RESEARCH ARTICLE

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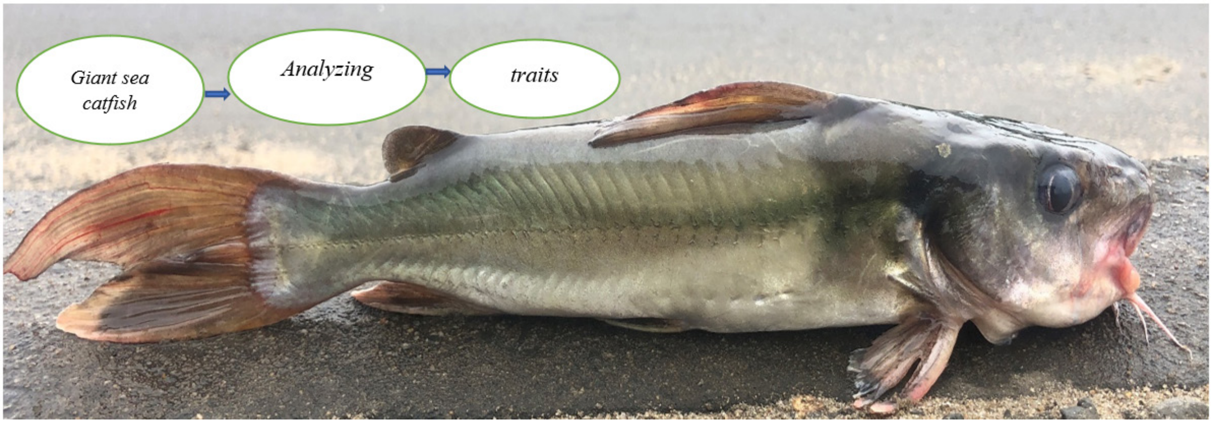

Highlights

- External morphometric parameters of *Arius gigas* were higher in the New Calabar River than those from Degema River population
- The meristic characters revealed variations in mean values of dorsal fin spine, pectoral fin ray, and pelvic fin ray
- The growth variability parameters from the Degema River for standard length exhibited allometric growth
- Further studies using molecular markers should be considered for making conservation plans for exploitable *A. gigas* species.

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Morphometric and meristic traits of giant sea catfish *Arius gigas* (boulenger 1911) from new Calabar river and Degema River, Rivers State, Nigeria

H E. Dienye[1,*], O. A. Olaniyi[1], S.A. Nwafili[1], U. Okoro[1] and N. Bamidele[2]

[1]*Department of Fisheries, Faculty of Agriculture, University of Port Harcourt, Choba, Nigeria*
[2]*Institute of Food Security, Environmental Resources and Agricultural Research, Federal University of Agriculture, Abeokuta, Nigeria*

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Abstract: Morphometric and meristic characters of the *Arius gigas* species were examined from two study areas (New Calabar and Degema Rivers) for a period of six months in Rivers State, Nigeria. Total of 200 individuals, 100 from each study site, were examined and analyzed. A majority of the values for external morphometric parameters of *A. gigas* were higher in the New Calabar River than those from Degema River population, with no significant differences exist ($p<0.05$) across the morphometric parameters except for pre-orbital length, post-orbital length and eye length. The meristic characters revealed variations in the mean values of dorsal fin spine (8.55±0.11 and 7.07±0.38), pectoral fin ray (5.96±0.06 and 4.23±0.26), and pelvic fin ray (14.99±1.21 and 7.51±0.52) in the study. A significant difference was noted in the number of dorsal fin spine ($p< 0.05$) between the two populations. The mean percentage of the Length of caudal peduncle (LoCP),1st and 2nd dorsal fin (DF), length of inter-dorsal fin (LoIDF) and length of adipose fin (LoAF) of *A. gigas* in the New Calabar River were significantly higher ($p<0.05$) than Degema River. Growth variability for standard length and all external parameters displayed allometric growth of *A. gigas* from Degema River. Further studies are recommended to corroborate the findings of the two populations using molecular markers for making conservation plans for exploitable *A gigas* species.

***Keywords*:** Morphometric parameters, Meristic characters, Giant See Catfish, *Arius giga,* Degema River, New Calabar River

INTRODUCTION

Traditional morphometrics has been used extensively in multidisciplinary approaches to stock identification since the turn of the century (Pepin and Carr, 1993; Kai and Nakabo, 2002; Turan et al., 2005) and has also been widely used for separating various species, populations and races; it also aids in determining sexual dimorphism (Analaura et al*.,* 2005). Morphological traits such as morphometrics and meristic have also been used to determine the evolutionary relationships between ancient and modern fish fauna (Deesri et al*.,* 2009). For both fishery biology and taxonomic studies, research on morphometric measurements and statistical relationships of fishes is essential. (Mustafa and Brooks, 2008). Additionally, they show the variations in body type between distinct individuals to differentiate between populations of the same species (Hirsch et al*.,* 2013). Also, the morphology of specimens from various locations typically varies from one another (Franičevič et al., 2005). The structure and form are unique to the species, and variations in its features are probably brought on by the habitats and dietary preferences of the various species variants. Which is determined by the physical and chemical properties of water and the fishes' evolutionary history (Cavalcanti et al*.,* 1999).

The stock or population structure of any fish species can be determined using a variety of techniques, such as genetic and phenotype analyses to describe growth rates, age composition, morphometrics, and micro constituents in calcified structures, as well as parasite loads and tagging returns. The easiest and most reliable way to identify specimens are morphological systematics, which includes meristic counts and morphometric measurements (Nayman, 1965). The morphometric analysis aids in understanding the relationship between body parts and in determining the source of stock, separation of stocks, or identification of the commercially-important species of fishes (Narejo et al., 2000).

