Quest Journals
Journal of Research in Agriculture and Animal Science
Volume 9 ~ Issue 5 (2022) pp: 17-24
ISSN(Online) : 2321-9459
www.questjournals.org

Research Paper

Meristic of nine populations of *Oreochromis niloticus,Sarotherodon galilaeus* and*Coptodon zillii*from the Nile and its tributaries in Sudan

Huda A. Hassan[1] and Zuheir N. Mahmoud[1*]
1= Department of Zoology, Faculty of Science, University of Khartoum, Sudan.

ABSTRACT: *The variations in 12 meristic traits were studied among and between nine populations of Oreochromis niloticus, Sarotherodon galilaeus and Coptodon zillii from at Kosti (White Nile), Sinnar (Blue Nile, Khashm El Girba (Atbara Rive) and Al Sabaloga (Main Nile).Discriminant analysis produced 2 DFs (the 1st and 2nd DFs) for meristic counts. Itexcluded pelvic fin rays, and anal and pelvic fin spines from being influential in discriminating species within and between sites. Of the nine retained meristic trait, the most influential one was dorsal fin spines, dorsal fin rays, anal fin rays and lower lateral line scales. The canonical discriminant function and the standard canonical discriminant function showed that 93.5% and 6.5% of the total variance were explained by Factor 1and Factor 2, respectively. In Factor 1, dorsal fin spines and ray, lower lateral line scales and Scales form anal fin origin, counting towards upper lateral line were the influential meristic traits, while in Factor 2 the pectoral fin rays and anal fin rays were the influential meristic traits. The significance of variation was tested using Wilks lambda and the chi-square test. The leave-one-out crosses validation showed that 86.0% of original grouped cases correctly classified and 80.0% of cross-validated grouped cases correctly classified. A dendrogram based on meristic counts data was constructed and showed two main clustering groups. One group included S. galilaeus from Al Sabaloga and C. zilli from Kosti and Khashm El Girba, the second group consisted of O. niloticus from all sites and S. galilaeus from Kosti and Sinnar. The findings of this study should be considered incichlids traditional genetic improvement programmes.*

KEYWORDS*: Cichlid, Meristic, Variability, Discriminant, Clustering, Nile.*

R*eceived 03 May, 2022;* ***R****evised 14 May, 2022;* ***A****ccepted 16 May, 2022 © The author(s) 2022.*
P*ublished with open access at* ***www.questjournals.org***

I. INTRODUCTION

Meristictraits of fish are countable structures such as number of scales between two landmarks or number of spines and rays in a fin[1]. These structures are important tools in taxonomic characterization of fish species [2], [3] and [4]. Meristic can be used to detect variations within the same fish species from different water bodies[5], [6] and [7]. According to[8],the meristic variation in *Alepisaurus ferex* and *A. brevirostris* from the Pacific Oceanshowed that that *A. ferox* population is geneticallyisolated from the Atlantic and IndianOcean populations. Greater number of scales above and below the lateral line were found in traditionally genetically improved farmed tilapia compared with genetically improved farmed *O. niloticus*. [9].

Studies on the number of gill rakers in *Leiopotheraponplumbeus* were made by [10] and in *C. zillii* and *O. aureus*was by [11]. Both researchers related differences in count to food and feeding habits. Fish species which feed on large food particles usually required small numbers of gill rakers, while those feeding on small food items need large gill rakers[12] and [13].

Based on the work of [14] on cyprinid; [15] on *Sarda*;[16] on*Oncorhynchus mykiss* and *O. mirideus*and [17] on *Coptodon guineensis*, variations in meristic counts are partially determined by environmental conditions. According to [18] and [19]meristic traits of fish are determined early during larval development in response to environmental factors.The results obtained by[20]showed that all meristic counts were statistically different among *O. niloticus*, *S. galilaeus*, *Pelmatolapia mariae* (The spotted tilapi)and *C. zillii* from Kainji Lake, Nigeria.[20] reported that *C. zillii* had more meristic count than any of the three species.Jawad*et al*.The cross-validated discriminant analysis for *C. zillii* from three locations along Shatt Al-Arab River, Iraq was applied by [11]. They [11] used meristic traits and found that the fish was correctly classified at 74.7% (Wilk's lambda=0.035, p<0.001). Referring to [21] study, meristic traits of *Clariasguineensis* from the Buguma Creek and the New Calabar River in Nigeria. They found that dorsal fin rays and spines as well as in the number of anal fin ray of population of New Calabar were slightly more than that of the Buguma Creek.

