Vestnik zoologii, **51**(4): 285–294, 2017
DOI 10.1515/vzoo-2017-0034

DE GRUYTER OPEN

UDC 597.551.4(669)

PHENOTYPIC DIVERSITIES OF FOUR POPULATIONS OF *CLARIAS GARIEPINUS* (SILURIFORMES, CLARIIDAE) OBTAINED FROM OGUN AND ONDO STATE WATERBODIES IN SOUTH-WESTERN NIGERIA

F. A. Ola-Oladimeji[1*], J. A. Oso[1], T. E. Oladimeji[2], E. O. Idowu[1], K. Adeleke[1], F. O. Urihe[1]

[1]*Department of Zoology and Environmental Biology, Ekiti State University, Ado-Ekiti, Ekiti State*
[2]*Department of Zoology, Obafemi Awolowo University, Ile-Ife, Osun State*
[*]*Corresponding author*
E-mail: folasade.majolagbe@eksu.edu.ng

Phenotypic Diversities of Four Populations of *Clarias gariepinus* (Siluriformes, Clariidae) Obtained from Ogun and Ondo State Waterbodies in South-Western Nigeria. Ola-Oladimeji, F. A., Oso, J. A., Oladimeji , T. E., Idowu, E. O., Adeleke, K., Urihe, F. O. — The study determined the variation in the morphological and meristic features among four populations of *Clarias gariepinus* Burchell, 1822 obtained from Owena Dam and River Oluwa in Ondo State and Rivers Omo and Ogbere in Ogun State, both in Nigeria. A total of ninety five (95) and one hundred and twenty (120) fish specimens collected from Ondo and Ogun states respectively were measured using standard procedures and the results were analysed using Analysis of variance and multivariate analyses. The results obtained from the ANOVA and Principal Component Analyses of *Clarias gariepinus* from the four populations revealed heterogeneity for most of their characters. Therefore, the morphological differences between the wild African catfish found in Ondo and Ogun state populations could be linked to genetic differences or environmental factors or a combination of both factors. Hence, this study concluded that the populations are different which could imply high genetic diversity if molecular marker techniques are employed in further studies.
Key words: ANOVA, Principal Component Analyses, populations, heterogeneity, morphological differences.

Introduction

African sharptooth catfish, *Clarias gariepinus* Burchell, 1822, is a tasty delicacy that is preferred and demanded by the populace more than some other freshwater fishes especially in Nigeria. Teugels (1986), Robbins et al. (1991) and Skelton (2001) among others have described and classified it in the past and a lot of research works (Majolagbe et al., 2011; Majolagbe et al., 2012; Olaniyi and Omitogun, 2012; Oso et al., 2013; Ola-Oladimeji, 2015; Adewumi and Ola-Oladimeji, 2016) have been done on this valuable species. Nevertheless, studies on it are still ongoing because knowledge is inexhaustible. Therefore, this study was carried out to determine if there is a significant morphological heterogeneity or homogeneity among the four populations of *Clarias gariepinus* using analysis of variance and Principal Component Analysis.

Material and methods

The study area

The fish specimens were collected from two states which are Ogun and Ondo in Nigeria. The two locations in Ogun State where *C. gariepinus* specimens were collected are Rivers Ogbere and Omo. River Ogbere has its geographical coordinates on 7°15′0″ N and 3°52′60″ E. It is located at an elevation of 118 meters above sea level. The coordinates of River Omo are between latitude 6.870919 and longitude 4.400532.

The two locations in Ondo State are Owena Dam and River Oluwa. Owena reservoir lies between latitude 7°15′ N, longitude 5°5′ E and latitude 7°4′ N, longitude 4°47′ E in Western Nigeria. The reservoir is about 300 m long and 9 m in its deepest part, with the capacity of approximately 600,000 m^3 and the catchments area controlled by the reservoir is 790 km^2 (Lasisi, 2002). The reservoir was primarily constructed as a source of water supply to the people. The vegetation around the reservoir is constituted by *Threoboma cacao*, Cola acuminate species, some forest trees, wild grasses amongst others.

River Oluwa is a large river in Ondo State, Nigeria, extending from Lat 7°2′00″ N down to the coast at Lat 6°1′00″ N, meandering through many towns and villages in Ilaje / Ese Odo between Long 4°31′30″ and 5°2′00″ E, before connecting to Lekki lagoon in the coastal belt (Omoniyi et al., 2011).

