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Observations on the Morphometric and Meristic Characters of Guinean Tilapia, *Coptodon guineensis* (Günther, 1892) (Family: Cichlidae) from the Buguma Creek and the New Calabar River in Nigeria

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Abstract

This research was conducted to study the morphological characteristics of *Coptodon guineensis* from brackish and fresh water habitats in Rivers State, Nigeria using morphometric measurements and meristic counts. A total of 200 specimens of *Coptodon guineensis*, (two groups of 100 each from two study sites) were examined and analyzed for morphometric differentiation. The results showed that almost all the values of the external morphometric parameters were higher in the New Calabar River population than those of the population from Buguma Creek. There were significant difference (p<0.05) in the weight, total length, standard length, pre anal fin length, pre pelvic fin length, penduncle depth and body depth. The mean percentage standard length to PrEOL of C. *guineensis* from Buguma Creek (10.54±0.29 %) was significantly higher p<0.05 than that from the New Calabar River (9.65±0.27 %) and the mean percentage SL to BD of C. *guineensis* from the New Calabar River (91.05±2.26 %) was significantly higher (p<0.05) than that from the Buguma Creek (84.56±1.54 %). All the external parameters displayed allometric growth expect for PoOL and BD. The morphometric relationships between SL vs PrAFL showed high coefficients of determination (>0.88) and moderate coefficient (>0.56) with PD in the population of the New Calabar River, while the population of the Buguma Creek PD showed high coefficients of determination (>0.62). The specimens investigated in this study reveal that the freshwater population could be phenotypically separable from the brackish water population.

Keywords: *Coptodon guineensis*, Guinean tilapia morphological characteristics, Buguma Creek, New Calabar River,

1. Introduction

Historically, the morphology of fishes has been the primary source of information for taxonomic and evolutionary studies. Under the basic concept of evolution, every species is believed to be undergoing micro and macro evolutionary process resulting in the expression of significant genetic variations at the levels of the species specific chromosome morphology/structure, gene controlled protein structure and polygene controlled morphometrics and metrics (Ayala and Keiger 1980). Also, as a rule, specimens originating from different areas differ from one another in morphology (Franičevič *et al*., 2005). The shape and structures are unique to the species, and the variation in its feature is probably related to the habit and habitat among the variants of this s pecies (Cavalcanti *et al*., 1999), which is determined by the evolutionary background of the fish and the physical and chemical characteristics of water.

Information on the sub-stock structure in fish populations is essential for the management of many stocks. Muzinic and Marr (1960) have stated the biological and fishery management principle that necessitates the racial/stock/sub-species differentiation of fishery resources as "the logical and practical reasons for identifying population units are that such units may have their own characteristics of recruitment, growth, natural mortality, migration, behavior etc. more or less independent of the characteristics of other population units within the same species." Grant *et al*., (1980) pointed out the importance of delineating the stocks and their boundaries which have become an essential part of fishery management/ conservation. For effective fishery management and implementation of the worthwhile stock rebuilding programs, knowledge of the stock structure, distribution of the fishing effort and mortality amongst the various components are essential, since each stock must be managed separately to optimize their yield (Grimes *et al*., 1987; Carvalho and Hauser 1994 ; Begg *et al*., 1999).

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There are many approaches that can be taken to determine the stock or population structure of any fish species including genetic analyses, phenotype analyses to detail the growth rates, age composition, morphometrics and micro constituents in calcified structures, together with parasite loads and tagging returns. Morphometric measurements and meristic counts are considered authentic and the easiest methods for the identification of specimen termed as morphological systematics (Nayman 1965). The morphometric analysis helps to understand the relation between body parts (Carpenter *et al*., 1996) and to know the origin of stock, separation of stocks, or identification of the commercially-important species of fishes (Devi *et al*., 1991; Kohinoor *et al*., 1995; Narejo *et al*., 2000).

