**Morphological Variation of Cichlids From Kainji Lake, Nigeria By**
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**Abstract** This study was designed to evaluate morphological variations of cichlids from the Kainji lake, Niger State in Nigeria. 200 samples of cichlids comprising four species (Oreochromis niloticus, Tilapia zilli, Pelmatolapia mariae and Sarotherodon galilaeus) were collected from the lake and a total of thirty morphometric measurements and meristic counts were recorded. Data was corrected to eliminate size effect on sample and subjected to discriminant function analysis to determine rate of divergence among species. Results obtained revealed significant variation in some morphometric parameters measured and all six meristic counts recorded. Growth pattern revealed negative allometric growth for O. niloticus (2.29), T. mariae (0.72) and S. galilaeus (2.47) while T. zilli, had a positive allometric growth. Discriminant analysis showed some levels of overlap across species for both morphometric measurement and meristic count. Interspecific distance was closest between T. zilli and O. niloticus (14.70) while the farthest distance was recorded between T. zilli and S. galilaeus (52.40). The observable overlap among species despite morphometric and genetic differences may have been as a result of similar species adaptations in response to the prevailing environmental conditions.

**Keywords** Tilapia; Lake; Morphometric parameters; Meristic count; Man made lake

**Introduction**
Despite the advent of techniques which directly examines biochemical or molecular genetic variation, conventional methods continues to have an important role in stock identification even to date (Swain & Foote, 1999). Morphological characters such as morphometric measurement and meristic count have been used to identify fish stocks (Turan et al., 2004) and remain the simplest and most direct way among methods of species identification. The study of differences and variability in morphometric and meristic characters of fish stocks is important in phylogenetics and providing information for subsequent studies on the genetic improvement of stocks.

Environmental changes in the habitats of the fish due to human activities and continuous constructions along coastal lines as well as the pollution of the aquatic environment by fertilizers and pesticides, are expected to cause some morphological changes within species. Both morphometric and meristic characters respond to changes in environmental factors and these responses differ from species to species. Mohamed (1990), (Goncalves et al., 1996), Froese & Pauly (1998) and (Mwanja et al., 2011) had stated that morphological change and divergence within species are expected to take place when fishes are exposed to new developmental and evolutionary forces that determine their body forms. A change could take place, either through natural hybridization or the effect of the environmental factors that operate in early stages of development (Nei, 1987; Currens et al., 1989; Mohamed, 2010). The present study was, therefore, designed to compare the morphological characteristics of the cichlids of Kainji lake by using a combination of both morphometric and meristic characters. The study also attempted to characterize the populations of these fishes in the lake and determine the morphological characteristics that contribute mostly to the variation of the cichlids in the lake, to our knowledge this is the first of such study aim at evaluating the morphological variation of fish in a dam constructed since 1968.

**Materials and Methods**

**The Study Area**
Lake Kainji, which is the largest man - made lake in
Nigeria, was created in 1968 after the damming of River Niger for electricity generation by the National Electric Power Authority (NEPA). The Lake lies between Latitudes 9°00'50"N and 10°55'S, and Longitudes 40°45'S - 40°45'E and between the borders of Sub-Saharan and Northern Guinea Savanna zones. It has a maximum length of 134 km, maximum width of 24.1 km, mean and maximum depth of 11 m and 60 m respectively, surface area of 1270 km\(^2\), a volume of 13 × 109 m\(^3\), and catchment's area of 1.6 × 106 km\(^2\) (Obot, 1989).

**Experimental Fish and Data Collections**

A total of 200 fishes were obtained from the lake Kainji for this study, meristic counts and morphometric measurement were determine as described by (Samaradivakara et al., 2012). The morphometric variables included 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 penduncle depth, caudal fin length, head width, head length, vomerine length, vomerine width, pectoral fin height, anal fin height and pre-orbital length. The meristic counts included anal fin ray, dorsal fin ray, caudal fin ray, pectoral fin ray, pelvic fin ray and dorsal fin spine. Body morphometric measurement such as total length, dorsal fin length, anal fin length, pectoral fin length, pelvic fin length, pre-pelvic fin length, pre-dorsal distance, body width, body depth, caudal penduncle depth, caudal fin length, pectoral fin height, anal fin height and dorsal fin height were expressed as percentages of standard length while head related morphometric parameters such as distance between occipital process, eye diameter, head width, vomerine length, vomerine width, snout length and pre-orbital length were expressed as percentages of head length.

