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Research Article

Variability of Morphometric of *Oreochromis niloticus, Sarotherdon galilaeus* and *Coptodon zilli* from the Nile and its tributaries in Sudan

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Abstract: This study assessed morphological variations of *Oreochromis niloticus, Sarotherodon galilaeus* and *Coptodon zilli* collected from the Nile and its tributaries. Nineteen morphometric measurements were recorded from each specimen. Data was subjected to discriminant function (CDF) analysis, Wilks' lambda test, t-test and Leave-one-out crosses validation to determine rate of divergence among species. The t-test showed wide variability in the significance (p>0.05 to p0.01) species and site wise in morphometric trait/total length and morphometric trait/head length. The body weight/standard length ratio was consistently significant ($p<0.05$). Function 1 and Function 2 of CDF clearly separated between O. niloticus and S. galilaeus from Sinnar as well as in Al Sabaloga, and between O. niloticus and C. zilli from Khashm El Girba as revealed by the high significance of Wilks lambda ($p<0.003$, $p<0.000$ and $p<0.000$, respectively). Based on 19 morphometric traits Leave-one-out reclassified the cross validated group at 66.7% and 84.6%, O. niloticus and S. galilaeus from Sinnar, respectively. From Al Sabaloga it reclassified O. niloticus at 97.9% and S. galilaeus at 0.0% due to its small sample size. In Khashm El Girba the cross validated group reclassified O. niloticus at 100% and C. zilli at 94.4%, respectively. Comparison between the values and variables clearly reduced the overlap when 3 traits were used instead of 19 traits. Cluster analysis placed S. galilaeus from Al Sabaloga in a separate branch of the dendrogram due to its small sample size.
Keywords: Cichlid, Meristic, Variability, Discriminant, Clustering, Nile.

INTRODUCTION

Variation in the morphometry measurements of fish species were recorded by a number of investigators. Clabaut *et al.* [1] found that the most important differences in body shape between cichlids species of Lake Tanganyika were related to body length as well as the proportion of sizes of head and caudal peduncle. Changes in body depth and head shape were the main variable in the invasive cichlid *Oreochromis mossambicu* (Firmat *et al.* [2] *and Oreochromis* sp. in Southern Louisiana Lorenz *et al.* [3]. Olufeagba *et al.* [4] evaluated morphological variations of cichlids from the Kainji Lake in Nigeria. Their discriminant analysis showed some overlap across the cichlids *Oreochromis niloticus, Coptodon zilli, Sarotherodon galilaeus* and *Pelmatolapia mariae*.

Azua *et al.* [5] compared variation in the morphometry measurements of *O. niloticus* and *C. zilli* obtained from Lower Benue River at Nigeria and related the variation in the morphological parameters recorded to the genetic makeup and environmental factors. Montoya-López *et al.* [6] from their work in different fish farms in Colombia *concluded that* shape in *Oreochromis* sp. vary between farms.

Ecological factors and genetic expressions could induce variation among populations of fish (Beacham [7]). In line with this is the work of Turan *et al.* [8] who found that the differences in Tilapiine spp is mainly in the head measurement. Mwanja *et al.* [9] studied morphological variation of Nile tilapia populations from major water bodies of Uganda. They related most of the variation to the fish body size, the peduncle length and the interorbital distances. Ndiwa *et al.* [10] found morphological differences between natural populations of Nile tilapia from hot spring populations in (Bogoria, Chelaba and Turtle Springs), and in saline environments in Lake Turkana basin (Turkana and Crocodile Lake populations) in Kenya.

The present study aimed to evaluate morphological variations of three cichlids (*O. niloticus*, *S. galilaeus* and *C.* zilli) from the Nile and its tributaries**.**

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MATERIAL AND METHODS

Live tilapia specimens were randomly collected from the commercial fishers from Sinnar (Blue Nile, 13°N, 33°); Khashm El Girba (Atbara River, 14°N, 35°E) and Al Sabaloga (River Nile, 16N, 32E). Fish identification followed Abu Gideiri [11]. The morphometric traits were measured from the left side of fish at the site of collection, using a measuring board accurate to 0.1cm. Morphometric index (MI) followed Lagler *et al.* [12]. Morphometric traits and their codes (Table 1) followed Hassan and Mahmoud [13].

