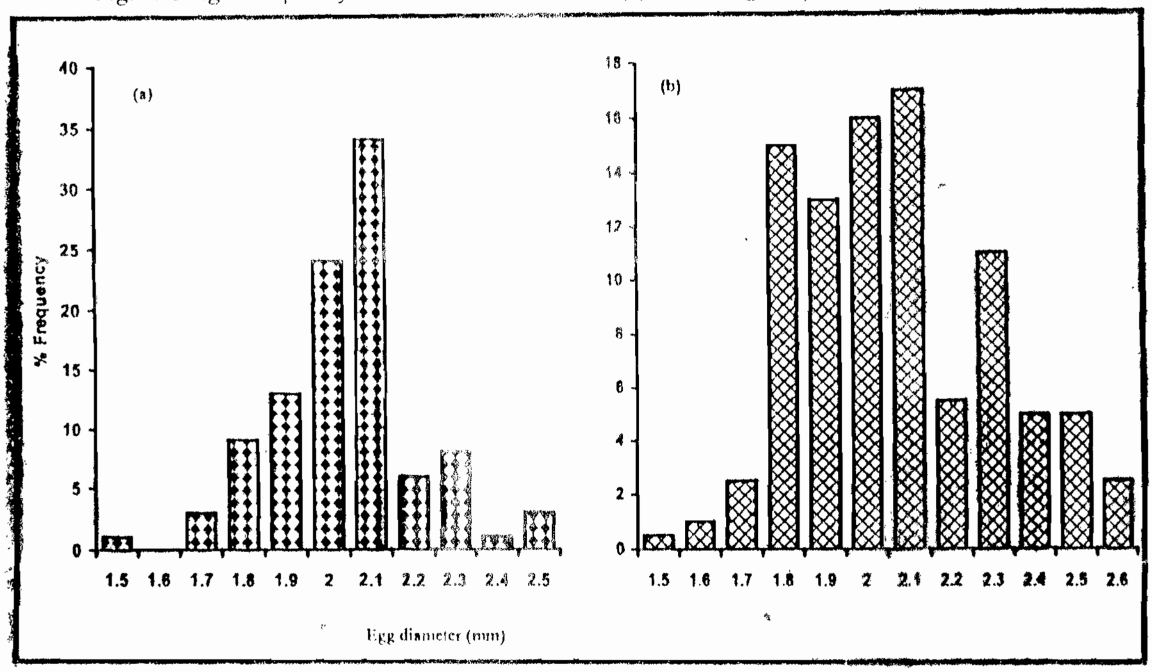

Fig. 3: The percentage egg diameter frequency distribution in *C. auratus (a)* and *C. nigrodigitatus* (b) in Agulu lake

whereas the weight varied between 9.3 and 160 g (mean 55.0±34.1 g). The population was more of individuals between 10 and 15 cm SL (Fig. 2b) which constituted 72% of the population. The ratio of male (21) to female (24) was not different from 1:1 (Z = 0.4422, P>0.05)

Morphometric relationships: The relationships between SL and FL (FL = aSL^b) of *C. auratus* and *C.*

nigrodigitatus were positively correlated and highly significant; *C. auratus*: FL =1.43 SL $^{0.942}$, r^2 = 0.992, P<0.001; *C. nigrodigitatus*: FL = 1.2 SL$^{0.991}$, r^2 = 0.999, P<0.001.The b-values were not different from 1 (P>0.05).

Table 1 is a summary of the LWR of the populations of *Chrysichthys* species in Agulu lake. All correlations were highly significant and the coefficients of determination ranged from 62 to100%.

The intercept, a, showed moderate heterogeneity among the populations (CV = 57.14%) and varied from 5 x 10^{-3} in male *C. nigrodigitatus* to 5.5 x 10^{-2} in female *C. auratus*. Conversely, the exponent, b, exhibited high homogeneity among the populations (CV = 9.04%) and ranged from 2.781 in female *C. auratus* to 3.656 in male *C. nigrodigitatus*.