The length-weight relationship was calculated using the equation given by LeCren (1951) and Ricker (1973) as follows
\[
\log W = a + b \log L
\]

The function condition factor (K) for each species was calculated from the equation:
\[
K = \frac{100 W}{L^2}
\]

Where K= condition factor, L= Standard length (cm), W= Weight (g)

**Statistical analysis**

To ensure that variations in this study were only attributed to body shape differences, and not to the relative sizes of the fish, size effects from the data set were eliminated, by standardizing the morphometric parameters using the allometric formula given by Elliott et al. (1995):
\[
M_{\text{adj}} = M \left( \frac{L_s}{L_o} \right)^b
\]

Where M is the original measurement, M\(_{\text{adj}}\) is the size-adjusted measurement, Lo is the TL of the fish, and Ls is the overall mean of the TL for all fish from all samples. Parameter b was estimated for each character from the observed data as the slope of the regression of log M on log Lo, using all fish in all groups. However, it has been established that meristic characters are independent of size of fish hence should not change during growth (Strauss, 1985; Murta, 2000) therefore the raw data were analysed without transformation as described above. Statistical analyses in the present study included descriptive statistics using Minitab 14 as well as univariate analysis of variance using Genstat\(^\text{®}\) discovery edition 4. Where significant differences occurred, Duncan's least significant difference was used to separate the mean values of morphometric and meristic parameters. Morphometric and meristic data were subjected to discriminate (?) function analysis (DFA) using Genstat\(^\text{®}\) discovery edition 4.

**Result**

Morphological variations of cichlids shows significant differences in most morphometric parameters except in pectoral fin length, pelvic fin length, pre-dorsal distance, vomerine width and snout length (Table 1-5), all meristic count however were statistically different among the species, *S. galilaeus* was observed to have higher values of morphometric parameters measured compared to other species. However, *T. zilli* had more meristic count than any other species under study. Expressing morphometric parameters as percentages of standard length (for body related parameters) and head length (for head related parameters) did not significantly change the trend of observation for most parameters as *S. galilaeus* still had higher percentages in ten out of fourteen parameter that were significantly different among the species. Growth pattern of the different species reveals that *O. niloticus, S. galilaeus* and *P. mariae* had a negative allometric growth pattern...
Table 1 Morphometric measurements and meristic counts of cichlids from Kainji Lake, Nigeria