Collection of fish samples

Sixty (60) specimens of *Clarias gariepinus* were collected each from River Ogbere and River Omo in Ogun state using cast nets. In Ondo State, a total of ninety five fish specimens were collected from both sites, 45 specimens were obtained from River Oluwa and 50 specimens from Owena Dam using cast nets.

Data Collection and methods

Eighteen morphometric and eight meristic measurements were carried out on each fish specimen. The body parts were measured following standard anatomical reference (Teugels, 1986). The specimen weights were first measured using the electronic weighing balance (OHAUS® SCOUT® SE402F) before the other morphometric measurements were carried out with a thread and metre rule. The meristic counts were done by counting.

These are the morphometric measurements investigated on

Total length (TL), Dorsal fin length (DFL), Anal fin length (AFL), Mouth length (ML), Snout length (SNL), Head length (HL), Pre-dorsal distance (PDD), Pre-ventral distance (PVD), Pre-pectoral distance (PPD), Width of occipital fontanelle (OFW), Distance between snout and occipital process (DSO), Body depth at anus (BDA), Distance between dorsal and caudal fin (DDCF), Distances between occipital process and dorsal fin (DODF),Caudal peduncle depth (CPD), Pectoral fin length (PFL), Eye diameter (ED), Pectoral spine length (PSL).

The following are the meristic counts

Number of barbells (nB), Dorsal fin ray (DFR), Anal fin ray (AFR), Number of spine (nS), Pectoral fin ray (PFR), Number of gill arch (nGA), Number of gill rakers (nGR), Number of Vertebrae column (nVC).

Statistical Analysis

Morphometric measurements were standardized to fish size (SL) in accordance with REIST (1985) to alleviate errors due to allometric growth using percentage standard length as it follows: Mn = (Mo/SL) %, where Mn is the corrected size, Mo is the original measurement (total length); and SL is the standard length. The measurements of each of the meristic traits were not standardized because meristic characters are fixed early in development and less susceptible to environmental variables.

Analysis of variance was carried out on the standardized morphometric measurements and the meristic counts using IBM SPSS Statistics (Version 21) to test the significance of morphological differences among the populations. This was followed by multivariate analyses using Paleontological Statistics (PAST) software (Hammer et al., 2006). PCA on the morphometric and meristic data were evaluated. Population centroids with 95 % ellipses obtained from the PCA scatter diagram were used to observe relationships among populations (Turan et al., 2005; Oladimeji et al., 2015; Ola-Oladimeji et al., 2016). PCA loadings were used to show the traits with the highest variation within the population (Oladimeji et al., 2015; Ola-Oladimeji et al., 2016) using the unweighted Pair Group Method with Arithmetic mean for phenogram or dendrogram grouping reported by Sneath and Sokal (1973).

Results

As in table 1, the morphometric means of all the populations for TL, PVD, ED traits were significantly different from each other. This was also observed for PDD trait though Owena dam and River Oluwa showed some partial significance. For DFL, HL, PPD, DDCF and CPD traits, R. Ogbere and Omo were significantly different while Owena dam and R. Oluwa were not significantly different. For AFL and ML, R. Ogbere and Owena dam were not significantly different while R. Omo and Oluwa were significantly different. This can be compared to PSL trait, of which R. Omo was observed to be significantly different from R. Ogbere and Owena dam while R. Oluwa had partial significance with the other three rivers.

For SNL trait, R. Ogbere was significantly different from the other rivers. For OFW and DODF, R. Ogbere and Omo were not significantly different while Owena dam and R. Oluwa were different. For DSO trait, R. Ogbere and Owena dam are significantly different but had partial significance with R. Omo and Oluwa which are not significantly different.

For BDA and PFL traits, R. Ogbere and Omo were not significantly different and Owena dam and R. Oluwa were also not significantly different.

For the meristic means, all the populations were not significantly different for nB, nS and nGA traits. However, for that of DFR trait, all the populations were significantly different. An almost similar occurrence was observed in nVC where R. Ogbere, Omo and Owena dam were significantly different while R. Oluwa showed partial significance with R. Omo and Owena dam. For AFR, R. Ogbere and Owena dam are significantly different while R. Omo and Oluwa are not significantly different. For PFR, R. Ogbere and Omo are similar while Owena dam and R. Oluwa are significantly different. For nGR, R. Ogbere and Omo are significantly different while Owena dam and Oluwa are similar.

