MORPHOLOGICAL VARIATIONS OF CULTURED AND WILD *Oreochromis niloticus* FROM IBADAN AND KAINJI IN NIGERIA

[1]OLUFEAGBA S. O., [2]ALADELE, S. E., *[1]OKOMODA V. T., [2]OKERE A.U., [2]ODUOYE, O. T. & [2]T. HASSAN

1. Department of Fisheries and Aquaculture, University of Agriculture Makurdi, Nigeria.
2. National Centre for Genetic Resources and Biotechnology, Ibadan, Oyo State, Nigeria.

*Correspondence: okomodavictor@yahoo.com, +234 80333 19959

ABSTRACT

This study investigated the morphological variations of wild and cultured Oreochromis niloticus from Kainji and Ibadan in Nigeria; wild fishes were collected from various landing sites of the Lake Kainji and Asejire, Ibadan. Cultured fish were collected from fish farms with known breeding history in the two environment, samples were stored under ice and transported to the laboratory for morphological characterization. Results obtained reveals significant higher values in most morphometric parameters of the cultured specimen from the different environments compared to their wild counterparts, however condition factor of the fish were higher for fishes in the wild (4.41 and 4.16 for Ibadan and Kainji respectively) compared to those in the cultured environment (2.94 and 3.44 for Ibadan and Kainji respectively). Discriminate analysis showed clear overlap of meristic data for the different environments; however in morphometric parameters, fish from the Lake Kainji slightly overlap with its culture counterpart from the same environment but clearly separate itself from those from Ibadan.

Keywords: Cichlidae, morphological parameters, growth pattern, Kainji Lake, Nigeria

INTRODUCTION

Morphometric is an important aspect of biology because it allows quantitative descriptions of organisms. This approach allowed scientists to compare shapes of different organisms much better and hence no longer have to rely on the use of word in descriptions that lead to misinterpretation by different scientist (Gelsvartas, 2005). Morphometric and the meristic methods remains the most easiest among methods for identifying species (Creech, 1992; Mamuris *et al*., 1998; Bronte *et al*., 1999; Hockaday *et al*., 2000). It is well established that the phenotypic variation analysis in morphometric characters or meristic counts is the most commonly used method to delineate stocks of fish and measure relationships and discreteness among other taxonomic categories (Avisar 1994; Turan, 1999). Despite the advent of technology which has led to direct examination of variation in organisms through molecular genetics, conventional methods used in stock identification continues to play a significant role even in the modern age (Swain and Foote, 1999).

However, the major limitation of this method at the intra-specific level is that morphological expression and differences is not directly under the control of the genes but subjected to environmental modification (Clayton, 1981). Phenotypic variation in natural stock sometimes reveals genetic adaptation to selection pressures (Endler, 1986; Schluter, 2000) and at other times, it reflects responses to prevailing environmental conditions (Levins, 1969; Berven *et al*., 1979; James, 1983). Most of the time, it probably a combination of both genetic and environmental influences, Phenotypic plasticity of fish allows adaptively response to environmental change by modification in physiological and behavioural pattern which leads to changes in morphology, reproduction and survival to mitigate the environmental effects (Stearns1983, Meyer, 1987). Such phenotypic adjustments do not necessarily result in genetic variation in the population and so cannot usually be taken as evidence of genetic differentiation. Morphological plasticity is commonly found in fish species dictated by environmental variability. Phenotypic variation as a result of environmental differenced has been widely used by fisheries scientist in differentiating species as well as populations within a species (Ihassen *et al*., 1981; Murta 2002).

