LENGTH-WEIGHT RELATIONSHIP, CONDITION FACTOR AND SEX RATIO OF TWO CHRYSICHTHYS SPECIES (PISCES: CLAROTEIDAE) OF SOCIO-ECONOMIC IMPORTANCE FROM KPONG RESERVOIR IN GHANA

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Abstract

A total of 392 combined samples of *Chrysichthys auratus* and *Chrysichthys nigrodigitatus* was obtained from experimental and artisanal fishing from inshore and offshore areas of Kpong Reservoir. *C. auratus* and *C. nigrodigitatus* exhibited hyperallometric (b = 3.17–3.23) and hypoallometric (b = 2.79 - 2.91) growth patterns, respectively. Fluctuating monthly condition factor for males, females and combined sexes observed for the two species based on standard length and total length could be attributed to changes in feeding activity and, or degree of nourishment, food availability, gonadal activity, and season. However, based on total length, October and June were periods of the best physiological condition for *C. auratus,* while for *C. nigrodigitatus*, December was the least physiological period. There were significantly more females than males while differences in sex ratio were significant at 95 per cent confidence interval (P = 1.354), indicating departure from the expected sex ratio of 1:1 for the two species. Regular assessment of biological, ecological and environmental characteristics of the species is recommended to provide requisite information for sustainable management of the species for reservoir fishery development and food security.

Introduction

One of the most important commercial catfish families of the Kpong Reservoir is the family Claroteidae (claroteid), previously a subfamily of Bagridae but separated from Bagridae by Mo (1991). *Chrysichthys* (Pisces: Claroteidae) is a genus of the family Claroteidae (claroteid catfish) and is reported to occur in all the river basins of Ghana, and widely distributed in all inland and coastal water bodies such as rivers, lakes, reservoirs, lagoons and estuaries (Dankwa, Abban & Teugels 1999, Vanderpuye, 1982, De-graaf & Ofori-Danson, deGraft & Vanderpuye, 1997, Ofori-Danson *et al*., 2002 and Braimah, 2003).

Chrysichthys supports commercial fisheries in many West African countries (Ikusemiju & Olaniyan, 1977) including Ghana (Quarcoopome & Amevenku, 2010), where the species additionally has culture potential (Ofori-Danson *et al*., 2002). In the Kpong Reservoir, Chrysichthys and Tilapia form the mainstay of socio-economic activities and the most important commercial food fish with Chrysichthys constituting about 30 – 35 per cent of the fish landed by artisanal fishermen (Quarcoopome *et al*., 2007). The importance of *Chrysichthys* species in the Kpong Reservoir was indicated by Vanderpuye (1982) before impoundment.

During the formative years, Dankwa (1982) reported that *C. auratus* was among the five commonest fish species. Though *C. nigrodigitatus* was not reported in the Kpong Reservoir before impoundment, Quarcoopome & Amevenku (2010) reported after almost three decades of impoundment that the species had become the most important based on weight and among the four most important based on number.

The length-weight relationship of fish is an important fishery management tool for estimating average weight at a given length group (Beyer, 1987) and assessing the relative well-being of a fish population (Bolger & Connoly, 1989). The condition factor is widely used as an index of the well-being of a fish or fish population in their habitat (Baker *et. al*., 1993) and based on the hypothesis that heavier fish of a given length are in better condition (Bagenal & Tesch, 1978).

There are several reports on length-weight relationship and condition factor of fish from different regions of the world including Africa. There are, however, fewer reports from Ghanaian inland waters particularly reservoirs. This study was undertaken to address the information and knowledge gap in fish length-weight relationship, condition factor and sex ratio of Ghanaian reservoirs to help in the management of fish species for reservoir fishery development, food security and sustainable socio-economic development.