Table 1. Mean and standard deviations (s.d.) of the phenotypic traits of four populations of *C. gariepinus* at $p < 0.05$

Phenotypic traits	Populations	Mean ± S.D.
TL, cm	R. Ogbere	114.9736 ± 3.08433^{c}
	R. Omo	$111.1586 \pm 2.77294^{ab}$
	Owena dam	$112.9138 \pm 8.37563^{bc}$
	R. Oluwa	109.8515 ± 3.30599^{a}
DFL, cm	R. Ogbere	63.7044 ± 4.80514^{a}
	R. Omo	68.4517 ± 4.91255^{b}
	Owena dam	77.2150 ± 6.78755^{c}
	R. Oluwa	79.3859 ± 11.66852^{c}
AFL, cm	R. Ogbere	42.2005 ± 2.19409^{a}
	R. Omo	49.4727 ± 3.01766^{b}
	Owena dam	43.9714 ± 2.96698^{a}
	R. Oluwa	47.5616 ± 8.01139^{b}
ML, cm	R. Ogbere	11.0865 ± 1.91309^{c}
	R. Omo	8.4342 ± 1.44553^{b}
	Owena dam	10.6932 ± 0.69928^{c}
	R. Oluwa	5.8841 ± 1.20834^{a}
SNL, cm	R. Ogbere	8.8597 ± 1.60902^{b}
	R. Omo	6.2548 ± 0.91966^{a}
	Owena dam	6.1442 ± 0.71103^{a}
	R. Oluwa	6.3935 ± 0.86693^{a}
HL, cm	R. Ogbere	29.4035 ± 1.50893^{c}
	R. Omo	23.7520 ± 1.74851^{b}
	Owena dam	19.1059 ± 2.64087^{a}
	R. Oluwa	19.9653 ± 2.62756^{a}
PDD, cm	R. Ogbere	33.5873 ± 2.32383^{c}
	R. Omo	29.7625 ± 4.61118^{b}
	Owena dam	28.7315 ± 2.58122^{ab}
	R. Oluwa	27.9077 ± 2.86827^{a}
PVD, cm	R. Ogbere	46.0664 ± 4.01339^{d}
	R. Omo	43.3821 ± 2.60376^{c}
	Owena dam	31.3662 ± 3.04104^{a}
	R. Oluwa	34.4810 ± 4.45777^{b}
PPD, cm	R. Ogbere	22.6390 ± 2.21101^{b}
	R. Omo	17.9737 ± 2.54268^{a}
	Owena dam	24.7614 ± 2.95101^{c}
	R. Oluwa	25.7211 ± 4.36452^{c}
OFW, cm	R. Ogbere	1.2366 ± 0.68751^{a}
	R. Omo	1.5718 ± 0.28694^{a}
	Owena dam	2.9253 ± 0.25176^{c}
	R. Oluwa	2.1446 ± 1.75096^{b}
DSO, cm	R. Ogbere	21.5893 ± 1.15138^{b}
	R. Omo	17.1528 ± 1.90438^{ab}
	Owena dam	14.3476 ± 1.61633^{a}
	R. Oluwa	$19.2519 \pm 23.39396^{ab}$
BDA, cm	R. Ogbere	15.7794 ± 3.62477^{a}
	R. Omo	15.1284 ± 1.59780^{a}
	Owena dam	19.0211 ± 2.79384^{b}
	R. Oluwa	18.4891 ± 2.90562^{b}
DDCF, cm	R. Ogbere	4.2951 ± 1.27929^{b}
	R. Omo	1.8153 ± 0.64129^{a}
	Owena dam	7.8222 ± 1.86498^{c}
	R. Oluwa	8.3123 ± 0.95199^{c}

Continue table 1.