Table-1: Morphometric traits measured and their codes

Morphometric trait	Codes
Total length is the distance from the rostral tip of the upper jaw to the tip of the dorsal lobe of the caudal fin.	TL
Standard length from the rostral tip of the upper jaw to the midpoint of the origin of the caudal fin.	SL
Body depth is the maximum depth of the body in front of the pelvic fin, starting from the dorsal fin base in a vertical plane	BD
Head length from the rostral tip of the upper jaw to the most posterior point of the operculum.	HL
Head width between both opercula in a normal position.	HW
Inter orbital width the minimum width of the dorsal margin of the bony orbits.	1OW
Snout length from the rostral tip of the upper jaw to the rostral point of the bony border of the orbit.	SNL
Lower jaw length from the rostral tip to the ventro-caudal tip of the lower jaw.	LJL
Premaxillary pedical length from the nostril tip of the upper jaw to the tip of the descending process of premaxilla.	PPL
Cheek depth from the ventral point of the bony margin of the orbit to the dorsal corner of the lower jaw.	CHD
Eye diameter is the maximum eye length.	ED
Lachrymal depth from the rostral corner of the bony orbit to the rostral corner of the lachrumal.	LAD
Dorsal fin base is the distance between the most rostral to the most caudal point of the dorsal fin base.	DFB
Anal fine base length is the distance between the most rostral ants the most caudal point to the anal fin base.	AFB
Pre-anal distance from the rostral tip of the upper jaw to the most rostral point of the anal fine base.	PRA
Pre-pectoral distance from the rostral tip of the upper jaw to the most rostral point of the pectoral fin base.	PRP
Prepelvic distance (PRV): from the rostral tip of the upper jaw to the most rostral point of the pelvic fin base.	PRV
Caudal peduncle length distance between the vertical line through the caudal point of the anal fin insertion and that through the caudal border of the hypurals.	CPL
Caudal peduncle Depth is the minimum depth of caudal peduncle.	CPD

STATISTICAL ANALYSIS

Morphometric index (MI) of Lagler *et al.* [12] followed the formulae:

MI = [Morphometric trait] ÷ [TL] and MI = [Morphometric character] ÷ [HL]

In Sinnar where the three species were detected, data was subject to Analysis of Variance (ANOVA) and K-independent sample test. In Khashm El Girba and Al Sabaloga where two species were detected the data was subject to t-test and two independent sample tests. To decide which trait contributes significantly in Canonical Discriminant Function (CDF), the Wilks' lambda (Λ) test was used. To determine rate of divergence among species the Leave-one-out crosses validation was used. Data analysis was perfumed by SPSS.

RESULTS

Sinnar samples

Oreochromis niloticus and *S. galilaeus* from Sinnar (Table 2) showed highly significant differences ($p<0.01$) in PRD/TL and significant differences ($p<0.05$) in HL/TL, HW/TL, SL/TL SNL/HL and PP/HL.

Table-2: Morphometric indices (mean ± SE) of *O. niloticus* and *S. galilaeus* from Sinnar using t-test (*=significant;=highly significant)**