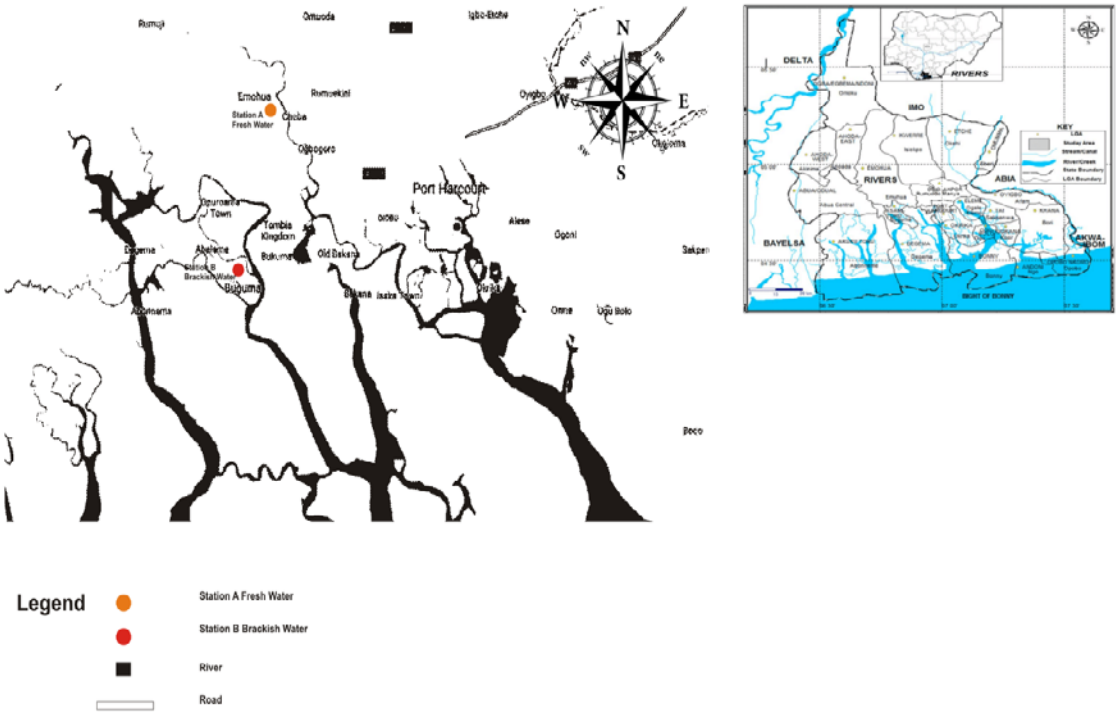
The family Cichlidae (Cichlids) represents the most species rich-family of vertebrates (Kocher 2004). The cichlids *Coptodon guineensis*, is a brackish water euryhaline species found along the West coast of Africa (Philippart and Ruwet 1982). Formerly included in *Tilapia*, in 2013 this genus was separated by (Dunz and Schliewen 2013). This species was formerly and wrongly referred to as *Tilapia melanopleura* in many parts around the world (Philippart and Ruwet 1982). The species, popularly-called *Tilapia guineensis*, can be easily separated from other Tilapia species occurring in Nigerian freshwaters because of its emarginated caudal fin and the prolongation of the rayed part of the dorsal fin (Adesulu and Sydenham 2007). The species also adapted to diverse habitat permanent and temporary rivers, opened and closed estuarine, lagoon, swampy lakes, deep lakes and coastal brackish lakes (Trewavas 1983). Cichlids exhibit remarkably high levels of genetic and morphological diversity, which affects their morphology, ecology, behaviour and genomes (Nelson 1994; Barlow 2000; Chakrabarty 2005).

In Nigeria, systematic studies are lacking, despite their great significance for a better management of the stocks. There are very few documented studies on population/stock structure in fishes using morphological traits in Nigeria. The objective of this study is to investigate the morphological variations in *Coptodon guineensis* from the New Calabar River and the Buguma Creek, and to prepare accurate guides for the identification of species in Nigeria.