The vast majority of Ariidae fish, also referred to as marine catfish, reside in tropical and temperate estuaries and shallow coastal waters. A few species are only found in freshwater in the upper tributaries of rivers 500 km from their river mouths, or they are only found in marine waters at depths of 150 m. (Marceniuk and Menzes, 2007). This family has 30 genera and 143 species, with 27 species belonging to the genus Arius (Froese & Pauly, 2016). Three to four species recorded in the Gulf of Guinea are also found in the Nigerian freshwaters; these are *Arius gigas*, *Arius lutiscutatus*, and *Arius heudeloti* (Schneider, 1990; Adesulu & Sydenham, 2007). The giant sea catfish can grow up to 165 cm (65 in) in length and 50 kg in weight (110 Ib). As a food fish and one of the most prevalent species in Nigeria's industrial coastal fisheries, it is significant commercially. However, overfishing and potential chemical pollution as a result of these factors have led to a population decline. The species is currently categorized as data deficient on the International Union for Conservation of Nature red list. (IUCN, 2019).

Systematic studies are not common in Nigeria, despite their

**Corresponding Author's Email: henry.dienye@uniport.edu.ng*
https://orcid.org/0000-0001-6254-9179

importance in improving stock management. In Nigeria, there are few published studies using morphological traits to analyse population/stock structure in fish. The goal of this study is to create accurate guides for species identification in Nigeria by looking into the morphological variations of *Arius gigas* from the New Calabar River and the Degema River.

MATERIALS AND METHODS

Description of Study Area

The study areas were the section of the New Calabar River and Degema River in Obu-Ama as shown in Figure 1. The New Calabar River lies between longitude 006º53´-53º86´E and latitude 04º53´-19º20´N in Choba, Rivers State, Nigeria. The New Calabar River, one of the river systems of the Niger Delta, contributes to the fisheries resources in Rivers State (Dienye & Woke, 2015). The downstream reach is brackish and is covered in mangrove swamps. Degema River in Obu-Ama town is a tributary emanating from the Sombreiro between Degema and Abonnema, Rivers State.

Collection and measurements of specimens

Two hundred individuals of *Arius gigas* were collected randomly from the two different study areas from local fishermen catches using various fishing gears, (cast nets and drum trap). The samples were collected for a period of 6 months. The specimens were transported in ice chests to the laboratory. Identification was done using the key given by (Schneider, 1990) and measurements were carried out immediately using a metre rule, a pair of calipers and a pair of dividers. All fish samples were measured for Total Length (TL), Standard Length (SL) and Body Weight (BW) to the nearest 0.1 cm and grams.

Morphometric and Meristic Data

Morphometric measurements were taken according to the descriptions given in Gupta and Gupta (2006). These were: Head Length (HL), Pre Orbital Length (PrOL), Eye Length (EL), Post Orbital Length (PoOL), Standard Length (SL), Total Length (TL), Fork Length (FL), Length of Pectoral Fin (LoPF), Body Depth (BD), Anal Fin (AF), Length of Caudal Peduncle (LoCP), Length of 1st Dorsal Fin (Lo1stDF), Length of 2nd Dorsal Fin (Lo2ndDF), Length of Inter-Dorsal Space (LoIDS), Length of Adipose Fin (LoAF). Five meristic characters were also investigated with the aid of a magnifying glass. These were: Anal Fin Ray (AFR), Pectoral Fin Ray (PFR), Pelvic Fin Ray (PVFR), Dorsal Fin Spine (DFS) and Anal Fin Spine (AFS).

Statistical Analysis

All morphometric measurement data were divided by SL and presented as ratios to standardize the variations in overall body size among the specimens (Hubbs & Lagler, 1947). For the morphometric measurements and meristic counts, the minimal, maximal, mean, and standard deviation were computed. To identify the significant differences between the two populations, a t-test was used.

A linear regression analysis was conducted to determine the growth variability of all the external morphometric characters studied in relation to SL and the strength of the relationship was assessed using the r^2 value. While the p-value was used to assess the relationship's importance, using log-log regressions, morphometric characters were scaled to their proper size between each character and SL. (Reist, 1985). The Analysis of Covariance (ANCOVA) was used to test for significant differences in slopes and intercepts among the relationships (Zar, 1984).