Morphometric trait/TL			Morphometric trait /HL		
Ratio	*O. niloticus* X±SE	*S. galilaeus* X±SE	Ratio	*O. niloticus* X±SE	*S. galilaeus* X±SE
W/TL	6.35±0.57	5.44± 0.19	IOW/HL	0.26±0.007	0.25±0.007
BD/TL	0.29±0.005	0.28±0.002	SNL/HL	0.36±0.014*	0.42±0.014*
HL/TL	0.25±0.006*	0.24±0.006*	PP/HL	0.33±0.017*	0.38±0.017*
HW/TL	0.22±0.004*	0.21±0.002*	CHD/HL	0.23±0.01	0.24±0.01
DFB/TL	0.15±0.003	0.15 ±0.003	ED/HL	0.26±0.02	0.25±0.01
PRD/TL	0.31±0.005**	0.28±0.005**	LAD/HL	0.21±0.01	0.23±0.01
PRA/TL	0.58±0.009	0.57±0.007	AFB/HL	0.60±0.02	0.65±0.02
PRP/TL	0.28±0.006	0.28 ±0.004	CPL/HL	0.38±0.02	0.39±0.02
PRV/TL	0.33±0.004	0.33±0.004	CPD/HL	0.51±0.01	0.50±0.01
SL/TL	0.81±0.002*	0.78± 0.006*			

In Sinnar samples CDF and SCDF analysis showed that in function 1, PRD, SL, HW, SNL, PP, HL, LAD, AFB, IOW, W, PRA, PRV and BD were the most influential morphometric traits (Table 3). This function had better separation of *O. niloticus* (function 1= 1.379) from *S. galilaeus* (function 1 = -1.273). The Wilks Lambda (Table 3) recorded highly significant (p=0.003) value for function 1 which is indicative of clear differences between *O. niloticus* from *S. galilaeus*.

Based on 19 morphometric traits Leave-one-out reclassified the original group at 66.7% for *O. niloticus* and 84.6% for *S. galilaeus* samples, respectively and reclassified the cross validated group at 66.7% and 84.6%, respectively (Table 4). When 3 morphometric traits were the reclassification became 83.3% for *O. niloticus* and 84.6 % for *S. galilaeus* original group and for cross validated group it was 74.2% and 84.6%, respectively (Table 4). As DS can't express one function graphically, comparison between the means showed clear separation between *O. niloticus* and *S. galilaeus*, when using 19 and 3 morphometric character (Figs. 1 and 2).

Table-3: Canonical discriminant function (CDF) and standardized canonical discriminate function (SCDF) derived from discriminant analysis of *O. niloticus* and *S. galilaeus* from Sinnar

Trait	19 – morphometric			3 – morphometric	
	CDF 1	SCDF 1	Loading	CDF 1	SCDF 1
PRD	31.688	0.752	0.488*	0.709	0.671
SL	14.496	0.341	0.379*	0.551	0.487
HW	38.876	0.522	0.369*	0.537	0.477
SNL	-2.766	-0.193	-0.319		
PP	-3.826	-0.326	-0.226		
HL	-9.168	-0.263	0.223		
LAD	-6.010	-0.079	-0.200		
AFB	-5.047	-0.502	-0.192		
IOW	12.513	0.448	0.187		
W	0.237	0.492	0.165		
PRA	-7.035	-0.278	0.144		
PRV	-13.986	-0.279	0.133		
BD	-10.200	-0.200	0.129		
CHD	-7.804	-0.348	-0.066		
CPL	2.837	0.262	-0.055		
ED	-1.703	-0.100	0.047		
CPD	5.843	0.396	0.046		
DFB	20.150	0.280	-0.007		
PRP	-1.788	-0.048	-0.006		
Significance of function 1 based on Wilks lambda =0.353; χ^2 =40.46; DF=19; p<0.003					

Table-4: Leave-one-out cross validation for *O. niloticus* and *C. zilli* by discriminant analysis using 19 morphometric characters from Sinnar.