Phenotypic traits	Populations	Mean ± S.D.
DODF, cm	R. Ogbere	10.8163 ± 1.42684[c]
	R. Omo	10.8231 ± 1.26840[c]
	Owena dam	8.23350 ± 0.97526[b]
	R. Oluwa	7.3956 ± 1.18673[a]
CPD, cm	R. Ogbere	6.7431 ± 1.22371[b]
	R. Omo	5.6618 ± 0.74850[a]
	Owena dam	12.4021 ± 1.69647[c]
	R. Oluwa	12.9620 ± 2.22994[c]
PFL, cm	R. Ogbere	11.9414 ± 1.82646[a]
	R. Omo	11.4351 ± 7.80048[a]
	Owena dam	46.9363 ± 3.92731[b]
	R. Oluwa	47.5690 ± 8.00403[b]
ED, cm	R. Ogbere	2.4038 ± 0.37998[d]
	R. Omo	1.8376 ± 0.23519[c]
	Owena dam	1.4302 ± 0.17858[b]
	R. Oluwa	1.0898 ± 0.31209[a]
PSL, cm	R. Ogbere	8.5291 ± 1.72228[a]
	R. Omo	9.2549 ± 1.51994[b]
	Owena dam	8.0595 ± 0.89388[a]
	R. Oluwa	8.7418 ± 1.17392[ab]
nB	R. Ogbere	6.72 ± 1.869[a]
	R. Omo	3.92 ± 0.381[a]
	Owena dam	4.00 ± 0.000[a]
	R. Oluwa	7.40 ± 15.944[a]
DFR	R. Ogbere	62.75 ± 6.749[a]
	R. Omo	69.83 ± 6.575[b]
	Owena dam	78.94 ± 3.197[d]
	R. Oluwa	75.04 ± 8.642[c]
AFR	R. Ogbere	44.13 ± 5.180[a]
	R. Omo	52.00 ± 5.940[b]
	Owena dam	58.52 ± 3.346[c]
	R. Oluwa	54.13 ± 13.576[b]
nS	R. Ogbere	1.00 ± 0.000[a]
	R. Omo	1.02 ± 0.129[a]
	Owena dam	1.00 ± 0.000[a]
	R. Oluwa	1.47 ± 2.191[a]
PFR	R. Ogbere	8.55 ± 1.281[a]
	R. Omo	7.83 ± 0.827[a]
	Owena dam	14.60 ± 2.688[c]
	R. Oluwa	10.96 ± 3.126[b]
nGA	R. Ogbere	1.95 ± 1.407[a]
	R. Omo	1.92 ± 2.540[a]
	Owena dam	1.00 ± 0.000[a]
	R. Oluwa	2.40 ± 6.566[a]
nGR	R. Ogbere	48.83 ± 7.947[c]
	R. Omo	18.53 ± 8.349[a]
	Owena dam	29.06 ± 4.456[b]
	R. Oluwa	29.82 ± 9.250[b]
nVC	R. Ogbere	59.25 ± 4.501[c]
	R. Omo	56.63 ± 3.710[b]
	Owena dam	54.3 2 ± 4.701[a]
		56.33 ± 5.469 [ab]

Note. Mean values for groups of each trait with different superscripts in the column are significantly different ($P < 0.05$).

Table 2. Univariate test results of all the phenotypic measurements of the *Clarias gariepinus* specimens

Phenotypic traits	Sum of Squares	Degree of freedom	Mean Square	F	Significance
TL, cm	794.952	3	264.984	11.334	0.000
DFL, cm	8634.893	3	2878.298	55.039	0.000
AFL, cm	1893.237	3	631.079	32.663	0.000
ML, cm	854.737	3	284.912	140.648	0.000
SNL, cm	293.953	3	97.984	79.369	0.000
HL, cm	3622.108	3	1207.369	265.306	0.000
PDD, cm	1044.180	3	348.060	32.473	0.000
PVD, cm	7932.636	3	2644.212	208.351	0.000
PPD, cm	1952.866	3	650.955	70.992	0.000
OFW, cm	88.085	3	29.362	36.283	0.000
DSO, cm	1546.766	3	515.589	4.440	0.005
BDA, cm	602.166	3	200.722	25.213	0.000
DDCF, cm	1515.272	3	505.091	321.852	0.000
DODF, cm	488.480	3	162.827	106.167	0.000
CPD, cm	2258.621	3	752.874	330.110	0.000
PFL, cm	67019.353	3	22339.784	640.324	0.000
ED, cm	50.829	3	16.943	202.773	0.000
PSL, cm	40.586	3	13.529	6.944	0.000
nB, cm	513.568	3	171.189	3.169	0.025
DFR, cm	8052.774	3	2684.258	62.761	0.000
AFR, cm	6031.759	3	2010.586	34.427	0.000
nS	7.566	3	2.522	2.508	0.060
PFR	1492.320	3	497.440	113.951	0.000
nGA	50.325	3	16.775	1.478	0.221
nGR	28519.736	3	9506.579	159.493	0.000
nVC	678.839	3	226.280	10.836	0.000

Note. Traits with significant difference are at $p < 0.05$.

Univariate analysis of variance of 215 specimens in table 2 showed significant differences ($p < 0.05$) among the means of the four studied populations for all the 18 standardized morphometric measurements revealing great heterogeneity in the populations. Similarly, six out of the eight meristic characters studied, showed significant differences ($p < 0.05$) among the means of the four studied populations also revealing high level of heterogeneity among the populations while nS and nGA were non-significant.