Apart from the b-value of immature *C. auratus* which exhibited isometric LWR (b=2.94 – 3.28), all the other populations of the species revealed negative allometric function (b<2.94). The b-values of female and combined *C. nigrodigitatus* showed isometric LWR, whereas males and the immature population exhibited positive (b>3.28) and negative allometric LWR respectively. The mean exponent (b=3.109; ± 0.281) is not significantly different from 3 (t-test, df = 7, P<0.05) indicating isometric LWR for the populations studied.

Gonad maturation of *C. auratus*: Table 2 shows that immature and maturing/ripening *C. auratus* were present throughout the year. High numbers of immature individuals were present from September to March. Ripe and spent individuals were found from April to September and were absent between October and March. The breeding season is from April to September.

Size at maturity (stage III): The male and female *C. auratus were* ripe at 11.2 cm SL and 10.8 cm SL respectively. The highest percentage of ripe males (32.35%) occurred between 12.5 and 13.4 cm SL, whereas it was between 12.0 and 13.8 cm SL in the female. In *C. nigrodigitatus*, the smallest ripe male was at 9.2 cm SL, whereas in the female it was at 10.0 cm SL. Most of the ripe males (24.0%) were between 10.1 and 11.6 cm SL; the females were in the range of 10 cm SL to 12 cm SL.

Fecundity: Table 3 shows that the fecundity of 17 female *C. auratus* ranged from 625 oocytes in an 8.7 cm SL fish to 2184 oocytes in a fish of 14.2 cm SL (mean 1163±461 oocytes). In *C. nigrodigitatus*, it ranged between 733 oocytes in a 10.2 cm SL fish and 1988 oocytes in a 14.6 cm SL individual (mean 1261±384 oocytes). All length-fecundity and body weight-fecundity correlations were positive and significant (P = 0.05) (Table 3). The interpopulational variability in the b-value of the exponential length-fecundity relationships (LFRs) was moderately heterogenous (CV = 21.66%) and ranged from b_{min} = 1.349 in *C. auratus* to b_{max} = 2.102 in *C. nigrodigitatus*. The mean exponent ($\bar{b}$ =1.765±0.382) is significantly different from 3 indicating that the cube law cannot be applied to the *Chrysichthys* species in Agulu lake.

For the exponential weight-fecundity relationships (WFRs), the interpopulational variability in the values of b showed moderate heterogeneity (CV=40.47%) and ranged from b_{min} = 0.289 in *C.auratus* to b_{max} = 0.834 in *C. nigrodigitatus* (Table 3). The mean weight exponent (b = 0.56±0.23) is significantly different from 1.0 indicating that fecundity does not relate linearly to fish weight.

Table 4: The food spectrum of *Chrysichthys* species in Agulu lake

	C. auratus		*C. nigrodigitatus*	
Food items	%FO	VI	%FO	VI
Animal components				
Nematoda	9.9	1.4	21.1	3.4
Annelida				
Oligochaetes	0.5	1.4	-	-
Crustacea				
Cladocerans	2.1	1.0	3.3	1.0
Copepods	-	-	1.1	0.6
Ostracods	0.5	1.3	-	-
Insecta				
Chaoborus larvae	13.0	3.1	22.3	24.0
Chironomus larvae	25.3	40.5	4.4	3.9
Ceratopogonids	3.5	3.1	2.2	2.1
Coleoptera	-	-	3.3	0.8
Insect remains	1.0	1.4	2.2	5.8
Mollusca				
Bivalves	0.5	0.2	-	-
Fish remains	0.5	0.2	2.2	1.0
Plant components				
Higher plant tissue (shoots, roots, seeds, fruits, etc)	13.5	14.0	17.8	15.7
Algae	1.6	1.0	1.1	0.6
Organic detritus	9.9	29.8	16.7	40.8
Sand grains	3.7	1.6	1.1	0.3
Unidentified items	0.5	+	1.1	+
No. examined	98		52	
% Empty stomach	34.6		30.0	
Dietary categories	15		14	