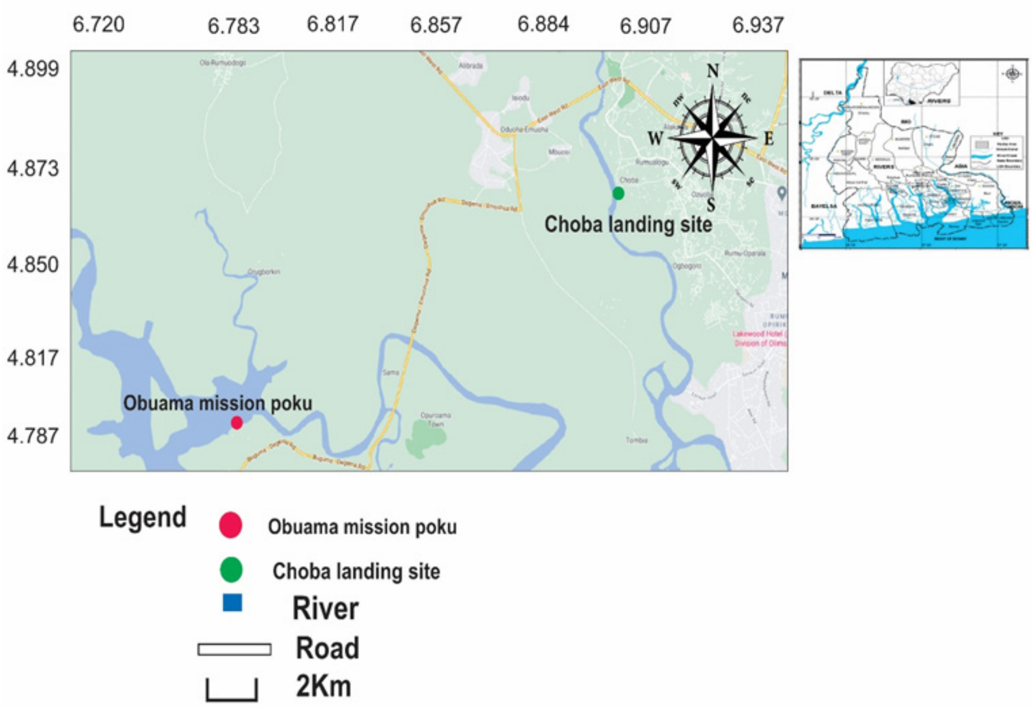

Figure 1: A map of showing the two study rivers, New Calabar River and Degema River in Obu-Ama, Nigeria.

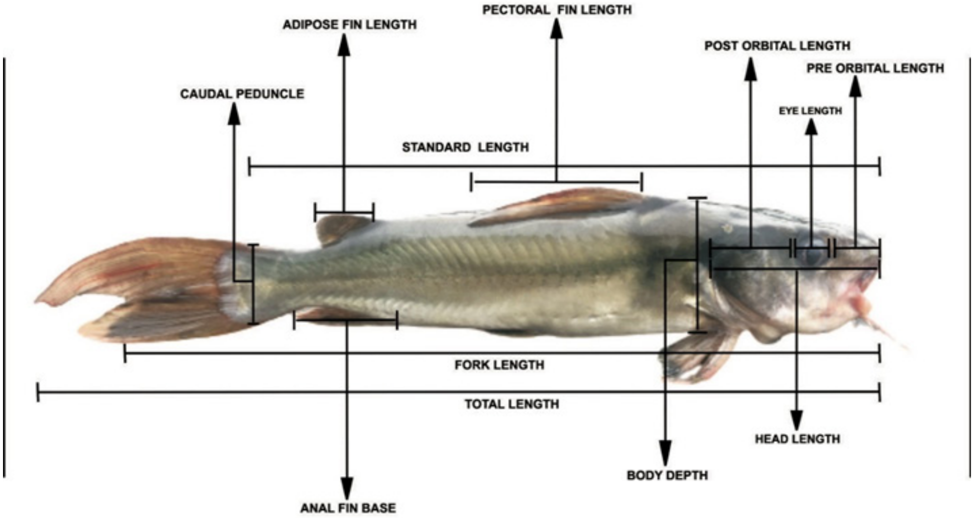

Figure 2: Morphometric measurement of *Arius gigas* (photo by Dienye et al., 2022)

RESULTS

A total of 200 *Arius gigas* (two groups of 100 each) from two study sites were examined and analyzed. Table 1 shows that the eye length was within the same mean from the two-population study (Figure 3). The statistical analysis of the morphometric parameters as shown in Table 1, indicates no significant differences ($p<0.05$) across the morphometric parameters studied except for PrOL, PoOL and EL.

Analyses of the meristic characters showed variation in the mean values of DFS, PFR, PVFR in the populations as shown in Table 2. Also, DFS was constant in both study areas while AFS was slightly lower in the New Calabar river than that of the Degema River. There is a significant difference in the number of DFS between the two populations ($p< 0.05$). The percentages of morphometric characters expressed as the % SL in Table 3, were significantly different between the two populations ($p<0.05$). The mean % SL to HL and EL from the Degema River and were significantly higher $p<0.05$ than that from the New Calabar River. The mean percentage of the 1st LoCP, 2nd DF, LoIDF and LoAF in the New Calabar River were significantly higher ($p<0.05$) than that from the Degema River. However, 8% morphometric variables in relation to SL were not significantly different between the two populations ($p>0.05$).

Table.4 shows significant differences ($p < 0.01$) in the mean % SL of all the meristic traits, except in the mean % SL of AFR and DFS for which there were no significant differences between the two populations ($p>0.05$). Table 5. revealed that the allometric growth is relative to the SL in most of the characters studied, apart from the LoCP with isometric growth pattern (b=3) from the New Calabar River. Further results of the growth variability of the external morphometric characteristics from the Degema River studied with respect to SL. Table 5 also revealed that all external parameters displayed allometric growth. The morphometric relationships between SL vs BD, HL and LoPF showed high coefficients of determination respectively in the population from the New Calabar River, while the population from the Degema River HL, FL PoL showed very high coefficients of determination. Only LoIS character had a very low level of relationship. In the five meristic characters analyzed, all did not express any relativeness to the SL. The correlation coefficient (r) values recorded in both populations were very low in Table 6.

The residual of HL, LoPF and BD plotted against SL showed a clear differentiation between the species as well as among the stocks in the different population in Figure 4a-c. The HL and BD in Degema River was higher than the New Calabar River in Figure 4a & b. On the contrary, the residual of the LoPF plotted against the SL showed that the PF from the New Calabar River was longer than that of the Degema River population in Figure 3c.