Oreochromis niloticus (Cichlidae; Teleostei), is a species of great aquaculture importance. It is native to Africa and has been introduced to many part of the world (especially tropical country) for the sake of aquaculture (Nyingi *et al*., 2009). It major advantage as an aquaculture candidate is particularly because its grows fast and easily reproduced in natural water and captivity (De Silva, 1997). However, after decades of introduction of the fish, adaptation to wide range of geographical conditions has led to significant phenotypic variations compared to the pure strains of broodstock. Environment impact (Turana *et al*., 2006) and extensive interbreeding leading to production of hybrids (El Serafy *et al*., 2007) have been largely implicated as the causes of

variations. There is paucity of information on the morphological variations of cultured and wild fish species in Nigeria. Hence the bases of this research which seek to investigate the biometric variation of *O. niloticus* from culture and wild environment in Kainji and Ibadan.

MATERIALS AND METHODS

The study areas and sample collection

Two study areas were chosen for data collection namely Ibadan and Kainji. Ibadan is located in south-west Nigeria and the capital of Oyo state. The Asejire Reservoir is on the coordinates 7° 21′ 45″ N 4° 08′ 00″ E and it is 30 kilometers east of Ibadan. It was built in the late 1960s with the sole aim of providing raw water supply to the Asejire and Osegere water treatment plants in Ibadan, hence, farming activity were banned in the catchment area. The water supply project was completed in the 1970's, with a startup capacity of about 80 million liters per day, with 80% of water production consumed domestically (CBN 1999). It is a perennial reservoir with high volume of water all year round (ADB 2010). *O. niloticus* wild specimens were gotten from the Asejire dam while cultured samples were collected from reputable fish farms with good breeding history in the area.

Kainji is a local government council in Niger State, Nigeria and the home of the largest man-made lake in Nigeria. The Lake Kainji was created in 1968 by damming the River Niger solely for the purpose of electricity generation; this was under the authority of the National Electric Power Authority (NEPA). The Lake coordinates is on Latitudes 9° 50' and 10° 55' N, and Longitudes 4° 25' - 4° 45' E and. The lake has a maximum length of about 134 km and a maximum width of 24.1 km, with a surface area of 1,270 km^2, a volume of 13 × 109 m^3, and catchment area of 1.6 x 106 km^2 it is the largest man-made lake in Nigeria (Obot, 1989). Fish specimens for wild collection were collected from the Lake Kainji while cultured fish were collected from the National Institute for Freshwater Fisheries Research (NIFFR), New Bussa, Niger State.

Data Collection

Thirty five fish samples of *O. niloticus* each were obtained from wild and culture environment of Kainji and Ibadan as specified earlier. Data on morphometric measurement and meristic counts were collected based on the method described by Samaradivakara *et al.* (2012). The morphometric variables measured includes total length, standard length, dorsal fin length, anal fin length, pectoral fin length, pelvic fin length, pre-pelvic fin length, distance between occipital process, pre-dorsal distance, eye diameter, body width, body depth, caudal peduncle depth, caudal fin length, head width, head length, vomerine length, vomerine width, pectoral fin height, anal fin height and pre-orbital length. While meristic counts for this study included pectoral fin ray, anal fin ray, caudal fin ray, pelvic fin ray dorsal fin ray, and dorsal fin spine. Body related Morphometric measurements were expressed as percentages of standard length and head length for Body related and head related morphometric parameters respectively.

The length-weight relationship and condition factor were calculated as follows:

LogW = a + b LogL (Equation by LeCren 1951 and Ricker 1973)

$$\text{Condition factor (K)} = \frac{100\,W}{L^3}$$

where L = Standard length (cm) and W = Weight (g)

Statistical analysis

Size variation where eliminated in this study by standardizing the morphological parameters using the allometric formula as stated by Elliott *et al.* (1995):

$$M_{adj} = M\,(Ls / Lo)^b$$

(M =original measurement, M_{adj} =size-adjusted measurement, Lo = Total Length of particular fish, Ls =overall mean of the TL for all fish sample, b =is the slope of regression graph of log M and log Lo using all fish samples)

Meristic characters are independent of fish size (Strauss, 1985; Murta, 2000) hence were used directly without transformation. Statistical analyses for this study included descriptive statistics for morphometric and meristic data using Minitab 14^{th} edition, and analysis of variance to determine where means are significantly different. Where this is observed, means were separated using Duncan's least significant difference. Also morphometric and meristic were further subjected to discriminant function analysis (DFA) using Genstat® discovery edition 4.

