Asian Journal of Advances in Research

5(1): 1-11, 2022

THE MORPHOMETRIC CHARACTERISTICS AND MERISTIC TRAITS AND CONDITION FACTORS OF *Sarotherodon galilaeus* FROM THREE MAJOR RESERVOIRS OF EKITI STATE, NIGERIA

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AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration between both authors. Author TAA designed the study, performed the statistical analysis, wrote the protocol, managed the literature searches and wrote the first draft of the manuscript. Author OF managed the analyses of the study. Both authors read and approved the final manuscript.

Received: 20 October 2021
Accepted: 27 December 2021
Published: 03 January 2022

Original Research Article

ABSTRACT

The study was carried out between July to October 2018. Seventy-one (71) *S. galilaeus*(48.6%) from Ado reservoir, Sixty-nine (69) from Egbe- reservoir (47.3%) and six (6) from Ero- reservoir (4.1%) making a total number of one hundred and fourth-six (146) respectively. The fish samples were collected directly from fishermen at the bank of each reservoir. Analysis of variance (ANOVA) was used. The mean body weight and total length of the fish were 179.28 ± 53.71^{c} and 21.17 ± 2.21^{c}, 102.71 ± 41.78^{b} and 17.75 ± 2.30^{b} and 61.60 ± 2.207^{a} and 15.17 ± 1.37^{a} from Ado, Egbe and Ero respectively. The results recorded on the mean body weights and total lengths of the fish from the three populations are statistically different. But there are morphologically similarities between and among the three populations. Principal component analyses and cluster analyses were further used to determine the closeness of the morphological characters using paleontological statistics (PAST) software. The condition factors (K) values are 0.1 ± 0.04, 0.18 ± 0.04 and 2.5 ± 0.8 from Ado, Egbe and Ero reservoirs respectively. The condition factors value from Ero population was significantly different from the other two populations showed that the two populations (Ado and Egbe) unlike Ero population are not well fed. The robustness of the fish from Ero reservoir may be as a result of enough fertility of the reservoir or that there was a lesser competition from other fish species for the available food resources. There is need to determine the condition factor(s) which favours the growth and development of the fish from Ado (Ureje) and Egbe reservoirs.

Keywords: Morphometric; characteristics; meristic; traits; *Sarotherodon galilaeus;* reservoir; condition factor and Ekiti- State.

1. INTRODUCTION

Reservoirs are man-made lakes which are formed by damming rivers to create an artificial impoundment for water storage, irrigation, hydropower electricity etc; this brings about lacustrine condition which can be conducive to the establishment and maintenance of fish stocks appropriate for exploitation through captured fisheries and aquaculture [1]. In Nigeria, nearly all the major rivers have been dammed for hydro-electric power generation and other activities such as fishery practices. *Sarotherodon galilaeus* are

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species of fish from the Cichlid family, an African freshwater fish, widely spread, and are found in lakes, rivers and other fresh or brackish water habitats in Northern and Central Africa. *Tilapia galilaeus* boosts the source of fish protein in many countries of the world and the consumption of tilapia in both the developing and industrialized countries has increased tremendously [2] *S. galilaeus* and other species of Tilapia are recommended by the Food and Agricultural Organization as cultural species because of their capabilities in contributing to the increased production of animal protein for man [3]. It possesses range of attributes that make them ideal for aquaculture practices among which are: they are easy to culture and grow rapidly, reproduce easily, adapt to a wide range of environmental conditions and accept artificial feeds easily. The fish has a good tasting with a mild flavour, are widely accepted as food fish, are used in many cuisines, their consumption is not restricted by religion observers, highly abundant and commercially important fish in natural and man-made lakes in Nigeria [4].

Morphometric characteristic and meristic traits analyses are parts of important rigorous tools used to differentiate closely related species of organism having huge similarity indices of various parameters [5]. Morphometric characters are not only essential to understand of the taxonomy but also the health of a species as well as its reproduction in an environment. The shape and structures are unique to each species and the variations in its features are probably related to the habit and habitat among these species [2]. Morphometric assessment of an animal species determines the inter relation between the body parameters like length, weight, dorsal fin length, anal fin length, etc. It's also helps in the understanding of the relation between body parts. Condition factor have been used by fish culturists as indicators as the general "well-being or fitness'' Condition factor is use for estimating the condition, robustness or degree of wellbeing of fish, based on this the heavier fishes are in better condition than lean ones and the lean fishes are considered to be at risk of harsh environmental conditions or poor feeding which may influences condition factor [6].