The present work studied the meristic traits of nine populations *Oreochromis niloticus* (L 1758), *Sarotherodon galilaeus*(L 1758) and *Coptodon zillii* (Gervais 1648) from the Nile, White Nile, Blue Nile and Atbara Rive in Sudan.

II. MATERIAL AND METHODS

Source of fish

Live tilapias specimens were randomly collected from the commercial fishers operating at Kosti (KO0 White Nile, Sinnar (SI) Blue Nile, Khashm El Girba (KEG) Atbara Riveand Al Sabaloga (AS) Main Nile. Fish specimens were morphologically identified following [22] and [23]. Meristic counts were carried out in the field. Twelve traits counted and their acronyms were given in Table 1.

Table 1.Meristic traits counted and their acronyms.

Number of	Acronym	Number of	Acronym
Dorsal fin spines	DFS	Pelvic fin rays	PFR
Dorsal fin rays	DFR	Scales on upper lateral line	ULLS
Anal fin spines	AFS	Scales on lower lateral line	LLLS
Anal fin rays	AFR	Scales form anal fin origin, counting towards upper lateral line	TRAS
Pectoral fin rays	PeFR	Scales on Pelvic fin	PFS
Pelvic fin spines	PFS	Scales on the cheek	CS

Statistical analysis

Data from KO was subject to ANOVA, while SI, KE and AS data was subject to t-test. To differentiate among the species, the data was subject to canonical discriminant analysis (CDF) and Wilks' lambda (Λ) test. Data analysis was perfumed by SPSS.

III. RESULTS

Statistical analysis (Table 2) excluded AFS, PeFS and PFR meristic trait from being influential in discriminating species within and between sites. Of the nine retained meristic trait, the most influential one was DFS followed by DFR, AFR and LLS. The rest of traits showed varied level of significance ($p>0.05$ to $p<0.01$).

Table 2. Statistical analysis of meristic traits of cichlids from different sites

Site	Species	Meristic trait								
		DFS	DFR	AFR	PeFR	ULLS	LLLS	TRAS	PFS	CS
Kosti	*Oreochromis niloticus*	**	**	**	*	**	Ns	*	ns	ns
	Sarotherodon galilaeus	**	**	**	Ns	**	Ns	*	ns	ns
	Coptodon zilli	**	**	**	*	**	Ns	*	ns	ns
Sinnar	*Oreochromis niloticus*	*	*	*	*	*	**	**	ns	**
	Sarotherodon galilaeus	*	*	*	*	*	**	**	ns	**
Khashm El Girba	*Oreochromis niloticus*	**	**	**	Ns	**	Ns	Ns	**	**
	Coptodon zilli	**	**	**	Ns	**	Ns	Ns	**	**
Al Sabaloga	*Oreochromis niloticus*	**	Ns	Ns	Ns	ns	*	Ns	ns	ns
	Sarotherodon galilaeus	**	Ns	Ns	Ns	ns	*	Ns	ns	ns

*=statistically significant, **= highly statistically significant and ns= not statistically significant.

Statistical analysis for KO samples using K-independent sample test showed highly significant differences ($p<0.01$) in DFS, DFR, AFR and LLLS and significant differences ($p<0.05$)in PFR and TRAS (Table II). The rest of characters showed insignificant differences ($p>0.05$). Wilks lambda test ($p=0.000$) indicated that the group centroids were extremely significantly different in Factor 1 of *O. niloticus* (1.882) resulted in clear separation of from *S. galilaeus* (-0.046) and *C. zilli* (-2.849). With respect to Factor 2 its value of (0.978) significantly separated *S. galilaeus* group from *O. niloticus* (-0.302) and *C. zilli* (-0.319),

The CDF and SCDF analysis of the 9 meristic counts (Table 3, Figs. 2 and 3) showed that 93.5% and 6.5% of the total variance were explained by Factor 1and Factor 2, respectively. In Factor 1, DFS, DFR, LLS, and TRA were the influential meristic counts, while in Factor 2 the pectoral soft and anal soft were the influential meristic count (Figs. 2 and 3). Re-classification based on 12 meristic counts selected 9 counts and showed 95.7%, 50% and 66% correct classification for *O. niloticus*, *S. galilaeus* and *C. zilli,* respectively with an average value of 76% (Table 4). The leave-one-out crosses validation showed that 86.0% of original grouped cases correctly classified and 80.0% of cross-validated grouped cases correctly classified. 86.0% of original grouped cases correctly classified and 80.0% of cross-validated grouped cases correctly classified.

