Morphometric and Meristic Variation of African Snakehead Fish *Parachanna obscura*, Günther, 1861 from Nigeria's Freshwater Environment

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ABSTRACT

To attain food security in Africa, the expansion of aquaculture through domestication of endemic species like *Parachanna obscura* is essential. Optimizing these resources requires a definition of the status of the natural populations that will supply broodstocks and seeds. Morphological variation based on 22 morphological and seven meristic features was investigated. The 12 river basins in Nigeria were purposively selected while one river in each of the basins was randomly chosen for *P. obscura* sampling. In total, 872 individuals from five rivers (Anambra, Ibbi, Imo, Katsina-Ala and Ogun) were collected and morphometric data taken for ANOVA and multivariate analyses. Standard length (0.969) and post orbital length (0.971) had highest correlation with total length, while anal fin base (0.379) and inter orbital length (0.427) were the least correlated with total length. Multivariate analysis revealed that the Katsina-Ala and Ogun River populations were the most discriminated from the others, based primarily on anal fin base length. Among the meristic characteristics were fin ray counts: dorsal (range 41-48), pectoral (13-17), pelvic 5-7), caudal (12-13), and anal (29-45). Notably, ranges of dorsal and anal fin ray counts observed herein were slightly wider than previously reported. The study revealed significant phenotypic variation to be considered to maximize benefits from future domestication efforts.

Keywords: Anal fin base, Aquaculture, Morphological variations, River basins

INTRODUCTION

There is an urgent need to further develop aquaculture in Africa, where the human population poses a challenge to food systems (FAO, 2020). This will demand ensuring more resourceful and sustainable use of natural resources, and better understanding of available resources and how they match current and future needs. Knowledge of the status of natural resources and their trends as a consequence of their exploitation are significant steps towards their sustainable management. Given this state of affairs, an important question is the phenotypic diversity of wild fishes that form the gene bank for aquaculture. Some declining fish species like the African snakehead *Parachanna obscura* show interesting aquaculture potential. There are two extant genera of snakeheads, *Channa* in Asia and *Parachanna* in Africa, together comprising about 37 species (Froese and Pauly, 2018). The genus *Parachanna* evolved due to the African species' suprabranchial cavity being of a slightly more primitive design than that of the Asian species. *Parachanna obscura* has an

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elongated body that is fusiform and sub-cylindrical, and the whole body is protected by cycloid, medium sized scales. The head is depressed anteriorly, relatively long and covered with cycloid scales larger than those on the body and symmetrical on the top (African Union Inter-African Bureau for Animal Resources, 2012). A few dark blotches that tend to connect on the back are present on either side of the ridge (Kpogue *et al*., 2013). It is the most widespread African Channidae (African Union Inter-African Bureau for Animal Resources, 2012) found in the inland waters of Africa and native to Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Democratic Republic of Congo, Cote d'Ivoire, Ethiopia, Gambia, Ghana, Guinea, Guinea Bissau, Mali, Niger, Nigeria, Senegal, Sierra Leone, Sudan and Togo (Teugels, 2003). The species forms an important part of the commercial catches from many of the rivers where they are found (Gautam *et al*., 2018).

Snakeheads are of commercial importance as a result of their good taste and high-quality flesh due to presence of prostaglandins, thromboxane and Omega-6 fatty acid (Gautam *et al*., 2018). The hardy nature, fast growth rate (2 $g \cdot day^{-1}$) and important economic attributes (Kpogue *et al*., 2013) of *P. obscura* epitomize significant aquaculture potential. However, natural stocks of *P. obscura*, like many Channidae, are overexploited and are not adequate to meet local demand (African Union Inter-African Bureau for Animal Resources, 2012; Song *et al*., 2013). Therefore, successful farming of this species will not only increase food production but also enhance the conservation of the natural stocks of *P. obscura* by reducing fishing pressure (Kpogue *et al*., 2013). Previous works towards attaining this goal have focused on the haematological and serum biochemistry profile (Adebayo *et al*., 2007; Osho *et al*., 2020a), diet and feeding pattern (Whenu and Fagade, 2012), biology (Odo *et al*., 2012), condition factor (Osho and Usman, 2019) and microbiota (Osho *et al*., 2020b). However, there is a dearth of information on the morphologic and meristic variation of populations of this species

MATERIALS AND METHODS

Study site and sample collection

Two-stage sampling (Environmental Protection Agency, 2002) was adapted for the collection of Parachanna obscura samples across 12 rivers under the 12 River Basin Development Authorities (RBDAs) of Nigeria: Anambra-Imo, Lower Niger, Upper Niger, Benin-Owena, Chad, Cross River, Hadejia-Jama'are, Lower Benue, Niger Delta, Ogun-Osun, Upper Benue, and Sokoto-Rima. One river in each of the basins was randomly chosen for sampling from the catch of local fishers as shown in Figure 1. These randomly selected rivers were Anambra, Imo, Ibbi, Kaduna, Katsina-Ala, Hadejia, Ogun, Sokoto, Great Kwa, Niger, Kaduna, Ovia, Lake Chad (representing Anambra-Imo, Niger Delta, Upper Benue, Lower Benue, Hadejia-Jama'are, Ogun-Osun, Sokoto-Rima, Cross River, Lower Niger, Upper Niger, Benin-Owena, and Lake Chad RBDAs, respectively).