The general health of a population of fish can be accessed through the growth features so possible variations in the measurable and countable characters will reveal the adaptation to environmental condition. Generally, species of fish that have different origin are morphological differentiated from each other. It's on this note that the present study was based to provide some basic information on morphometric characteristics, meristic traits and condition factor of *S. galilaeus* from Ado, Egbe and Ero water reservoirs Ekiti State, Nigeria.

2. MATERIALS AND METHODS

2.1 Study Area

Sarotherodon galilaeus samples were collected from Ado- Ekiti reservoir in Ado- Ekiti, Egbe- reservoir in Egbe- Ekiti and Ero- reservoir in Ikun- Ekiti, Ekiti, Nigeria.

2.1.1 Ado- ekiti reservoir (Ureje reservoir)

It is situated on an undulating plane of an average height of about 440m above sea – level and surrounded by highlands. The reservoir lies between latitude 7^0 37' north and longitude 5^0 13' East of the Equator.

The Ado- Ekiti reservoir, Ado- Ekiti was constructed by putting a dam across Ureje River in Ado – Ekiti in 1958 for the supply of water for domestic uses and production of fish for Ado- Ekiti community and its environment. The full capacity of the reservoir was about 47 million gallons of water.

2.1.2 Egbe water reservoir

The reservoir is located in an undulating plane surrounded by highlands of which run – offs also feed the reservoir during raining periods. Egbe water reservoir was constructed by putting a dam across Osse River. The River takes its source from Kwara State, Nigeria and flows from the north to south of Ekiti through Ode- Ekiti to Egbe – Ekiti. The location of the reservoir is on latitude 7^0 $36^!$ And longitude 5^0 $36^!$ East of the Equator; it was built in 1957 by damming this Osse River at Egbe – Ekiti. The reservoir was commissioned in 1989. And it covers an area of 26.5 hectares with the depth of about 64m. The capacity of the reservoir is about 144 million cubic meters.

2.1.3 Ero –reservoir

Ero reservoir is a tropical reservoir situated at Ikun – Ekiti. It is an earth filled embankment with a length of 662m and an impoundment area of 4.5km. It was commissioned in 1985. The water level is about 504 containing about 2009million cubic meters. It lies between latitudes 7^0 $15^!$ – 8^0 $5^!$ And 4^0 $45^!$ – 5^0 $45^!$

2.2 Collections of Fish Samples

Fish samples used in this study were collected from landing sites through artisanal fishermen at the bank of the water reservoirs on every Monday at Ero-reservoir, Wednesday at Egbe- reservoir and Friday at Ado- Ekiti reservoir within a week for a period of twelve weeks July to October, 2018. The fish were collected with the aid of cast netting of 2.5 – 3.5 mm mesh size, bamboos and hooks. The fish samples collected were counted and sorted in to different species on the field and were transported to the Post Graduate Laboratory of Zoology and Environmental Biology Department, Ekiti State University, Ado – Ekiti for further practicals.

2.3 Identification of Fish Samples

S. galilaeus was identified by following the method of [7] and [8]

2.4 Data Collection

Twenty four (24) morphometric characters and Eleven (11) meristic traits were taken on each fish specimen. These parts were measured following standard anatomical reference [9]. The specimens weights (measurement of the fish mass) were first measured using the electronic Citizen weighing balance (MP-3000 with max-3000g and min-5g).

Standard Length (SL), Total Length (TL), Weight (W), Dorsal Fin Length (DFL) , Anal Fin Length (AFL), Pectoral Fin Length (PFL), Spine Length (SPL), Head Length (HL), Snout Length (SNL) Length of occipital fontanelle (OFL), Pre-Anal Distance (PAD), Pre- Ventral Distance (PVD), Pre-Pectoral Distance (PPD), Pre- dorsal distance (PDD), Distance between Dorsal and Caudal fin (DDCF), Distance between Occipital process and Dorsal fin (DODF), Caudal peduncle Depth (CPD), Body Depth (BD) (Width), Head Width (HW), Inter -orbital Distance (ID), Eye Diameter (ED), Occipital fontanelle Width (OFW), Distance between snout and Occipital process (DSO) and Mouth Length (NL).

Eleven (11) meristic traits counted include: number of barbells (nB), numbers of Gills (nG), number of Spines (nS), number of Gill Arch (nGA), Number of Gill Filaments(nGF), number of Gill rakers (nGR), Dorsal fin rays (DFR), Anal Fin rays (AFR), Pectoral Fin Rays(PFR), Pelvic Fin rays (PvFR), Number of vertebrae Colum (nVC) were counted.