2. Materials and Methods

2.1. Study Area

The samplings were conducted at the New Calabar River and Buguma Creek in Rivers State, Nigeria (Figure 1). The New Calabar River is situated about 15 km from Port Harcourt City, located in Obio - Akpo Local Government Area of Rivers State between longitude 6.8985°E and latitude 4.8888°N of the Greenwich meridian. The New Calabar River is characterized by fresh water. The Buguma Creek is located southeast of Niger Delta between Longitude 6°47°E and 6°59°E and Latitude 4°31°N and 4°59°N in Asari - Ton Local Government Area Rivers State. The Buguma Creek system consists of a main creek channel and some associated interconnecting creeks, lying along the coast of Nigeria. The Buguma Creek is characterized by brackish water.



Map showing the sampling site.

C. guineensis were identified using the keys and works of (Adesaulu and Sydenham 2007). One hundred specimens of *C. guineensis* were randomly selected from the local fishermen catches using cast net, gillnet and beach seine at the two locations and were then taken to the laboratory. The samples of *C. guineensis,* ranging between 120 mm and 150 mm standard length, were collected monthly from both sites over the period from February to July of 2017. The specimens were transported in ice chests to the laboratory, where measurements started immediately to avoid shrinkage. Various equipment including Calipers, a pair of divider, and a graduated meter rule were used in the measurements. Morphometric measurements were taken according to the descriptions given in Gupta and Gupta (2006). All fish were measured for total length (TL) and standard length (SL) to the nearest 0.1 cm, and were weighed (body weight, BW) to the nearest 0.1. The following morphometric data were taken from the left side of the fish body. These were: Standard length (SL), Total length (TL), Weight (W), Dorsal fin length (DFL), Head length (HL), Peduncle Length (PL), Peduncle depth (PD), Body depth (BD), Eye diameter (ED), Pre dorsal fin length (PrDFL), Pre anal fin length (PrAFL), Pre pelvic fin length (PrPFL), Caudual fin length (CFL), Pre orbital length (PrOL) and Post orbital length (PoOL). Seven meristic characters were also investigated with the aid of a magnifying glass. These were: Dorsal fin ray (DFR), Anal fin ray (AFR), Pectoral fin ray (PFR), Pelvic fin ray (PVFR), Scales along lateral line (SALL), Dorsal fin spine (DFS) and Anal fin spine (AFS)**.**

In order to standardize the differences in the overall body size among the specimens, all the morphometric measurement data were divided by standard length (SL) and were presented as ratio (Hubbs and Lagler 1947). Basic descriptive statistics (minimum, maximum, mean, and standard deviation) were calculated for the morphometric measurements and meristic counts. A t-test was applied to determine the significant differences in the two populations.

For the purpose of growth variability of all the external morphometric characters studied with respect to standard length, linear regression analysis was carried out and the strength of the relationship was determined using the r^2 value. While *p*-value was used to determine the significance of the relationship. Morphometric characters were adjusted to size by running log-log regressions between SL and each character (Reist 1985). The Analysis of Covariance (ANCOVA) Zar (1984) was used to test for significant differences in slopes and intercepts among the relationships.

3. Results

A total of 200 specimens of *C. guineensis* (two groups of 100 each) from two study sites were examined and analyzed. Table 1 shows that almost all the values of the external morphometric parameters were higher in the New Calabar River population than those of the population from the Buguma Creek. For example, the total length and total weight of *C. guineensis* from the New Calabar River (17.06 ± 0.44cm and 124.55 ± 10.34g respectively) were higher than those of the Buguma Creek (14.75 ± 0.29 cm and 81.12 ± 6.730g respectively). Similar results were recorded for all of the morphometric measurements, apart from the eye diameter and penduncle length (1.18 ± 0.02cm and 1.76 ± 0.05cm respectively), that were slightly higher in the population of *C. guineensis* from Buguma Creek than those from the New Calabar River (1.17 ± 0.02cm and 1.65 ± 0.05cm respectively). However, the pre-orbital length was constant with a mean value of 2.20±0.03 recorded for the New Calabar River population and 2.20±0.04 in the population from the Buguma Creek (Figure 1). The statistical analysis of the morphometric parameters as shown in Table 1, indicates that there were significant differences ($p<0.05$) in the weight, total length, standard length, pre- anal fin length, pre-pelvic fin length, penduncle depth and body depth along with other features as the eye diameter, head length, pre-orbital length, post-orbital length and penduncle length which showed that the fish, in all probability, were obtained from two statistically-indistinguishable races or stocks.