Live samples of *Parachanna obscura* were collected from the catch of fishers (who used Malian traps) every two months for 18 months (May, 2018 to October, 2019). The samples confirmed as *P. obscura* using guides by Olaosebikan and Raji (2013) and Froese and Pauly (2018) and then transported to the laboratory in oxygenated aquaria.

As a result, significant numbers of *P. obscura* were only encountered in five of the rivers sampled: Anambra (180), Ibbi (180), Imo (157), Katsina-Ala (180) and Ogun (180). The species was not encountered in Rivers Kaduna and Hadejia, while the catch was scanty in Rivers Niger, Great Kwa, Ovia and Sokoto. Lake Chad could not be assessed due to the Boko Haram insurgency in that region of Nigeria.

Morphological measurements

Morphometric characters were measured to the nearest 0.1 cm using a pair of dividers and a

traits were recorded: counts of dorsal, pectoral, pelvic, anal, and caudal fin rays; number of scales on lateral line; and number of lateral blotches. *Parachanna obscura* does not exhibit sexual dimorphism, therefore both sexes were combined for data collection.

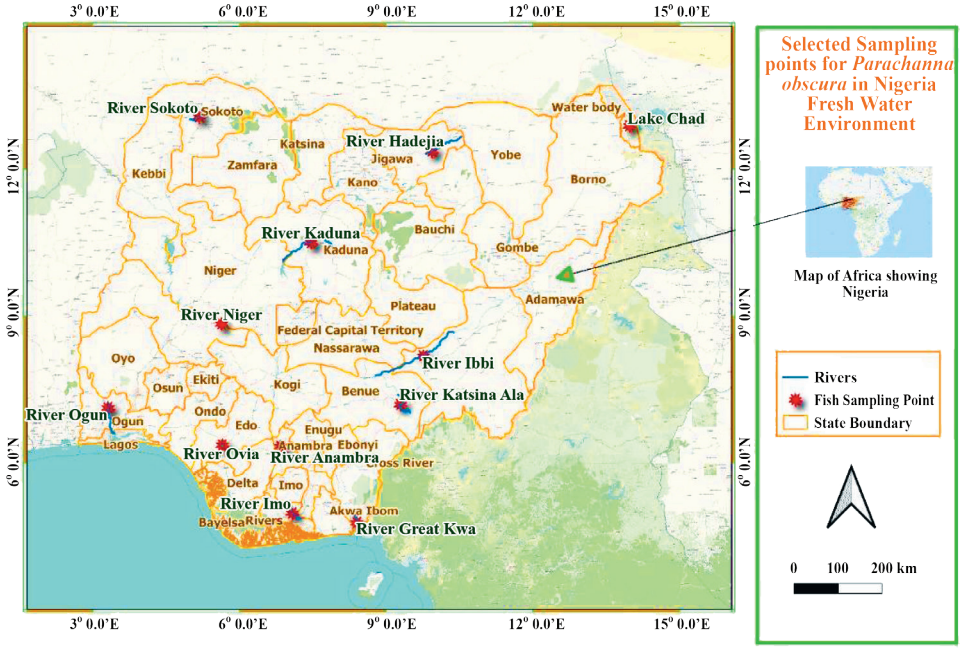

Figure 1. Map of Nigeria showing sampled rivers and collection points.

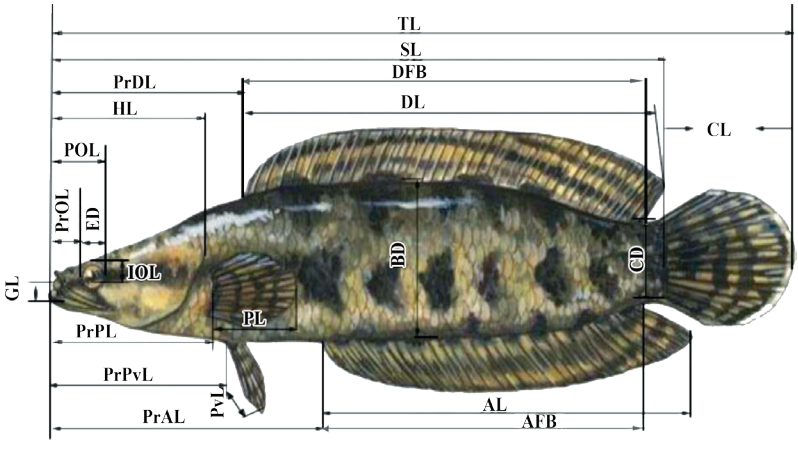

Figure 2. Illustration showing morphometric characters measured in *Parachanna obscura*.