2.5 Condition Factor

The condition factor (K) which is defined as the wellbeing of the fish was calculated. K is a useful index for monitoring of feeding intensity, age and growth rates. The K value was determined by using

$$K = \frac{W}{L^3} \times 100$$

Where, W = weight of fish in grammes and L = length of fish in centimetres

2.6 Data Analysis

One way analysis of variance (ANOVA) was carried out on morphometric measurements to test the degree of variation among the fish species from the three location at P= 0.05 probability.

Morphometric measurements were standardized to fish size (SL) in accordance with [5] 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 the meristic characters are fixed early in development and less susceptible to environmental variables.

The data obtained from the morphometric characteristics and meristic traits were then analyzed with Principal Component Analysis (PCA) and Cluster Analysis (CA). PCA and CA on morphometric and meristic data were evaluated using Paleontological Statistics (PAST) software. Population centroids with 95% ellipses obtained from the PCA scatter diagram were used to observe the relationships among populations [5]. PCA loading method was used to show the traits with the highest variation within the population and CA was used to show the relationship in their Clustering patterns [10] using the unweight Pair Group Method with arithmetic mean for phenogram or dendrogram grouping.

3. RESULTS

Sarotherodon galilaeus is ovoid or oviform, short and wide body surface, silvery colouration with black stripes or bands, has scales all over its body, no barbell, 4 gills, 14-17 dorsal spines, 13-15 dorsal soft rays, 27-29 dorsal fin rays (both spine and soft), 4 pairs of gill arches (upper and lower), 1040-1280 gill filaments, 180-280 gill rakers, 10-14 anal fin rays, 10-`12 pectoral fin rays, 6 pelvic fin rays and 25-38 vertebral columns depending on the habitats as shown in the Table 1.

Morphometric characteristics and meristic traits mean values of *Sarotherodon galilaeus* from Ero, Egbe and Ado- Ekiti reservoirs are listed in Table 2. The results shows that, the mean body weight (BW) of *S. galilaeus* from the three populations which ranged from 61.60 ± 22.07 from Ero- reservoir to 179.28 ± 53.71 in Ado- Ekiti reservoir respectively. The mean weight of *S. galilaeus* sample from Ero- reservoir was not statistically different from Egbe- reservoir population, but significantly different from Ado- Ekiti reservoir fish population (p> 0.05). The mean values of the total length and standard length of the fish samples from Ero- reservoir and Egbe- reservoir are not significantly different from each other (p=0.05), but significantly different from the population of Ado-Ekiti reservoir (p>0.05). The mean eye diameter of *S. galilaeus* was not significantly different across the three populations. The distance between occipital process and dorsal fin, distance between snout and occipital fontanelle from Egbe and Ado- Ekiti reservoirs populations are not statistically different (P= 0.05) from each other, but significantly different from Ero- reservoir population (p>0.05). Mouth length of *S. galilaeus* from Ero and Ado- Ekiti populations are not significantly differ, but significantly different from Egbe- reservoir population. All the morphometric characters of *S. galilaeus* from Ero and Egbe reservoirs populations was not significantly different from each other, but significantly different from Ado- Ekiti reservoir population at 95% level of significant. The mean number of gill filaments of *S. galilaeus* ranged from 1089.10 ± 60.72 from Egbe- reservoir to 1234.76 ± 136.88 from Ado- Ekiti reservoir respectively. The number of gill filaments of *S. galilaeus* samples from Ado- Ekiti reservoir are not statistically different from Egbe population (p=0.05), but significantly different from Ero population. The mean values for number of gills, number of gill arches, pectoral fin rays and pelvic fin rays of *S. galilaeus* are not significantly different across the populations (P= 0.05) as shown in the Table 2.