Analyses of the meristic characters revealed variation in the dorsal fin ray with the New Calabar River population having 13-14 and 10-13 for the Buguma Creek (Table 2). Also, the New Calabar dorsal fin spine range (14-17) was slightly more than that of the Buguma Creek range (15-16). The results further showed a significant difference in the number of anal fin ray ($p< 0.05$) between the two populations. The pelvic fin rays, pelvic spines and anal fin spines remained constant between the two populations.

Table 1. Mean and standard error for morphometric of *Coptodon guineensis* from the Buguma Creek and the New Calabar River.

Traits	New Calabar River		Buguma Creek		F	t	*p*-value
	Range	Mean ± SE	Range	Mean ± SE			
Weight	23 – 640	124.55 ± 10.34 [a]	17 – 520	81.12 ± 6.73 [b]	11.449	3.522	0.00
Total length	3.5 - 29.8	17.06 ± 0.44 [a]	1.5 - 23.5	14.75 ± 0.29 [b]	10.371	4.335	0.00
Standard length	6.2 - 24.9	13.45 ± 0.38 [a]	5.7 - 19.5	11.27 ± 0.23 [b]	23.39	4.86	0.00
Pre orbital length	1 - 3.1	1.22 ± 0.03	0.4 - 2.1	1.16 ± 0.03	2.795	1.552	0.12
Post orbital length	1.1 - 2.7	2.20 ± 0.03	1.2 - 3.5	2.20 ± 0.04	9.761	0.068	0.95
Head length	2.1 - 5.3	3.43 ± 0.04	2.2 - 4.5	3.37 ± 0.04	0.846	1.045	0.30
Eye diameter	1 – 2	1.17 ± 0.02	0.9 - 2.2	1.18 ± 0.02	0.413	-0.557	0.58
Pre-dorsal fin length	2.4 - 5.6	3.73 ± 0.04	2.6 - 4.8	3.69 ± 0.04	1.178	0.637	0.53
Pre anal fin length	2.1 - 21.8	9.22 ± 0.39 [a]	4.2 – 15	7.16 ± 0.23 [b]	22.854	4.557	0.00
Pre pelvic fin length	2.6 - 5.8	3.88 ± 0.04 [a]	2.8 - 4.9	3.75 ± 0.04 [b]	3.865	2.112	0.04
Caudual fin length	3 - 4.9	3.89 ± 0.04 [a]	3 – 4.4	2.24 ± 0.08 [b]	35.911	17.926	0.00
Peduncle length	0.8 - 3.4	1.65 ± 0.05	1 – 3.4	1.76 ± 0.05	0.02	-1.617	0.11
Peduncle depth	1.1 - 3.9	2.26 ± 0.08 [a]	1 – 3.4	1.83 ± 0.04 [b]	40.543	4.716	0.00
Body depth	5.6 - 23.8	11.87 ± 0.39 [a]	3.2 - 13.4	9.36 ± 0.17 [b]	9.756	5.957	0.00

[abc]Mean (± Standard error) in the same column having similar superscript are not significantly different (p>0.05). F = Levene's Test for Equality of Variances, t= t- Test.

Table 2. Mean and standard error for meristic of *Coptodon guineensis* from the Buguma Creek and the New Calabar River.