+ Insignificant amount

Egg diameter: The mean diameter of ripe oocytes in *C. auratus* varied from 1.5 mm to 2.5 mm (mean 2.04 ±0.32 mm). The frequency distribution of the egg diameter depicts a unimodal distribution with a peak at 2.1 mm (Fig. 3a). In *C. nigrodigitatus*, the egg diameter ranged between 1.5 mm and 2.6 mm (mean 2.05±0.36 mm). About 64% of the ripe eggs were of diameter ranging from 1.8 to 2.10 mm (Fig. 3b).

Food and feeding habits: Table 4 shows the percentage frequency of occurrence (%FO) and the volumetric index (VI) of the food items of *C. auratus* and *C. nigrodigitatus*.

C. auratus fed on food of plant and animal origin with the animal component dominating (56.8%, %FO; 53.6%, VI) (Table 4). Insecta ranked highest in percentage frequency of occurrence (42.8%) and by volume (48.1%), followed by plant materials (15.1%, %FO; 15.0%, VI) and organic detritus (9.9%, %FO; 29.8%, VI). The most important individual food items were chironomid larvae (25.3%,%FO; 40.5%,VI), higher plant material (13.5%,%FO; 14.0%, VI), *Chaoborus* larvae (13.0%, %FO; 3.1%, VI), organic detritus (9.9%, %FO; 29.8%,VI) and nematodes (9.9%,%FO; 1.4%,VI). *C. auratus* is more of a substrate and mid-water, than a water surface, feeder.

The food of *C. auratus* in relation to size indicated that organic detritus ranked first with 22.2% (%FO) followed by *Chaoborus* larvae (17.8%), nematodes (15.6%) and plant materials (15.6%) in the diet of the small-sized individuals (Table 5).

Algae, ostracods and oligochaetes were not encountered in their diet. In the large-sized specimens, chironomid larvae were the most frequently eaten food item (24.3%), followed by plant materials (23.0%), nematodes (16.2%) and organic detritus (12.2%). Bivalves and fish were absent in the stomachs of the specimens examined (Table 5). The Spearman's rank correlation (r=0.518, P<0.05) and Raabe's coefficient factor (R = 62.7%) indicate a strong similarity in the food preferences of small- and large-sized *C. auratus* in Agulu lake.

In the food of *C. nigrodigitatus*, the %FO of the animal component (62.1%) predominated over that of the plant materials (18.9%) (Table 4). The main food items by %FO were nematodes (21.1%), *Chaoborus* larvae (22.3%), higher plant materials (17.8%) and organic detritus (16.7%). In terms of VI, organic detritus was the most important food item (40.8%), followed by *Chaoborus* larvae (24.0%) and higher plant materials (15.7%).

Comparison of the food of *C. auratus and C. nigrodigitatus* indicated a strong correlation between the food preferences of the two species as shown by the Spearman's rank correlation factor (r = 0.75) which was positively significant. In addition, the high significant values of Raabe's factor (R = 59.0%, %FO; R = 56.8%, VI) obtained in the analyses of the food collaborate the strong similarity in the food items consumed by *C. auratus* and *C. nigrodigitatus* in Agulu lake.

Table 5: The percentage frequency of occurrence (%FO) of the food of the small-sized and large-sized *C. auratus* in Agulu lake

Food items	% FO of size groups	
	Small	Large
Nematoda	15.6	16.2
Annelida		
Oligochaetes	-	1.4
Crustacea		
Cladocerans	6.7	2.7
Ostracods	-	1.4
Insecta		
***Chaoborus* larvae**	17.8	1.4
Chironomid larvae	8.9	24.3
Ceratopogonids	6.9	4.1
Insect remains	-	2.7
Mollusca		
Bivalves	2.2	-
Fish remains	2.2	-
Higher plant materials	15.6	23.0
Algae	-	4.1
Organic detritus	22.2	12.2
Sand grains	2.2	6.8
Number examined	60	36