| Parameter                  | Months                  | Mean          | Minimum | Maximum |
|----------------------------|-------------------------|---------------|---------|---------|
| Total length               | *O. niloticus*          | 12.04 ± 0.57<sup>b</sup> | 6.00    | 18.40   |
|                            | *S. galilaeus*          | 15.36 ± 0.40<sup>b</sup> | 10.50   | 20.80   |
|                            | *P. mariae*             | 12.72 ± 0.35<sup>b</sup> | 11.70   | 13.80   |
|                            | *T. zilli*              | 12.38 ± 0.80<sup>b</sup> | 8.60    | 17.50   |
| P-value                    |                         | 0.001         |         |         |
| Standard Length            | *O. niloticus*          | 9.45 ± 0.44<sup>b</sup> | 4.20    | 13.00   |
|                            | *S. galilaeus*          | 12.14 ± 0.35<sup>b</sup> | 8.00    | 16.70   |
|                            | *P. mariae*             | 10.24 ± 0.42<sup>ab</sup> | 9.10    | 11.50   |
|                            | *T. zilli*              | 9.77 ± 0.65<sup>b</sup> | 7.00    | 14.10   |
| P-value                    |                         | 0.001         |         |         |
| Weight                     | *O. niloticus*          | 36.48 ± 5.09<sup>b</sup> | 7.00    | 105.00  |
|                            | *S. galilaeus*          | 85.78 ± 9.12<sup>b</sup> | 30.00   | 290.00  |
|                            | *P. mariae*             | 21.54 ± 0.72<sup>b</sup> | 19.78   | 23.20   |
|                            | *T. zilli*              | 42.83 ± 9.30<sup>b</sup> | 11.70   | 112.40  |
| P-value                    |                         | 0.001         |         |         |
| Dorsal Fin Lt              | *O. niloticus*          | 5.42 ± 0.31<sup>b</sup> | 2.00    | 8.00    |
|                            | *S. galilaeus*          | 7.42 ± 0.20<sup>a</sup> | 5.00    | 9.60    |
|                            | *P. mariae*             | 4.76 ± 0.20<sup>b</sup> | 4.30    | 5.40    |
|                            | *T. zilli*              | 5.69 ± 0.38<sup>b</sup> | 3.80    | 8.50    |
| P-value                    |                         | 0.001         |         |         |
| Anal fin Lt                | *O. niloticus*          | 1.89 ± 0.12<sup>b</sup> | 0.70    | 3.30    |
|                            | *S. galilaeus*          | 2.55 ± 0.09<sup>a</sup> | 1.60    | 3.90    |
|                            | *P. mariae*             | 1.58 ± 0.06<sup>b</sup> | 1.40    | 1.80    |
|                            | *T. zilli*              | 1.65 ± 0.14<sup>b</sup> | 1.00    | 2.60    |
| P-value                    |                         | 0.246         |         |         |
| Pectoral fin Lt            | *O. niloticus*          | 0.75 ± 0.11   | 0.10    | 2.40    |
|                            | *S. galilaeus*          | 0.80 ± 0.03   | 0.50    | 1.10    |
|                            | *P. mariae*             | 0.62 ± 0.05   | 0.50    | 0.70    |
|                            | *T. zilli*              | 0.57 ± 0.05   | 0.30    | 1.00    |
| P-value                    |                         | 0.246         |         |         |
| Pelvic fin Lt              | *O. niloticus*          | 1.05 ± 0.27   | 0.10    | 5.20    |
|                            | *S. galilaeus*          | 0.59 ± 0.03   | 0.30    | 1.00    |
|                            | *P. mariae*             | 0.52 ± 0.04   | 0.40    | 0.60    |
|                            | *T. zilli*              | 0.43 ± 0.05   | 0.2     | 0.90    |
| P-value                    |                         | 0.10<sup>f</sup> |         |         |
| Pre-pelvic fin Lt          | *O. niloticus*          | 3.97 ± 0.22<sup>b</sup> | 2.10    | 6.00    |
|                            | *S. galilaeus*          | 5.27 ± 0.14<sup>a</sup> | 3.90    | 7.20    |
|                            | *P. mariae*             | 3.90 ± 0.13<sup>b</sup> | 3.40    | 4.10    |
|                            | *T. zilli*              | 3.75 ± 0.23<sup>b</sup> | 2.70    | 5.10    |
| P-value                    |                         | 0.001         |         |         |
| Distance btw occipital     | *O. niloticus*          | 3.00 ± 0.16<sup>b</sup> | 1.50    | 4.60    |
|                            | *S. galilaeus*          | 3.79 ± 0.12<sup>a</sup> | 2.60    | 5.80    |
|                            | *P. mariae*             | 2.14 ± 0.12<sup>c</sup> | 1.70    | 2.30    |
|                            | *T. zilli*              | 2.27 ± 0.24<sup>c</sup> | 1.20    | 4.00    |
| P-value                    |                         | 0.001         |         |         |
| Pre-dorsal distance        | *O. niloticus*          | 3.49 ± 0.22   | 1.10    | 5.50    |
|                            | *S. galilaeus*          | 3.69 ± 1.47   | 3.70    | 5.20    |
|                            | *P. mariae*             | 3.92 ± 0.16   | 3.50    | 4.40    |
|                            | *T. zilli*              | 3.69 ± 0.33   | 1.80    | 5.70    |
| P-value                    |                         | 0.91          |         |         |
| Parameter             | Months          | Mean     | Minimum | Maximum |
|-----------------------|-----------------|----------|---------|---------|
| Eye diameter          | *O. niloticus*  | 1.76 ± 0.29<sup>a</sup> | 0.30    | 2.50    |
|                       | *S. galilaeus*  | 1.01 ± 0.03<sup>a</sup> | 0.60    | 1.40    |
|                       | *P. mariae*     | 0.82 ± 0.02<sup>a</sup> | 0.80    | 0.90    |
|                       | *T. zilli*      | 0.95 ± 0.06<sup>ab</sup> | 0.60    | 1.50    |
| P-value               |                 | 0.001    |         |         |
| Body width            | *O. niloticus*  | 2.79 ± 0.26<sup>b</sup> | 1.00    | 5.70    |
|                       | *S. galilaeus*  | 5.71 ± 0.19<sup>a</sup> | 4.00    | 8.20    |
|                       | *P. mariae*     | 3.50 ± 0.16<sup>b</sup> | 3.10    | 4.00    |
|                       | *T. zilli*      | 2.01 ± 0.22<sup>c</sup> | 1.20    | 3.90    |
| P-value               |                 | 0.001    |         |         |
| Body width            | *O. niloticus*  | 2.94 ± 0.26<sup>a</sup> | 1.00    | 5.70    |
|                       | *S. galilaeus*  | 5.71 ± 0.19<sup>a</sup> | 4.00    | 8.20    |
|                       | *P. mariae*     | 3.50 ± 0.16<sup>b</sup> | 3.10    | 4.00    |
|                       | *T. zilli*      | 2.01 ± 0.22<sup>c</sup> | 1.20    | 3.90    |
| P-value               |                 | 0.001    |         |         |
| Caudal penduncle depth| *O. niloticus*  | 2.94 ± 0.90<sup>b</sup> | 0.90    | 6.00    |
|                       | *S. galilaeus*  | 2.75 ± 0.13<sup>a</sup> | 1.40    | 4.10    |
|                       | *P. mariae*     | 1.30 ± 0.16<sup>b</sup> | 0.90    | 1.80    |
|                       | *T. zilli*      | 3.84 ± 0.36<sup>b</sup> | 2.10    | 6.20    |
| P-value               |                 | 0.001    |         |         |