3.1 One-way analysis of variance (ANOVA) of *S. galilaeus* from Ero, Egbe and Ado-Ekiti reservoirs

One-way analysis of variance (ANOVA) revealed that there were no significant differences (P>0.05), for *Sarotherodon galilaeus* between the Ero and Egbe studied populations (Ero-reservoir and Egbe-reservoir) but significantly difference from Ado- Ekiti population and within each population for nearly all the 24 morphometric characters revealing great homogeneity between Ero and Egbe populations and heterogeneity from Ado- Ekiti populations which include: standard length (SL), total length (TL), weight (W), Dorsal fin length (DFL), Anal fin length (AFL), Pectoral Fin length (PFL), Spine length (SPL), Head Length (HL), Length of Occipital Fontanelle (OFL), Pre-anal Distance (PAD), Pre-Ventral Distance (PVD), Pre-Pectoral Distance (PPD), Pre-Dorsal Distance (PDD), Caudal Peduncle (CPD), Body Depth (BD), Head Width (HW), Inter Orbital Distance (ID), Eyes Diameter (ED) and Occipital Fontanelle Width (OFW); As shown in the Table 2. However, there were significant differences (P= 0.05) between and within populations for most of the meristic characters studies which include numbers of spine (nS), numbers of gill Filament (NGF), numbers of gill raker (nGR), Anal Fin Rays (AFR), Dorsal Fin Rays (DFR) and Number of Vertebrate Column (nVC). But have no significant differences (P>0.05) in the meristic characters like: numbers of gills (nG), numbers of gill arches, Pectoral Fin Rays (PFR) and Pelvic Fin Rays (PvFR) as shown in the Table 2.

The principal component analysis of morphometric of *sarotherodon galilaeus*, the PCA scatter diagram using 95% of ellipses for morphometric of *S. galilaeus* specimens obtained from the three populations or locations (reservoirs) showed great homogeneity between populations from Ero-reservoir (red), Egbe-reservoir [blue] and Ado- Ekiti reservoir (pink) as the circles are inside one another. i.e pink and blue are inside the red circle as shown in Fig 1. The cluster analysis (dendrogram) for S. *galilaeus* from the three reservoirs using Rho similar measure also confirm that *S. galilaeus* from Ero-Reservoir (red), Egbe-reservoir (blue) and Ado- Ekiti reservoir (pink) overlapped (i.e. mixed)and also has a single ancestor that is a single origin (Fig 3). The PCA scatter diagram using 95% of ellipses for meristic

Table 1. Meristic traits frequency for *S. galilaeus* across the three main reservoirs (Ero, Egbe and Ado-Ekiti reservoirs)

S. galilaeus		nB	nG	nS	nGA	nGF	nGR	AFR	PFR	PvFR	DFR	nVC
	Ero		4	14-16	8	1200-1280	260-280	10-12	11-12	6	25-27	25-27
	Egbe		4	15-16	8	1040-1240	200-216	12-14	10-12	6	27-28	22-25
	Ado		4	15-17	8	1040-1240	180-216	11-14	12	6	27-29	30-38

nB= number of barbells, nG= number of gills, nS= number of spine, nGA= number of gill arches, nGF= number of gill filaments, nGR= number of gill rackers, AFR= anal fin rays, PFR= pectoral fin rays, PvFR= pelvic fin rays, DFR=dorsal fin rays, nVC= number of vertebral column

Table 2. Mean values of the morphometric and meristic characters of *Sarotherodon galilaeus* from Ero, Egbe and Ado- Ekiti reservoirs of Ekiti- State, Nigeria

Characteristics	ERO MEAN±SD	EGBE MEAN±SD	Ado MEAN±SD
SL	12.33±0.98[a]	14.07±1.60[a]	16.58±1.93[b]
TL	15.17±1.37[a]	17.75±2.30[a]	21.17±2.21[b]
W	61.60±22.07[a]	102.71±41.78[a]	179.28±53.71[b]
DFL	6.20±1.02[a]	7.62±1.12[a]	9.49±1.14[b]
AFL	2.05±0.27[a]	2.46±0.29[a]	2.97±0.47[b]
PFL	3.93±0.96[a]	4.87±0.92[a]	6.07±0.75[b]
SPL	5.20±0.37[a]	5.12±0.89[a]	7.60±6.37[b]
HL	4.15±0.26[a]	4.87±0.67[a]	5.80±0.60[b]
SNL	1.35±0.26[a]	1.45±0.16[a]	1.51±0.12[b]
OFL	1.67±0.32[a]	1.83±0.23[a]	2.07±0.34[b]
PAD	8.58±1.06[a]	9.75±1.88[a]	12.09±1.35[b]
PvD	5.12±0.66[a]	5.75±0.62[a]	6.92±0.71[b]
PPD	4.53±0.50[a]	4.51±0.55[a]	5.40±0.49[b]
PDD	4.95±0.23[a]	5.31±0.76[a]	6.49±0.66[b]
DDCF	1.33±0.08[a]	1.64±0.22[b]	1.87±0.32[b]
DODF	2.02±0.04[b]	1.51±0.15[a]	1.70±0.25[a]
CPD	2.00±0.13[a]	2.04±0.42[a]	2.52±0.27[b]
BD	4.83±0.53[a]	5.63±0.81[a]	6.80±0.76[b]
HW	3.28±0.18[a]	3.27±0.61[a]	4.19±1.03[b]
ID	1.55±0.08[a]	1.61±0.23[a]	2.01±0.52[b]
ED	1.25±0.12[a]	1.04±0.11[a]	1.20±0.20[a]
OFW	1.12±0.08[a]	1.34±0.38[a]	1.78±0.27[b]
DSO	2.98±0.04[b]	2.02±0.23[a]	2.48±0.35[a]
NL	1.52±0.10[b]	1.17±0.17[a]	1.45±0.13[b]
nG	4.00±0.00[a]	4.00±0.00[a]	4.14±1.19[a]
nS	15.33±0.82[a]	15.29±0.46[a]	15.87±0.51[b]
nGA	8.00±0.00[a]	8.00±0.00[a]	8.00±0.00[a]
nGF	1226.67±41.31[b]	1089.10±60.72[a]	1234.76±136.88[b]
AFR	11.17±0.75[b]	2.68±0.58[a]	11.82±0.42[b]
PFR	11.83±0.41[a]	11.83±0.58[a]	11.82±0.42[a]
PvFR	6.00±0.00[a]	5.99±o.12[a]	6.00±0.00[a]
DFR	26.50±0.84[a]	27.51±0.53[b]	27.51±0.53[b]
nVC	25.33±0.82[a]	25.78±2.18[a]	29.30±3.23[b]