Experimental

Study area

The Kpong Reservoir (Fig. 1) lies on 6° 10' N and 0° 5' E and covers a surface area of about 35 km^2 with a maximum depth of approximately 15 m and mean depth of 5 m (Anon., 1977). Formed in 1981 downstream of Akosombo in the Eastern Region of Ghana, the Kpong Reservoir currently serves multiple purposes which include thriving fisheries. The study area falls within the dry equatorial climate zone, which is characterized by two peak rainfall seasons in June and September, and a dry season usually spanning the period from November to February. Antwi & Ofori-Danson (1993) reported maximum and minimum monthly mean air temperatures of 37.2 °C, and 21 °C, respectively, and mean surface water temperature of 29.2 °C. The topography is undulating, rugged, mountainous and interspersed with low lying plains to the west and east. The vegetation falls within the semi-deciduous rainfall and coastal savanna zone of Ghana. Besides agriculture, fishing is one of the main economic activities of the people and it is undertaken all year round except for no fishing days observed on Thursdays at Kpong (Quarcoopome *et al*., 2007). Claroteids are mainly caught using monofilament gill nets, cane or basket traps and, to some extent, hook and line.

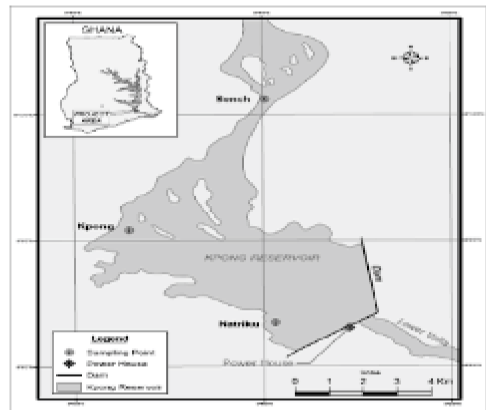

Fig. 1 Map showing sampling stations on the Kpong Reservoir

Sampling and data collection

Out of a total of 392 fish specimen obtained, half was from artisanal catches and the other half from experimental catches. The artisanal and experimental catches were obtained monthly at three sampling stations in the Kpong Reservoir, namely Kpong, Senchi and Natriku between April and December 2009. Experimental fishing was carried out in both inshore and open waters with sets of monofilament and multifilament gill nets ranging in mesh size from 12.5 mm to 76.2 mm. Artisanal catches were obtained from fishermen who used assorted fishing gear such as gill nets of mesh sizes ranging between 30.0 mm and 127.0 mm, basket traps, hook and line among others. Fish sampled were individually identified using identification keys by Lévêque, Paugy & Teugels (1992) and Dankwa *et al*. (1999). The sex of each fish was determined by visual inspection and where sex could not be determined it was recorded as undetermined. The body weight of each fish was measured to the nearest 0.1 g using a beam balance (KERN, EMB 500, Kern & Sohn, GmbH, Germany) while total length (TL) and standard length (SL) were measured to the nearest 0.1 cm and 1.0 mm, respectively, using a measuring board.

Data analysis

Microsoft Excel version 2007 spreadsheet was used to perform all data analyses, compute parameters as well as generate graphs. Analysis was done in respect of either total length and standard length or male, female and combined where combined includes male, female and undetermined specimen put together, or standard length class at 35 mm interval.

Length-weight relationship

The weight (W) of fish is exponentially related to the length (L) according to the equation $W = aL^b$, where *a* is the intercept, and *b* is the slope of the log-transformed relation (Le Cren 1951, Froese, 2006) and referred to as the growth constant. Based on *b*, Froese, Tsikliras & Stergiou (2011) reported that one can check whether the growth of a fish population is isometric, hypoallometric (also termed negative allometric) or hyperallometric (also termed positive allometric). The length-weight relationship (LWR) was determined according to species, sex, and length class using length and weight data obtained from fish sampled.

The degree of association between length and weight was expressed by a correlation coefficient "r" which could take values ranging between – 1 and +1. According to Pauly (1983) when "r" is negative, it means that one variable tends to decrease as the other increases and there is a negative correlation (corresponding to a negative value of 'b' in regression analysis). When "r" is positive it means that the one variable increases with the other and there is positive correlation (which corresponds to a positive value of *b* in regression analysis) (Pauly, 1983).

