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MORPHOMETRIC AND MERISTIC VARIATION OF CICHLIDS IN ZOBE RESERVOIR, KATSINA STATE, NIGERIA

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ABSTRACT
Tilapia are diverse species with high similarities within and among genera, hence, they can easily be misidentified using a few body features. Wrong identification of fish species might lead to wrong estimation and faulty management strategies. Morphomeristic methods are ancient methods of fish taxonomy and are still in use globally. This study investigates the similarities and differences among the Cichlids species in Zobe reservoir using a total of 100 fish samples belonging to the Cichlidae family and identified using field guide. Out of the fish collected, 72 were used for the morphomeristic analysis (18 per species identified) using 24 morphometric characteristics and 6 meristic counts. Morphometric and meristic data were normalized and analyzed using Principal Component Analysis and Canonical Discriminant Analysis with PAST Software. Four species, Oreochromis niloticus, Oreochromis mossambicus, Coptodon zillii and Sarotherodon galilaeus belonging to three genera were identified in the study area. The Principal Component Analysis (PCA) resolved 3 components which accounted for 83.32% of the total between species variation but still showed high level of overlaps among the species. The overlap was for O niloticus, O. mossambicus and S. galilaeus. 1st and 2nd Canonical Discriminant Analysis (CDA) accounts for 92.34 % and 95.0% in morphometric and meristic counts of among-group total variability respectively. The Discriminant analysis for morphometric data showed partial speciation and overlaps between the species, while meristic counts revealed complete speciation in gill rakers, lateral line scales, number of dorsal and anal rays. Morphomeristic identification of cichlids should be based on meristic counts especially gill rakers, lateral line scale, dorsal and anal rays. Therefore, a field guide with meristic counts should be employed always.

Keywords: Canonical Discriminant, Principal Component, Phylogeny, Taxonomy, Tilapia.

INTRODUCTION

Fishes display a variety of body shapes, sizes and colors, hence, understanding and identifying them is a prerequisite in systematics, taxonomy, conservation, fishery management and studies of natural history (Rasmussen *et al*., 2009). Cichlidae is a family of fish commonly known as tilapia which originated in and are extensively distributed throughout the African and Middle-Eastern countries. For a number of reasons, several species have been brought into several countries in Africa and other parts of the world (Blessing, 2019). The morphological diversity of cichlids is astounding. The main reason for their dominating character has been a large-scale trophic biology radiation that has happened quickly and often in a number of lakes, reservoirs and rivers (Albertson *et al*., 2003; Gu *et al*., 2014 and Hu 2015). With a global catch (harvest) of 7.2 million tonnes in 2022 species in the tilapia family together with carp rank the second most important group of fish caught in the wild, fourth most common group of fish species farmed worldwide, making them the sixth most important fish family worldwide (FAO, 2023). Since the tilapiine complexes are composed of several species, accurate identification is necessary for proper management (Sogbesan *et al*., 2017). However, identification and differentiation of fish species within the tilapia family is challenging (Nagl *et al*., 2001). Fish are typically identified by their physical characteristics, which allow diverse species to be grouped into the appropriate genera (Victor *et al*., 2009). In fisheries biology, morphological features are frequently utilized to assess the connections and discreteness between different taxonomic groupings (Turan, 1998) supported by a number of well-established morphometrics (Umoh *et al*., 2015). Morphological characteristics of the body form and structure that can be measured or counted make up the majority of useful criteria utilized in fish taxonomy. A reliable taxonomic trait in fisheries studies must be genetically inherent, observed easily and differ from one taxonomy to another (Mojekwu and Anumudu, 2015). Morphomeristic features served as the main basis for fish taxonomy and systematics and are frequently employed to classify taxa, sometimes even down to the species or sub-species level. Measurable morphometric characteristics and countable meristic qualities are utilized to distinguish between stocks of fish species that are considered significant for assessing population structure and serving as a foundation for fish identification (Subodh, 2020). Trait-based methods are now becoming popular in describing species relationship with changes to their various environments (Mouillot *et al*., 2013). These methods characterize species using important features or traits that can be the physiological, morphological, behavioral and biochemical characteristics of an organism and therefore assist scientist to have an insight on species responses to the condition of the environment in addition to their contribution to the overall function of the ecosystem (Violle *et al*., 2014). According to Mojekwu and Anumudu (2015), a thorough explanation of a fish's biometric characteristics is crucial for both identification and research on the degree of racial variation within the species. In order to distinguish between distinct fish populations and to differentiate taxonomic units, morphometric and meristic characteristics are reliable techniques for specimen identification (Siti and Ahmad, 2018). Despite the development of sophisticated tools that may directly identify organisms, morphological methods of fish identification play a crucial role in stock identification (Normala *et al*., 2017). Sustainable management of fish genetic resources requires an awareness of fish species taxonomy and systematics (Wazir *et al*., 2015), since certain species share only slight physical variations, precise species identification is crucial for fisheries research including ichthyoplankton surveys in order to anticipate future stock levels and adjust fishing quotas (Vivek *et al*., 2014). Zobe Reservoir which is situated in Katsina State's Dutsin-Ma Local Government Area, is an earth-fill structure that was finished in 1983 (Salele *et al*., 2023: Dasuki *et al*., 2014). The Cichlidae family had the greatest number of individual species in this particular body of water according to earlier studies by Ahmad *et al*. (2014) and Nababa *et al*. (2022). However, there is currently no information available regarding the morphomeristic variation of the Cichlids in the reservoir. Thus, this study highlights the morphological variance that distinguishes the Tilapia species found in the water body and classifies the cichlid species from the Zobe reservoir based on morphomeristic features.