Note: TL = total length; SL = standard length; HL = head length; PrOL = pre orbital length; POL = post orbital length; ED = eye diameter; IOL = inter orbital length; PrDL = pre-dorsal fin length; PrPL = pre-pectoral fin length; PrPvL = pre-pelvic fin length; PrAL = pre-anal fin length; DL = dorsal fin length; DFB = dorsal fin base; PL = pectoral fin length; PvL = pelvic fin length; AL = anal fin length; AFB = anal fin base; CL = caudal fin length; CD = caudal depth; BD = body depth; DFB = dorsal fin base; AFB = anal fin base and GL = gape length (Adapted from Olanrewaju [2017] and Myers *et al*. [2021])

Data management and statistical analyses

Size effects from the data set were eliminated by standardizing the morphometric parameters using the allometric formula by Elliott *et al*. (1995):

$$Madj = M (Ls/Lo)$$

Where M = measurement, Madj = size-accustomed dimension, Lo = total length of fish, and Ls = mean of total length for all fish. Factor b was calculated for each character as a slope of the regression of logM on logLo, using all fish groups (Sarower-E-Mahfuj, 2019). Morphometric measurements and meristic counts were analyzed using one-way analysis of variance (ANOVA), followed by mean comparisons using Duncan's multiple range test. Differential function analysis was used to calculate regressions among morphometric parameters while principal components and canonical discriminant function were analyzed as described by Yakubu and Okunsebor (2011). Cluster analysis in Palaeontological Statistics (PAST) software was also used to generate a dendrogram showing the diversity of fish among populations at a bootstrap value based on 1000 pseudo-replications.

RESULTS

Summary of morphometric and meristic parameters

Most of the parameters measured were significantly different ($p<0.05$) among populations, as shown in Table 1. Fish from River Ogun were the largest in body size, and this was reflected in all the morphometric parameters taken. Individuals from the Benue River were the smallest. The fish from Rivers Anambra and Imo were similar in size, and consequently similar in most of the morphometric parameters taken. Total length ranged between 14.92±0.78 and 29.92±0.60 cm. The standard length and head length ranged from 12.63±0.68 to 25.39±0.56 cm and from 3.81±0.20 to 7.70±0.15 cm, respectively.

Average values of pre-dorsal fin length and pre-pectoral fin length followed the same pattern of variation among the river populations. These two parameters did not differ significantly between the Anambra and Imo populations. Caudal fin length ranged between 2.38±0.12 and 4.51±0.86 cm among all five populations, with the least and highest values recorded in the Benue and Ogun populations, respectively. As shown in Table 2, the mean dorsal fin ray counts ranged from 41.34±0.11 to 47.71± 01.07, with the lowest and highest values recorded from Anambra and Ibbi, respectively. Only the Taraba population was significantly different ($p<0.05$) from the rest.

Differential function and principal component analyses

The correlation matrix indicates positive relationships among various morphometric parameters (Table 3). Standard length, post orbital length, standard length and head length showed the highest correlation with total length, while anal fin base length and inter orbital length showed the least correlation with total length. Principal component score plots (Figure 3) reveal that Ogun River and Katsina-Ala populations each form distinct clusters while the others overlap. The biplot (Figure 4) shows that anal fin base length was the most significant morphometric parameter that could be used to discriminate the populations. Figures 5 and 6 show that the Katsina-Ala population was most different from the others based on the meristic qualities, of which anal fin ray count was the most important discriminant. A close look at Figure 3 reveals that the Anambra and Imo populations were morphologically more similar to the Ogun population, while the Ibbi population was closer to the Katsina-Ala population. This grouping is supported by the dendrogram depicted in Figure 7.

Table 1. Mean±standard error of mean (cm), F and p-values of morphometric measurements (MM) of *Parachanna obscura* from five rivers in Nigeria.