Group	Aspect	Species	19 – traits			3 – traits		
			O. niloticus	***S. galilaeus***	**Total**	***O. niloticus***	***S. Galilaeus***	**Total**
Original	Count	*O. niloticus*	22	2	24	20	4	2
		S. galilaeus	2	24	26	4	22	26
	%	*O. niloticus*	91.7	8.3	100	83.3	16.7	100
		S. galilaeus	7.7	92.3	100	15.4	84.6	100
Cross-validated	Count	*O. niloticus*	16	8	24	19	5	24
		S. galilaeus	4	22	26	4	22	26
	%	*O. niloticus*	66.7	33.3	100	79.2	20.8	100
		S. galilaeus	15.4	84.6	100	15.4	84.6	100

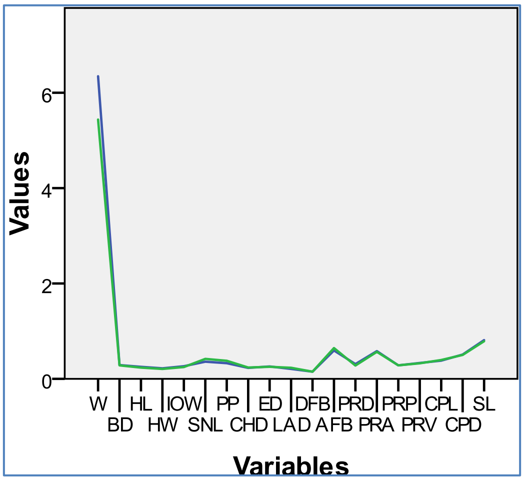

Fig-1: Comparison between the means in *O. niloticus* (black line) and *S. galilaeus* (green line) from Sinnar using 19 morphometric traits

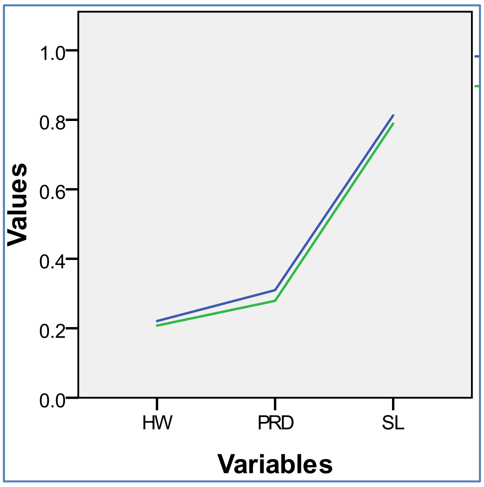

Fig-2: Comparison between the means in *O. niloticus* (black line) and *S. galilaeus* from Sinnar using 3 morphometric traits

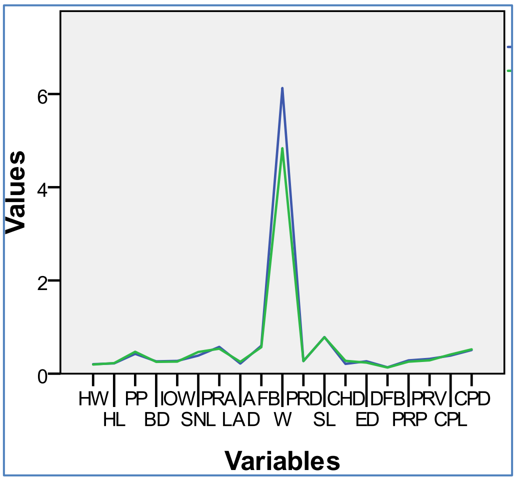

Fig-3: Comparison between the means in *O. niloticus* and (black line) *C. zilli* (green line) from Khashm El Girba using 19 morphometric traits

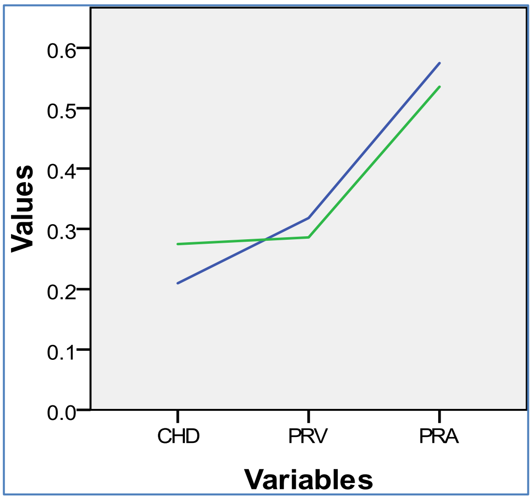

Fig-4: Comparison between the means in *O. niloticus* and *C. zilli* (green line) from Khashm El Girba using 3 morphometric traits