Principal Component Analyses of morphometric and meristic traits of Clarias gariepinus morphometrics

The PCA scatter diagram for the morphometrics of *Clarias gariepinus* specimens obtained from the two states showed distinct heterogeneity because none of the traits between the two states overlapped although both rivers in each state had many characters in common (fig. 1).

Table 3. PCA loadings for the morphometrics of *Clarias gariepinus* obtained from the four Rivers showing Pre-ventral distance (PVD) as the trait with the highest variation

Traits, cm	PCA loadings
TL	0.02456
DFL	–0.3237
AFL	–0.0359
ML	0.03106
SNL	0.03077
HL	0.1552
PDD	0.07291
PVD	0.2574
PPD	–0.1193
OFW	–0.02697
DSO	0.0842
BDA	–0.07851
DDCF	–0.1127
DODF	0.06474
CPD	–0.1449
PFL	–0.854
ED	0.01921
PSL	0.007327

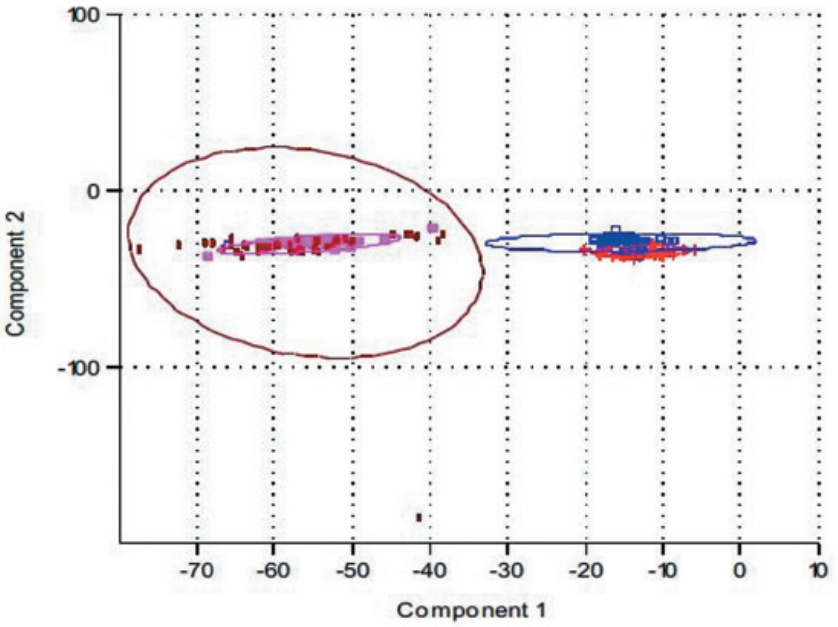

Fig. 1. PCA scatter diagram for morphometrics of *Clarias gariepinus* obtained from the four rivers.
The red colour indicates River Ogbere and blue colour indicates River Omo while the pink colour indicates Owena dam and brown colour indicates River Oluwa.

Fig. 2 and table 3 illustrate the values of PCA loadings for the morphometrics of *Clarias gariepinus* obtained from the four Rivers showing Pre-ventral distance (PVD) as the trait with the highest variation.

Meristics

The PCA scatter diagram for meristics of *Clarias gariepinus* from the rivers in the two states also showed heterogeneity of traits: Owena dam, Rivers Oluwa and Omo, share some similar traits while River Ogbere shared less traits with the rest (fig. 3).

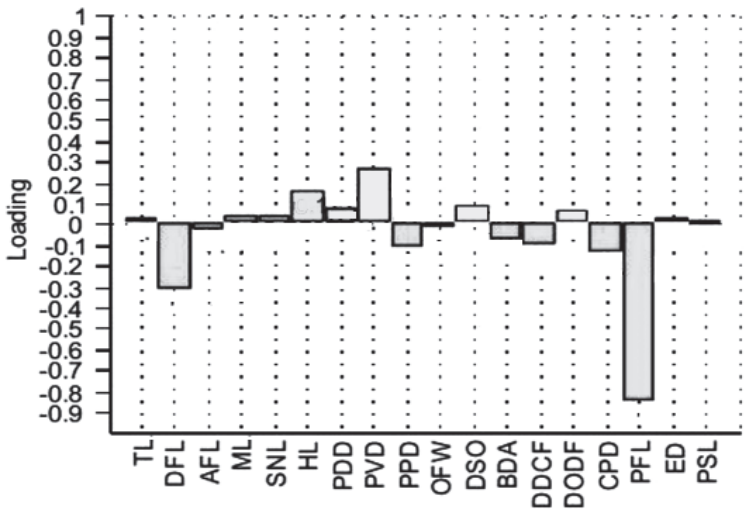

Fig. 2. PCA loadings for the morphometrics of *Clarias gariepinus* obtained from the four rivers.