Mean values in the same column with the same superscript are not significantly different from each other (P= 0.05)

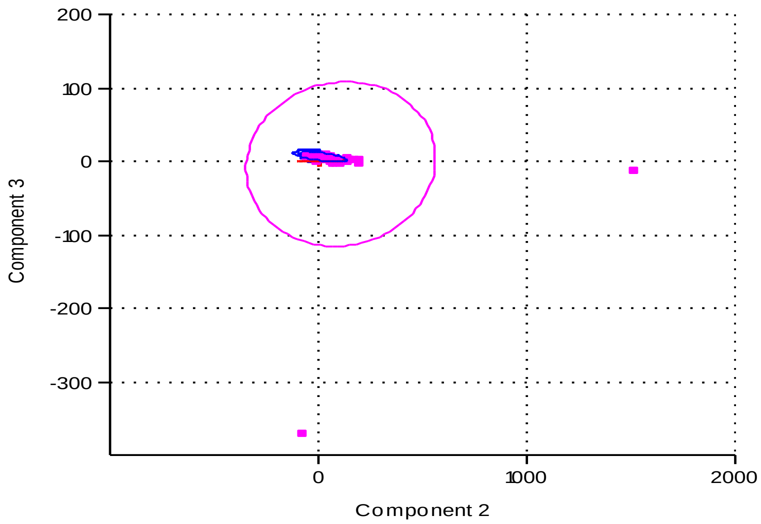

Fig. 1. PCA scatter diagram for morphometric characteristics of *S. galilaeus* from Ero (red), Egbe (blue), Ado- Ekiti (pink) dams using 95% ellipses

traits of *S. galilaeus* obtained from three (reservoirs) populations also showed that there is an overlapping of data between populations from Ero-reservoir (red), Egbe-reservoir (blue), and Ado- Ekiti reservoir (pink) indicating that there is a great homogeneity between the three populations (Fig 2).

The morphometric characters loadings on PCA of the principal components analysis, showed weight as the character most responsible for variation among the studied populations of *S. galilaeus* with PCA loading of 0.9652 as shown in Fig 4 and Table 3a. The PCA loadings for meristic characters of *S. galilaeus* showed number of gill filament (nGF) as