MATERIALS AND METHODS

Study Area

The earth-fill Zobe Reservoir was finished in 1983 and is located in the Dutsin-Ma LGA of Katsina State at latitude 12°23'18" N and longitude 7°28'29" E (Fig. 1). At its base, the dam is 2,750 meters broad, 360 meters long, and 48 meters high. The reservoir, which has a storage capacity of 179 million cubic acre (mca), is bounded by the Karaduwa and Gada, two significant rivers (Dasuki *et al*., 2014: Salele *et al*., 2023). Agriculture and the provision of portable drinking water are the dam's primary uses, followed by fishing (Salele *et al*., 2023).

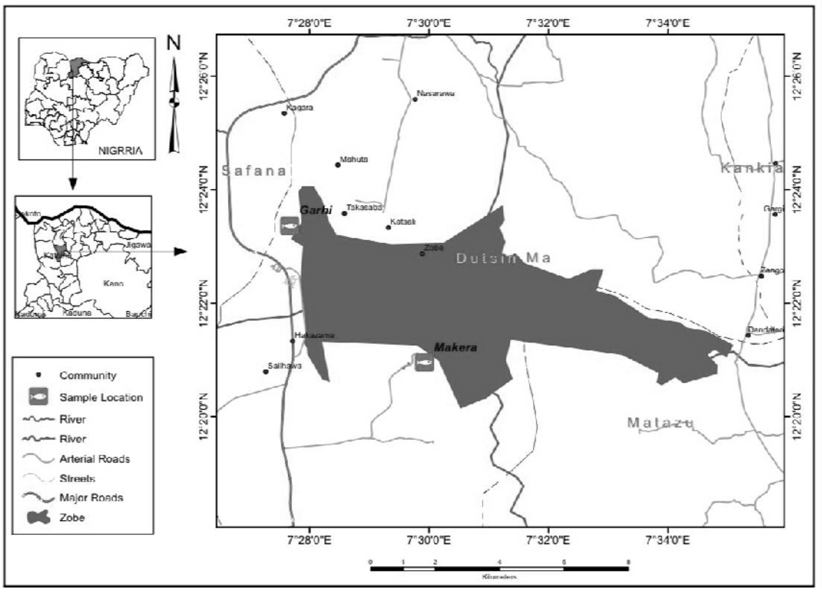

Figure 1: Map of the study area (Salele *et al*., 2023).

Sample collection

A total of one hundred (100) distinct species of tilapia fish were chosen at random from the two major landing sites of the Zobe reservoir, Makera and Garhi, out of the total seven landing sites on the water body. After that, the samples were transported in an ice box from the landing places to the biology lab of the Federal University Dutsin-ma. Fish were identified using the field guide by Olaosebikan and Raji (2013). After identification, the fish were separated into different species, and morphometric measurements and meristic counts were performed in accordance with established procedures of Neuman *et al*. (2011) and Adedeji *et al*. (2017).