DISCUSSION

In this research, both morphometric characteristics evidently established variations among the two populations of *A. gigas*. Thirteen out of the sixteen parameters considered were significantly different in both populations, indicating that the samples were obtained from two statistically distinguishable races or stocks. For example, the TL and TW of *A. gigas* from the New Calabar River were higher than those from the Degema River. This may be attributed to environmentally–induced morphological differences. Similar results were recorded regarding all the morphometric measurements. This is similar to the findings of Olopade et al. (2018) and Akinrotimi et al. (2018), who found that PreOL, PoOL and EL showed no significant difference between the different populations of the species they studied (*Coptodo guineensis* and *Sarotherodon melanotheron)*. Wimberger (1992) reported that, it is well known that morphometric characters can show high plasticity in response to differences in environmental conditions, as the species is widely tolerant to extreme environmental conditions such as food abundance and temperature. Therefore, the distinct environmental structures from the two population may be as a result of high Diet, which has also been shown to cause

Table 1: Mean and standard error for morphometric of *Arius gigas* from the two population.

Parameters	Choba		Degema		F	t	p-value
	Range	Mean ± SE	Range	Mean ± SE			
Weight (Grms)	65 – 745	193.00±100.75 [a]	26 – 1233	140.85±163.02 [b]	1.736	2.73	0.01
Head Length (HL)	3.5 - 9.7	5.77±1.19	3 - 11.5	5.55±1.53	2.99	1.12	0.27
Standard Length (SL)	13.9 - 30.5	20.17±3.16 [a]	11.1 – 36	18.18±4.24 [b]	5.139	3.76	0.00
Total Length (TL)	16.1 – 248	26.81±22.68 [a]	14 - 46	22.07±5.23 [b]	0.962	2.05	0.04
Fork Length (FL)	5.3 - 33.5	21.76±3.66 [a]	11.8 - 39.5	19.62±4.52 [b]	2.93	3.69	0.00
Length Of Pectoral Fin (LoPF)	1.2 - 4.2	2.40±0.52 [a]	1 - 4.1	2.10±0.61 [b]	2.161	3.79	0.00
Body Depth (BD)	9.2 – 21	12.89±2.15 [a]	7 - 26	11.59±3.21 [b]	5.362	3.36	0.00
Anal Fin (AF)	1.5 - 4.3	2.48±0.50 [a]	1.1 - 5.5	2.20±0.76 [b]	6.039	3.15	0.00
Length Of Caudal Peduncle (LoCP)	1 - 4.7	2.76±0.71 [a]	1.3 - 5.1	2.45±0.61 [b]	1.9	3.31	0.00
Length Of 1st Dorsal Fin (Lo1[st]DF)	0.4 - 1.5	0.84±0.20 [a]	0.4 - 1.7	0.67±0.24 [b]	1.674	5.52	0.00
Length Of 2nd Dorsal Fin (Lo2[nd]DF)	0.4 - 1.7	0.76±0.19 [a]	0.3 - 1.6	0.62±0.21 [b]	1.116	4.79	0.00
Length Of Inter-dorsal Space (LoIDS)	0.8 - 6.6	1.64±0.77 [a]	0.5 - 2.2	1.03±0.31 [b]	28.975	7.33	0.00
Length Of Adipose Fin (LoAF)	1.1 - 3.9	2.20±0.55 [a]	0.5 - 4.6	1.76±0.64 [b]	0.792	5.31	0.00
Pre-Orbital Length (PrOL)	0.9 – 21	2.45±2.00	0.9 - 5.3	2.07±0.72	1.092	1.82	0.07
Post Orbital Length (PoOL)	1.7 - 4.9	2.62±0.59	1.2 - 5.6	2.45±0.75	5.33	1.72	0.09
Eye Length (EL)	0.9 - 1.9	1.25±0.18	0.9 - 2	1.20±0.20	0.662	1.71	0.09

[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 traits of *Arius gigas* the two populations.

Parameters	Choba		Degema		F	t	p-value
	Range	Mean ± SE	Range	Mean ± SE			
Anal Fin Ray (AFR)	5 - 11	8.55±0.11 [a]	0 – 13	7.07±0.38 [b]	136.38	3.74	0.00
Pectoral Fin Ray (PFR)	4 - 10	5.96±0.06 [a]	0 – 14	4.23±0.26 [b]	148.05	6.55	0.00
Pelvic Fin Ray (PFR)	7 - 132	14.99±1.21 [a]	1 – 18	7.51±0.52 [b]	2.29	5.74	0.00
Dorsal Fin Spine (DFR)	0 - 12	1.94±0.12	0 – 8	1.90±0.21	44.69	0.16	0.87
Anal Fin Spine (AFS)	0 - 3	0.65±0.06 [b]	0 – 10	1.76±0.29 [a]	76.93	-3.68	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 3: Morphometric characters of *Arius gigas* expressed as percentage of Standard length from the two population.