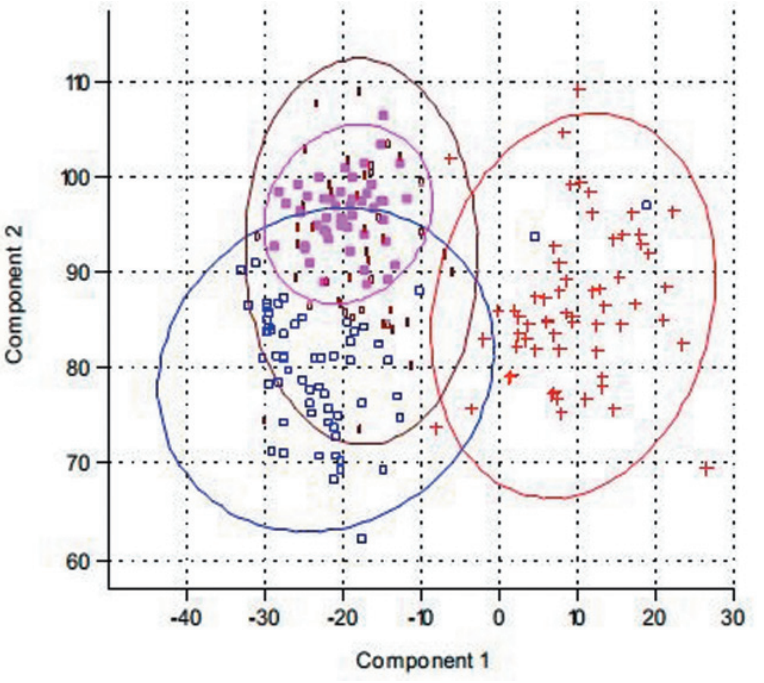

Fig. 3. PCA scatter diagram for meristics of *Clarias gariepinus* obtained from the four rivers. The red colour indicates River Ogbere and blue colour indicates River Omo, while pink colour indicates Owena dam and brown colour indicates River Oluwa.

For their PCA loadings, nGR was the character most responsible for variation among the four populations, as shown in fig. 4 and table 4.

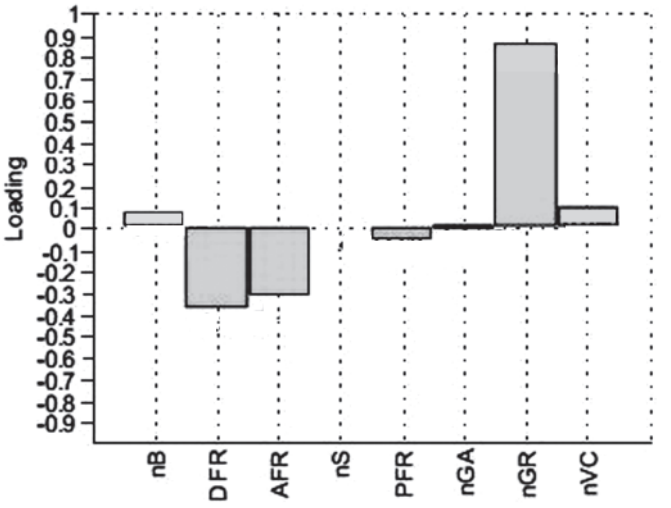

Fig. 4. PCA loadings for meristics of *Clarias gariepinus* obtained from the four rivers.

Table 4. Character values of PCA loadings for the meristics of *Clarias gariepinus* obtained from the four rivers, showing number of gill rakers (nGR) as the trait with the highest variation

Characters	PCA loadings
nB	0.07125
DFR	–0.380
AFR	–0.3251
nS	–0.0003217
PFR	–0.05599
nGA	0.01451
nGR	0.8553
nVC	0.09876

Discussion

Fishes are predisposed to changes in the environment and acclimatize rapidly by altering the necessary morphometrics. Also, morphological characters exhibit high plasticity in response to variations in environmental conditions (Wimberger 1992).