Morphomeristic Characteristics

Twenty-four (24) morphological measurements and Six (6) meristic counts were carried out according to Neuman *et al*. (2011) and Adedeji *et al*. (2017) for each specimen. Body weight was measured using a weighing balance. The morphometric characteristics measured include the Total Length (TL), Standard Length (SL), Body Depth (BD), Head Length (HL), Snout Length (SnL), Eye diameter (ED), Dorsal Fin Length (DFL), Anal Fin Length (AFL), Pelvic Fin Length (PvFL) (Left And Right), Pectoral Fin Length (PFL), Pre orbital Length (PrOb), Caudal Peduncle Length (CPL), Caudal Peduncle Depth (CPD), Pre dorsal Length (PDL), Pre Anal Length (PAL), Lower Lip Width (LLW), Lower Jaw Width (LJW), Pelvic Distance (PD), Cheek Distance (CD), Lower Lip Length (LLL), Upper Lip Length (ULL), Pelvic Spine Length (PSL), Last Dorsal Spine (LDS) and Third Anal Spine (TAS) while the meristic counts are Dorsal Spine (DS), Dorsal Ray (DR), Anal Spine (AS), Anal Ray (AR), Lateral-Line Scale (LLS), and Gill Raker (GR).

Statistical Analysis

Morphometric and meristic measurements of 72 cichlids, 18 from each species identified were presented using descriptive statistics (mean±standard error). All data was normalized before subjecting to One way Analysis of Variance to compare each parameter among the species, where significant difference was observed, DMRT was used to separate the means. To make sure that variances in this study were exclusively attributable to differences in body form and not related to the sizes of the fish, the data were adjusted by size-adjustment method described by Elliott *et al*. (1995), in order to remove size influence on the sample (Olufeagba *et al*., 2015: Okomoda *et al*., 2022) as follows:

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

Where

M=original measurement,

M_{adj}=size-adjusted measurement,

Lo=TL of the fish,

Ls=overall mean of the TL for all specimens.

In order to ascertain the rate of divergence among species, the raw data were therefore examined and subjected to Discriminant Function Analysis (DFA). Following the application of multivariate techniques to the data, Principal Component Analysis (PCA) was used to display the linear combinations of correlated variables. Nonetheless, since it has been demonstrated that meristic counts are independent of their sizes, they were examined without taking size into account (Strauss, 1985; Murta, 2000: Olufeagba *et al*., 2015). Paleontological Statistics PAST Software version 4.6 and IBM SPSS version 23 were used for all analysis.

RESULTS

Four (4) species comprising of *Oreochromis niloticus*, *Oreochromis mossambicus*, *Sarotherodon galilaeus* and *Coptodon zillii* were identified in the study area. The differences in tails and head shape were used to identify species. The analysis of variance for the morphometric data showed significantly differences among species, with *O niloticus* having significantly higher Lower Lip Length (LLL), Upper Lip Length (ULL), Pelvic Spine Length (PSL), Last Dorsal Spine (LDS) and Third Anal Spine (TAS) than all the other species. While *O. niloticus, S. galilaeus* and *O. mossambicus* have significantly higher Eye diameter (ED), Pectoral Fin Length (PFL), Lower Lip Width (LLW), Lower Jaw Width (LJW) and Cheek Distance (CD) than *C. zillii. However, O. niloticus, C. zillii,* and *O. mossambicus* have significantly higher Caudal Peduncle Length (CPL) than *S. galilaeus. O mossambicus* and *O. niloticus* have significantly higher Pre-anal Length (PAL) than *C. zillii* and *S. galilaeus* (Table 1). In the meristic data, *O. niloticus* has significantly higher dorsal rays than *O. mossambicus.* Whereas *O. mossambicus* have significantly higher dorsal spine, anal rays and gill raker counts while *C. zillii* have higher number of lateral line scales (Table 2).

Table 1: Mean (±Standard Error) of Morphometric Characteristics of Tilapiine Cichlids from Zobe Reservoir.