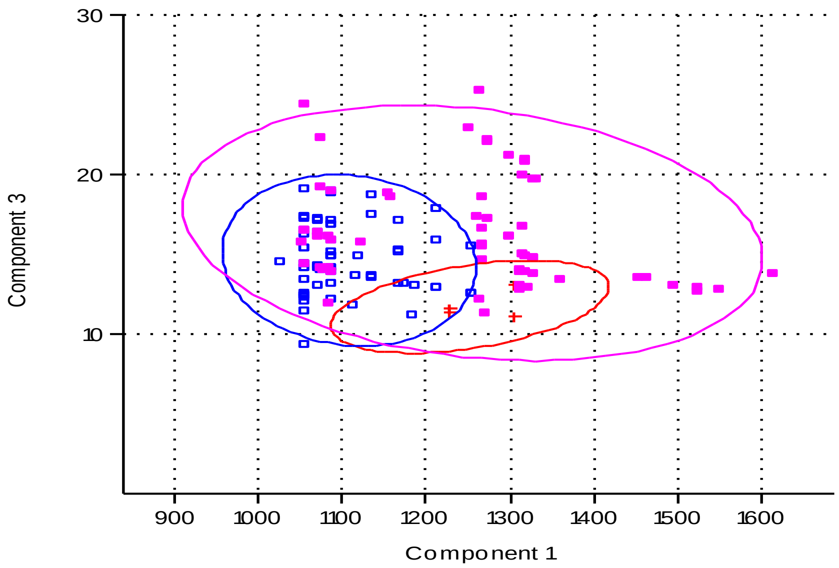

Fig. 2. PCA scatter diagram for meristic traits of *S. galilaeus* from Ero (red), Egbe (blue), Ado- Ekiti (pink) dams using 95% ellipses

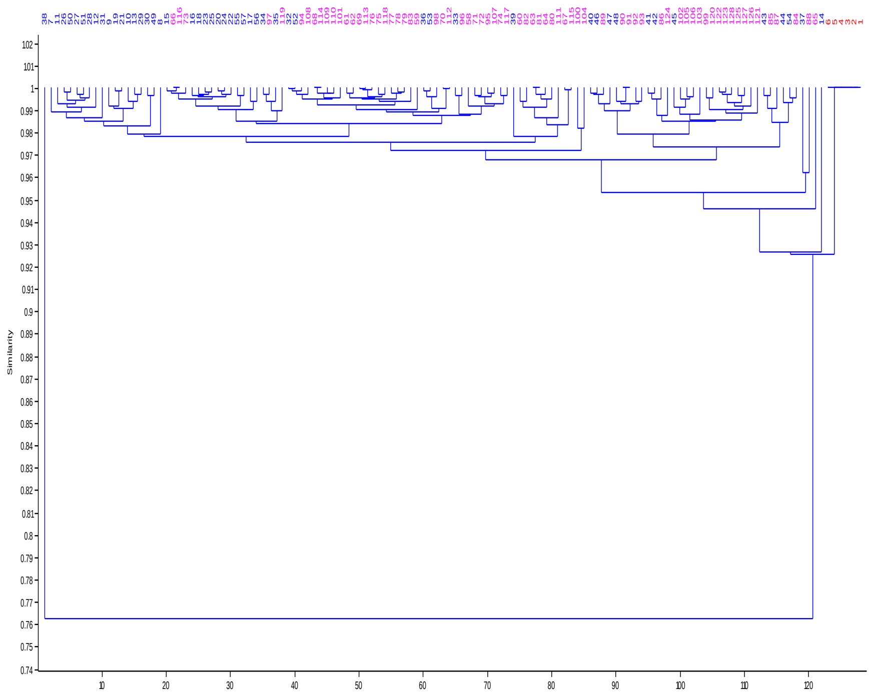

Fig. 3. Cluster analysis for morphometric of *S. galilaeus* from Ero (red), Egbe (blue) and Ado- Ekiti (pink) dams using rho similarity

the meristic character most responsible for variation among the studied populations of *S. galilaeus* with PCA Loading of 0.993 as shown in Fig. 5 and Table 3b.

The Eigen values and corresponding percentage of variance from principal component analysis (PCA) of the morphometric and meristic characters respectively for *S. galilaeus* across the three studied populations are shown in Tables 4a and 4b respectively. These components are showing the distribution of variation among the components in the PCA, PCI accounted for 100% of the variation, PC VIII for 9.1% and PC IV for 8%. (Table 4a) for meristic character, PCI accounted for 6.5% of the 8d variation, PC II for 3.4% and PC IX for 3.6% (Table 4b).

Table 3a. PCA Loadings for morphometric of *S. galilaeus* from Ero, Egbe and Ado- Ekiti reservoirs

Traits (cm)	Loadings
TL	0.1751
W	0.9652
DFL	0.0788
AFL	0.02736
PFL	0.02189
SPL	0.06019
HL	0.04378
SNL	0.01642
OFL	0.02189
PAD	0.09302
PVD	0.04706
PPD	0.04378
PDD	0.05472
DDCF	0.01423
DODF	0.02298
CPD	0.02189
BD	0.06019
HW	0.0383
ID	0.01642
ED	0.01094
OFW	0.01094
DSO	0.03283
NL	0.01642