| Caudal fin lt         | *O. niloticus*  | 1.58 ± 0.12<sup>b</sup> | 0.60    | 3.30    |
|                       | *S. galilaeus*  | 2.10 ± 0.06<sup>a</sup> | 1.40    | 3.00    |
|                       | *P. mariae*     | 1.46 ± 0.07<sup>b</sup> | 1.30    | 1.60    |
|                       | *T. zilli*      | 1.46 ± 0.13<sup>b</sup> | 0.90    | 2.30    |
| P-value               |                 | 0.001    |         |         |
| Head width            | *O. niloticus*  | 2.59 ± 0.14<sup>b</sup> | 1.60    | 4.30    |
|                       | *S. galilaeus*  | 3.64 ± 0.15<sup>a</sup> | 2.30    | 5.50    |
|                       | *P. mariae*     | 1.80 ± 0.58<sup>b</sup> | 0.70    | 3.40    |
|                       | *T. zilli*      | 2.33 ± 0.29<sup>b</sup> | 1.10    | 4.90    |
| P-value               |                 | 0.001    |         |         |
| Head lt               | *O. niloticus*  | 3.30 ± 0.14<sup>b</sup> | 1.70    | 4.60    |
|                       | *S. galilaeus*  | 4.04 ± 0.13<sup>a</sup> | 2.50    | 5.80    |
|                       | *P. mariae*     | 3.48 ± 0.16<sup>ab</sup> | 3.00    | 3.90    |
|                       | *T. zilli*      | 3.14 ± 0.24<sup>b</sup> | 2.10    | 4.90    |
| P-value               |                 | 0.001    |         |         |
| Vomerine lt           | *O. niloticus*  | 0.63 ± 0.05<sup>b</sup> | 0.20    | 1.10    |
|                       | *S. galilaeus*  | 0.72 ± 0.04<sup>a</sup> | 0.40    | 1.30    |
|                       | *P. mariae*     | 0.54 ± 0.12<sup>ab</sup> | 0.20    | 0.80    |
|                       | *T. zilli*      | 0.83 ± 0.09<sup>b</sup> | 0.50    | 1.60    |
| P-value               |                 | 0.001    |         |         |
| Vomerine width        | *O. niloticus*  | 0.46 ± 0.19 | 0.10  | 4.40    |
|                       | *S. galilaeus*  | 0.17 ± 0.02 | 0.10  | 0.50    |
|                       | *P. mariae*     | 0.26 ± 0.04 | 0.20  | 0.40    |
|                       | *T. zilli*      | 0.19 ± 0.01 | 0.10  | 0.30    |
| P-value               |                 | 0.353    |         |         |
| Pectoral fin height   | *O. niloticus*  | 3.31 ± 0.23<sup>b</sup> | 1.40    | 5.20    |
|                       | *S. galilaeus*  | 4.50 ± 0.16<sup>a</sup> | 3.30    | 7.00    |
|                       | *P. mariae*     | 2.00 ± 0.08<sup>b</sup> | 1.70    | 2.20    |
|                       | *T. zilli*      | 3.07 ± 0.26<sup>c</sup> | 1.80    | 5.20    |
| Parameter          | Months | Mean       | Minimum | Maximum |
|--------------------|--------|------------|---------|---------|
| Anal fin height    |        |            |         |         |
| *O. niloticus*     |        | 2.23 ± 0.13<sup>b</sup> | 0.70    | 3.20    |
| *S. galilaeus*     |        | 3.23 ± 0.14<sup>a</sup> | 1.70    | 5.30    |
| *P. mariae*        |        | 2.06 ± 0.17<sup>b</sup> | 1.70    | 2.70    |
| *T. zilli*         |        | 2.47 ± 0.29<sup>b</sup> | 1.20    | 4.90    |
| P-value            | 0.001  |            |         |         |
| Dorsal fin height  |        |            |         |         |
| *O. niloticus*     |        | 2.23 ± 0.21<sup>c</sup> | 0.80    | 5.70    |
| *S. galilaeus*     |        | 3.14 ± 0.15<sup>a</sup> | 1.60    | 4.30    |
| *P. mariae*        |        | 2.12 ± 0.15<sup>c</sup> | 1.80    | 2.60    |
| *T. zilli*         |        | 2.98 ± 0.29<sup>b</sup> | 1.30    | 5.10    |
| P-value            | 0.002  |            |         |         |
| Snout lt           |        |            |         |         |
| *O. niloticus*     |        | 1.40 ± 0.32 | 0.20    | 9.00    |
| *S. galilaeus*     |        | 1.09 ± 0.05 | 0.30    | 1.60    |
| *P. mariae*        |        | 0.92 ± 0.06 | 0.70    | 1.00    |
| *T. zilli*         |        | 0.87 ± 0.11 | 0.40    | 1.90    |
| P-value            | 0.561  |            |         |         |
| Anal fin ray       |        |            |         |         |
| *O. niloticus*     |        | 9.00 ± 0.21<sup>b</sup> | 8.00    | 12.00   |
| *S. galilaeus*     |        | 10.00 ± 0.15<sup>a</sup> | 9.00    | 12.00   |
| *P. mariae*        |        | 9.00 ± 0.49<sup>bc</sup> | 7.00    | 10.00   |
| *T. zilli*         |        | 8.00 ± 0.33<sup>c</sup> | 6.00    | 10.00   |
| P-value            | 0.001  |            |         |         |
| Dorsal fin ray     |        |            |         |         |
| *O. niloticus*     |        | 12.00 ± 0.24<sup>a</sup> | 7.00    | 15.00   |
| *S. galilaeus*     |        | 12.00 ± 0.09<sup>b</sup> | 11.00   | 14.00   |
| *P. mariae*        |        | 10.00 ± 0.25<sup>c</sup> | 10.00   | 11.00   |
| *T. zilli*         |        | 12.00 ± 0.43<sup>c</sup> | 9.00    | 16.00   |
| P-value            | 0.019  |            |         |         |
| Caudal fin ray     |        |            |         |         |
| *O. niloticus*     |        | 16.00 ± 0.25<sup>b</sup> | 13.00   | 20.00   |
| *S. galilaeus*     |        | 16.00 ± 0.16<sup>b</sup> | 12.00   | 17.00   |
| *P. mariae*        |        | 15.00 ± 0.45<sup>b</sup> | 14.00   | 16.00   |
| *T. zilli*         |        | 22.00 ± 1.43<sup>c</sup> | 13.00   | 31.00   |
| P-value            | 0.001  |            |         |         |
| Pectoral fin ray   |        |            |         |         |
| *O. niloticus*     |        | 11.00 ± 0.42<sup>b</sup> | 5.00    | 13.00   |
| *S. galilaeus*     |        | 11.00 ± 0.12<sup>b</sup> | 9.00    | 12.00   |
| *P. mariae*        |        | 11.00 ± 0.04<sup>b</sup> | 10.00   | 12.00   |
| *T. zilli*         |        | 13.00 ± 1.32<sup>a</sup> | 7.00    | 22.00   |
| P-value            | 0.001  |            |         |         |
| Pelvic fin ray     |        |            |         |         |
| *O. niloticus*     |        | 6.00 ± 0.51<sup>b</sup> | 5.00    | 16.00   |
| *S. galilaeus*     |        | 6.00 ± 0.08<sup>b</sup> | 5.00    | 6.00    |
| *P. mariae*        |        | 5.00 ± 0.00<sup>b</sup> | 5.00    | 5.00    |
| *T. zilli*         |        | 10.00 ± 0.69<sup>c</sup> | 5.00    | 15.00   |
| P-value            | 0.001  |            |         |         |
| Dorsal fin spine   |        |            |         |         |
| *O. niloticus*     |        | 16.00 ± 0.18<sup>a</sup> | 13.00   | 17.00   |
| *S. galilaeus*     |        | 15.00 ± 0.07<sup>bc</sup> | 15.00   | 16.00   |
| *P. mariae*        |        | 14.00 ± 0.20<sup>b</sup> | 13.00   | 14.00   |
| *T. zilli*         |        | 14.00 ± 0.25<sup>c</sup> | 12.00   | 15.00   |
| P-value            | 0.001  |            |         |         |
| Preobital lt       |        |            |         |         |
| *O. niloticus*     |        | 1.07 ± 0.06<sup>b</sup> | 0.60    | 1.90    |
| *S. galilaeus*     |        | 1.71 ± 0.05<sup>a</sup> | 1.10    | 2.40    |
| *P. mariae*        |        | 1.24 ± 0.12<sup>b</sup> | 0.80    | 1.50    |
| *T. zilli*         |        | 1.17 ± 0.11<sup>b</sup> | 0.70    | 1.80    |
| P-value            | 0.001  |            |         |         |