Condition factor

Condition factor (CF) also known as coefficient of condition and length–weight factor was estimated by the equation $CF = 100 \times W L^{-3}$ (Ricker, 1975), where W was the body weight (g) and L was the total length (cm) or standard length in centimetres. Mean condition factor for males and females were tested for statistical significance by Analysis of Variance.

Sex ratio

Monthly sex ratio for each species was computed and tested for statistical significance by the chi-square method based on the null hypothesis of 1:1 ratio of male to female at 95 per cent confidence interval (CI). Sex ratio for various length groups of the two species was computed and tested for significance at 95 per cent confidence interval.

Results

Length- weight relationship

From Table 1 the exponent *b* ranged between 3.17 and 3.23 for *C. auratus* and between 2.79 and 2.91 for *C. nigrodigitatus*. The correlation coefficient r values ranged between 0.931 and 0.954 for *C. nigrodigitatus* and between 0.950 and 0.969 for *C. auratus*.

TABLE 1

Length-weight relationship for males and females of C. nigrodigitatus *and* C. auratus *from Kpong Reservoir*

Species	*N*	*SL range (cm)*	*a*	*b± s.e.*	*r*
C. auratus					
Males	37	7.5 – 21.5	8.512×10^{6}	3.17±0.085	0.969
Females	52	8.0 – 19.5	6.026×10^{6}	3.23±0.102	0.950
Combined	119	7.4 – 21.5	6.456×10^{6}	3.22±0.107	0.962
C. nigrodigitatus					
Males	94	8.4 – 31.5	2.8×10^{5}	2.91±0.101	0.953
Females	131	8.9 – 30.5	5.0×10^{5}	2.79±0.118	0.931
Combined	273	5.5 – 31.5	3.729×10^{5}	2.85±0.134	0.954

S.E. – standard error

TABLE 2a

Analysis of variance (ANOVA) of length-weight relationship for C. nigrodigitatus *from Kpong Reservoir at 95 % CI*

Source of variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Between groups	3.5361	1	3.5361	79.754	1×10^{-17}	3.8629
Within groups	19.331	436	0.0443			
Total	22.867	437				

TABLE 2b

Analysis of variance (ANOVA) of length-weight relationship for C. auratus *from Kpong Reservoir at 95 % CI*

Source of variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Between groups	6.718273	1	6.7182731	166.8917	6.95×10^{34}	3.8569
Within groups	24.31419	604	0.0402553			
Total	31.03247	605				

Condition factor

There were fluctuations in the mean monthly condition factor for the two Claroteid species with respect to males, females and combined specimen, which were found to be significant based on chi-square analysis at 95 per cent confidence interval as shown in Table 3a & b.

TABLE 3a

Monthly mean condition factor based on total length for C. auratus *and* C. nigrodigitatus *from Kpong Reservoir*

Species/	C. auratus			C. nigrodigitatus		
Month	*Male*	*Female*	*Combined*	*Male*	*Female*	*Combined*
April	0.803	0.738±0.139	0.943±0.512	0.869±0.017	0.748±0.230	0.832±0.163
May	NC	0.652±0.008	0.72±0.160	0.875±0.091	0.974±0.269	0.877±0.161
June	1.000±0.109	0.952±0.196	1.01±0.171	0.627±0.188	0.772±0.217	0.738±0.208
August	0.763±0.097	0.838±0.226	0.814±0.168	0.791±0.167	0.757±0.122	0.771±0.142
September	0.797±0.097	0.704±0.161	0.762±0.128	0.788±0.160	0.810±0.253	0.800±0.204
October	1.900±0.305	1.140±0.518	1.189±0.561	0.809±0.338	0.685±0.196	0.956±1.323
November	0.618	0.739±0.112	0.688±0.089	0.938±0.168	0.805±0.178	0.865±0.234
December	0.829±0.228	0.835±0.160	0.830±0.192	0.615±0.182	0.710±0.147	0.671±0.167
Mean	0.955±0.430	0.829±0.162	0.869±0.168	0.789±0.108	0.783±0.083	0.814±0.083