Table 3b. PCA loadings for meristic characters of *S. galilaeus* in Ero, Egbe Ado- Ekiti reservoirs

Traits (cm)	Loadings
Nb	**0**
nG	**0.0005506**
nS	**0.001527**
nGA	**1.467E-41**
nGF	**0.993**
nGR	**0.1171**
AFR	**-0.0004913**
PFR	**0.0001696**
PvFR	**5.3E-5**
DFR	**-0.0007902**

4. DISCUSSION

Fishes are predisposed to changes in the environment and acclimatize rapidly by altering the morphometric characters. The phenotypic characters exhibit high plasticity in response to variations in environmental conditions. In this study, measurement of morphometric characters as well as meristic counts were used to characterized fish populations as they still remains dependable tools especially on the field and they are sensitive to any environmental change.

The results of this present study revealed that *S. galilaeus* obtained from three populations were phenotypically (morphologically) similar. The PCA scatter diagram for morphometric characters of *S. galilaeus* showed the length of the relationship or similarity. The circles data fussed inside one another, between population of *S. galilaeus* (Fig 1) from Ado-Ekiti Reservoir (pink), Egbe-Reservoir (blue) and Ero-Reservoir (red) as observed on the PCA scatter diagram implies that these populations are phenotypically homogeneity based on their morphometric characters. These level of phenotypically homogeneity was confirm by using 95% Ellipse of Rho similarity measure cluster analysis (Fig 3) which revealed that the *S. galileaus* also have a single origin ancestor which indicate *S. galilaeus* from the three populations are homogeneous. Also the PCA scatter diagram using 95% ellipses for meristic characters (Fig. 2). This implies that the overlapped data between populations of *S. galilaeus* from Ero-Reservoir (Red), Egbe-Reservoir (Blue) partially and almost completely overlap between Ado- Ekiti Reservoir (Pink) and the other two reservoirs; as observed on the PCA diagram. This confirms their homogeneity as the clusters were completed fused. All the traits were clearly shown to be similar between the three populations and little variations were shown to exist within the populations.

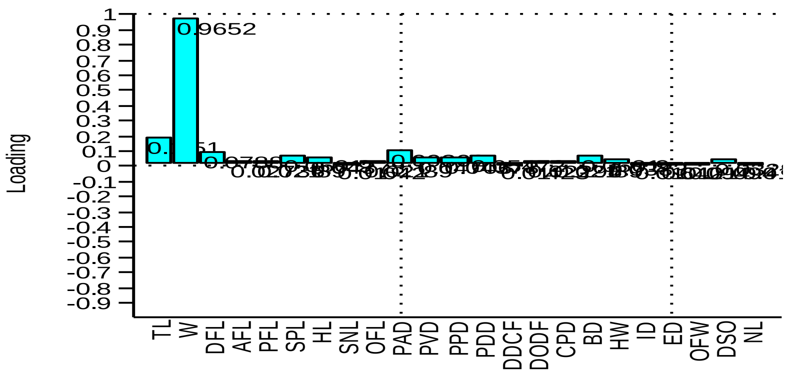

Fig. 4. PCA Loadings for morphometric of *S. galilaeus* from Ero, Egbe and Ado- Ekiti reservoirs

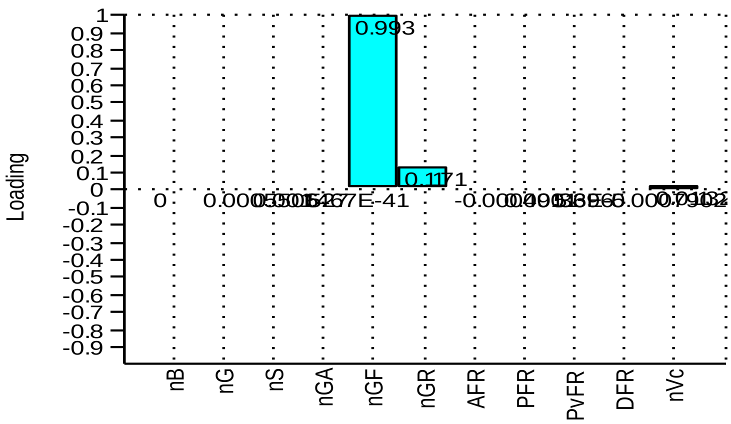

Fig. 5. PCA loadings for meristic characters of *S. galilaeus* Ero, Egbe and Ado- Ekiti reservoirs

Table 4a. Principal component PC showings the distribution of variations of morphometric data for *S. galilaeus* from Ero, Egbe Ado- Ekiti reservoirs