RESULTS

The result of the present study reveals not less than seven morphometric parameters were jointly significantly higher in the cultured specimen from the different environment compared to their wild counterparts (Table 1). In summary the study recorded differences in seventeen morphometric parameters out of twenty three and in four of five meristic counts (Table 2). Expressing the morphometric parameters as percentages of standard length and head length for body and head related morphological measurement respectively did not change the trend of result observed (Table 3).

Table 1: Mean morphometric measurements of *Oreochromis niloticus* from wild and cultured environment of Ibadan and Lake Kainji

Parameters	IBA Cultured	IBA Wild	KAJ Cultured	KAJ Wild	P-value
Total length	14.89 ± 0.22^{a}	13.19± 0.60^{bc}	13.79± 0.43^{ab}	12.04 ± 0.57^{c}	0.001
Standard length	12.17± 0.21^{a}	10.58± 0.49^{b}	11.57± 0.38^{ab}	9.45± 0.44^{c}	0.001
Dorsal fin length	7.64 ± 0.49^{a}	5.96± 0.29^{b}	6.21± 0.20^{b}	5.42± 0.31^{b}	0.001
Anal fin length	2.06± 0.06	1.98± 0.09	1.82± 0.09	1.89± 0.12	0.239
Pectoral fin	0.75± 0.02	0.65 ± 0.04	1.30± 0.47	0.75± 0.11	0.197
Pelvic fin length	0.63± 0.03^{b}	0.55± 0.09^{b}	0.67± 0.09^{b}	1.05± 0.27^{a}	0.009
Pre-pelvic distance	4.73± 0.07^{a}	4.39± 0.23^{ab}	4.44 ± 0.15^{ab}	3.97± 0.22^{b}	0.022
Distance between occipital	3.15± 0.08	3.25± 0.53	2.48± 0.54	3.00± 0.16	0.479
Pre-dorsal distance	4.42± 0.08^{a}	4.01± 0.17^{a}	4.09± 0.13^{a}	3.49 ± 0.22^{b}	0.001
Diameter of eye	1.08± 0.02^{b}	1.08± 0.15^{b}	1.05± 0.04^{b}	1.76± 0.29^{a}	0.005
Body width	4.42± 0.08^{a}	4.03± 0.19^{a}	4.21± 0.19^{a}	2.79± 0.26^{b}	0.001
Body Depth	2.39± 0.12^{b}	2.03± 0.13^{bc}	1.89± 0.09^{c}	2.94± 0.26^{a}	0.001
Caudal peduncle	1.70± 0.04^{ab}	1.48± 0.07^{b}	1.85± 0.15^{a}	1.58± 0.12^{ab}	0.001
Caudal fin length	3.05± 0.09^{a}	2.61± 0.10^{b}	2.34± 0.05^{b}	2.61± 0.13^{b}	0.001
Head Width	2.78± 0.16	2.93± 0.22	2.38± 0.16	2.58± 0.14	0.124
Vomerine length	1.02± 0.08^{a}	0.72± 0.05^{bc}	0.82± 0.03^{b}	0.63± 0.05^{c}	0.001
Vomerine Width	0.29± 0.01^{ab}	0.16± 0.02^{b}	0.10± 0.00^{b}	0.46± 0.19^{a}	0.049
Pectoral fin height	3.93± 0.13	3.73± 0.19	3.69± 0.15	3.31± 0.23	0.101
Anal fin height	2.92± 0.11^{a}	2.47± 0.14^{bc}	2.69± 0.16^{ab}	2.23 ± 0.13^{c}	0.003
Dorsal fin height	2.78± 0.09^{a}	2.34± 0.13^{b}	2.46± 0.14^{ab}	2.23 ± 0.21^{b}	0.004
Snout height	1.33± 0.04	1.08± 0.06	1.17± 0.05	1.40± 0.38	0.622
Pre-orbital length	1.49± 0.04^{a}	1.24± 0.07^{b}	1.13± 0.05^{bc}	1.07± 0.06^{c}	0.001
Pectoral fin height	11.20 ± 0.12^{b}	12.00 ± 0.20^{a}	10.83± 0.22^{b}	11.00± 0.42^{b}	0.011