Traits	New Calabar River		Buguma Creek		F	t	*p*-value
	Range	Mean ± SE	Range	Mean ± SE			Mean ± SE
Dorsal fin ray	13 - 14	12.05 ± 0.14 [b]	10 – 13	12.64 ± 0.07 [a]	19.366	-3.685	0.00
Dorsal fin spine	14 - 17	15.57 ± 0.06	15 – 16	15.64 ± 0.05	8.03	-0.903	0.37
Scale along the lateral line	19 - 25	21.82 ± 0.10	19 – 23	21.87 ± 0.29	2.021	-0.161	0.87
Anal fin ray	9 -10	9.84 ± 0.04 [a]	8 – 10	9.12 ± 0.03 [b]	2.667	14.623	0.00
Pelvic fin ray	5	5.00 ± 0.00	5	5.00 ± 0.00	-	-	-
Anal fin spine	3	3.00 ± 0.00	3	3.00 ± 0.00	-	-	-
Pelvic fin spine	1	1.00 ± 0.00	1	1.00 ± 0.00	-	-	-

[abc]Mean (± Standard error) in the same column having similar superscript are not significantly different (p>0.05).

F = Levene's Test for Equality of Variances, t= t Test.

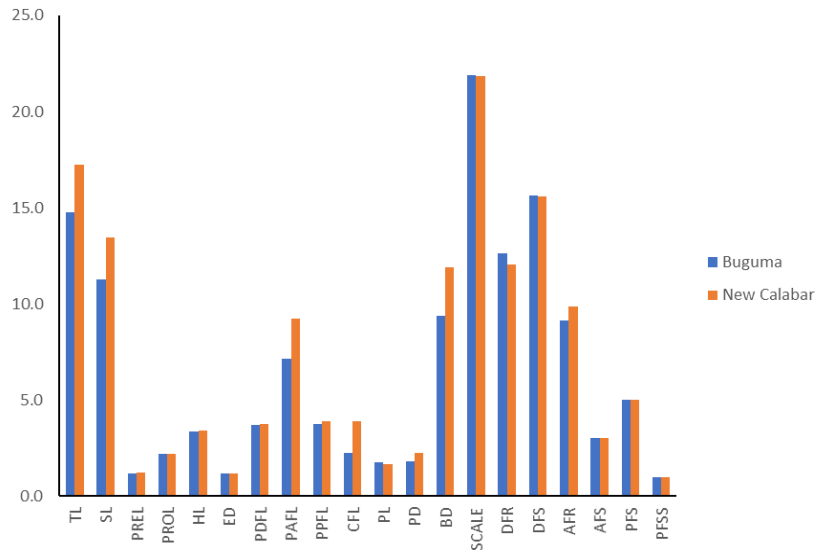


Figure 1. Comparison between the morphometric characters of the *Coptodon guineensis* in the Buguma Creek and the New Calabar River.

The percentages of morphometric characters expressed as the percentage of standard length, % SL, morphometric (Table 3) , were found to be significantly different between the two populations (p<0.05). The mean percentage standard length to PrEOL of *C. guineensis* from the Buguma Creek (10.54±0.29 %) was significantly higher p<0.05 than that from the New Calabar River (9.65±0.27 %), and the mean percentage BD to SL of *C. guineensis* from the New Calabar River (91.05±2.26%) was significantly higher (p<0.05) than that from the Buguma Creek (84.56±1.54%). However, eight percentage morphometric variables in relation to the standard length revealed highly significant differences between the two populations (p<0.01). The spcimens investigated in this study revealed some discrimination indicating that the freshwater population could be separable from the brackish water population.

The comparative study of the meristic counts with the standard length revealed clearer discriminating differences between the specimens of the two populations than the morphometric measurements (Table. 4). There were significant differences (p < 0.01) in the mean percentage standard lenght of all the meristic traits, except in the mean percentage standard length of AFR for which there were significant differences between the two populations (p < 0.05). Only PD showed no significant difference between the two populations in the percentage of morphometric variables in relation to the standard length.

In this study, eleven characters were regressed against the standard length, and several correlations were observed as in Table 5. Examination of *C guineensis* from the New Calabar River indicated that the allometric growth is relative to the standard length in most of the characters considered apart from the PrOL, PL, ED and PD with isometric growth pattern (b=3). Further results of the external morphometric characteristics' growth variability of the *C guineensis* from the Buguma Creek studied with respect to SL (Table 5), showed that all the external parameters displayed allometric growth expect for PoOL and BD. The morphometric relationships between SL vs PrAFL showed high coefficients of determination (>0.88) and moderate coefficient (>0.56) with PD in the population from the New Calabar River, while the population from the Buguma Creek PD showed high coefficients of determination (>0.62). The remaining characters had a very low level of relationship (Table 5). In the four meristic characters analyzed, all did not express any relativeness to the standard length. The correlation coefficient (r) values recorded in both populations were very low (Table 6).