PC	Eigen Value	% Variance

PC	Eigen Value	% Variance
1	5.49392E12	100
2	21417.9	3.8985E-7
3	1114.12	2.0279E-8
4	44.2907	8.0618E-10
5	35.5258	6.4664E-10
6	31.4459	5.7238E-10
7	12.2157	2.2235E-10
8	5.03605	9.1666E-11
9	4.54403	8.271E-11
10	3.47526	6.3257E-11
11	3.19391	5.8135E-11
12	2.87226	5.2281E-11
13	2.38577	4.3426E-11
14	1.85687	3.3799E-11
15	1.65684	3.0158E-11
16	1.27454	2.3199E-11
17	1.2405	2.258E-11
18	1.11114	2.0225E-11
19	0.958524	1.7447E-11
20	0.804662	1.4646E-11
21	0.396687	7.2205E-12
22	0.345111	6.2817E-12
23	0.231903	4.2211E-12

Table 4b. Distribution of variation of meristic data for *S. galilaeus* among the principal components

PC	Eigen Value	% Variance
1	16332.39	6.53
2	576.935	3.4099
3	8.2797	0.048936
4	0.673191	0.0039788
5	0.491601	0.0029055
6	0.324668	0.0019189
7	0.230855	0.0013644
8	0.207332	0.0012254
9	0.00622837	3.6812E-5
10	2.03119E-18	1.2005E-20
11	0	0

The condition factor (K) values for S. galilaeus from Ero, Egbe and Ado- Ekiti reservoirs are 2.5 ± 0.8, 0.18 ± 0.02 and 0.2 ± 0.1 respectively. The values are significantly different from one another

The PCA loadings (Fig 4a and Table 4b) also illustrated that little variations existed in these populations and indicate the precise character with the little variation- weight (0.9652). And PCA loadings for the meristic characters also revealed nGF (0.993) as the character with highest variation. The meristic characters were homogenous and hence, perfectly continuous and this disagrees with [11], which is quantitative traits or characters, but is characterized with a finite range of phenotypes, and this study, also agrees with [12], who 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.

4.1 Condition Factor (K)

The mean condition factor (K) of the fish which strongly depend on fish length for *S. galilaeus* from Ero was higher than that of Egbe and Ado- Ekiti reservoirs population samples. When there is variation in the condition factor from the three different populations, it suggests that the fish under this study are not from the same source. The condition factor defines the wellbeing of the fish in a particular environment. According to [13], fish with higher K values are in a better condition than those fish with lower K values with respect to their lengths. A value of K for *S. galilaeus* from Ero population is greater than 1. This indicates that the feeding of the fish from

Ero population might be adequate. This implies that the fish from Ero population may have access to adequate food to the required level or caught from well naturally fertilized ecological niche or that there is little competition for the available food materials in the ecological niche.

Whiles the values of K for *S. galilaeus* from Egbe and Ado- Ekiti populations are lesser than 1. This means that the feeding of *S. galilaeus* from Egbe and Ado-Ekiti Populations might be inadequate. And this implies that these fish populations may not have been recast fed to the required level or caught from not well naturally fertilized ecological niche or there is more competition for available food substances in the ecological niche. So, there is need to determine the reasons for better growth and development of *S. galilaeus* collected from Egbe and Ado- Ekiti reservoirs.

The fish sufficiently fed had ‘K’ values equals or greater than 1 while undernourished fish had ‘K’ less than 1. The result of this study suggests similarity in the morphological composition and the condition factor of both *S. galilaeus*, from Ero, Egbe and Ado-Ekiti populations.

5. CONCLUSION

The results obtained in this study established morphologically homogeneity in both morphometric and meristic characters of *Sarotherodon galilaeus* inhabiting the three different reservoirs of study based on multivariate analysis of the morphometric and meristic characters. There is need to further determine the favourable factors of the growth and development of *S. galilaeus* in the subsequent studies of Ero, Egbe and Ado- Ekiti reservoirs, Ekiti- State, Nigeria.

ACKNOWLEDGEMENTS

The author(s) appreciate Dr. (Mrs) E.O Idowu of the Department of Zoology and Environmental Biology, EKSU, for the identification of the specimens, Dr. (Mrs) F.A Ola-Oladimeji of the Department of Zoology and Environmental Biology, EKSU, for her assistance in the analysis and my wife Mrs Akindele Temitayo. A. for her supports during the practical. This study is mainly sponsor by the Corresponding Author.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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