Parameter	*O. niloticus*	*O. mossambicus*	*C. zillii*	*S. galilaeus*
SL	9.84±0.23	9.62±9.62	9.62±0.98	10.41±0.74
BD	4.32±0.38	4.43±0.25	4.04±0.52	4.77±0.28
HL	2.71±0.35	2.18±0.87	2.35±0.26	2.99±0.21
SnL	1.14±0.12	1.01±0.48	1.23±0.93	1.43±0.12
ED	0.73±0.16^{a}	0.76±0.03^{a}	0.64±0.61^{b}	0.82±0.23^{a}
DFL	5.61±0.43	5.55±0.22	5.41±0.5	5.33±0.31
AFL	2.65±1.19	2.11±0.48	2.03±0.22	1.94±0.56
PVFL	2.95±0.29^{a}	2.65±0.83^{b}	2.56±0.32^{b}	3.18±0.18^{a}
PFL	3.29±0.25^{a}	3.24±0.13^{a}	2.69±0.38^{b}	3.64±0.15^{a}
PrOb	5.61±0.43	5.55±0.22	5.41±0.51	5.33±0.51
CPL	2.35±0.27^{a}	1.95±0.04^{ab}	2.07±0.15^{a}	1.58±0.71^{b}
CPD	1.52± 0.21	1.44±0.27	1.38±0.15	1.36±0.86
PDL	3.73±0.27	3.32±0.23	3.76±1.27	3.73±0.2.63
PAL	7.37±0.47^{a}	7.15±0.36^{a}	6.86±0.47^{b}	6.69±0.29^{b}
LLW	1.05±0.13^{a}	0.74±0.37^{b}	1.03±0.05^{a}	1.03±0.08^{a}
LJW	1.44±0.21^{a}	0.77±0.01^{b}	1.31±0.05^{a}	1.21±0.13^{a}
CD	1.24±0.11^{a}	0.65±0.02^{b}	1.15±0.05^{a}	1.04±0.14^{a}
LLL	1.26±0.96^{a}	0.66±0.02^{b}	0.50±0.52^{b}	0.64±0.07^{b}
ULL	1.55±0.12^{a}	0.66±0.02^{b}	0.57±0.05^{b}	0.65±0.07^{b}
PSL	2.13±0.08^{a}	1.17±0.04^{b}	1.02±0.15^{b}	0.99±0.06^{b}
LDS	2.25±0.11^{a}	1.12±0.05^{b}	0.96±0.07^{b}	0.82±0.05^{b}
TAS	2.15±0.12^{a}	1.13±0.06^{b}	0.81±0.13^{c}	1.17±0.05^{b}

Values with different letters as superscript in each row indicate significant difference (P<0.05). Total Length (TL), Standard Length (SL), Body Depth (BD), Head Length (HL), Snout Length (SnL), Eye diameter (ED), Dorsal Fin Length (DFL), Anal Fin Length (AFL), Pelvic Fin Length (PvFL) (Left And Right), Pectoral Fin Length (PFL), Pre orbital Length (PrOb), Caudal Peduncle Length (CPL), Caudal Peduncle Depth (CPD), Pre dorsal Length (PDL), Pre Anal Length (PAL), Lower Lip Width (LLW), Lower Jaw Width (LJW), Pelvic Distance (PD), Cheek Distance (CD), Lower Lip Length (LLL), Upper Lip Length (ULL), Pelvic Spine Length (PSL), Last Dorsal Spine (LDS) and Third Anal Spine (TAS)

Table 2: Mean (±Standard Error) of Meristic Characteristics of Cichlids from Zobe Reservoir.

Parameter	*O. niloticus*	*O. mossambicus*	*C. zillii*	*S. galilaeus*
DS	16.61±0.14[b]	17.0±0.0[a]	15.67±0.12[c]	15.0±0.0[d]
DR	17.11±0.33[a]	16.61±0.59[b]	15.67±0.47[c]	15.00±0.00[c]
AS	3.00±0.00	3.00±0.00	3.00±0.00	3.00±0.00
AR	11.28±0.46 [b]	11.89±0.46[a]	11.44±0.60[b]	11.00±0.00[b]
LLS	8.00±0.00[c]	9.00±00[b]	10.00±0.00[a]	8.56±0.50[b]
GR	34.89±0.83[b]	37.22±0.64[a]	29.05±2.81[c]	32.06±0.71[c]

Values with different letters as superscript in each row indicate significant difference (P<0.05). Dorsal Spine (DS), Dorsal Ray (DR), Anal Spine (AS), Anal Ray (AR), Lateral-Line Scale (LLS), and Gill Raker (GR) (Fig 2).

The values of Kaiser Meyer Olkin (KMO) for the overall matrix are 0.667 and Bartlett's Test of Sphericity is significant and therefore qualify the data for PCA. The PCA of the full normalized dataset for the population of cichlids resolved three (3) components with eigen values >1 that accounted for 83.32% of the total between species variation (table 3). The 3 components have both negative and positive values and showed overlaps between the species except *Coptodon zillii* (Figure 3 and 4). PC1 accounted for 50.51%, PC2 20.85% and PC3 accounted for 11.96 %. Visual analysis of PCA shows overlaps among all the species in plot 1, and overlaps between *O. niloticus, O. mossambicus* and *S. galilaeus* in plot 2. This result therefore necessitates the use of discriminant analysis.