Table 6: Fulton's condition factor of *Chrysichthys* species in Agulu lake

Month	Condition factor			
	C. auratus		*C. nigrodigitatus*	
	Male	Female	Male	Female
June' 90	2.83	3.92	3.64	3.11
July	2.99	3.08	2.54	2.93
August+				
September	3.44	3.33	2.89	2.07
October	3.08	3.57	2.41	2.60
November	3.25	-	3.00	2.76
December	2.14	2.42	2.07	-
January' 91	2.39	2.35	2.52	-
February+				
March	2.58	2.73	2.73	2.67
April	3.31	3.07	3.46	3.17
May	3.18	3.52	3.09	3.57
June	2.73	2.91	-	-
July	2.57	3.51	2.01	3.20
Mean	2.87	3.13	2.76	2.89
SD	0.401	0.521	0.521	0.434

+ Samples with ≤ 3 individuals were not included in the analysis.

Fulton's condition factor: The mean monthly condition factor of male *C. auratus* varied from 2.14 in December to 3.44 in September (mean 2.87±0.401), whereas in the female it varied between 2.35 in January and 3.92 in June (mean 3.12± 0.597) (Table 6). The condition factor for males did not differ significantly from that of females (t=2.222 < 3.169, t_{10}:0.05). In *C. nigrodigitatus*, the condition in the males varied from 2.01 in July to 3.64 in June (2.76±0.521) and in the females, from 2.07 in September to 3.57 in May (mean 2.89±0.434) (Table 6). There was no significant difference between the condition factor of male and female *C. nigrodigitatus*.

Discussion

The maximum length (26.6 cm SL) of *C. auratus* in this study, which is intermediate between its size in Tiga and Kainji lakes (Sturm, 1984, 20.6 cm SL; Ajayi, 1987, 20.6 cm SL) and in River Niger (Motwani and Kanwai, 1970, 41.0 cm SL; Imevbore, 1970, 28.8 cm SL), appears to be a consequence of the poor exploitation of the fish, and the fairly abundant fish food, especially *Chaoborus* and chironomid larvae, in Agulu lake. As a result, the fish seems to have attained the size imposed on it by its genetic potential.

The b-values of the LWR of the *Chrysichthys* species (2.781 – 3.656) fell within the limits reported as typical of most fishes (Carlander, 1969, b = 2.5 – 3.5; Royce, 1972, b = 2.0 – 3.5; Lagler et al., 1977, b = 2.5 – 4.0; King, 1996a, b = 2.158 – 3.376) and are consistent with the values for other *Chrysichthys* populations in Nigerian waters (King, 1996a,b; b = 2.880 – 3.114). The implication of the mean exponent (b = 3.109) not being different from 3 is that the cube law can be applied to the species studied. Similar mean exponent of 3 has been reported by Carlander (1969) and Ruiz-Ramirez et al. (1997). Growth in these fishes is, therefore, isometric.

The b-values of the LFR of this study (b = 1.349 – 2.102) fell within the range reported for some Antarctic fishes (Kock and Kellermann, 1991, b = 1.088 – 6.0899). However, the lower limit of the b-range of our result was below the range (1.563-5.771) reported by King (1997) in Nigerian waters. It seems probable that the range of Kock and Kellermann (1991) may be more typical of fishes generally. The mean exponent ($\bar{b}$ = 1.765) indicates that the *Chrysichthys* species exhibit substantial fish size – egg size changes. The fecundity of the *Chrysichthys* species of this study compares favourably with those of other *Chrysichthys* species in fresh water lentic habitats (Ajayi,1987, F= 120-2250, Kainji lake; Sturm, 1984, F=327-1466, Tiga lake; Nwadiaro and Okorie, 1986, F= 550-2450, Oguta lake; Ikusemiju,1976, F=896-4168, Lagos lagoon) but contrasts with the fecundity of those recorded in River Niger (Imevbore,1970, F=34200 for a 28.8 cm SL *C. auratus* and 18740 for *C. nigrodigitatus*). Though we acknowledge the effect of rich and abundant food on the fecundity of fishes (Nikolsky, 1969), we hypothesize that there may indeed be two strains of *Chrysichthys* species, one adapted to lacustrine conditions and the other to riverine habitats, resulting in the dichotomy in fecundity. This phenomenon probably also explains the differences in the size at maturity of lake and river populations of *Chrysichthys* species so far studied (Fagade and Adebisi,1979; Ajayi, 1987; Imevbore,1970), especially where the food supply to both environments are comparable, as in Agulu lake and River Niger. An investigation to ascertain the nature of the chromosomes of the lake and river *Chrysichthys* populations may help to clarify the situation. The nature of the environment in which the strains live may also play a vital role (Moyle & Cech, 1996