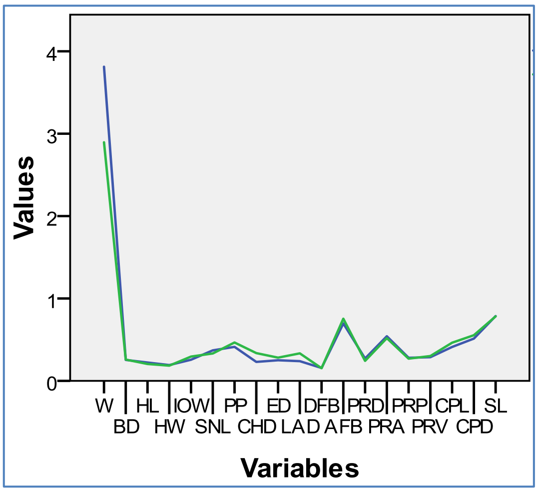

Fig-5: Comparison between the means in *O. niloticus* (black line) and *S. galilaeus* (green line) from Al Sabaloga using 19 morphometric traits

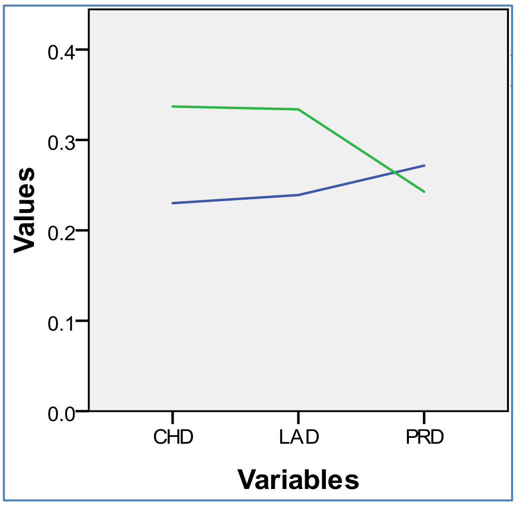

Fig-6: Comparison between the means in *O. niloticus* (black line) and *S. galilaeus* (green line) from Al Sabaloga using 3 morphometric traits

Khashm El Girba samples

Khashm El Girba samples (Table 5) showed highly significant differences ($p<0.01$) between *O. niloticus* and *C. zilli* in W/TL, PRA/TL, PRP/TL, PRV/TL, SNL/HL, CHD/HL and LAD/HL. While significant differences ($p<0.05$) in indices were found in BD/TL, PP/HL and ED/HL.

Table-5: Morphometric indices (mean ± SE) of *O. niloticus* and *C. zilli* in Khashm El Girba using t-test (*=significant;=highly significant).**

Morphometric character/TL			Morphometric character/HL		
Ratio	***O. niloticus*** **X±SE**	***C. zilli*** **X±SE**	**Ratio**	***O. niloticus*** **X±SE**	***C. zilli*** **X±SE**
W/TL	6.13± 0.13**	4.84±0.28**	IOW/HL	0.28±0.008	0.26±0.007
BD/TL	0.26±0.003*	0.25±0.004*	SNL/HL	0.39±0.009**	0.47±0.02**
HL/TL	0.22±0.003	0.22±0.005	PP/HL	0.43±0.005*	0.47±0.01*
HW/TL	0.2040.002	0.20±0.003	CHD/HL	0.21±0.003**	0.27±0.004**
DFB/TL	0.14±0.002	0.13±0.002	ED/HL	0.27±0.006*	0.27±0.003*
PRD/TL	0.27±0.002	0.27±0.003	LAD/HL	0.22±0.005**	0.25±0.009**
PRA/TL	0.57±0.002**	0.54±0.006**	AFB/HL	0.06± 0.01	0.57±0.02
PRP/TL	0.29±0.003**	0.26±0.002**	CPL/HL	0.39±0.007	0.41±0.02
PRV/TL	0.31±0.001**	0.29±0.003**	CPD/HL	0.51±0.003	0.52±0.02
SL/TL	0.79±0.002	0.78±0.003			