Table 3. Morphometric characters of *C. guineensis* expressed as percentage of Standard length from the Buguma Creek and the New Calabar River.

Morphometric Traits	New Calabar River	Buguma Creek	F	t	*p*-value
Pre orbital length	9.65±0.27	10.54±0.29*	0.512	-2.232	0.03
Post orbital length	17.64±0.50	20.29±0.53**	0.002	-3.62	0.00
Head length	27.32±0.73	30.98±0.64**	1.514	-3.757	0.00
Eye diameter	9.24±0.24	10.93±0.28**	2.441	-4.562	0.00
Pre dorsal fin length	29.71±0.79	33.99±0.71**	1.505	-4.032	0.00
Pre anal fin length	66.55±1.15**	62.48±0.81	6.681	2.896	0.00
Pre pelvic fin length	30.91±0.83	34.66±0.84**	0.223	-3.184	0.00
Caudual fin length	30.89±0.83**	20.54±0.81	0.269	8.912	0.00
Peduncle length	12.46±0.28	15.65±0.34**	0.392	-7.159	0.00
Peduncle depth	16.87±0.38	16.26±0.23	9.621	1.356	0.18
Body depth	91.05±2.26*	84.56±1.54	21.116	2.371	0.02

*Significant at p>0.05 ; **Significant at p>0.01

Table 4. Meristic count characters of *Coptodon guineensis* expressed as percentage of standard length from the Buguma Creek and the New Calabar River.

Meristic counts	New Calabar River	Buguma Creek	F	t	*p*-value
No of scale along the lateral line	174.38±4.62	202.16±5.08**	0.001	-4.047	0.00
Dorsal fin ray	96.52±2.83	116.98±2.55**	0.576	-5.372	0.00
Dorsal fin spine	124.44±3.31	144.81±3.15**	0.599	-4.457	0.00
Anal fin ray	78.76±2.10	84.39±1.80*	3.008	-2.036	0.04
Anal fin spine	23.99±0.64	27.79±0.60**	0.322	-4.338	0.00
Pelvic fin ray	39.99±1.06	46.31±1.00**	0.321	-4.338	0.00
Pelvic fin spine	8.00±0.21	9.26±0.20**	0.32	-4.339	0.00

*Significant at p>0.05; **Significant at p>0.01

Table 5. R^2 values and beta (B) values for the morphometrics measured against the standard length.

Morphometric Traits	New Calabar River		Buguma Creek		Overall	
	R^2	B	R^2	B	R^2	B
Pre orbital length	0.05	3.21	0.11	2.78	0.08	3.38
Post orbital length	0	-0.68	0.02	0.91	0.00	0.39
Head length	0.02	1.27	0.11	2.03	0.05	1.83
Eye diameter	0.17	1.01	0.01	0.86	0.05	3.78
Pre dorsal fin length	0.02	1.27	0.09	1.91	0.04	1.69
Pre anal fin length	0.88	0.91	0.9	0.98	0.90	0.94
Pre pelvic fin length	0.01	1.09	0.02	0.81	0.03	1.30
Caudal fin length	0.07	2.47	0	0.15	0.11	1.05
Peduncle length	0.48	3.30	0.49	3.22	0.35	3.93
Peduncle depth	0.56	3.52	0.64	4.32	0.62	3.83
Body depth	0.24	0.49	0.37	0.84	0.33	0.59

Table 6. R^2 values and beta (B) values for the meristic counts measured against the standard length.