MM	Anambra (n = 180)	K.Ala (n = 180)	Imo (n = 157)	Ogun (n = 180)	Ibbi (n = 180)	F-value	p-value
TL	25.99±0.44^{b}	14.92±0.78^{d}	25.11±0.46^{b}	29.92±0.60^{a}	22.34±0.67^{c}	76.81	0.000
SL	21.64±0.38^{b}	12.63±0.68^{d}	20.70±0.40^{b}	25.39±0.56^{a}	18.48±0.56^{c}	72.79	0.000
HL	6.80±0.12^{b}	3.81±0.20^{d}	6.80±0.13^{b}	7.70±0.15^{a}	5.68±0.17^{c}	77.07	0.000
IOL	1.81±0.38^{b}	1.07±0.40^{c}	1.93±0.37^{ab}	2.40±0.27^{a}	1.57±0.05^{b}	7.94	0.000
PrOL	1.03±0.22^{c}	0.60±0.35^{e}	1.22±0.20^{b}	1.46±0.36^{a}	0.82±0.03^{d}	104.15	0.000
POL	4.83±0.10^{b}	2.64±0.16^{d}	4.72±0.10^{b}	5.64±0.12^{a}	4.09±0.13^{c}	73.96	0.000
ED	0.87±0.01^{b}	0.51±0.02^{d}	0.96±0.11^{a}	0.96±0.18^{a}	0.62±0.19^{c}	142.50	0.000
PrDL	7.07±0.11^{b}	4.09±0.20^{d}	6.93±0.12^{b}	8.27±0.15^{a}	6.08±0.18^{c}	90.44	0.000
PrPL	6.74±0.10^{b}	3.70±0.17^{d}	6.71±0.12^{b}	7.76±0.15^{a}	5.77±0.17^{c}	93.37	0.000
PrPvL	7.94±0.13^{b}	4.76±0.21^{d}	8.91±0.21^{a}	9.10±0.18^{a}	7.21±0.19^{c}	67.50	0.000
PrAL	11.03±0.20^{b}	6.33±0.34^{d}	9.75±0.33^{bc}	12.96±0.26^{a}	10.45±0.27^{c}	71.87	0.000
DL	13.37±0.30^{b}	7.75±0.36^{d}	13.10±0.26^{bc}	15.71±0.35^{a}	12.20±0.41^{c}	58.29	0.000
PL	3.60±0.73^{b}	2.49±0.43^{c}	3.51±0.12^{b}	4.12±0.11^{a}	2.91±0.09^{c}	14.13	0.000
PvL	2.54±0.50^{b}	1.41±0.72^{d}	2.49±0.04^{b}	2.76±0.62^{a}	2.09±0.09^{c}	55.20	0.000
AL	9.30±0.17^{b}	5.64±0.28^{d}	8.72±0.18^{bc}	10.69±0.23^{a}	8.43±0.27^{c}	57.28	0.000
CL	4.22±0.07^{b}	2.38±0.12^{d}	4.24±0.89^{b}	4.51±0.86^{a}	3.53±0.13^{c}	65.69	0.000
BD	4.39±0.13^{b}	2.08±0.16^{d}	4.28±0.15^{b}	6.09±0.18^{a}	3.77±0.15^{c}	76.01	0.000
CD	1.96±0.04^{b}	0.96±0.87^{c}	1.85±0.04^{b}	2.92±0.26^{a}	2.03±0.08^{b}	18.30	0.000
DFB	2.39±0.05^{b}	1.03±0.12^{d}	2.28±0.06^{b}	2.63±0.06^{a}	1.83±0.06^{c}	70.32	0.000
AFB	2.34±0.58^{b}	1.05±0.18^{c}	2.79±0.54^{a}	3.32±0.2^{a}	1.74±0.65^{b}	13.58	0.000
GL	2.59±0.58^{c}	0.82±0.92^{e}	3.08±0.57^{b}	3.71±0.95^{a}	1.88±0.08^{d}	165.01	0.000

Note: TL = total length; SL = standard length; HL = head length; IOL = inter orbital length; PrOL = pre orbital length; POL = post orbital length; ED = eye diameter; PrDL = pre-dorsal fin length; PrPL = pre-pectoral fin length; PrPvL = pre-pelvic fin length; PrAL = pre-anal fin length; DL = dorsal fin length; PL = pectoral fin length; PvL = pelvic fin length; AL = Anal fin length; CL = caudal fin length; BD = body depth; CD = caudal fin depth; DFB = dorsal fin base; AFB = anal fin base; GL = gape length; Values within each row superscripted with different letters are significantly different ($p<0.05$).

Table 2. Mean±standard error of mean, F and p-values of meristic counts (MC) of *Parachanna obscura* from five rivers in Nigeria.

MC	Anambra	Katsina-Ala	Imo	Ogun	Ibbi	F-value	p-value
DFR	41.34±0.11^{b}	42.92±1.14^{b}	42.59±0.13^{b}	41.71±0.13^{b}	47.71±01.07^{a}	19.82	0.000
PFR	15.41±0.80^{b}	13.49±0.27^{d}	16.19±0.11^{a}	15.33±0.12^{b}	14.79±0.29^{c}	24.24	0.000
PvFR	6.00±0.00^{a}	5.85±0.10^{ab}	6.00±0.00^{a}	5.84±0.04^{b}	5.58±0.074^{c}	11.04	0.000
CFR	12.54±0.07^{a}	12.51±0.11^{a}	12.32±0.08^{a}	12.59±0.12^{a}	12.55±0.05^{a}	0.97	0.422
AFR	29.48±0.11^{b}	45.12±1.80^{a}	29.51±0.13^{b}	29.14±0.13^{b}	30.78±0.25^{b}	107.72	0.000
BL	6.41±0.73^{b}	6.85±0.96^{a}	5.50±0.08^{c}	6.79±0.10^{b}	6.41±0.05^{a}	23.58	0.000
BR	6.41±0.74^{b}	7.22±0.89^{a}	5.50±0.08^{c}	6.40±0.11^{b}	7.07±0.05^{a}	35.00	0.000
SLL	64.60±0.35^{b}	64.71±0.94^{b}	64.41±0.41^{b}	62.95±0.69^{b}	64.75±0.71^{a}	11.46	0.000
SLR	64.60±0.35^{b}	64.71±0.94^{b}	64.41±0.41^{b}	62.95±0.69^{b}	64.88±0.71^{a}	11.46	0.000