NC – No male *C. auratus* caught

Sex ratio

The observed differences in monthly sex ratio for *C. auratus and C. nigrodigitatus* were statistically significant at 95 per centConfidence Interval ($P > 0.05$) (Table 4a, 4b). This suggests that sex ratio in both species is not 1:1 and that observed differences are not due to chance or sampling error. Fig. 2a and 2b show the temporal distribution of males and females of the two species during the study period. The sex ratio for combined sexes for both *C. auratus and C. nigrodigitatus* was 1:1.354 (Table 4a & 4b). Fig. 3 shows the standard length class structure for both species and sexes.

TABLE 4a

Chi-square analysis of monthly sex ratio for C. nigrodigitatus *from Kpong Reservoir* n = 219

Month	*Males*	*Females*	*Total*	*Ratio*	χ^2 *Calc.*	χ^2 *Critical*	$P_{0.05}$
April	3	6	9	4.5	0.5		NS
May	5	4	9	4.5	0.0555		NS
June	4	13	17	8.5	2.382		S
August	17	20	37	18.5	0.1216		NS
September	25	18	43	22.5	0.5697		NS
October	15	26	41	20.5	1.4756		S
November	5	22	27	13.5	5.3518		S
December	19	17	36	18.0	0.0555		NS
Total	93	126	219		10.512	1.354	S

S = Significant; NS = Not significant

TABLE 4b

Chi-square analysis of monthly sex ratio for C. auratus *from Kpong Reservoir n = 87*

Month	*Males*	*Females*	*Total*	*Ratio*	χ^2 *Calc.*	χ^2 *Critical*	$P_{0.05}$
April	1	5	6	3.0	1.33		NS
May	0	2	2	1.0	1.0		NS
June	5	8	13	6.5	0.346		NS
August	4	5	9	4.5	0.055		NS
September	9	10	19	9.5	0.026		NS
October	3	9	12	6.0	1.5		S
November	1	2	3	1.5	0.1666		NS
December	14	9	23	11.5	0.543		NS
Total	37	50	87		4.971	1.354	S

S = significant; NS = Not significant

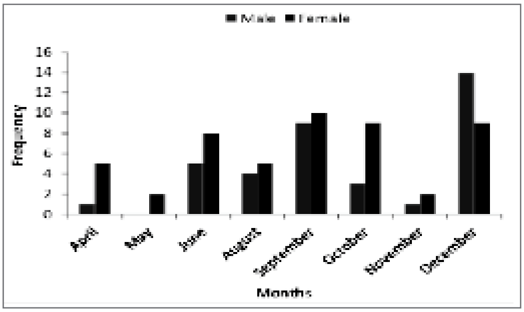

Fig. 2a. *Temporal distribution of male and female C. auratus* from Kpong Reservoir

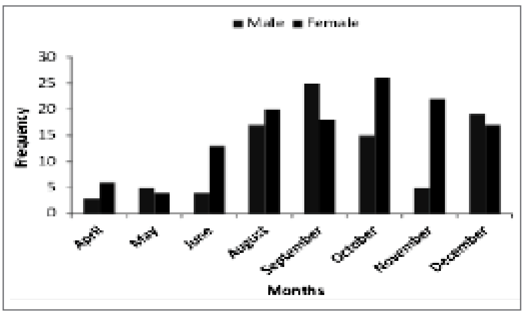

Fig. 2b. *Temporal distribution of male and from* C. nigrodigitatus from Kpong Reservoir