Leave-one-out cross validation discriminant analysis using meristic counts(Table 3) showed that:

1. In *O. niloticus* the original grouped cases were correctlyclassified at an average of 94.65% and the cross-validated grouped cases were correctly classified at an average of 93.60%.
2. For *S. galilaeus* the original grouped cases were 100% correctly classified and the cross-validated grouped cases were correctly classified at an average of 89.10%.
3. The original grouped cases of *Coptodon zillii* were correctly classified at an average of 97.20% and the cross-validated grouped cases were correctly classified at an average of 87.80%.

Table 3. Leave-one-out cross validation discriminant analysis* using nine meristic counts.

Aspect		Study site	Predicted Group Membership				Total
			Oreochromis niloticus from				
			KO	SI	KEG	AS	
Original	Count	KO	22	0	0	1	23
		SI	0	22	0	2	24
		KEG	0	1	38	0	39
		AS	3	0	0	45	48
	%	KO	95.7	0	0	4.3	100
		SI	0	91.7	0	8.3	100
		KEG	0	2.6	97.4	0	100
		AS	6.2	0	0	93.8	100
Cross-validated	Count	KO	22	0	0	1	23
		SI	1	21	0	2	24
		KEG	0	1	38	0	39
		AS	3	0	0	45	48
	%	KO	95.7	0	0	4.3	100
		SI	4.2	87.5	0	8.3	100
		KEG	0	2.6	97.4	0	100
		AS	6.3	0	0	93.8	100
Aspect		Study site	*Sarotherodon galilaeus* from				Total
			KO	SI	AS		
		KO	12	0	0		12
		SI	0	26	0		26
		AS	0	0	3		3
	%	KO	100	0	0		100
		SI	0	100	0		100
		AS	0	0	100		100
Cross-validated	Count	KO	9	3	0		12
		SI	2	24	0		26
		AS	0	0	3		3
	%	KO	75	25	0		100
		SI	7.7	92.3	0		100
		AS	0	0	100		100
Aspect		Study site	*Coptodon zillii* from				Total
			KO		KEG		
		KO	15		0		15
		KEG	1		17		18
	%	KO	100		0		100
		KEG	5.6		94.4		100
Cross-validated	Count	KO	13		2		15
		KEG	2		16		18
	%	KO	86.7		13.3		100
		KEG	11.1		88.9		100

*In cross validation, each case is classified by the functions derived from all cases other than that case.

*Oreochromis niloticus***from four locations**

1. Discriminant analysis of meristic counts classified 95.7%, 87.5%, 97.4.3% and 93.8% of the samples from KO, SI, KEGand AS, respectively at an overall average of 94% (Table 4).
2. *Oreochromis niloticus* samples from KEG are clearly separated from KO, SI and AS samples. The samples of SA showed minor overlap (Fig. 1).

Wilks lambda test (p=0.000) indicated that the group centroids were extremely significantly different in Factor1and resulted in clear separation of *O. niloticus*(KEG)from those of SI, KO and SA(Factor 1=5.821, 0.279, -2.852 and -3502, respectively). With respect to Factor 2 its value p=0.000 significantly separated SI samples from AS, KEG and KO (Factor 2=1.226,0.778, -0.200 and -2.564, respectively).The Wilks lambda test p=0.000 of Factor 3 significantly separated AS samples from KEG, KO and SI (Factor 3=0.851, 0.532, -0.549 and -2.039, respectively).

Table 4. The CDF and SCDF from discriminate analysis of *Oreochromis niloticus* from four locations using nine meristic counts.

Trait	CDF			SCDF			Loading		
	1	2	3	1	2	3	1	2	3
DFS	-0.147	0.020	2.248	-0.051	0.007	0.776	-0.060	0.026	0.426*
DFR	0.010	-0.157	1.202	0.005	-0.087	0.667	-0.001	-0.123	0.473*
AFR	-0.677	-2.863	0.462	-0.243	-1.030	0.166	0.054	-0.379	0.393*
PeFR	0.385	0.080	-0.417	0.225	0.047	-0.243	0.068*	0.001	0.015
ULLS	-0.013	0.112	0.122	-0.036	0.317	0.344	-0.058	0.325*	0.197
LLLS	3.325	-11.531	3.789	0.123	-0.425	0.140	0.057	-0.291*	0.200
TRAS	9.195	0.947	0.485	1.052	0.108	0.055	0.935*	0.008	0.141
PFS	-0.102	0.843	0.358	-0.115	0.955	0.405	0.016	0.259	0.468*
CS	-0.089	0.494	-0.208	-0.086	0.480	-0.202	-0.042	0.255*	0.006

Significance of Function 1,2 and 3 based on Wilks lambda

Function	Wilks lambda	χ^2	DF	Significance
1	0.010	582.165	27	0.000
2	0.172	222.678	16	0.000
3	0.460	98.172	7	0.000