Note: DFR = dorsal fin ray; PFR = pectoral fin ray; PvFR = pelvic fin ray; CFR = caudal fin ray; AFR = anal fin ray; BL = blotches on left side of body; BR = blotches on right side of body; SLL = lateral line scales on left side of body; SLR = lateral line scales on right side of body; Values within each row superscripted with different letters are significantly different ($p<0.05$).

Table 3. Correlation coefficients of morphometric measurements of *Parachanna obscura* from five rivers in Nigeria.

	TL	SL	IOL	HL	PrOL	POL	ED	PrDL	PrPL	PrPvL	PrAL	DL	PL	PvL	AL	CL	BD	CD	DFB	GL	AFB
TL	1.000																				
SL	0.969	1.000																			
IOL	0.427	0.443	1.000																		
HL	0.966	0.935	0.423	1.000																	
PrOL	0.788	0.765	0.354	0.796	1.000																
POL	0.971	0.885	0.449	0.931	0.778	1.000															
ED	0.769	0.740	0.314	0.770	0.723	0.737	1.000														
PrDL	0.974	0.951	0.435	0.961	0.814	0.923	0.767	1.000													
PrPL	0.959	0.932	0.420	0.958	0.807	0.917	0.765	0.976	1.000												
PrPvL	0.893	0.861	0.402	0.891	0.733	0.832	0.717	0.900	0.893	1.000											
PrAL	0.884	0.866	0.388	0.875	0.712	0.835	0.643	0.889	0.874	0.763	1.000										
DL	0.928	0.898	0.406	0.912	0.728	0.860	0.679	0.924	0.907	0.848	0.852	1.000									
PL	0.647	0.623	0.293	0.635	0.542	0.623	0.506	0.642	0.586	0.578	0.581	0.616	1.000								
PvL	0.918	0.887	0.426	0.915	0.739	0.879	0.732	0.919	0.913	0.864	0.816	0.882	0.633	1.000							
AL	0.936	0.912	0.421	0.927	0.748	0.908	0.688	0.930	0.919	0.855	0.848	0.882	0.593	0.880	1.000						
CL	0.887	0.871	0.419	0.872	0.685	0.830	0.751	0.883	0.851	0.832	0.765	0.843	0.597	0.841	0.842	1.000					
BD	0.868	0.855	0.379	0.838	0.741	0.797	0.303	0.855	0.846	0.776	0.817	0.823	0.581	0.818	0.834	0.736	1.000				
CD	0.469	0.471	0.209	0.459	0.499	0.441	0.354	0.467	0.473	0.451	0.449	0.442	0.312	0.454	0.462	0.411	0.480	1.000			
DFB	0.890	0.858	0.406	0.882	0.701	0.852	0.716	0.878	0.871	0.834	0.773	0.825	0.585	0.858	0.855	0.832	0.792	0.435	1.000		
GL	0.822	0.801	0.386	0.823	0.807	0.828	0.771	0.849	0.838	0.767	0.718	0.762	0.553	0.766	0.775	0.750	0.751	0.455	0.770	1.000	
AFB	0.379	0.374	0.103	0.400	0.385	0.386	0.348	0.386	0.385	0.347	0.349	0.344	0.227	0.352	0.363	0.322	0.393	0.233	0.402	0.373	1.000

Note: TL = total length; SL = standard length; IOL = inter orbital length; HL = head length; PrOL = pre orbital length; POL = post orbital length; ED = eye diameter; PrDL = pre-dorsal fin length; PrPL = pre-pectoral fin length; PrPvL = pre-pelvic fin length; PrAL = pre-anal fin length; DL = dorsal fin length; PL = pectoral fin length; PvL = pelvic fin length; AL = Anal fin length; CL = caudal fin length; BD = body depth; CD = caudal fin depth; DFB = dorsal fin base; GL = gape length; AFB = anal fin base