Meristic counts	New Calabar River		Buguma Creek		Overall	
	R^2	B	R^2	B	R^2	B
Dorsal fin ray	0.002	-0.11	0	0.21	0.01	-0.29
Dorsal fin spine	0.003	0.36	0.01	0.45	0.00	0.27
Anal fin ray	0.017	-1.34	0.01	0.8	0.04	1.38
No of scale along the lateral line	0.002	0.15	0.01	0.07	0.00	0.07

Of the eleven morphometric characters, only two differ significantly (p<0.05) between the two populations, these characters are the head length and Pre-Orbital Length. The remaining nine characters exhibited no significant difference (p>0.05) between the two populations (Table 7).

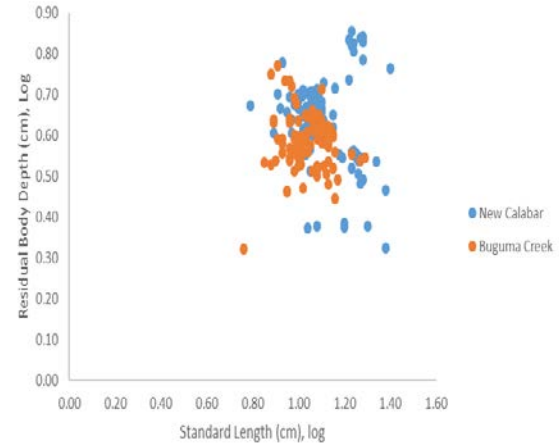
Table 7. R^2 values and F values for the morphometrics measured against the standard length. P<0.05 showed significant variation in the morphometrics of the population.

Morphometric Traits	Df	df_{error}	F	p-value	R^2
Head Length	1	196	4.537	0.034*	0.063
Eye Diameter	1	196	1.549	0.215	0.056
Caudal fin length	1	196	0.079	0.779	0.574
Peduncle length	1	196	2.585	0.109	0.459
Body depth	1	196	1.215	0.272	0.411
Post Orbital length	1	196	8.214	0.005**	0.135
Post orbital length	1	196	3.07	0.081	0.018
Pre dorsal fin length	1	196	3.191	0.076	0.05
Pre anal fin length	1	196	0.449	0.503	0.857
Pre pelvic fin length	1	196	0.494	0.483	0.041
Peduncle depth	1	196	0.001	0.976	0.637

*Significant at p<0.05, **Significant at p<0.01

Analysis of the covariance (GLM on Log transformed data, with SL as covariate) indicated that *C. guineensis* in the two locations differed significantly in the relative body depths (F 1,197df= 16.494; p<0.001), caudal fin length (F 1,197df= 223.92; p<0.001) and peduncle length (F 1,197df= 36.88; p<0.001). But no statistical difference was observed regarding the remaining parameters.

The residual of body depth as well as the residual of caudal fin length plotted against standard length showed a clear differentiation between the species as well as among the stocks. The body depth of *C. guineensis* in the New Calabar River was higher compared to that of the population from the Buguma Creek (Figure 2). On the contrary, the residual of the peduncle length plotted against the standard length showed that the peduncle of the population from the Buguma Creek was longer than that of the New Calabar River population.



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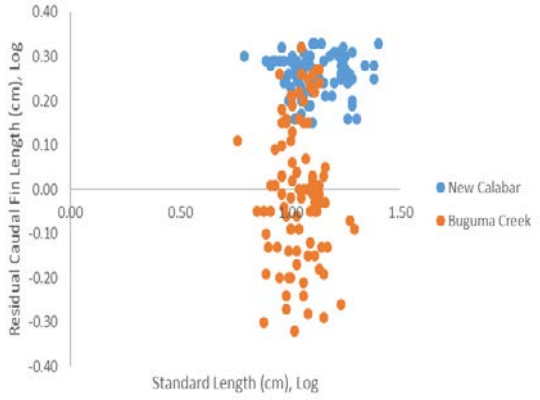
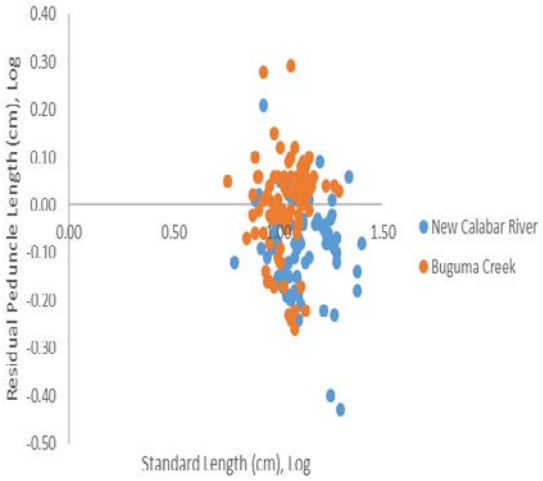


b



c

Figure 2. Results of residual body depth (a), caudal fin length (b) and peduncle length (c) plotted against standard length in the two sites