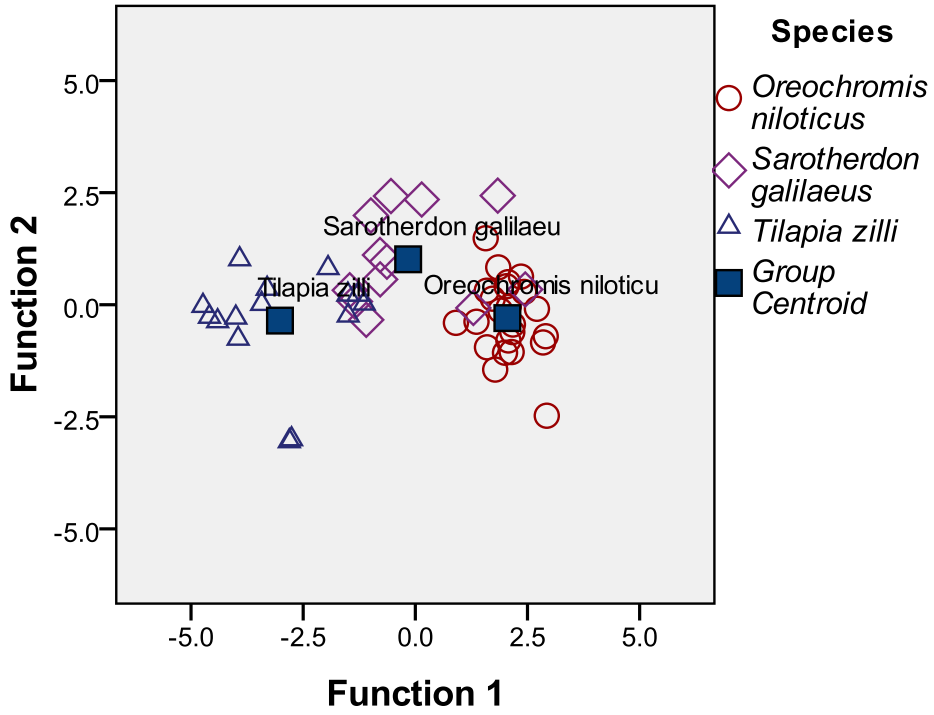


Fig. 1. Scatter plot of Canonical discriminant function of 9 meristic counts of three cichlids from Kosti.

*Sarotherodongalilaeus***from three locations**

Discriminant analysis (Table V) showed clear overlap between *S. galilaeus* sample from KO and SIwhich are distinctfrom AS samples (Fig. 3).

1.Function 1 separated AS samples from KO and SI.This separation is extremely highly significant (p<0.000) as indicated by Wilks lambda (9.630, AS; -0.427. SI and -1.482 KO).

2.Function 2 insignificantly (p>0.05) separated SI samples from KO and AS because Wilks lambda=0.494 is more than p=0.05.

reclassification of meristic counts, classified 75.0%, 92.3% and 100% of KO, SI and AS samples, respectively with an overall average at 100% (Table 5).

Table 5. The CDF and SCDF from discriminate analysis of *S. galilaeus* from threelocations using meristic counts.

Trait	CDF		SCDF		Loading	
	1	2	1	2	1	2
DFS	-0.693	0.019	-0.352	0.010	-0.050	0.159*
DFR	0.112	0.068	0.081	0.050	0.023	-0.074*
AFR	-0.105	0.558	-0.100	0.533	-0.009	0.240*
PeFR	1.467	-3.507	0.194	-0.464	0.235	-0.237*

ULL	0.025	0.182	0.111	0.817	0.054	0.479*
LLL	-0.546	-14.25	-0.020	-0.534	0.063	-0.427*
TRAS	2.053	-0.860	0.545	-0.228	-0.047	-0.292*
PFS	4.636	0.338	1.128	0.082	0.827*	0.149
CS	0.326	0.347	0.291	0.310	0.076	0.212*

Significance of function 1 and 2 based on Wilks lambda				
Function	Wilks lambda	χ^2	DF	Significance
1	0.088	82.626	18	0.000
2	0.804	7.398	8	0.494