Mean in the same column with different superscript differ significantly (P<0.05)
Table 2: Morphometric measurements of cichlid from lake kainji expressed as percentages of standard length

| Parameters          | O. niloticus | S. galilaeus | P. mariae | T. zilli | P-value |
|---------------------|--------------|--------------|-----------|----------|---------|
| Total length        | 127.85 ± 1.42| 126.80 ± 0.80| 124.48 ± 1.68 | 126.92 ± 1.26 | 0.666   |
| Dorsal fin lt       | 57.13 ± 1.84a| 61.33 ± 0.84a| 46.71 ± 2.25b | 58.42 ± 1.04ab | 0.001   |
| Anal fin lt         | 19.99 ± 0.85b| 20.96 ± 0.41a| 15.48 ± 0.65b | 16.76 ± 0.64b | 0.001   |
| Pectoral fin lt     | 8.64 ± 1.42  | 6.59 ± 0.15  | 6.10 ± 0.57  | 5.79 ± 0.24  | 0.198   |
| Pelvic fin lt       | 12.53 ± 3.52a| 4.78 ± 0.16b | 5.07 ± 0.29ab| 4.35 ± 0.33b | 0.044   |
| Pre-pelvic lt       | 42.06 ± 1.15ab| 43.65 ± 0.62a| 38.16 ± 0.81bc| 38.68 ± 0.95c | 0.004   |
| Pre-dorsal distance | 36.93 ± 1.52  | 54.40 ± 11.20| 38.42 ± 1.69  | 37.22 ± 1.65  | 0.316   |
| Body width          | 30.06 ± 2.57b | 46.99 ± 0.69a| 34.16 ± 0.61b | 20.40 ± 1.41c | 0.001   |
| Body depth          | 30.33 ± 1.91b | 22.49 ± 0.74a| 12.61 ± 1.61d | 38.69 ± 1.54a | 0.001   |
| Caudal peduncle de  | 17.39 ± 1.50  | 17.32 ± 0.19 | 14.29 ± 0.62  | 14.68 ± 0.43  | 0.227   |
| Caudal fin lt       | 27.93 ± 0.88  | 29.28 ± 0.49  | 25.71 ± 0.82  | 27.28 ± 1.30  | 0.174   |
| Pectoral fin height | 34.28 ± 1.18b | 37.31 ± 0.97a| 19.53 ± 0.31c | 31.13 ± 0.89b | 0.001   |
| Anal fin height     | 23.72 ± 1.02ab| 26.29 ± 0.67a| 19.97 ± 0.88b | 24.67 ± 1.82ab| 0.047   |
| Dorsal fin height   | 23.00 ± 1.28b | 25.78 ± 0.91b| 20.63 ± 0.71b | 29.87 ± 1.51a | 0.002   |