Table 3: Principal Component Analysis for Morphomeristic traits of Tilapiine Population in Zobe reservoir

Parameters	Component 1	Component 2	Component 3
SL	0.021	-0.098	-0.029
BD	0.017	-0.062	-0.198
HL	0.031	-0.083	0.092
SnL	-0.006	-0.048	0.062
ED	0.005	-0.012	-0.055
PrOb	0.005	-0.061	0.005
AFL	0.036	0.052	0.110
PvFL	0.028	-0.059	-0.017
PFL	0.031	-0.067	-0.250
DFL	0.009	0.032	-0.020
CPL	0.015	0.076	0.165
CPD	0.007	0.015	0.002
PDL	0.004	-0.024	0.195
PAL	0.026	0.072	-0.016
LLW	0.005	-0.019	0.146
LJW	0.015	-0.014	0.292
CD	0.012	-0.013	0.272
LLL	0.046	0.032	0.084
ULL	0.061	0.046	0.169
PSL	0.066	0.074	0.179
LDS	0.076	0.099	0.229
TAS	0.082	0.043	0.113
Dorsal Spine	0.077	0.127	-0.657
Dorsal Ray	0.055	0.004	0.022
Anal Spine	0.0000	0.000	0.000
Anal Ray	0.048	-0.220	0.230
Lateral Line Scale	0.250	0.890	0.055
Gill rakers	0.947	-0.254	-0.035
Eigenvalue	10.61	4.38	2.520
% Variance	50.51	20.85	11.96
Cumulative Variance %	50.51	71.35	83.32

Based on the first and second discriminate functions (DF), the relationship between the morphometric and meristic parameters among cichlids from the Zobe reservoir were examined. The 1st DF of morphometric parameters accounted for 67.18%, while the 2nd DF accounted for 25.36% of the 92.34 % differences between (Table 4). Conversely, the first and second DF of the meristic count analysis explained 61.75% and 33.35 % variability respectively and together they explained 95.0 % of morphomeristic variability (table 5). Base on the discriminant analysis, the most significant variables for function 1 were body depth, pre-orbital length, pectoral fin length, lower lip width, lower jaw width and upper lip length While for function 2, they were snout length, eye diameter, dorsal fin length, lower lip length and pelvic spine length. Lateral-line scale, gill rakers, dorsal ray and anal ray were the most significant meristic characteristic for group discrimination. The 1st plot of discriminant analysis of the morphometric measurements (figure 5) showed an overlap between *O. mossambicus* and *C. zillii*. While *S. galilaeus* and *O. niloticus* clustered separately from other species. The 2nd plot (figure 6) showed an overlap between *S. galilaeus, C. zillii* and *O. mossambicus*. For meristic counts, considering the 1st function, all the species cluster independently highlighting lateral-line scales, gill rakers, dorsal rays and anal rays as the major sources of variation between species (figure 7). In the 2nd function, there were overlaps among all the species. *O. niloticus* overlap broadly with *C. zillii*, followed by *C. zillii* overlapping with *S. galilaeus* and *O. niloticus* slightly overlapping with *O. mossambicus* (figure 8).

Table 4: Discriminant Function Coefficient of Variables from Morphometric parameters

Variables	Function 1	Function 2	Function 3
SL	0.057	0.124	0.087
BD	**0.707**	-0.238	0.159
HL	0.516	-2.754	**1.079**
SnL	-12.551	**81.28**	-13.356
ED	-13.762	**71.331**	-17.484
PrOb	**13.997**	-79.409	13.142
AFL	0.305	**0.631**	0.586
PvFL	-0.116	-0.243	-0.096
PFL	**1.547**	-3.1329	-0.969
DFL	-0.6633	**2.1467**	1.5685
CPL	-4.2817	-0.953	-2.341
CPD	-1.168	0.049	-1.489
PDL	0.203	1.358	**1.558**
PAL	-1.2664	0.441	-0.967
LLW	**4.632**	-2.586	1.136
LJW	**3.840**	-0.421	1.212
CD	-6.956	1.401	**2.537**
LLL	0.762	**2.229**	-1.902
ULL	**1.799**	-3.085	0.263
PSL	3.841	**5.068**	4.472
LDS	-5.631	-1.235	-1.876
TAS	-4.535	-4.589	-1.061
Eigenvalue	24.46	9.24	2.77
% Variance	67.18	25.36	7.46

Table 5: Discriminant Function Coefficient of Variables from Meristic counts.