Morphometric Traits	Choba	Degema	F	t	p-value
Head Length	28.51±0.31 [b]	30.33±0.26 a	8.48	-4.56	0.00
Total Length	134.19±12.28	121.73±0.91	2.10	1.02	0.31
Fork Length	108.33±0.95	108.06±0.37	0.43	0.26	0.79
Length Of Pectoral Fin	11.87±0.14	11.50±0.17	2.26	1.71	0.09
Body Depth	63.95±0.42	63.67±0.78	9.06	0.32	0.75
Anal Fin	12.34±0.16	11.96±0.19	1.81	1.54	0.13
Length Of Caudal Peduncle	13.57±0.24	13.51±0.16	11.73	0.21	0.83
Length Of 1st Dorsal Fin	4.13±0.07 [a]	3.62±0.07 [b]	0.05	5.54	0.00
Length Of 2nd Dorsal Fin	3.76±0.06 [a]	3.39±0.06 [b]	0.82	4.30	0.00
Length Of Interdorsal Space	8.11±0.36 [a]	5.68±0.11 [b]	84.75	6.43	0.00
Length Of Adipose Fin	10.77±0.21 [a]	9.49±0.18 [b]	1.66	4.55	0.00
Pre-Orbital Length	12.21±1.21	11.13±0.17	2.65	0.89	0.38
Post Orbital Length	12.95±0.18	13.36±0.17	0.44	-1.67	0.10
Eye Length	6.06±0.13 [b]	6.71±0.08 [a]	1.94	-4.19	0.00

*Superscripts of the same alphabet are not significantly different across the column (P>0.05).

**Superscripts of different alphabets are significantly different (P<0.05).

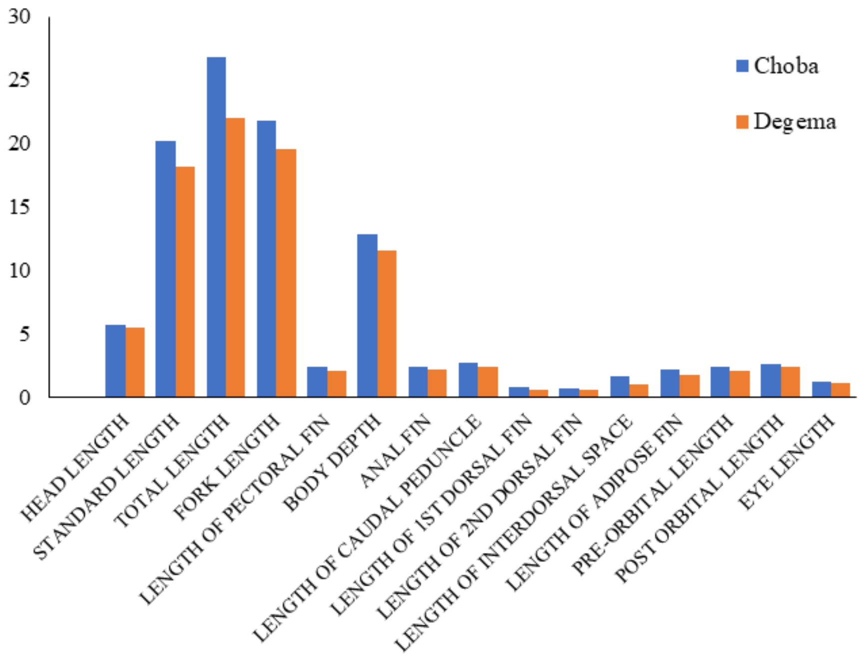

Figure 3: Comparison between morphometric traits of *Arius gigas* the two populations.

Table 4: Meristic count characters of *Arius gigas* expressed as percentage of standard length from the two population.

	Choba	Degema	F	t	p-value
Anal Fin Ray	43.17±1.07	39.61±2.20	54.80	1.45	0.15
Pectoral Fin Ray	29.94±0.59 [a]	23.65±1.53 [b]	64.38	3.83	0.00
Pelvic Fin Ray	75.10±5.81 [a]	40.89±2.59 [b]	0.65	5.40	0.00
Dorsal Fin Spine	9.88±0.76	11.37±1.31	42.08	-0.98	0.33
Anal Fin Spine	3.20±0.32 [b]	10.93±1.85 [a]	86.11	-4.09	0.00

*Superscripts of the same alphabet are not significantly different across the column (P>0.05)

**Superscripts of different alphabets are significantly different (P<0.05)

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

	Choba		Degema		Overall	
	R^2	B	R^2	B	R^2	B
Head Length	0.74	2.28	0.93	2.66	0.83	2.56
Fork Length	0.58	0.66	0.98	0.93	0.83	0.83
Length Of Pectoral Fin	0.74	5.23	0.77	6.11	0.77	5.79
Body Depth	0.85	1.35	0.81	1.19	0.83	1.25
Anal Fin	0.56	4.76	0.77	4.91	0.71	4.96
Length Of Caudal Peduncle	0.58	3.37	0.79	6.18	0.67	4.66
Length Of 1st Dorsal Fin	0.59	11.94	0.73	15.23	0.69	13.53
Length Of 2nd Dorsal Fin	0.52	12.04	0.79	17.62	0.69	15.10
Length Of Inter-dorsal Space	0.06	1.02	0.63	10.90	0.19	2.59
Length Of Adipose Fin	0.53	4.22	0.79	5.89	0.70	5.10
Pre-Orbital Length	0.02	0.24	0.91	5.56	0.13	0.94
Post Orbital Length	0.57	4.08	0.84	5.19	0.73	4.88
Eye Length	0.41	11.11	0.72	17.54	0.58	15.12

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

	Choba		Degema		Overall	
	R^2	B	R^2	B	R^2	B
Anal Fin Ray	0.04	-0.55	0.07	0.29	0.05	0.30
Pectoral Fin Ray	0.02	0.79	0.08	0.46	0.10	0.59
Pelvic Fin Ray	0.00	0.01	0.10	0.25	0.04	0.08
Dorsal Fin Spine	0.01	-0.28	0.05	-0.44	0.03	-0.40
Anal Fin Spine	0.03	0.82	0.07	-0.37	0.05	-0.41