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

Table 3: Head related morphometric measurements of cichlid from lake kainji expressed as percentages of head length

| Parameters          | O. niloticus | S. galilaeus | P. mariae | T. zilli | P-value |
|---------------------|--------------|--------------|-----------|----------|---------|
| Distance btw occip  | 91.48 ± 3.80a| 95.65 ± 3.61a| 61.43 ± 1.62b| 70.66 ± 2.90b | 0.001   |
| Diameter of eye     | 49.78 ± 7.15a| 25.46 ± 0.99b| 23.72 ± 1.01b| 31.25 ± 1.87b | 0.001   |
| Head width          | 79.30 ± 3.57b| 92.56 ± 5.30a| 49.50 ± 14.20c| 71.91 ± 4.10bc| 0.001   |
| Vomerine lt         | 18.49 ± 0.95b| 18.34 ± 0.95b| 15.13 ± 2.93b| 26.15 ± 1.46c | 0.001   |
| Vomerine width      | 14.45 ± 6.34  | 4.25 ± 0.45   | 7.36 ± 0.83  | 6.45 ± 0.62  | 0.293   |
| Snout lt            | 43.50 ± 12.30 | 27.53 ± 1.22  | 26.43 ± 1.31 | 27.09 ± 2.09 | 0.410   |
| Preorbital lt       | 32.49 ± 0.96c | 42.93 ± 1.43a| 35.36 ± 2.29bc| 37.00 ± 1.60b | 0.001   |