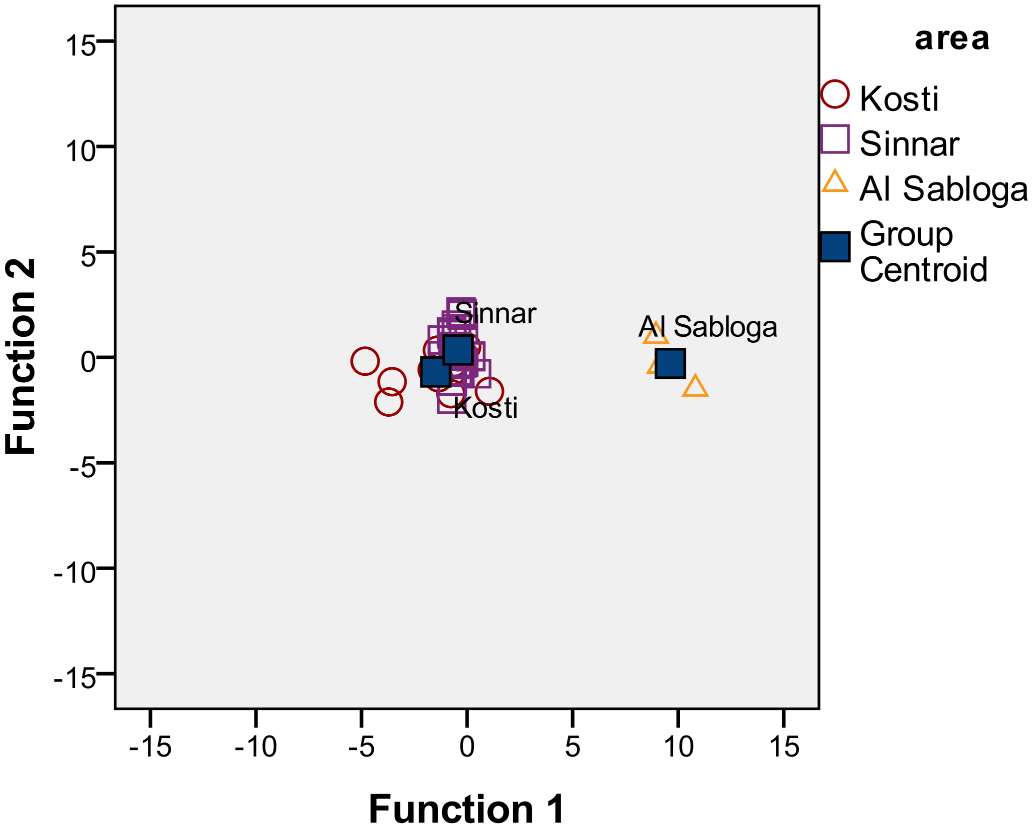
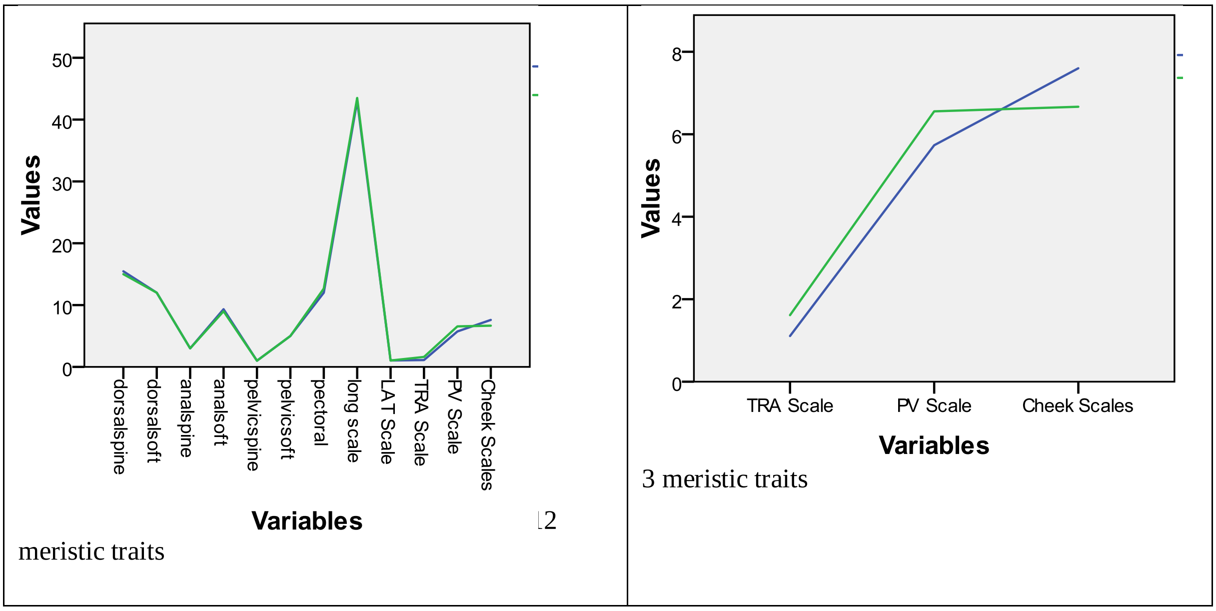


Fig. 2. Scatter plot of Canonical discriminant of *S. galilaeus* from three locations using nine meristic traits.