Mean in the same row with different superscript differ significantly (P < 0.05)

Table 2: Mean meristic count of *Oreochromis niloticus* from wild and cultured environment of Ibadan and Lake Kainji

Parameters	IBA Cultured	IBA Wild	KAJ Cultured	KAJ Wild	P-value
Anal fin ray	8.48± 0.14^{ab}	8.37± 0.09^{ab}	8.13± 0.07^{b}	8.77± 0.21^{a}	0.020
Dorsal fin ray	11.69± 0.14^{b}	12.03± 0.16^{b}	13.00± 0.17^{a}	11.87± 0.24^{b}	0.001
Caudal fin ray	16.31± 0.29	15.90 ± 0.07	15.87± 0.09	16.17± 0.25	0.351
Pelvic fin ray	5.29± 0.23^{b}	4.97± 0.13^{b}	5.03± 0.11^{b}	6.33 ± 0.51^{a}	0.001
Dorsal fin spine	16.20 ± 0.12^{b}	15.97± 0.11^{v}	16.93± 0.04^{a}	15.87± 0.18^{b}	0.001

Mean in the same row with different superscript differ significantly (P < 0.05)

Table 3: Mean morphometric measurements expressed as percentages of standard length and head length of wild and cultured *Oreochromis niloticus* from Ibadan (IBA) and Lake Kainji (KAJ)

Parameters	IBA Cultured	IBA Wild	KAJ Cultured	KAJ Wild	P-value
Total length	123.01±1.66^{bc}	125.51±1.74^{ab}	119.57±1.10^{c}	127.85± 1.42^{a}	0.001
Dorsal fin length	63.30±4.18^{a}	56.49± 0.86^{ab}	53.98± 0.86^{b}	57.13±1.84^{ab}	0.020
Anal fin length	16.97± 0.45^{b}	19.14± 0.64^{a}	16.04± 0.80^{b}	19.99± 0.85^{a}	0.239
Pectoral fin	6.26± 0.22	6.33± 0.34	11.02±3.86	8.64±1.42	0.282
Pelvic fin length	5.22± 0.25^{b}	5.31±1.08^{b}	5.89±1.08^{b}	12.53±3.52^{a}	0.016
Pre-pelvic distance	39.11± 0.65^{b}	41.65± 0.83^{a}	38.49± 0.61^{b}	42.06±1.15^{a}	0.004
Dist. Btw Occipital	26.02± 0.59	32.53±6.44	23.52±6.68	32.39±1.59	0.400
Pre-dorsal distance	34.59± 0.79	38.44± 0.88	35.05± 0.38	36.93±1.52	0.216
Diameter of eye	8.94± 0.22^{b}	10.54±1.57^{b}	9.14± 0.30^{b}	17.63±2.57^{a}	0.001
Body width	36.48± 0.55^{a}	38.19± 0.80^{a}	36.27± 0.71^{a}	30.06± 2.57^{b}	0.001
Body Depth	19.83± 1.05^{b}	19.49± 1.23^{bc}	16.17± 0.62^{c}	30.33± 0.26^{a}	0.001
Caudal peduncle	14.03± 0.32^{b}	14.17± 0.31^{b}	15.68± 0.86^{ab}	17.39±1.50^{a}	0.023
Caudal fin length	25.12± 0.74^{b}	25.56± 0.98^{ab}	20.87± 0.86^{c}	27.93± 0.88^{a}	0.001
Head Width	22.95±1.24^{b}	27.82±1.46^{a}	19.99±1.13^{b}	28.20±1.53^{a}	0.001
Vomerine length	8.32± 0.61^{a}	6.65± 0.35^{b}	7.13± 0.19^{b}	6.48± 0.31^{b}	0.007
Vomerine Width	2.42± 0.10^{ab}	1.53± 0.13^{b}	0.89± 0.03^{b}	5.56±2.56^{a}	0.048
Pectoral fin height	32.51±1.08^{ab}	34.98± 0.52^{a}	31.83± 0.85^{b}	34.28±1.18^{ab}	0.077
Anal fin height	23.99± 0.77	22.99± 0.61	20.94± 0.70	23.00±1.28	0.736
Dorsal fin height	22.94± 0.68	22.17± 0.75	20.94± 0.70	23.00± 1.28	0.321
Snout height	10.97± 0.34	10.07± 0.37	10.09± 0.23	16.21±5.01	0.321
Pre-orbital length	12.26± 0.29	11.88± 0.43	9.69± 0.28	11.55± 0.45	0.238