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

Table 4: Length-Weight relationship and condition factor of selected fish species from Domu dam

| Parameters          | O. niloticus | S. galilaeus | P. mariae | T. zilli | P-value |
|---------------------|--------------|--------------|-----------|----------|---------|
| a (Intercept)       | -0.76        | -0.80        | 0.60      | -1.69    | -       |
| b (Growth Pattern)  | 2.29         | 2.47         | 0.72      | 3.26     | -       |
| r² (Regression Coefficient) | 0.64     | 0.58         | 0.75      | 0.98     | -       |
| K                   | 4.16 ± 0.48a | 4.56 ± 0.27a | 2.06 ± 0.19b | 3.67 ± 0.12ab | 0.041   |

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

Table 5: Interspecies distance of cichlid from Kainji lake Nigeria

| Parameters          | O. niloticus | S. galilaeus | P. mariae | T. zilli |
|---------------------|--------------|--------------|-----------|----------|
| O. niloticus        | 0.00         |              |           |          |
| S. galilaeus        | 34.98        | 0.00         |           |          |
| P. mariae           | 34.46        | 39.29        | 0.00      |          |
| T. zilli            | 14.70        | 52.40        | 45.53     | 0.00     |

(2.29, 2.47, and 0.72 respectively), while T. zilli had a positive allometric growth (3.26), condition factor however was higher in O. niloticus and S. galilaeus (4.16 and 4.27) and lower in P. mariae (2.06). Interspecific distance between the cichlids under study reveals the shortest distance between T. zilli and O. niloticus (14.70) while the longest distance was observed between T. zilli and S. galilaeus (52.40).
Relationships of the morphometric measurement and meristic count analysis among cichlids from lake Kainji was considered according to the 1st and 2nd discriminant function (DF) (Figures 1 and 2 respectively). The 1st DF accounted for 42% and the 2nd DF accounted for 25% of among-group variability of the morphometric data, and together they explained 67% of total among-group variability. On the other hand, the 1st and 2nd DF of the meristic count analysis accounted for 47% and 27% respectively of the among-group variability, together they explained 74% of total among-group variability. According to the canonical discriminant function coefficients obtained for the morphometric data, the most influential variables for 1st DF were distance between occipital process, pre-dorsal distance, pectoral fin length, vomerine length, head length, head width, pre-pelvic distance while caudal fin ray, pelvic fin ray and pectoral fin ray constituted the most influential meristic variable for discrimination of the groups.

Plots of canonical discriminant functions 1 of the morphometric measurements (Figure 1) clearly showed a complete separation between S. galilaeus and other species, hence a well separated and absolutely differentiated groupings along the first function, however there was noticeable overlap between O. niloticus and the other two species. Considering the 2nd DF, O. niloticus overlap broadly with P. mariae and S. galilaeus, however T. zilli only overlap broadly with S. galilaeus and slightly with O. niloticus. For meristic counts, there were broad overlap between O. niloticus, S. galilaeus and P. mariae considering the first function. T. zilli clearly separate from other species but slightly overlap with O. niloticus. Second function however shows a significant overlap of T. zilli with all other species while overlap between O. niloticus, and S. galilaeus clearly separated from P. mariae.

Discussions

Fish has been said to demonstrate greater variances in morphological traits both within and between populations of species than any other vertebrates (Allendorf et al., 1987; Wimberger, 1992). This study recorded significant differences in nine out of fourteen for body related morphometric parameters, six of eight for head related parameters and in all meristic counts. Earlier studies by Beacham (1985), Beacham & Murray (1985), Beacham & Withler (1985), (Beacham et al., 1988), (Lund et al., 1989) and (Kinnison et al., 1998) on Salmon has shown that morphometric parameters can be highly variable among and within conspecific populations, either correlating with geographical and habitat variation or having a genetic component, based on differences among groups in a common environment.

Allendorf and Phelps (1988), (Swain et al., 1991) and Wimberger (1992) had highlighted environmental conditions such as food abundance and temperature as causes of fish high morphological plasticity, (Solomon et al., 2015) had also suggested genetic variation caused by inbreeding, crossbreeding and other practices that can diluted gene pool as the major cause of differences in cultured and wild African catfish. However the marked differences of morphology in the present study may be linked to genetic differences of the species.

It has been reported by some fish biologists that ‘b’ values usually range from 2.0 to 4.0 for many fish species (LeCren, 1951). According to the observation of the length-weight relationship of this study, all the species except P. mariae were within this range. Negative allometric growth implies the fish becomes
more slender as it increase in weight while positive allometric growth implies the fish becomes relatively shorter or deeper-bodied as it increases in length (Riedel et al., 2007). This was evident in this study as *T. zilli* had shorter body width (20.40) while *S. galilaeus, P. mariae* and *O. niloticus* have significantly larger body width (46.99, 34.16 and 30.06 respectively). The value of “b” in GIFT and GIFU was reported to be 2.69 and 2.72 respectively by (Shahririar Nazrul et al., 2011). (Narejo et al., 1999) and Al-Baz and Grove (1995) also reported value of regression coefficient b in *Temualosa ilisha* as 3.0246 for males and 3.0345 for females and 2.68 for males and 3.16 for females respectively. While Hile (1936) and Martin (1949) observed that the value of regression coefficient (b) usually lies between 2.5 and 4.0 in *Leochthys artedi*.