*Coptodon zillii***from two locations**

Although DS reduced the meristic counts to12, a high degree of overlap was found between KO and KEGsamples (Fig. 3). A clear separation was obtained when 3 meristic counts were used (Fig.3). Wilks lambda was extremely highly significant (p<0.000) and the CDFand SCDF explained the high loading of the meristic counts (Table VI).

The reclassification based on 12 meristic counts classified 86.7% and 88.9% of KOand KEG samples respectively with an average of 87.8% (Table VI), while the 3 meristic counts yielded 73.3% and 100% for KO and KEG, respectively with an average of 86.65% (Table VI).



12 meristic traits

3 meristic traits

Fig. 3. Comparison between the mean in *C. zillii* from Kosti, blue lineand Khashm El Girba, green line.

Table 6. The CDF and SCDF of discriminate analysis of *C. zillii* from 3 locations using meristic counts.

Trait	12 meristic		3 meristic		
	CDF 1	SCDF 1	CDF 1	SCDF 1	Loading
DFS	-0.683	-0.237			-0.374
DFR	-0.359	-0.288			-0.284
AFR	0.297	0.144			-0.195
PeFR	0.833	0.473			0.334
ULLS	0.371	0.700			0.075
LATS	-12.407	-0.313			-0.060
TRAS	1.496	0.492	1.569	0.516	0.438*
PVS	0.810	0.446	1.226	0.674	0.425*
CS	-1.140	-0.809	-0.742	-0.526	-0.383*
Significance of Function 1 based on Wilks lambda, DF = 8					
Wilks lambda = 0.235		χ^2= 39.122		Significance = 0.000	

The cluster analysis

To summarize the relationships among the populations of tilapias; a matrix of taxonomic distance that yielded a tree for comparison was made. The matrix showed two main clustering groups. The first group included *S. galilaeus* from SA and *C. zilli* from KO and KEG. The second group consist of two sub cluster, *O. niloticus* from SI and KO and KEG clustering together, while *O. niloticus* from SA and *S. galilaeus* from KO clustering together (Fig. 4).

```
C A S E         0         5        10        15        20        25
  Label     Num +---------+---------+---------+---------+---------+
  S KO        5   -+---+
  S SI        6   -+   +-------------+
  O SA        4   -----+             +-----------------------------+
  O KO        1   -------+-------+   |                             |
  O KH        3   -------+       +---+                             |
  O SI        2   ---------------+                                 |
  T KO        8   -------+-------------+                           |
  T KH        9   -------+             +---------------------------+
  S SA        7   ---------------------+
```

Fig. 4. A dendrogram generated by clustering using arithmetic average analysis of comparison between three cichlids from KO, SI, KEG andAS based on medics count.

IV. DISCUSSION

Individuals of different species that develop in an area would be expected to share a similar phenotype variability, in response to common environmental and genetic influences [20] and [24]. Clear variations in the number of scale above and below the lateral line in traditionally genetically improved and genetically improved farmed *O. niloticus* was found by [9].

The present study showed that Discriminant analysis of meristic counts classified 95.7%, 87.5%, 97.4.3% and 93.8% of *O. niloticus* from KO, SI, KEG and AS, respectively at an overall average of 94%.*Oreochromis niloticus* samples from KEG are clearly separated from KO, SI and AS. The creditability of Discriminant analysis is in agreement with [11] who found in *C. zillii* and *O. aureus* 77.2% of original grouped cases and 76.9% cross validated grouped cases were correctly classified

In Kainji Lake, Nigeria[20] found that all meristic counts were statistically different among *O. niloticus*, *S. galilaeus*, *P. mariae* (spotted tilapia) and *C. zillii* with the latter with more meristic count.According to[7]variability occurred in morphometric and meristic traits in 15 populations of *O. niloticus* and *S. galilaeus* collected from the Blue Nile, White Nile and the Nile in Sudan.Discriminant analysis was applied by [11] to study data for *C. zillii* and *Oreochromis aureus*collected from three locations along Shatt al-Arab River, Iraq. [11] used meristic traits and found that the fish was correctly classified at 74.7% (Wilk's lambda=0.035, p<0.001). They attributed this to environmental and/genetic factors.In line with this are the findings of the present study.