Mean in the same row with different superscript differ significantly (P < 0.05)

Table 4: Length-weight relationship and condition factor of *Oreochromis niloticus* from wild and cultured environment of Ibadan (IBA) and Lake Kainji (KAJ)

Parameters	IBA Cultured	IBA Wild	KAJ Cultured	KAJ Wild	P-value
A	-0.549	-0.447	-0.334	-1.169	-
B	1.925	1.874	1.771	2.445	-
r^2	0.53	0.82	0.57	0.682	-
K	2.94± 0.09^{c}	4.41± 0.43^{a}	3.44± 0.24^{bc}	4.16± 0.48^{ab}	0.001

Mean in the same row with different superscript differ significantly (P < 0.05)

Result of length-weight relationship of fish from this study (Table 4) reveals all populations of fish studied had a negative allometric growth, b value was highest in wild samples from Kainji (2.45) and lowest in cultured fish from Kainji (1.77), Ibadan samples however had value of 1.93 and 1.87 for cultured and wild samples respectively. The condition factors of the fish in this study were higher for wild samples (4.41 and 4.16 for Ibadan and Kainji respectively) compared to samples collected from the cultured environment (2.94 and 3.44 for Ibadan and Kainji respectively).

The results of sample centroids of the discriminate function scores based on the morphometric and meristic count of the fish under study is presented in the canonical graphs of Figs 1 and 2 respectively. This shows low variability in meristic characters as graph clearly shows wide overlapped among the fish specimen from the different area and in different culture medium, overlap was so much interwoven that the different populations could hardly be segregated into discreet unit according to the place and culture medium that they were raised from (Fig. 2). However, morphometric data clearly clustered wild samples from Kainji in to a distinct group, overlapping slightly with the culture counterpart from the same environment and completely separate from the samples from Ibadan.