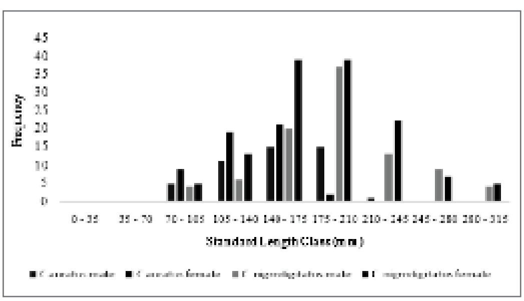

Fig. 3.*Structure of male and female* Chrysichthys auratus *and* Chrysichthys nigrodigitatus *from Kpong Reservoir with respect to standard length class*

Discussion

Length-weight relationship

According to Froese,Tsikliras & Stergiou (2011), for isometric growth, $b = 3$ and all fish dimensions increase at the same rate; for hypoallometric growth, $b < 3$ and fish increase less in weight than predicted by its increase in length, i.e. it becomes more elongated as it grows; and for hyperallometric growth, $b > 3$ and fish increase more in weight than predicted by its increase in length, i.e., it becomes less elongated or more roundish as it grows. From Fish Base (Froese, 2006), the analyses of a large number of LWRs show that values of the slope *b* generally range between 2 and 4 with 90 per cent of the values ranging from 2.7 to 3.4.

The growth constant values for both species in this study were within the expected range of 2.5 and 3.5 reported for most fish (Carlander, 1969, 1977) ,and within the range of 2.9 and 4.8 recommended as suitable for mature freshwater tropical fish (Bagenal & Tesch, 1978). The growth constant '*b*' estimated for male, female and combined sexes for *C. auratus* and *C. nigrodigitatus* separately was not equal to 3, indicating that the growth pattern in both species was not isometric but rather allometric and, therefore, growth was not dimensional. For *C. auratus* male (*b*=3.17), female (*b*=3.23) and combined (*b*=3.22), hyperallometric growth patterns corresponding to b>3 was computed, which means that fish become stouter as they increase in length. On the other hand for *C. nigrodigitatus* male (*b*=2.91), female (*b*=2.79), and combined (*b*=2.85) exhibited hypoallometric growth pattern which means that fish become more slender as they increase in length.

Contrary to the finding in this study, Quarcoopome (2010) reported that *C. nigrodigitatus* from Weija Reservoir exhibited near isometric growth pattern (*b*=3.04) which was similar to the finding of Entsua-Mensah, Osei-Abunyewa & Palomares (1995) for *C. nigrodigitatus* (*b*=3.01) in the Volta Lake. A similar study in the Volta Lake by Ofori-Danson, deGraaf & Vanderpuye (2002) indicated that both females and males of *C. auratus* exhibited isometric growth pattern, contrary to the finding in this study while *C. nigrodigitatus* exhibited hypoallometric growth pattern similar to the finding in this study. Contrary to the finding in this study, Entsua-Mensah, Osei-Abunyewa & Palomares (1995) reported that combined specimen for *C. auratus* in the tributaries of River Volta in Ghana exhibited hypoallometric (b = 2.94) growth pattern characteristics. Differences in sample size and other factors, including prevailing environmental conditions may account for the differences in the growth patterns of Chrysichthys reported in the Volta Lake and Weija Reservoir compared with the findings in this study.

Offem, Samsons & Moniyi (2009) reported that combined specimen of *C. nigrodigitatus* and *C. auratus* from Cross River in Nigeria exhibited hypoallometric and hyperallometric growth patterns, respectively, similar to findings in this study. In the Epe Lagoon in Nigeria, Fafioye & Oluajo (2005) reported that the combined *C. nigrodigitatus* population exhibited isometric growth pattern unlike the hypoallometric pattern in this study due to differences in the ecological and environmental conditions of a lagoon compared with a reservoir.

Generally in this study, strong correlation existed between length and weight in both *C. auratus* and *C. nigrodigitatus* from Kpong Reservoir, however, correlation was stronger in males than in females of *C. auratus* compared to *C. nigrodigitatus*.