Based on 19 morphometric traits in Khashm El Girba samples, Leave-one-out reclassified the original group at 100% for *O. niloticus* and 100% for *C. zilli* samples, respectively and reclassified the cross validated group at 100% and 94.4%, respectively (Table 6). Comparison between the morphometric showed less overlap when using 3 traits as compared with 19 traits (Figs. 3 and 4).

Table-6: Leave-one-out cross validation for *O. niloticus* and *C. zilli* by discriminant analysis using 19 morphometric characters from Khashm El Girba.

Aspect	**Aspect**	**Species**	**Predicted Group Membership**		**Total**
			O, niloticus	***C. zilli***	
Original	Count	*O. niloticus*	39	0	39
		C. zilli	0	18	18
	%	*O. niloticus*	100	0	100
		C. zilli	0	100	100
Cross-validated	Count	*O. niloticus*	39	0	39
		C. zilli	1	17	18
	%	*O. niloticus*	100	0	10
		C. zilli	5.6	94.4	100

In Khashm El Girba samples the CDF and SCDF for factor 1 ranked CHD, PRV and PRA with high loading (Table 7). Factor1 yielded extremely significant separation (Wilks lambda $p<0.000$) between *C. zilli* (function1= -2.38) for *O. niloticus* (function1=5.157).

Table-7: CDF and SCDF derived from discriminant analysis of *O. niloticus* and *C. zilli* from Khashm El Girba

Factor	19 – morphometric		3 – morphometric model		Loading
	CDF 1	SCDF 1	CDF 1	SCDF 1	
CHD	45.296	0.766	-46.223	0.685	0.510
PRV	-53.588	-0.555	54.688	-0.727	-0.412
PRA	-17.373	-0.346	14.376	-0.390	-0.261
PRP	-21.373	-0.317			-0.250
W	0.002	0.001			-0.185
SNL	3.296	0.200			0.170
LAD	17.679	0.570			0.152
PP	8.292	0.340			0.146
ED	-9.211	-0.324			-0.109
BD	4.954	0.092			-0.007
HW	-0.278	-0.004			-0.065
DFB	23.442	0.269			-0.065
AFB	-1.771	-0.129			-0.058
CPL	3.112	0.176			0.056
CPD	-2.536	-0.104			0.051
LOW	8.104	0.350			-0.045
HL	44.717	0.858			0.038
SL	8.880	0.127			-0.0034
PRD	25.276	0.303			-0.017
Significance of function 1 based on Wilks lambda =0.096, χ^2 =123.163, F=5, p<0.000.					

Al Sabaloga samples

Al Sabaloga samples showed significant differences (p<0.05) between *O. niloticus* and *S. galilaeus* (Table 8) in W/TL and PP/HL in morphometric indices.

Table-8: Morphometric indices (mean ± SE) of *O. niloticus* and *S. galilaeus* from Al Sabaloga using t-test (*=significant;=highly significant)**