Results of the morphometric characterization in the present study revealed that the *C. gariepinus* obtained from the four populations were morphologically different. This corresponds to the results obtained from morphometric characterization of *C. gariepinus* from the African waters showing interstrain morphometric variation (Teugels, 1982; Rognon et al., 1998). In addition, Solomon et al. (2015) noted significant differences in all the morphometric characters measured on *C. gariepinus* collected from the cultured and wild environments in Benue State of Nigeria. These differences were also recorded in three of five meristic counts made although the results of the study showed little or no variability in meristic counts compared to the morphometric characters studied. Ola-Oladimeji et al. (2016) also reported morphological differences between *C. gariepinus* strains obtained from both wild and cultured populations in Ekiti State, Nigeria.

In this study, none of the morphometric traits of all the populations was similar that is no four populations had similar morphometric traits while meristic traits such as nS and nGA were similar for all the populations. This implies that there is variation in the four populations and the fish have not been interbreeding.

It was reported by Turan et al. (2005) that there were high morphological variation among six populations of *Clarias gariepinus* in Turkey. It was also suggested that this could result from differences in environmental conditions such as temperature, turbidity, food availability, and water depth. This agrees with Kara et al. (2011) who reported that morphological diversity among fish populations in different habitats may not only be caused by genetic factors but also by environmental factors. Also, the multivariate analysis of variability in traits of *Heterobranchus bidorsalis* from three locations in Nigeria as reported by Agbebi et al. (2009) indicated that fish from Gboko (Benue State) was characteristically separated from those obtained from Onitsha (Anambra State) and Jos (Plateau State). It was thus concluded that Gboko strains were unique and distinct.

Variations in body form have important fitness consequences on fish both in cultured and wild populations (Gatsz, 1998; Guilliet et al., 2003). The fish from the two states also showed colour differences which might be caused by environmental factors. Specimens obtained from Omo were darker than Ogbere specimens. Similarly, those obtained from Oluwa were darker than those from Owena. This may suggest that the fish stock examined had made morphological variations to better fit to their environmental conditions.

The PCA scatter diagram for morphometrics of *Clarias gariepinus* specimens showed distinct variation compared to ANOVA. All the traits were clearly shown to be different between the two states and some variations were shown to exist within each state. The PCA loadings also illustrated that variations existed in these populations and indicated the precise trait with the highest variation- PVD; which could not be produced from ANOVA. The PCA loadings for the meristic traits also revealed nGR as the trait with the highest variation; this gives detailed information of ANOVA result. The PCA scatter diagram for the meristic traits of the populations under study confirms their heterogeneity as all the clusters were not completely fused. In addition, the meristic traits were heterogeneous and hence, not perfectly discontinuous and this agrees with Klug et al. (2011) that they are quantitative

traits, but are characterized with a finite range of phenotypes. Solomon et al. (2015) reported that discriminant and cluster analyses of morphometric parameters showed a high variance among the populations studied, hence the catfish specimens were categorized into individual environments by sex. The meristic counts, however, overlapped broadly showing no divergence among the populations. Also, Oladimeji et al. (2015) reported that all the clusters produced by the Principal components analysis (PCA) on the morphometric and meristic characters of *T. zillii*, overlapped revealing a low level of differentiation among the three populations studied.

Although the studied populations are the same species, little or no gene flow had occurred among them which may be due to their locations. This is evidenced in the high level of heterogeneity reported in this study. Hence, the populations of *Clarias gariepinus* are phenotypically different. To detect the diversity further, use of molecular techniques should be employed. This could help in conserving the genetic resources in these populations for further breeding studies.

References

Adewumi, A. A., Ola-Oladimeji, F. A. 2016. Performance characteristics and feed utilization of African Catfish (*Clarias gariepinus*) fed varying inclusion levels of fermented mulberry leaf. *Direct Research Journal of Agriculture and Food Science*, **4** (5), 87–93.

Agbebi, O. T., Olufeagba, S. O., Mbagwu, I. G., Ozoje, M. O., Aremu, A. 2009. Morphological characteristics and body indices of *Heterobranchus bidorsalis* from three geographical locations in Nigeria. *Journal of Fisheries International*, **4** (4), 68–72.

Gatsz, A. J. J. 1998. Community organization of fishes as indicated by morphological features. *Ecology*, **608**, 711–718.

Guilliet, J. M., Hain, D. C., Hood, C. S. 2003. The effect of phylogeny on interspecific body shape variation in daters (Pisces: Percidae). *Systematic Biology*, 52, 488–500.

Hammer, Ø. Harper, D. A. T., Ryan, P. D. 2006. PAST Paleontological Statistics version 1.58. http:/ /folk. Uio. no/ohammer/past.

Klug, W. S., Cummings, M. R., Spencer, C. A., Palladino, M. A. 2011. *Concept of Genetics*. 10th edition. Pearson Benjamin Cummings, California, 1–660.