Variables	Function 1	Function 2	Function 3
DS	-1.275	-1.647	-1.603
DR	**0.796**	-0.208	0.119
AS	0	0	0
AR	**2.827**	1.708	0.415
LLS	-0.393	0.164	**0.453**
GR	0.0127	**0.209**	0.0216
Eigenvalue	13.55	7.32	1.07
% Variance	61.75	33.35	4.89

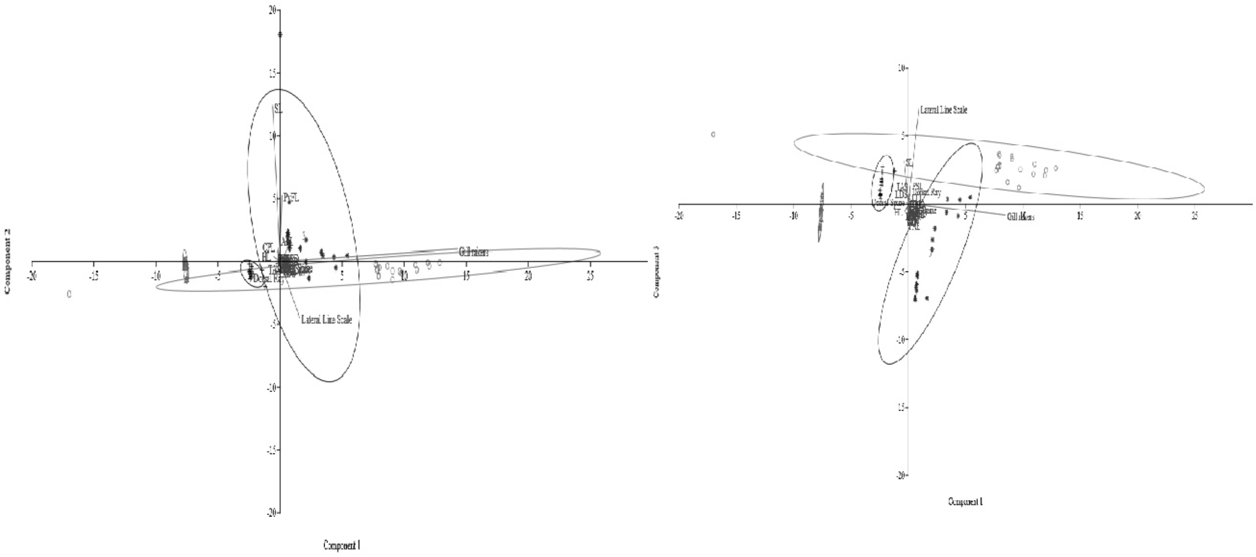

Figure 3 and 4: 1st Plot of PCA (PC1/PC2) and 2nd plot of PCA (PC2/PC3)
Keys: *O niloticus, O mossambicus, S. galilaeus* and *C. zillii.*

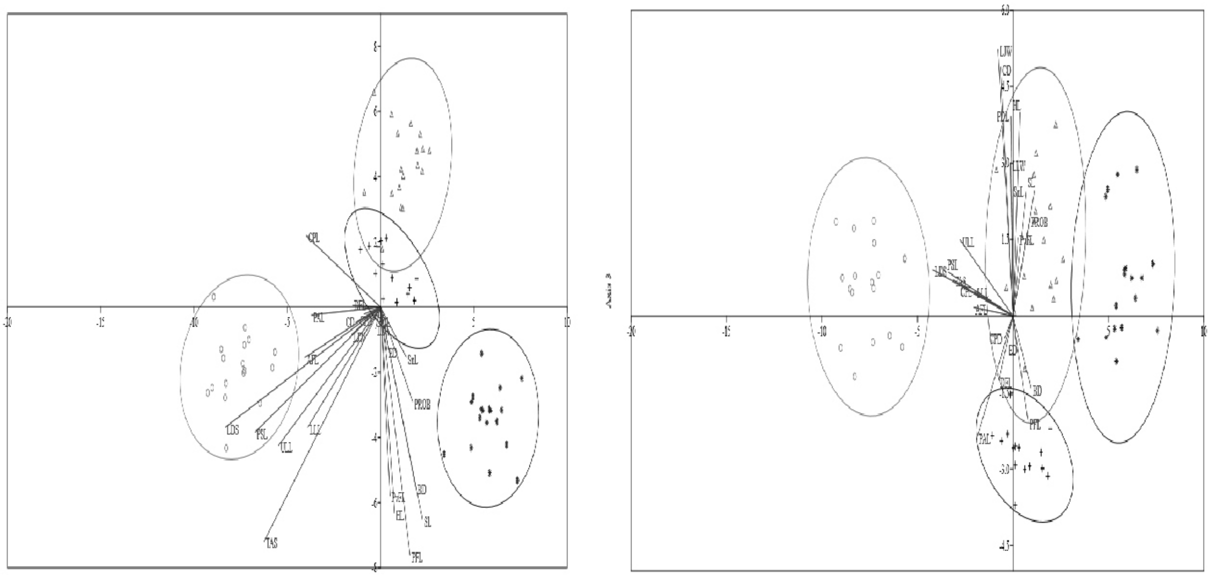

Figure 5 and 6: 1st and 2nd plot of canonical function of morphometric traits.
Keys: *O. niloticus, O. mossambicus, S. galilaeus* and *C. zillii.*