Morphometric trait/TL			Morphometric trait/HL		
Ratio	*O. niloticus* X±SE	*S. galilaeus* X±SE	Ratio	*O. niloticus* X±SE	*S. galilaeus* X±SE
W/TL	3.8± 0.29*	2.9±0.19*	IOW/HL	0.26±0.006	0.29±0.02
BD/TL	0.25±0.001	0.26±0.01	SNL/HL	0.37±0.006	0.33±0.03
HL/TL	0.22±0.002	0.204±0.01	PP/HL	0.41±0.006*	0.47±0.04*
HW/TL	0.19±0.001	0.18±0.01	CHD/HL	0.23±0.005	0.34±0.08
DFB/TL	0.27±0.003	0.15±0.01	ED/HL	0.25±0.006	0.28±0.008
PRD/TL	0.27±0.003	0.24±0.02	LAD/HL	0.24±0.003	0.33±0.08
PRA/TL	0.54±0.003	0.52±0.01	AFB/HL	0.7±0.011	0.75±0.04
PRP/TL	0.28±0.004	0.27±0.12	CPL/HL	0.41±0.006	0.46±0.15
PRV/TL	0.29±0.003	0.3±0.004	CPD/HL	0.79±0.005	0.78±0.05
SL/TL	0.79±0.002	0.78±0.004			

The CDF and SDCF for factor 1 (Table 9) explains 100% of the total variance in 19 morphometric with LAD, CHD, PRD, CPL, PP, CPD, HL, PRA, IOW, SNL, ED, HW, AFB and PRV being most influential morphometric measurements. Function 1 = 0.274 for *O. niloticus* and =-4.389 for *S. galilaeus.* This is an extremely significant separation between the two species as indicated by Wilks' lambda (p<0.000).

Table-9: CDF and SCDF from discriminant analysis of *O. niloticus* and *S. galilaeus* from Al Sabaloga using different morphometric traits.

Trait	19 – morphometric		3– morphometric		Loading
	CDF 1	SCDF 1	CDF 1	SCDF 1	
LAD	17.193	0.608	17.723	0.440	0.454
CHD	14.111	0.654	9.492	0.627	0.390
PRD	-19.000	-0.380	-29.843	-0.596	-0.245
CPL	8.937	0.361			0.217
PP	-5.782	-0.263			0.198
CPD	-0.309	-0.012			0.187
HL	-1.945	-0.032			-0.185
PRA	-14.662	-0.349			-0.164
IOW	15.621	0.629			0.162
SNL	-24.001	-0.080			-0.142
ED	-6.165	-0.259			0.128
HW	6.376	0.063			-0.123
AFB	6.999	0.564			0.120
PRV	15.310	0.343			0.107
W	0.132	0.261			-0.078
PRP	13.101	0.349			0.068
BD	-16.257	-0.213			0.056
SL	-16.082	-0.220			-0.047
DFB	-31.763	-0.380			-0.042
Significance of Function 1 based on Wilks lambda=0.444, χ^2 =38.167, DF=4, p<0.000					

Reclassification based on 19 morphometric traits original group reclassification gave 100% for both species. Cross-validated group reclassified *O. niloticus* at 97.9% and 0.0% for *S. galilaeus* due to its small sample size (Table 10). The 3 morphometric traits with high loading managed to reclassify 66.7% *S. galilaeus* and 100% *O. niloticus* (Table 10).

Table-10: Leave-one-out cross validation for *O. niloticus* and *S. galilaeus* by discriminant analysis using 5 morphometric characters from Al Sabaloga

Group	Aspect	Species	Predicted Group Membership		Total
			O. niloticus	*S. galilaeus*	
Original	Count	*O. niloticus*	48	0	48
		S. galilaeus	0	3	3
	%	*O. niloticus*	100	0	100
		S. galilaeus	0	100	100
Cross-validated	Count	*O. niloticus*	47	10	48
		S. galilaeus	3	0	3
	%	*O. niloticus*	97.9	2.1	100
		S. galilaeus	100	0	100

Comparing the mean between the two species failed to discriminate them when 19 morphometric were used (Fig. 5), but when 3 morphometric characters were used a distinct discrimination curve was obtained (Fig.6).