Lasisi, M. 2002. Owena/Ondo Water Supply Scheme. Ondo State Water Corporation (OSWC), 2–3.

Majolagbe, F. A., Awopetu, J. I., Omitogun, O. G. 2011. Cytogenetical study of *Clarias gariepinus* (Burchell, 1822) and *Heterobranchus bidorsalis* (Geoffroy Saint-Hilaire, 1809) and their reciprocal hybrids. *Adamawa State University Journal of Scientific Research*, **1** (1), 32–38.

Majolagbe, F. A., Awodiran, M. O., Awopetu, J. I. 2012. Electrophoretic Studies of *Clarias gariepinus* (Burchell 1822) and *Heterobranchus bidorsalis* (Geoffroy Saint-Hilaire 1809) and their hybrids. *Ife Journal of Science*, **14** (1), 167–176.

Olaniyi, W. A., Omitogun, O. G. 2012. Induction of diploid gynogeneic larvae of African catfish, *Clarias gariepinus* Burchell (1822). *Ife Journal of Agriculture,* 25, 73–82.

Oladimeji, T. E., Awodiran, M. O., Komolafe, O. O. 2015. Genetic differentiation studies among natural populations of *Tilapia zillii*. *Notulae Scientia Biologicae*, **7** (4), 423–429.

Ola-Oladimeji, F. A. 2015. Comparison of Fitness Traits between Reciprocal Hybrids and Parentals of *Clarias gariepinus* (Burchell, 1822) and *Heterobranchus bidorsalis* (Geoffroy Saint-Hilaire, 1809). *IOSR Journal of Pharmacy and Biological Sciences*, **10** (5), 78–82.

Ola-Oladimeji, F. A., Awodiran, M. O., Fagbuaro, O., Akomolafe, A. O. 2016. Morphological characterization of wild and cultured *Clarias gariepinus* (Burchell 1822) using principal component and cluster analyses. *Notulae Scientia Biologicae,* **8** (4), 428–436.

Omoniyi, I. T. Agbon, A. O., Akegbejo-Samsons, Y. 2011. The Food Habits of *Ctenopoma pethereci*, Gunther (Pisces: Anabantidae) in River Oluwa, Ondo State, Nigeria. *West African Journal of Applied Ecology*, 19, 1–7.

Oso, J. A, Majolagbe, F. A, Idowu, E. O. Fagbuaro, O. 2013. Fecundity of two dominant fish species in Ado Reservoir, Southwest Nigeria. *Albanian Journal of Agricultural Sciences*, **12** (4), 603–607.

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.

Robins, C. R., Bailey, R. M., Bond, C. E., Brooker, J. R., Lachner, E. A., Lea, R. N., Scott, W. B. 1991. World fishes important to North Americans. Exclusive of species from the continental waters of the United States and Canada. *American Fisheries Society, Special Publication*, **21**, 243.

Rognon, X., Teugels, G., Guyomard, R., Andramanga, M., Volckaert, F., Agnèse, J. F. 1998. Morphometric and allozyme variation in the African catfishes, *Clarias gariepinus* and *C. anguillaris*. *Journal of Fish Biology*, **53**, 192–207.

Skelton, P. 2001. *A complete guide to the freshwater fishes of Southern Africa*. Struik Publishers, Cape Town, 1–262.

Sneath, P. H., Sokal, R. R. 1973. *The principle and practice of numerical classification. Numerical Taxonomy*. W. H. Freeman and Co. San Francisco, USA, 1–573.

Solomon, S. G., Okomoda, V. T., Ogbenyikwu, A. I. 2015. Intraspecific morphological variation between cultured and wild *Clarias gariepinus* (Burchell) (Clariidae, Siluriformes). *Archives of Polish Fisheries*, **23**, 53–61.

Teugels, G. G. 1982. Preliminary results of a morphological study of five African species of the subgenus *Clarias (Clarias*) (Pisces; Clariidae). *Journal of Natural History*, **16** (3), 439–464.

Teugels, G. G. 1986. A systematic revision of the African species of the genus Clarias (Pisces; Clariidae) *Annales de Musée Royal de l'Afrique Centrale, Sciences Zoologiques*, **247**, 63–72.

Turan, C., Yalcin, S., Turan, F., Okur, E., Akyurt, I. 2005. Morphometric comparisons of African catfish, *Clarias gariepinus* populations in Turkey. *Folia Zoological*, **54** (1–2), 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 the Linnean Society*, **45**, 197–218.

Received 29 March 2017
Accepted 23 May 2017