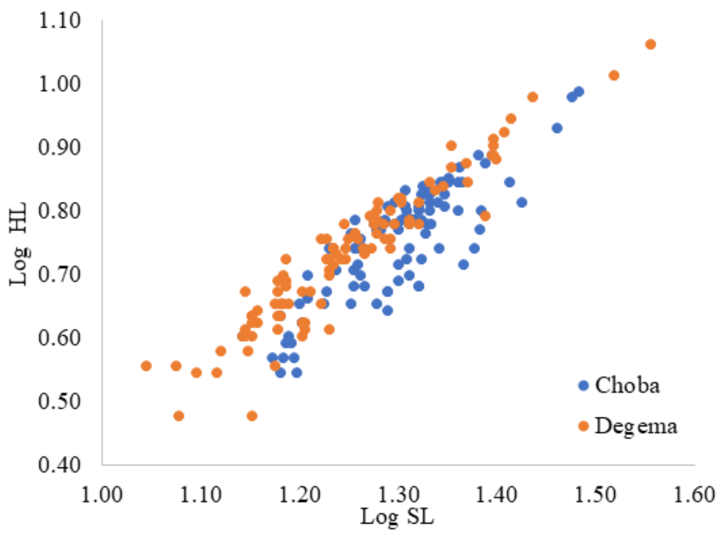

Figure 4a: Relationship between the Head length and Standard Length from the two populations, Choba and Degema.

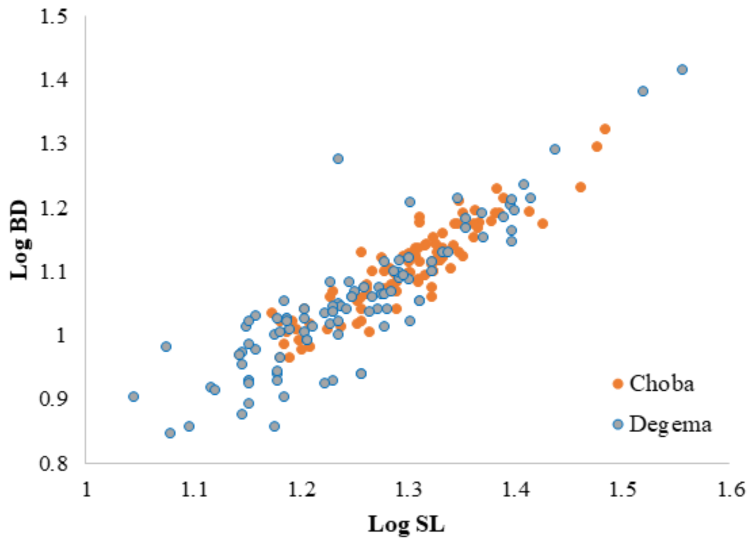

Figure 4b: Relationship between the Body depth and Standard Length from the two populations, Choba and Degema.

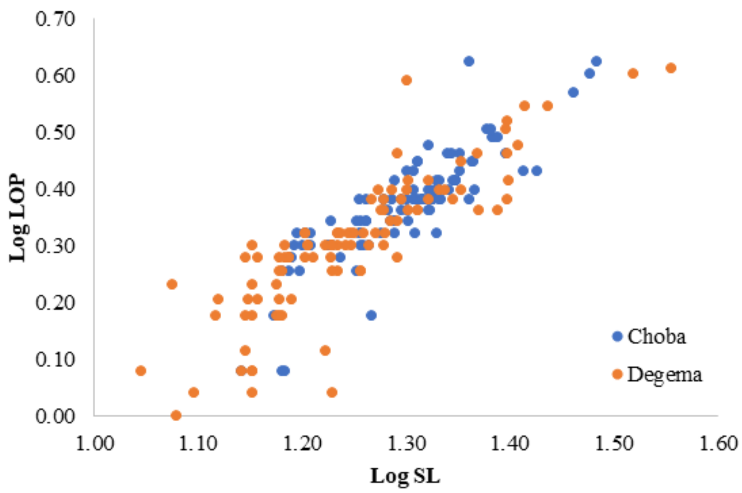

Figure 4c: Relationship between the Length of Pectoral Fin and Standard Length from the two populations, Choba and Degema.

variation in the morphology of the fish species. Winkler and Greve (2002) reported that the main environmental factors influencing the growth and reproductive cycle of crustaceans appear to be water temperature, light cycle, and food conditions. Dunham et al. (1979) also stated that morphometric parameters can be highly variable between and within nonspecific populations, either correlating with geographical and habitat variation or having a genetic component based on differences between groups in a common environment. Solomon et al., (2015) also reported that the analyses of morphometric characters revealed abundant variations among different populations.

Fish have been said to demonstrate greater variance in morphological traits both within and between populations of species than any other vertebrates (Currens et al., 2016). The meristic parameters considered in this study also showed a difference between the populations; out of the five meristic counts examined, only one exhibited a slight variation in AFS between the two populations. Eyo and Mgbenka (1992) reported that specific differences in the meristic counts were exhibited in the AFR and the vertebral count in the Clariids of the Anambra River, Nigeria. According to Olopade et al. (2018), the deviations reported in the morphological structures among different populations of fish species were a common biological phenomenon. And according to Swain & Foote (1999), the phenotypic variation in the morphological characters or meristic counts may be caused by environmental factors in addition to genetic factors. Water clarity, water depth and flow, food availability, and physical complexity were listed by Krabbenhoft et al., (2009) as the environmental factors underlying the morphological changes. The composition of the fish assemblage with commercial netting, according to Layman et al., (2005), may play a significant role in the morphological differences.