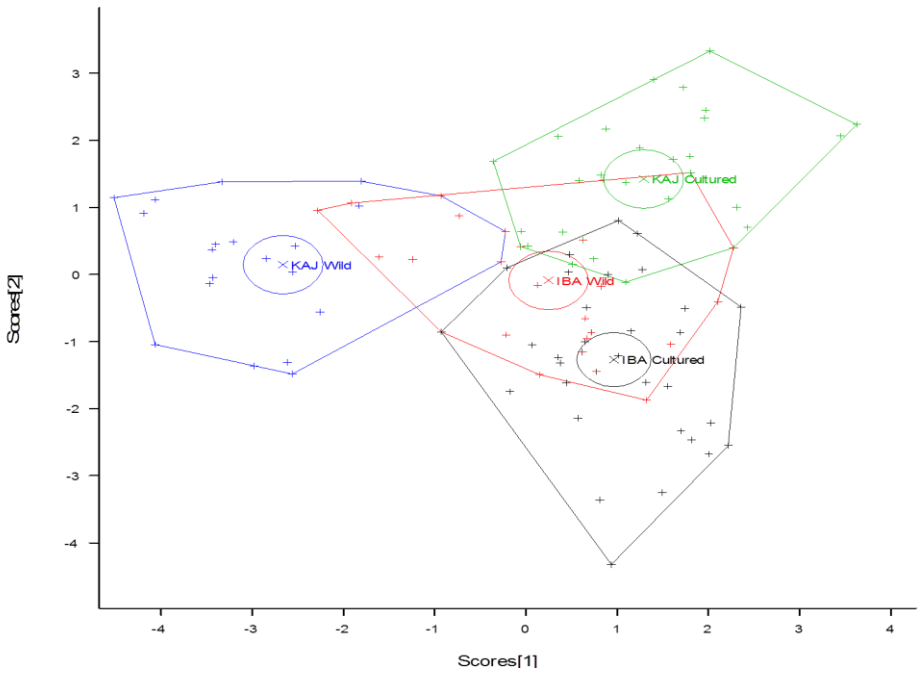

Fig. 1: Sample centroids of the discriminant function scores based on morphometric measurement of *Oreochromis niloticus* from Ibadan and Kainji Lake

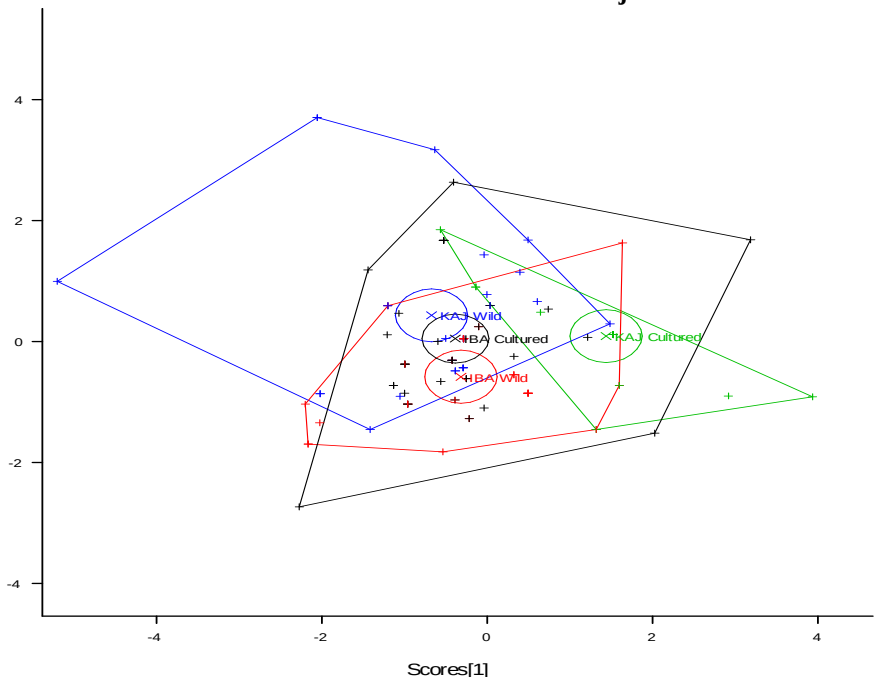

Fig. 2: Sample centroids of the discriminant function scores based on meristic count of *Oreochromis niloticus* from Ibadan and Kainji Lake