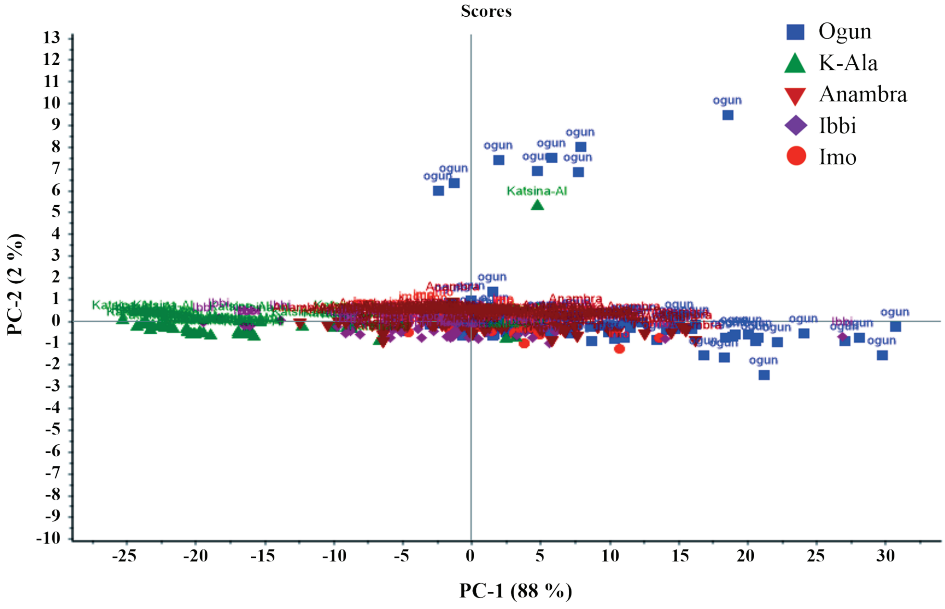

Figure 3. Principal components analysis score plots for *Parachanna obscura* populations based on morphometric parameters.

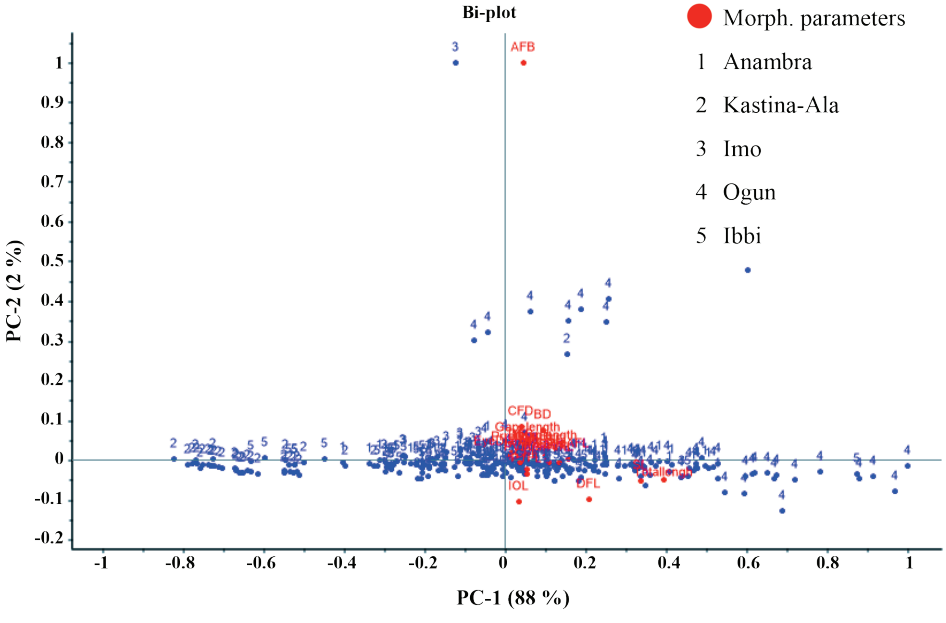

Figure 4. Principal components analysis biplot of *Parachanna obcura* from five rivers in Nigeria based on morphometric variation.

Note: Abbreviations as detailed in Table 1

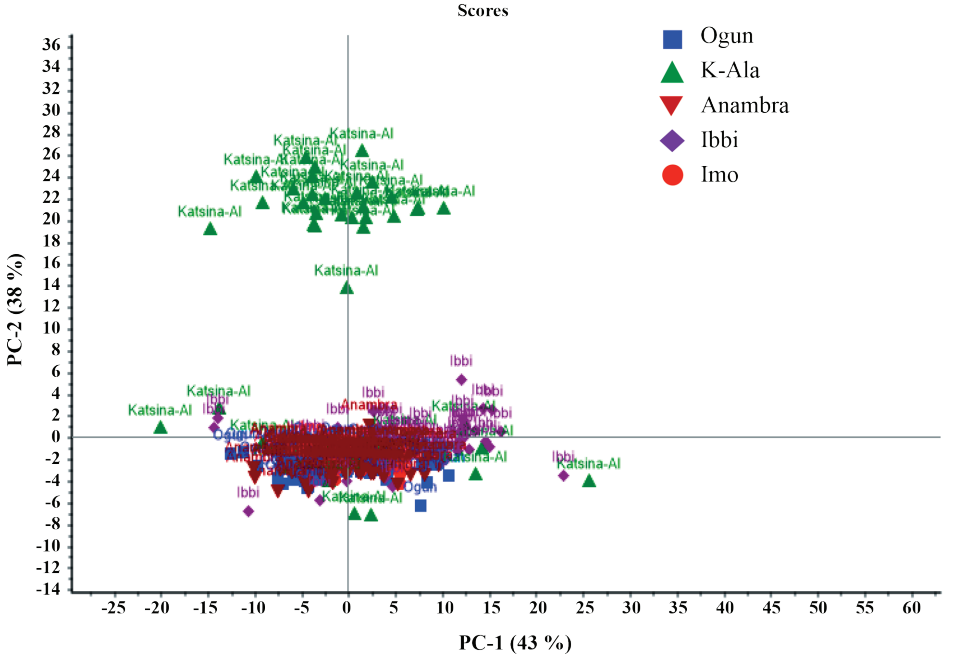

Figure 5. Principal components analysis score plot of *Parachanna obscura* populations from five rivers in Nigeria based on meristic characteristics.