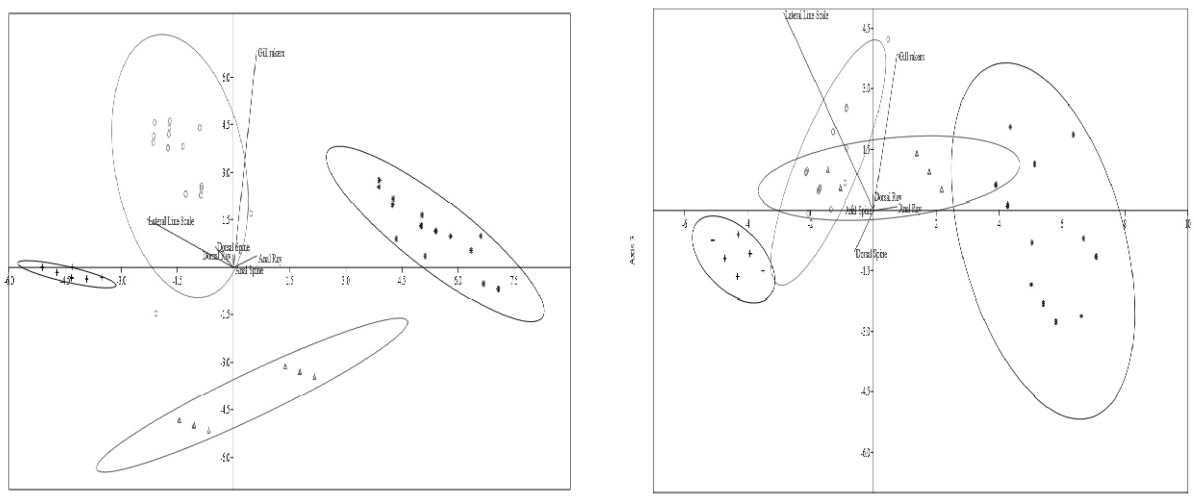

Figure 7 and 8: 1st and 2nd plot of canonical function of meristic counts.
Keys: *O. niloticus, O. mossambicus, S. galilaeus* and *C. zillii.*