Samples of*O. niloticus* from KEG are clearly separated from KO, SI and AS. This is probably due to high siltation in KEG dam area. Clear overlap between *S. galilaeus* sample from KO and SI but not with AS samples. The latter site is a cataract characterized by highly saturated water due to white water

Coptodon zillii from KO and KEGshowed a high degree of overlap in meristic traits.[20] used the first function and reported broad overlap between *O. niloticus*, *S. galilaeus* and *P. mariae*. *Coptodon zilli* was clearly separate from *S. galilaeus* and *P. mariae* but slightly overlap with *O. niloticus*. When [20] used the second function they found significant overlap of *C. zilli* with all other species while overlap between *O. niloticus* and *S. galilaeus* clearly separated from *P. mariae*. In *Coptodon guineensis* dorsal fin rays and spines, and anal fin ray of population of New Calabar were a slightly more than that of the Buguma Creek [21].

In the present study a dendrogram based on meristic counts data was constructed and showed two main clustering groups. One group included *S. galilaeus* from AS and *C. zilli* from KO and KEG, the second group consisted of *O. niloticus* from all sites and *S. galilaeus* from Kosti and Sinnar. [11] used cluster analysis and principal component analysis and showed that populations of *C. zillii* and *O. aureus* were divided into two group's area wise. Thus clustering analysis should be used in similar studies.

According to [25]meristic characters were less useful than the morphometric data when comparing morphological variability and [26] stated that meristic counts overlapped broadly showing no difference between the populations of *O. niloticus*. This is in marked contrast with present findings and those of [1], [6] and [15].

V. CONCLUSIONS

The results gave an insight to the presence of phenotypic subgroups in the population of *O. niloticus*, *S. galilaeus* and *C. zillii* from the Nile and its tributaries in Sudan. There is need to validate the studyusing other stock identification tools such as truss networkanalysis, genetic markers i.e. mitochondria, DNA, nuclear genome,chemical composition of fish hard parts etc.The findings of this study should be considered incichlidstraditional genetic improvement programmes.

Ethics approval, consent to participateand publish: Notapplicable.
Human and animal rights: Not applicable.
Availability of data and materials: Not applicable.
Conflict of interest: The authors declare no conflict of interest, financial or otherwise.

ACKNOWLEDGEMENTS

Thanks are due to the Ministry of Higher Education and Scientific Research for funding. The facilities provided by Kosti Fish Research Centre, Sinnar Malaria Research Centre, Khashm El Girba Dam Authority are highly appreciated.

REFERENCES

[1]. Rawat, S. Benakappa, S., Kumar, J., Soman, C., et al. (2017). Study on the meristic characteristics and their variations among the population of splendid ponyfish, *Eubleekaria splendens* (cuvier, 1829) along the Indian coast. J. of Exp. Zool., India. Vol. 20: Supplement 1,1549-1552. Accessed June 30, 2020.

[2]. Turan, C., Oral, M., Ozturk, B. &Duzunes, E. (2006). Morphometric and meristic variation between stocks of bluefish (*Pomatomussaltatrix*) in the Black, Marmara, Aegena and Northeastern Mediterranean seas. Fish Res, 79,139-147.

[3]. Mahmoud, Z.N.&Hassan, H.A.(2019). Discriminant Analysis as a Tool for Characterization of *Oreochromis niloticus* (Chiclidae). Cross Current Int J Agri Vet Sci, Aug-Sep, 1(4), 84-90.

[4]. Kamboj, N. & Kamboj, V. (2019). Morphometric and meristic study of four freshwater fish species of river Ganga. The Indian Journal of AanimalSciences. 89(4),470-473. Accessed June 29, 2020.

[5]. Nakamura, T. (2003). Meristic and morphometric variations in fluvial Japanese charr between river systems and among tributaries of a river system. Environ. Biol. Fishes. 66,133-140.

[6]. Saijina, M., Chakraborty, S.K. & Sudbeesan, D. 2013. Morphometric and meristic analyses of horse mackerel, *Megalaspis cordyla* (Linnaeus, 1758) populations along the Indian coast. Indian J. of Fisheries. 60(4), 27-34.

[7]. Hamid, O. M. O. 2017. Estimation of Variation in *Oreochromis niloticus* and *Sarotherodon galilaeus* using Morphometric, Merisitic, Quality Characteristics and Molecular Markers. Ph. D. Thesis. Department of Zoology, Faculty of Science, University of Khartoum, Sudan.