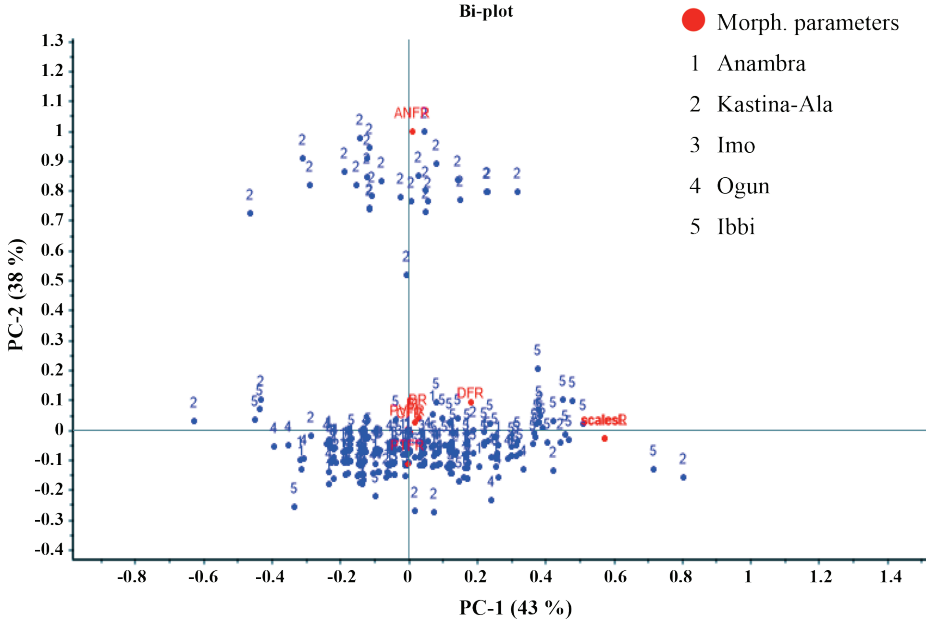

Figure 6. Principal components analysis biplot of *Parachanna obscura* populations from five rivers in Nigeria based on meristic parameters.

Note: Abbreviations as detailed in Table 2

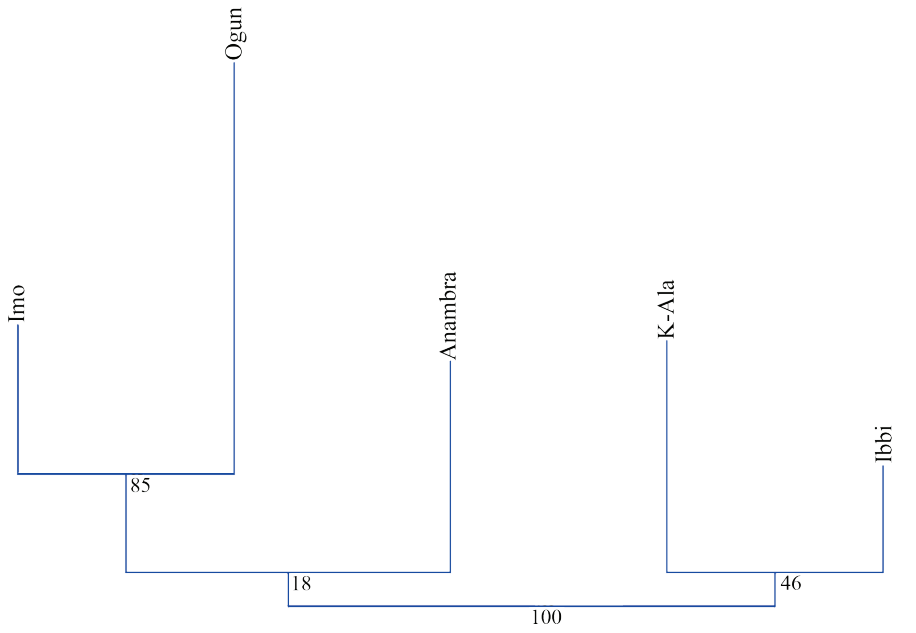

Figure 7. Neighbor-joining tree based on morphometric parameters of *Parachanna obscura* populations from five rivers in Nigeria.