The meristic counts showed more distinct discriminating differences between the samples of the two populations. According to (Cakić et al., 2002), the differences in the morphological and meristic characteristics of the specimens are related to the aquatic ecosystems from which they were derived. In this study, the mean morphometric characteristics expressed as the % SL were slightly higher in the New Calabar River than Degema River, except HL, POL and EL.

This study indicated that all the external parameters displayed allometric growth, which is relative to the SL in most of the characters considered apart from the LoCP with an isometric growth pattern (b=3) from the New Calabar River. The morphometric relationships imply that variations in the dimensions of the various body parts are related to variations in the entire body. Allometric growth indicates that the fish's weight increased or decreased in proportion to the cube of their SL, so adults may differ from juveniles in appearance (Bagenal & Tesch, 1978). All five meristic characters under analysis lacked any relativeness to the average length of all meristic variables under investigation. Since the meristic characteristics are known to be independent of fish size, they shouldn't change as the fish grows (Strauss, 1985). The residual of HL, PFL, and BD plotted against SL demonstrated a distinct differentiation between species as well as among stocks in the various populations.

CONCLUSION

The analysis of morphometric characters obtained in this study shows that there are three morphologically distinct populations of *A. gigas* in the two populations and that these differences may be due to body shape and not size. Ecological factors may be drivers for such variations, as has been shown for other fish species. The findings of this study may be used in developing management strategies for the study area in the future also, both the univariate and multivariate analyses clearly demonstrate morphological variations among the two populations. Future studies to corroborate the findings of the populations of *A. gigas* using molecular markers should be considered for making conservation plans for exploitable *A gigas* species.

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DECLARATION OF CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

Adesulu, E. A., & Sydenham, D. H. J., (2007). The Freshwater and Fisheries of Nigeria, Macmillan Nigeria Publishers, Lagos, Nigeria, 397

Akinrotimi, O.A., Ukwe, O.I.K., & Amadioha, F. (2018). Morphometric Characters and Meristic Counts of Black Chin Tilapia (*Sarotherodon melanotheron*) from Buguma, Ogbakiri and Elechi Creeks, Rivers State, Nigeria. *International Journal of Poultry and Fisheries Science* **2** (1): 1-8. doi: 10.15226/2578-1898/2/1/00106

Analaura, I.A., Esther, C.S., Manuel, G.C., & Elaine, E.B. (2005). Comparative Morphometrics of two Populations of *Mugil curema* (Pisces: Mugilidae) on the Atlantic and Mexican Pacific Coasts *Science Marine* **70** (1): 139-145. ISSN 0188-8897

Bagenal, T.B., & Tesch, F.W. (1978). Age and Growth. In: Bagenal T.B (Ed.), Methods for Assessment of Fish Production in Freshwater, 3rd ed. IBP Handbook No. 3, *Blackwell Scientific Publications,* Oxford: 101-136.

Cakić, P., Lenhardt, M., Mićković, D., Sekulić, N., & Budakov, L.J. (2002). Biometric Analysis of *Syngnathus abaster* Populations. *Journal of Fisheries Biology* **60**:1562-1569

Cavalcanti, M.J., Monteiro, L.R., & Lopez, P.R.D. (1999). Landmark Based Morphometric Analysis in Selected species of Serranid Fishes (Perciformes: Teleostei). *Zoological Studies* **38**: 287-294.

Currens, K.P., Sharpe, C.S., Hjort, R., Schreck, C.B., & Li, H.W. (2016). Effects of Different Environments on Fish Morphology. *Journal of Science* **45**:127-134.

Deesri, U., Cavin L., Claude, J., Suteethorn, V., & Yuangdetkla, P. (2009). Morphometric and Taxonomic Study of a Ray-finned Fish Assemblage (*Lepidotes buddhabutrensis,* Semionotidae) from the Late Jurassic - earliest Cretaceous of NE Thailand. *Geological. Society, London, Specialty Publication* **315**: 115-124. Doi: https://DOI./10.1111/j.1475-4983.2012.01184.

Dienye, H.E., & Woke, G.N. (2015). Physico-Chemical Parameters of the Upper and Lower Reach of the New Calabar River Niger Delta. *Journal of Fisheries and Livestock Production* **3**:154. doi:10.4172/2332-2608.1000154

Dienye, H.E., Olopade, O.A., & Okoro, U. (2022) Morphometric and Meristic Traits of Giant Sea Catfish *Arius gigas* (Boulenger 1911) From New Calabar River and Degema River, Rivers State, Nigeria (B.Sc. project) Department of Fisheries, Faculty of Agriculture, University of Port Harcourt) (Unpublished)

Dunham, A.E., Smith, G.R., & Taylor, J.N. (1979). Evidence for Ecological Character Displacement in Western American Catostomic Fishes. *Evolution* **33**(3):877–896.

Eyo, J.E., & Mgbenka, B.O. (1992). Aspect of the Biology of *Clarias gariepinus* in Anambra River Basin I: Oocyte Diameter Fecundity and Sex Ratio. *Journal of Agricultural Science and Technology* **2** (I):47-51

Franičevič, M., Sinovčić, G., Čikeś, V., & Zorica B. (2005). Biometry Analysis of the Atlantic Bonito, Sarda sarda (Bloch, 1753) in the Adriatic Sea. *Acta Adriatica,* **46** (2): 213222.