Condition factor

Fish condition factor is an index which expresses the degree of well-being, relative robustness, and interactions between biotic and abiotic factors in fish physiological condition (Froese, 2006). Thus, fish condition factor is an indicator of fish welfare in the specific habitat, and measures various ecological and biological factors such as degree of fitness, gonad development and the suitability of the environment with regard to feeding (Mac Gregoer, 1959). Fish condition factor is important to understanding the life cycle of fish and contributing to their adequate management. When the condition factor value is high it means that the fish has attained a better condition and *vice versa*. Fish condition factor can be affected by a number of factors such as stress, sex, season, availability of food, and other water quality parameters (Khallaf, Galal & Athuman 2003).

Fluctuating monthly condition factors for males, females and combined specimen with no clear patterns observed for the two species, based on standard length and total length, could be attributed to changes in feeding activity and, or degree of nourishment, food availability, gonadal activity, and season. However, based on total length, October and June were periods of the best physiological condition for male, female and combined *C. auratus,* indicating effects of suitable ecological, environmental and biological factors in the rainy season. Similarly, for males, females and combined *C. nigrodigitatus* based on total length, December was the least physiological period, indicating the effects of stress from unsuitable ecological, environmental and biological factors in the dry season. Male *C. auratus* and male *C. nigrodigitatus* were in better condition than their females based on the overall mean condition factor and total length. Male *C. auratus* was in better condition than the female based on standard length. Female *C. nigrodigitatus* was in better condition than the male based on standard length similar to what Quarcoopome (2010) reported in the Weija Reservoir.

In Weija Reservoir, male, female and combined *C. nigrodigitatus* condition factors based on standard length were 1.965±0.059, 2.025±0.110 and 1.996±0.039, respectively (Quarcoopome, 2010), all of which were higher than those observed in the Kpong Reservoir for the same sex and species in this study. Fafioye & Oluajo (2005) reported that in Epe Lagoon in Nigeria *C. nigrodigitatus* had mean condition factor of 0.8±0.2 which is comparable to the results of this study, based on total length despite the differences in environmental conditions. The percentage of individuals with condition factor values above mean values for each species indicate that nearly half of the *Chrysichthys* population is in good condition.

Sex ratio

Sex ratio and size structure constitute basic information in assessing reproductive potential and establishing stock size in fish populations

(Vazzoler, 1996). For combined sex of *C. auratus* and *C. nigrodigitatus* from the Kpong Reservoir, differences in sex ratio were significant at 95 per cent confidence interval indicating that there was departure from the expected sex ratio of one male to one female. The reason for the departure from 1:1 sex ratio is not clear but could have been influenced by differentiation in fish growth of the sexes as well as food availability (Vincentini & Araujo, 2003). There were significantly more females than males at 95 per cent confidence interval for the months of April and October with respect to *C. auratus*. Similarly, there were significantly more females than males at 95 per cent CI for the months of June, October and November for *C. nigrodigitatus*. This observation could be attributed to differential growth rates of males and females coupled with abundance and availability of preferred food which favour females.

Conclusion

Hyperallometric and hypoallometric growth patterns were observed for *C. auratus* and *C. nigrodigitatus,* respectively. Fluctuating monthly condition factors were observed for males, females and combined specimen with no clear patterns for the two species based on standard length and total length. Based on total length, however, October and June were periods of the best physiological condition for male, female and combined *C. auratus* while for males, females and combined *C. nigrodigitatus* based on total length, December was the least physiological period. The percentage of individuals with condition factor values above the mean values for each species indicate that nearly half of the *Chrysichthys* population is in good condition. Differences in sex ratio were significant at 95 per cent confidence interval for *C. auratus* and *C. nigrodigitatus,* indicating that there was departure from the expected sex ratio of one male to one female.

Recommendation

To support food security, reservoir fishery development and sustainable management interventions, *Chrysichthy* species in Kpong Reservoir require regular assessment of biological, ecological and environmental characteristics.

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