DISCUSSION

Despite advances in the use of molecular techniques in charactering fish species, the important of collecting necessary morphological data cannot be over emphasized. The result of the present study reveals significantly higher values in most morphometric parameters of the cultured specimen from the different environment compared to their wild counterparts (Table 1). Although fish demonstrate greater morphological variation within and between populations than any other vertebrates in the world (Allendorf *et al*., 1987; Wimberger 1992),

the observable difference in this study must have been as a result of the management system given under captivity compared to wild fish, hence influencing size of cultured fish to be larger than those of the wild fish. This position is further confirmed by the result of Table 3 which shows the reversed trend as morphological parameters were expressed as percentages of the standard length. Environmental conditions such as food abundance and temperature has been implicated as the main causes of fish morphological plasticity (Allendorf and Phelps 1988, Swain *et al*. 1991 and Wimberger 1992). Also Solomon *et al*. (2015) had suggested that differences in cultured and wild African catfish could also have been initiated by genetic variation due to inbreeding, crossbreeding and practices that can dilute fish genetic makeup. In summary the study recorded differences in seventeen morphometric parameters out of twenty three and in four of five meristic counts. The study of Olufeagba *et al*. (2015) recorded significant difference in nine out of fourteen body related morphometric parameters and in six out of eight head related parameters, also there was significant differences in all meristic counts of the four cichlids assessed from Lake Kainji, Solomon *et al*. (2015), however, reported significant differences in all morphometric parameters and in three out of five meristic counts of cultured and wild *Clarias gariepinus* from Benue state Nigeria. The differences in the observations of the different studies, however, must have been related to differences in fish species used and the degree of the effects of the identified phenomenon causing the morphological variation (e.g. environment condition, genetic variability, management level, etc.).

The results represented in the canonical graphs shows low or no variability in meristic characters compared to morphometric characters. It is clearly observed that the meristic counts overlapped so widely among the fish specimen from both area and both culture environment that the populations could hardly be discriminated from one another (Fig. 2). However, morphometric data shows fish specimen from wild in Lake Kainji to cluster as a distinct group, overlapping slightly with his culture counterpart from the same environment and separate itself from the fish from other environment which clearly overlap. Solomon *et al*. (2015) also reported similar finding in line with the observation of complete overlap in meristic characters for cultured and wild *Clarias gariepinus*. However, they observed that abundant morphometric variation among populations with the fish collected from the different locations clustering into the four distinct groups, Olufeagba *et al.* (2015), reported distinct cluster into different groups in four cichlids of Lake Kainji. Vidalis *et al*. (1994) had earlier stated that meristic characters may follow a predetermined variability at a very narrow range, because divergence of the meristic counts from a standard range could be fatal for the individual no matter what condition is imminent. Several authors have also considered meristic characters as a less informative tool than the morphometric data (Misra and Carscadden, 1987) when comparing morphological variations in fishes. Dunham *et al*. (1979) Allendorf, (1988) Thompson, (1991) Wimberger, (1992) has opined that fish are more susceptible to environmentally induced morphological variation than any other vertebrate, and probably reflect the differences in feeding environment, prey types, food availability or other features. However, the variance of the observation of Olufeagba *et al*. (2015) compared to previously reported studies is due to the scope of the research which focus on morphological variation of the different species of the cichlid family in Lake Kainji, hence variations observed were fundamentally induced genetically, however, other referenced study look closely at environmental induced variations and their effects on morphological plasticity of the fish.

The value of 'b' has been given to be between 2.5 to 4.0 for many species of fish (Pervin and Mortuza, 2008). According to the observed length weight relationship of fish specimen from the various location and culture chamber, all populations of fish studied had a negative allometric growth since the b value were less than the reference value 3 (Table 4). Negative allometric growth implies the fish becomes tiny as weight increase (Riedel *et al*., 2007). Condition factor of wild fishes were higher in this study compared to those in the cultured environment. According to Khallaf *et al*. (2003) condition factor of fish can be affected by a number of factors such as stress, sex, season, availability of feeds, and other water quality parameters.

CONCLUSION

The study has reveal morphological differences in both culture and wild stock of *O. niloticus* from both environment under study, however, it is important to note that phenotypic characteristics is a combined function of genetic and environmental factor, hence further research should be conducted to study genetic variation of the fish species from the different environment, this will explicitly determine whether environmental differences leading to morphological variations noticed in this study has further induced genetic variations in the fish species.

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