However, differences in the ‘b’ value reported by the various authors is due to species variation, strain variation, stock variation, differences in environmental factors, sex variation etc. Higher condition factors were observed for *S. galilaeus* and *O. niloticus* while *P. mariae* had the least value. Differences in Condition factor can be due to different reasons which includes; stress, sex, season, availability of feeds, and other water quality parameters (Khalil et al., 2003). Hence the availability and abundance of food at the time of sampling must have been the reason for the differences in the condition factor of the fish. The values of relative condition factor in Shahririar Nazrul et al., (2011) experiment ranged from 0.897-1.06 for GIFT and 0.876-1.097 for GIFU and were lower than that recorded in the present study.

For the discriminant analyses of the morphometric parameters, distance between occipital process, pre-dorsal distance, pectoral fin length, vomerine length, head length, head width, pre-pelvic distance contributed heavily to canonical discriminant function 1. While caudal fin ray, pelvic fin ray and pectoral fin ray constituted the most influential meristic variable for discrimination of the groups. (Samaradivakara et al., 2012) had earlier reported standard length, body height and pre-dorsal distance as major contributors to canonical discriminant function 1 in morphometric parameters of four Tilapia Populations in Selected Reservoirs of Sri Lanka. However, Haddon & Willis (1995) stated that Morphometrics of the head and body depth have been regarded as the most important characters for discrimination of angler fish (*Lophius vormernus*), Pacific herring (*Clupea pallasi*) and Orange roughy (*Hoplostethus atlanticus*) (Leslie & Grant, 1990; Schwegert, 1990; Haddon & Willis 1995) (while Turan et al., 2005) reported HL as the only important parameter for discrimination of six population of African catfish in Turkey. Eyo (2003) reported that among four Clarias species (*Clarias ebriensis, C. albopunctatus, C. gariepinus* and *C. anguillaris*), congeneric differences occurred in pectoral fin base length and frontal width, pelvic fin base length, Pectoral fin base length, Pectoral fin base length, pelvic fin space, pelvic anal fin space, prenasal barbell length, and in 6 residual characters namely Total Length, prepectoral length, pectoral fin base, length, dorsal fin base length, outer mandibular barbel space and eye diameter. Specific differences among Distichodus species studied by Nwani and Ude, (2005) reveals that pelvic fin height, dorsal fin height, anal fin height, pectoral-pelvic fin space, pelvic anal fin space, head length and caudal peduncle depth were of significant taxonomic importance in discriminating all the studied Distichodus species. Nevertheless, in general, fishes demonstrate greater variance in morphological traits both within the same species or different species or between populations than other vertebrates and reflect differences in feeding environment, prey types, food availability or other features (Dunham et al., 1979; Allendorf, 1988; Thompson, 1991; Wimberger, 1992). It is also important to note that Among the principal morphological variables that aid in the discrimination this species and populations, some are related to feeding habits while the others are to swimming capacity and maintenance of the fish in the water column.

Overlapping variation in morphometric characters lead to great difficulty in identifying different stocks. Jerry and Cairns (1998) indicated that phenotype of an individual is a manifestation of its underlying genotype, as expressed in the local environment during development. Consequently, individuals of different species that develop and mature in the environment or area would be expected to share a similar phenotype, as they are likely to experience common environmental and genetic influences (Chambers, 1993). Hence the noticeable overlap among different species for morphometric and meristic count. (Vidalis et al., 1994) had argued that meristic characters may follow a
predetermined variability at a very narrow range, and divergence of the meristic counts from a standard range could be fatal for the individual. Several authors have considered meristic characters less useful than the morphometric data (Misra & Carascadden, 1987) when comparing morphological variations. Furthermore, studies on meristic characters of horse mackerel (Murta, 2000), shrimp (Munasinghe & Thushari, 2010) were less informative, when compared with the morphometric ones however, this study have shown that caudal fin ray, pelvic fin ray and pectoral fin ray constituted can be used to discrimination species of Tilapia. Generally the observable overlap among species despite genetic differences may have been as a result of similar species adaptations in response to the prevailing environmental conditions since the creation of the lake.

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