[8]. Francis, M.P. (1981). Meristic and morphometric variation in the lancet fish, *Alepisaurus*, with notes on the distribution of *A. ferox* and *A. brevirostris.* New Zealand Journal of Zoology, 8(3), 403-408, DOI: 10.1080/03014223.1981.10430620

[9]. Nazrul, K.S., Mamun, A., Sarker, B. & Tonny, U. (2011). Morphological variability of the 11th generation strain of Nile tilapia, (*Oreochromis niloticus*) and traditional genetically improved farmed tilapia J. Bangladesh Agril. Univ. 9(2), 345-349.

[10]. Quilang, J.P., Basiao, Z.U., Pagulayan, R.C., Roderos, R. R. et al.(2007). Meristic and morphometric variation in the silver perch, *Leiopotherapon plumbeus* (Kner, 1864), from three lakes in the Philippines, J. of Applied Ichthyology, 23,561-567.

[11]. Jawad, L.A., Habbeb, F.S. & Al-Mukhtar, M.A.)2018). Morphometric and meristic characters of two cichlids, *Coptodon zillii* and *Oreochromis aureus* collected from Shatt al-Arab River, Basrah, Iraq, International J. of Marine Science, 8(2),12-25. DOI:

[12]. Nikolsky, G.V. (1963). The Ecology of Fishes. New York, NY: Academic Press.

[13]. Amundsen, P.A., Bløhn, T. &Vega, G.H. (2004). Gill racer morphology and feeding ecology of two sympatric morphs of European whitefish (*Coreg onuslazarettos*), AnnalsZoologicalFennec, 41,291–300.

[14]. Weisel, G. F. (1955). Variations in the number of fin rays of two cyprinid fishes correlated with natural water temperature. Ecology, 1955, 36:1-6. Accessed June 29 2020.

[15]. Franicevic, M., Sinovcic, G., Cikes, V. & Zorica, B. (2005). Biometry analysis of the Atlantic bonito, *Sarda* (Bloch, 1753) in the Adriatic Sea. ActaAdriatica, 46,213-222.

[16]. Chase, P.D. (2014). Meristics. In: S.X. Cadrin, L.A. Kerr and S. Mariani (Eds) Stock Identification Methods: Applications in Fishery Science, 2nd ed. pp.171-184. AP.

[17]. lanivi, A., Olopade, A., Dienye, H.E., Jimba, B. et al. (2018). Observations on the Morphometric and Meristic Characters of Guinean Tilapia, *Coptodon guineensis* (Günther, 1892) (Family: Cichlidae) from the Buguma Creek and the New Calabar River in Nigeria. Jordan Journal of Biological Sciences. Vol. 11(3), 247-255.

[18]. Taning, V. (1952). Experimental study of meristic characters in fishes. Biological Review, 27: 169-193.https://doi.org/10.1111/j.1469-185X.1952.tb01392.x.

[19]. Templeman, W. and Pitt, T. K. (1961). Vertebral numbers of redfish, *Sebastes marinus* (L.), in the North-West Atlantic, 1947-1954 – ICES Rapp. Proc.-Verb. 150: 56-89.

[20]. Olufeagba, S.O., Aladele, S.E., Okomoda, V.T., Sifau, M.O. et al. (2015). Morphological Variation of Cichlids from Kainji Lake, Nigeria. Int. J. Aqua. Vol.5 (26):1-10.

[21]. Olopade, O.A., Dienye, H.E., Jimba, B. & Bamidele, N.A. (2018). Observations on the Morphometric and Meristic Characters of Guinean Tilapia, *Coptodon guineensis* (Günther, 1892) (Family: Cichlidae) from the Buguma Creek and the New Calabar River in Nigeria. Jordan Journal of Biological Sciences. Vol. 11(3),247-255.

[22]. Abu Gideiri, Y.B. (1984). Fishes of the Sudan, Khartoum University Press, 126pp.

[23]. Bailey, R.G. (1994). A guide to the fishes of the river Nile in the republic of Sudan. Jorn. Nat. Hist. 28,937-970.

[24]. Chambers, R.C. (1993). Phenotypic variability in fish populations and its representation in individual based models. Transactions of the American Fisheries Society, 122,404-414.

[25]. Misra, R.K. & Carscadden, J.E. (1987). A multivariate analysis of morphometries to detect differences in populations of capelin (*Mallotus villosus*). J. du Conseil int.pour l'Exploration de la Mer., 43,99-106.

[26]. Jawad, L. A.; Ibáñez, A. L.; Kiki, M. &Gnohossou, P. (2020). Determination of body shape and meristics characters variations in wild and cultured populations of cichlid fish, *Oreochromis niloticus*, from the Republic of Benin, West of Africa.Fisheries and Aquatic Life. 28(3),186-194.