Ripe and spent gonads and the breeding season of *C. auratus* in Agulu lake occur from the beginning to peak rainy season At this period, there is increased flooding and rise in water level. Bruton (1979a), Mgbenka and Eyo (1992) and Ezenwaji (1998) have emphasized the influence of these exogenous environmental parameters in triggering maturation and spawning in siluroids, particularly *Clarias* in South Africa and in the lower Niger drainage basin to which Agulu lake belongs. The abundant food generated at this time ensures fast growth for survival of the progeny. The unimodal distribution of oocyte diameter in the *Chrysichthys* species indicates that the oocytes are spawned once. Hickling and Rutenberg (1936) and Welcomme (1975) report that such ovarian distribution is associated with a single spawning. This spawning takes place between April and September in Agulu lake.

Chrysichthys species subsist on food of animal and plant origin, feeding especially at the bottom and mid-water (Sandon and Tayid 1953; Imevbore and Bakare, 1970; Ikusemiju and Olaniyan, 1977; Ajayi, 1987; Erondu, 1990). The dominance of animal food suggests availability and the high energy content of the food, particularly when young fish are consumed. Bruton (1979b) reports that the energy derived from fish is much more than that from invertebrates and accounts for the recorded growth of *Clarias gariepinus* in lake Sibaya, South Africa. However, a wide variety of food of animal origin is ingested depending on the type of animal fish food prevalent in the particular environment.

Remarkably similar food items were found in the gut of *C. auratus* and *C. nigrodigitatus*. The moderately high Raabe's factor and Spearman's rank coefficient depict overlap in their food niche and suggest strong inter-specific competition. Yet, they coexist in Agulu lake. Competitive exclusion principle stipulates displacement and possibly extinction of the weaker by the stronger competitor when two species compete for identical resources in the same niche. Coexistence of the two *Chrysichthys* species of this study may be attributed to their dependence on slightly different amounts of food. Thus, while *C. auratus* fed more on chironomids, higher plant materials and *Chaoborus* larvae, *C. nigrodigitatus* depended more on *Chaoborus* larvae, nematodes, higher plant materials and organic detritus in that order. In addition, the diversification of the food items, of which there are about 15 in the *Chrysichthys* species of this study, may also be a means of reducing inter-specific competition for the favoured available food items. Ikusemiju and Olaniyan (1977) made a similar observation on the food of *Chrysichthys* species in Lekki lagoon. The arguments adduced above also apply to the size groups of *C. auratus* of this study. The small-sized group of this species ingested mainly *Chaoborus* larvae, organic detritus, nematodes and higher plant materials, whereas the large-sized group subsisted mainly on chironomids, higher plants materials and nematodes. Different size groups of these food types may have been consumed by the different size groups of *C. auratus*. Thus, the size groups of *C. auratus* and the congener in Agulu lake were able to cohabit despite the overlap in their trophic niche.

An overview shows that the *Chrysichthys* species in Agulu lake attain appreciable size because of the abundant food available in the habitat. This enables them to be moderately fecund and to spawn during the rising water at the beginning of the flood phase of the hydrological regime. Poor exploitation of the species lead to their high abundance and size in the lake which is an important nursery ground for many fish species.

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