4. Discussion

In this study, both morphometrics clearly demonstrated variations among the two populations of *C. guineensis* from the New Calabar River and the Buguma Creek. For example, the total length and total weight of *C. guineensis* from the New Calabar River were higher than those of the Buguma Creek. This may be attributed to environmentally–induced morphological differences. Similar results were recorded regarding all the morphometric measurements apart from the eye diameter and penduncle length that were slightly higher in the population of *C. guineensis* from the Buguma Creek than the New Calabar River. This could be attributed to turbidity and feeding habits of the fish in the Buguma Creek. The eye diameter which contributed heavily to the regional differentiation, may reflect differences in turbidity (Matthews, 1988). Diet has been shown to cause variation in the morphology not only in fish, but also in most organisms (Fermon and Cibert 1998). Water temperature, light cycle and food conditions seem to be the principal environmental factors influencing the growth and reproductive cycle of crustaceans (Pezzack and Corey 1979; Winkler and Greve 2002). Solomon *et al*., (2015) reported that the analyses of morphometric characters revealed abundant variations among different populations. Out of the seven meristic counts examined, only two exhibited slight variations between the two populations and significant difference in dorsal fin ray and anal fin ray between the two populations. Eyo and Mgbenka (1992) found that specific differences in the meristic counts were exhibited in both the anal fin ray and the vertebral count in the Clariids of Anambra River, Nigeria. The divergences in the morphological structures among the populations of fish species are a common biological phenomenon. Swain and Foote (1999) stated that the phenotypic variation in the morphological characters or meristic counts may not only be genetic but may also be environmentally-induced. Krabbenhoft *et al*. (2009) described the environmental factors underlying the morphological changes as water clarity, water depth and flow, food availability and physical complexity. Layman *et al.* (2005) also proposed that the fish assemblage composition in combination with the commercial netting play an important role in the morphological differences.

The meristic counts revealed clearer discriminating differences between the specimens of the two populations than the morphometric measurements. The differences in the morphological and meristic characters of the specimens are supposed to be in association with the aquatic ecosystems from which they originated (Cakić *et al*., 2002; Franičević *et al*., 2005). In this study, the mean head length expressed as the percentage of standard length was slighly higher in the population from the Buguma Creek than that of the New Calabar River. This result came in agreement with Stiassny *et.al.* (2008).

C guineensis from the New Calabar River indicated that the allometric growth was relative to standard length in most of the characters considered apart from PrOL, PL, and PD with the isometric growth pattern. *C guineensis* from the Buguma Creek studied with respect to SL showed that all the external parameters displayed allometric growth expect for PoORL and BD. This implies the changes in the different dimensions of the body parts that are correlated with changes in the whole body. The allometric growth suggests that the weight of the fish increased faster or decreased in relation to the cube of their standard lengths; therefore, adults may appear different

from the young ones (Bagenal and Tesch 1978). All the four meristic characters analyzed did not express any relativeness to the standard length of all the meristic variables studied apart from the influence of size. It has been established that the meristic characters are independent of the fish size; hence, they should not change during growth (Strauss 1985).

5. Conclusion

The morphological variations examined in this paper are preliminary and provide an insight into populations of the same species from two different habitats.There was a clear morphological differentiation between these two groups of fish. The specimens from the Buguma Creek were generally smaller than those from the New Calabar River. Also, both the univariate and the multivariate analyses clearly demonstrate morphological variations among the two populations. The genetic analysis must be conducted on the same species and locations for future researches.

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