Froese, R., & Pauly, D. (2016). Fish Base. www.fishbase.org. World Wide Web electronic publication Accessed on August 2016

Hirsch, P.E., Eckmann, R., Oppelt, C. & Behrmann-Godel, J., (2013). Phenotypic and Genetic Divergence within a single Whitefish form – Detecting the Potential for Future Divergence. *Evolutionary Applications*. Pp.1752-4571. Published by John Wiley & Sons Ltd 6. 1119–1132 ISSN

Hubbs, C.L., & Lagler, K.F. (1947). Fishes of the Great Lakes Region. *Cranbrook Institute of Science Bulletin* **26**, 186

International Union for Conservation of Nature. (2019). The IUCN Red List of Threatened Species. *Version* 2

Kai, Y., & Nakabo, T. (2002). Morphological Differences among Three Colour Morphotypes of *Sebastes inermis* (Scorpaenidae). *Ichthyology Research* **49**: 260-266. doi :10.1007/s102280200037

Krabbenhoft, T.J, Collyer, M.L., & Quattro, J.M. (2009). Differing Evolutionary Patterns Underlie Convergence on Elongate Morphology in Endemic Fishes of lake Waccamaw, North Carolina. *Biological Journal of the Linnean Society*, **98**: 636-645.

Layman, C.A, Langerhans, R.B & Winemiller, K.O. (2005). Body size, not other morphological traits, characterizes cascading effects in fish assemblage composition following commercial netting. *Canadian Journal of Fisheries and Aquatic Science* **62**: 2802-2810 doi: https://DOI/10.1139/f05-183

Marceniuk, A. P., & Menezes, N. A., (2007). Systematics of the Family Ariidae (Ostariophysi, Siluriformes), with a Redefinition of the Genera. *Zootaxa,* 1416,126.10.11646/zootaxa.1416.1.1

Mustafa, M.G., & Brooks, A.C. (2008). Status of Fisheries Resource and Management Approach in the Open 'Beels 'of Bangladesh. A comparative Case Study. *Asian Fisheries Science* **21**: 189-203. doi: https:// DOI./10.33997/j.afs.2008.21.2.005

Narejo, N.T, Jafri, S.I.H., & Shaikh, S.A. (2000). Studies on the Age and Growth of Palri, *Gudusia chapra* (Clupeidae: Teleostei) from the Keenjhar Lake (District Thatta) Sindhu, Pakistan*. Pakistan Journal of Zoology* **32**: 307-312.

Nayman (1965**)**. Growth and Ecology of Fish Population. *Journal of Animal Ecology* **20**: 201-219.

Olopade, O.A., Dienye, H.E., Jimba, B., & Bamidele, N.A. (2018). 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. *Jordan Journal of Biological Sciences* **11**(3); 247 – 255. ISSN 1995-6673

Pepin, P., & Carr, S.M. (1993). Morphological, Meristic and Genetic Analysis of Stock Structure in Juvenile Atlantic Cod (*Gadus morhua)* from the New Found Land Shelf. *Canadian Journal of Fisheries and Aquatic Science* 1924- 1933. doi: 10.1139/f93-215

Reist, J.D. (1985). An Empirical Evaluation of Several Univariate Methods that Adjust for Size Variation in Morphometric Data. *Canadian Journal of Zoology* **63** 1429-1439. doi https://DOI./10.1139/z85-213

Schneider, W. (1990). Food and Agriculture Organisation (FAO). Species Identification Sheets for Fishery Purposes, Field Guide to the Commercial Marine Resources of the Gulf of Guinea, Prepared and Published with the Support of the FAO Regional Office for Africa. Rome, FAO, 268.

Solomon, S.G, Okomoda, V.T., & Ogbenyikwu, A.I. (2015). Intraspecific Morphological Variation between Cultured and Wild *Clarias gariepinus* (Burchell) (Clariidae, Siluriformes) *– Arch Polish Fisheries* **23**:53-61 doi: https://DOI./10.1515/aopf-2015-0006

Strauss, R.E. (1985). Evolutionary Allometry and Variation in Body Form in the South American Catfish genus Corydoras (Callichthydae). *Systematic Biology* **34**:381-396. doi: 10.1093/sysbio/34.4.381

Swain, D., & Foote, C.J. (1999). Stocks and Chameleons: The use of Phenotypic Variation in Stock Identification. *Fishery Research* **43**: 113–128. doi:https://DOI./10.1016/S0165-7836%2899%2900069-7

Turan, C., Yalcin, S., & Akyurt, O.E. (2005). Morphometric Comparison of African Catfish *Clarius gariepinus*, Population in Turkey. *Folia Zoology* **54**: 165-172.

Wimberger, P. H. (1992). Plasticity of Fish Body Shape. The Effects of Diet, Development, Family and Age in two Species of Geophagus (Pisces; Cichlidae). *Biological Journal of Linnean Society* **45**:197-218. doi:10.1111/J.1095-8312.1992.TB00640.X

Winkler, G., & Greve, W. (2002). Laboratory Studies of the Effect of Temperature on Growth, Molting and Reproduction in the Co-occurring *Mysids Neomysis integer* and *Praunus flexuosus*. *Marine Ecology Progress Series* **235**: 177–188. doi:10.3354/meps235177.

Zar, J.H. (1984). Bio-Statistical Analysis. *2nd Ed, Prentice-Hall Inc*., Englewood Cliffs, New Jersey, USA.