Discussion

Compared to other vertebrates, fish species exhibit greater diversity and variances in morphological traits both within and between populations of species (Olufeagba *et al*., 2015). As a result, fishery resource utilization depends heavily on the quality of the current strain, which is essential for any successful fisheries program (Adedeji, 2017). From the results of this study, significant differences were observed in twelve morphometric parameters and five meristic counts. This finding did not agree with some of the findings of the analysis of variance of morphological variations of cichlids in Kainji lake by Olufeagba *et al*. (2018), who revealed significant differences in most morphometric parameters except in pectoral fin length, pelvic fin length, pre-dorsal distance, vomerine width and snout length. However, it corresponds with pre-dorsal distance, vomerine width and snout length among the traits that are not significant between the species. In the meristic data, five out of six traits *are* significantly different among the species. This finding agrees with Olufeagba *et al*. (2018) who revealed meristic counts to be significantly different between all the Cichlids species found in Kainji lake. This may be due to similarities between the species in the Cichlidae family despite differences in the study area. Morphological variation should only be related to differences in body shape not to the fish size (Saber *et al*., 2014). The PCA for the normalized data have both negative and positive values which indicates body shape variations which agrees with the findings of Normala *et al.* (2017) which revealed that any component having both negative and positive signs, have shape variation while components with only negative or positive coefficients varies due to size. However, the PCA values revealed a mixed coefficients and high level of overlaps among all the species especially *O. niloticus, O. mossambicus* and *S. galilaeus* based on visual examination. This suggests that discrimination is not totally possible based on PCA. These findings corroborate the earlier studies of Adedeji (2017) and El-Serafy *et al*., (2007) that also documented high level of overlaps among tilapia species making it impossible to differentiate those species from north eastern part of Nigeria and Egypt repectively on basis of morphometrics based on PCA. Canonical discriminant functions enable calculation of the variable variance and consequently compare directly the relative contribution of each variable (morphometric or meristic character) into each factor (Huda and Zuheir, 2019). According to the canonical discriminant function, the most significant variables for function 1 were body depth, pre-orbital length, pectoral fin length, lower lip width, lower jaw width and upper lip length While for function 2, they were snout length, eye diameter, dorsal fin length, lower lip length and pelvic spine length. 1st Plot of canonical discriminant functions of the morphometric measurements showed an overlap between *O. mossambicus and C. zillii*. While *S. galilaeus* and *O. niloticus* clustered separately from other species. The 2nd plot showed an overlap between *S. galilaeus, C. zillii* and *O. mossambicus*. These traits did not correspond with the results of Olufeagba *et al*. (2017), who found distance between occipital process, pre-dorsal distance, pectoral fin length, vomerine length, head length, head width and pre-pelvic distance to be the discriminating characters between the cichlids in Kainji lake. In their study *O. niloticus* did not overlaps with any of the three species, but it is somewhat similar to this study in the broad overlap between *C. zillii* and *S. galilaeus*. However, the results from this study are in agreement with the finding of Huda and Zuheir, (2019) which revealed an overlap in the morphometric characters of *S. galilaeus* and *C. zillii* and separation from *O, niloticus,* with similar morphological traits such as snout length**,** body depth, premaxillary pedical length, inter orbital width, dorsal fin base and pre-pelvic distance, but there are still some levels of overlaps between the species. This finding is in agreement with El-Serafy *et al*. (2007) and Olufeagba *et al.* (2015) that reported striking similarities and overlapping among tilapia species, making it impossible to differentiate those species on basis of morphometrics. More so, the findings also agree with Saber *et al.* (2014), that reported the use of morphomeristic traits to obtain baseline information in study of variation between fish species which can be considered in conservational policy and restocking programs. Results from the meristic counts of the sampled species revealed an overlap in function 1 and speciation in function 2 between the species. Number of anal spines and dorsal spines as highlighted in the 1st function were almost the same across the species in the Cichlidae family in Zobe reservoir, which may be a uniting trait for the species. In the 2nd function of meristic counts, number of lateral-line scales, gill rakers, dorsal rays and anal rays constituted the most influential meristic variable for discrimination of the groups. These findings were similar to that of Olufeagba *et al*., (2017), which identified caudal fin ray, pelvic fin ray and pectoral fin ray as the most influential meristic variable for discrimination of the groups. This indicates that tilapia species can be separated easily using rays found in their fins. Moreso, studies from Kelabat Bay and Tukak Strait by Siti and Ahmad (2018) revealed pectoral rays to be the most important variable in discriminating Selangat Fish (*Anodontostoma species*) between Kelabat Bay and Tukak Strait, in Indonesia. Further-more, Osho *et al*. (2022) revealed anal fin ray count to be the most important discriminant between African Snakehead Fish (*Parachanna obscura*), from Anambra, Ibbi, Imo, Katsina-Ala and Ogun states in Nigeria. However, Sabry *et al*. (2006), found number of lateral line scales, dorsal and anal fins to differentiate *O. niloticus*, *O aureus*, *S. galilaeus* and *C. zillii* in the Nile River. Lateral line scales are also reported as the most important meristic variate for characterizing tilapia species from various water bodies in South Africa (Makeche *et al*., 2022: Skelton, 2001). Similarly, this study tallies with El-Serafy *et al*. (2007) in number of lateral-line scales, dorsal ray and anal ray, but didn't coincide with dorsal spine among the meristic counts that successfully deafferented *O. niloticus*, *O. aureus*, *S. galilaeus* and *C. zillii* in Egypt. This may be due to fish adaptation as a result of differences in their environments as reported earlier by Caillon *et al*. (2018).

CONCLUSION

The present study provided baseline information to be used in understanding cichlids species in Zobe reservoir and the application can be extended to other water bodies. Although, tilapiine group shows similar morphological characters yet they still showed some certain level of discreetness as a result of genetical differences and or external environmental factors. Morphometric data showed similarities and overlaps among tilapia species, making it impossible to completely differentiate those species on the basis of morphometric parameters. Lateral-line scales, gill rakers, dorsal ray and anal ray are the major sources of variation among all the Cichlids in Zobe reservoir. Morphomeristic identification of cichlids should be based on meristic counts especially gill rakers, lateral line scale, dorsal and anal rays. Therefore, field guide with meristic counts should be employed always.

Authors contribution

All the authors were actively involved at different levels of the research. All the authors were involved in the design of the research, while the first author sampled the fish species used, the first and last authors analyzed, interpret the data and read the final manuscript and agreed to the submission.

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