Cluster analysis

To summarize the relationships among the populations of *O. niloticus*, *S. galilaeus* and *C. zilli*, a matrix of taxonomic distance that yielded a tree for comparison was made. The tree showed two main clusters, the *S. galilaeus* of Al Sabaloga cluster in separate branch due to its small sample size. The second cluster consists of a number of sub clusters. *Oreochromis niloticus* of Sinnar is accommodated in a sub cluster closer to the sub cluster of *C. zilli* from Khashm El Girba. The third sub cluster included *O. niloticus* from Al Sabaloga and Khashm El Girba and *S. galilaeus* from Sinnar (Fig. 7).

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CASE          0        5        10        15        20        25
Label      No.+---------+---------+---------+---------+---------+

O KEG      6   ---------
S SI     5   ----------------------------
O SA      4   ---------               --------------------
C KEG      3   ----------------------------
O SI      2   -------------------------------------
S SA      1   ------------------------------------------------
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Fig-7: Dendrogram generated by clustering comparison between *O. niloticus*, *S. galilaeus* and *C. zilli* from Sinnar, Al Sabaloga and Khashm El Girba based on morphometric traits

DISCUSSION

Cichlids are largely freshwater fish [14] but many species can tolerate brackish water for extended periods like *Cichlasoma urophthalmus* [15] or diffuse into brackish coastlines between rivers like *Oreochromis*, *Sarotherdon* and *Coptodon* spp. (Nelson and Joseph [16]. However, few cichlids such as *Etroplus maculates*, *Etroplus suratensis* and *Sarotherdon melanotheron* inhibit brackish or salt water (Frank [17]). This high tolerability of diversified habitats impacted fish morphometry. It may induce variation among populations of fish (Beacham [7]).

Morphometric studies carried out successfully discriminated the fish populations in the different sampling areas as apparent from the findings of: Bailey [18] on flat fish populations Saborido *et al*. [19] on *Sebastes mentella* and Palma and Andrade [20] on *Diplodus sargus*, *Diplodus punntazo* and *Lithognathus mornurus.*

The present study recorded significant variation ($p<0.05$-0.01) in the morphometric traits of *O. niloticus*, *S. galilaeus* and *C. zilli* from Sinnar, Khashm El Girba and Al Sabaloga It identified a number of traits in each site which differs among the species from different locations. This is online with the findings in cichlids species reported by Clabaut *et al*. [1] and Olufeagba *et al.* [4]; in the invasive C. *mossambicu* Firmat *et al*. [2] and *Oreochromis* sp. in Southern Louisiana (Lorenz *et al*.[3]).

Olufeagba *et al.* [4] discriminant analyses showed some overlap across *O. niloticus*, *S. galilaeus* and *C. zilli*) from the Kainji Lake in Nigeria. The present work in the same species confirmed the overlap between the species location wise but significantly ($p<0.003$-0.000) reduced it when 3-traits instead of 19-traits were subject to Leave-one-out cross validation analysis. Moreover, Function 1 and Function 2 of CDF clearly separated between *O. niloticus* and *S. galilaeus* from Sinnar as well as in Al Sabaloga, and between *O. niloticus* and *C. zilli* from Khashm El Girba as revealed by the high significance of Wilks lambda ($p<0.003$, $p<0.000$ and $p<0.000$, respectively). Hossain *et al*. [21] studied morphometric of *Labeo calbasu*, and found Function 1 accounted for 75.5% and the Function 2 accounted for 24.5% of the among-group variability. Samaradivakara *et al*. [22] found morphological differences between four *O. niloticus* populations and reported standard length and body depth contributing largely to Function 1.

Cluster analysis placed *S. galilaeus* from Al Sabaloga in a separate branch of the dendrogram due to its small sample size, the rest of populations where accommodated in three sub clusters. Samaradivakara *et al*. [22] obtained two clusters for O. *niloticus* for each of the two rivers.

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CONCLUSION

These analyses indicated that there was high morphological variation among the different populations of Nile tilapia probably due to genetic differences and/or environmental factors.

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