Note: Numbers at each node represent bootstrap values based on 1000 pseudo-replications

DISCUSSION

Parachanna obscura caught from Katsina-Ala and Ibbi rivers were smaller in size than those from the other rivers. This may be due to the fact that these two rivers become dry after the rainy season. The fish normally survive the dry season by burrowing in bottom mud of lakes, canals and swamps, provided that their skin and air-breathing apparatus remain moist; during this time they subsist on stored fat. On the other hand, the longer rainy season experienced by the other three rivers maintains their flow and ensures that fish in those populations can be active and grow throughout the year.

The average total lengths of *P. obscura* sampled in Rivers Anambra, Imo and Ogun were above the size at first maturity, 24.5 cm (Kpogue *et al*., 2013). This implies that many of the harvested fish were adults, and had the chance to reproduce and add to recruitment before they were caught. However, the samples obtained from Rivers Katsina-Ala and Ibbi had average total lengths below 24.5 cm, with the mean size of Katsina-Ala fish being much below the size at maturity. The harvest of immature fish could affect abundance of these populations over time.

High correlation coefficients were observed among all the morphometric parameters measured, indicating positive linear relationships among all of them. This means that growth in one morphometric parameter of *P. obscura* corresponds to positive growth in another, as affirmed by Safi *et al*. (2014). This finding is also in agreement with the observations of Oniye *et al*. (2006), who documented a high regression coefficient between pectoral and pelvic fin lengths of *Protopterus annectens*. It is also consistent with Elamin *et al*. (2011), who reported high correlations between total length and other morphometric parameters of *Plectropomus pessuliferus* and *P. areolatus*.

Multivariate analysis revealed some morphological discrimination among the various populations of *P. obscura* from different water bodies. The Katsina-Ala and Ogun river populations were the most separated from the others, although the Ogun population had several members that shared the attributes of the other populations. The Anambra, Imo and Ibbi populations were clustered together in a way that reveals higher levels of gene flow among them. Statistical support for the differentiation of populations was mostly based on anal fin base length. This finding is similar to Mwanja *et al*. (2014), who reported that morphological variation among *Bagrus docmak* populations of the major Ugandan water bodies was mostly contributed by fin lengths (anal and caudal fins). Fin lengths are related to swimming and sleekness of fish (Plaut, 2000), and fish from larger rivers that swim against higher flows normally have sleeker bodies with longer fins than fish in smaller rivers or lacustrine environments. This could account for the variation observed in this study, because the fishes from Ogun, Anambra and Imo Rivers were harvested from strongly flowing reaches, while those of Katsina-Ala and Ibbi were mostly harvested from flood plains with slowly moving water. In general, fishes exhibit more difference in morphological characteristics both within and among populations than other vertebrates, and are more vulnerable to environmentally induced morphological variation (Wimberger, 1992). This may be a result of their varied feeding environments, prey and predator types, among other features. The causes of variation in morphometric and meristic characters may range from genetic variability to the influence of environmental factors (Wimberger, 1992). Therefore, morphometric and meristic relationships of fish can be used to assess the well-being of individuals and to determine possible variation between separate stocks of the same species (King, 2007). Morphometric analyses are also powerful tools for testing and displaying variation and identifying stocks of species with unique morphological characteristics. This will enable better management of species subunits and optimizing the commercial and culture potentials of fishery resources (Mojekwu and Anumudu, 2015).

Meristic counts are well-established features and more primitive than morphometric measurements, and therefore usually provide stronger evidence for speciation (Fakunmoju *et al*., 2014). In the present study, five fin ray counts (with ranges) were recorded for *P. obscura*: dorsal fin (41-48); pectoral fin (13-17); pelvic fin (5-7); caudal fin (12-13) and anal fin (29-45). The number of blotches on the sides of the fish ranged from 5 to 8, while the number of scales on the lateral line ranged from 62 to 64. The results are similar to Froese and Pauly (2018), which documents *P. obscura* as having 39-45 dorsal fin rays, 26-32 anal fin rays, and 5-8 blotches on sides. Note that ranges of dorsal and anal fin ray counts were somewhat wider in this study. Bibi *et al*. (2008) reported variation in meristic characters in *Nematalosa nasus* and *Pseudobagrus ichikawa*, while the dependence of meristic counts on body size of *Crossocheilus latius latius* have been reported (Brraich and Akhter, 2015).

Though the present study was based on phenotypic traits, it has been generally established that phenotypes are determined by genetic and environment factors. Thus, the present results imply the presence of genetic diversity among populations of *P. obscura* in Nigerian waters. Furthermore, these populations will serve as a potential gene pool for genetic improvement, where high genetic diversity within a base population is a prerequisite (Gjerde, 2005).

CONCLUSION

The present study revealed that the populations of *Parachanna obscura* from the Ogun and Katsina-Ala rivers were the most distinct from other sampled Nigerian rivers based on morphometric characters and meristic counts, respectively. The study also showed that the anal fin base length and anal fin ray count were important discriminants among the different populations of *P. obscura*.

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