

## Discriminant Analysis as a Tool for Characterization of *Oreochromis Niloticus* (Chiclidae)

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**Abstract:** The growing demand on *Oreochromis niloticus* as a popular food increased interest in its aquaculture. This necessitated proper differentiation of *O. niloticus* from different localities to help in choosing the best specimens for brood stock production for Nile tilapia farming. Discriminant analysis was used to quantify morphometric measurements and meristic counts of *O. niloticus* from Kosti, Sinnar, Khashm El Girba and Al Sabloga area. Function 1 of Discriminant analysis separated *O. niloticus* sample from Kosti, Sinnar, and Khashm El Girba samples. Function 3 separated Kosti samples from other areas. Function 3 separated Kosti samples from other areas. Function 2 separated Kosti and Khashm El Girba samples from Sinnar and Al Sabloga samples. Discriminant analysis showed high degree of purity of *O. niloticus* with an overall average of 85.1%, this because the specimens from one location sharing characters with other from different location are very few. Wilks lambda analysis showed extremely highly significant difference ( $p < 0.000$ ) between the three functions. This analysis selected 12 morphometric characters (PP, HL, HW, IOW, AFB, CD, LAD, SNL, CPL, ED, CPD and PRP) to be used with high accuracy to discriminate between *O. niloticus* from the four sampling locations. Leave-one-out cross validation for *O. niloticus* from four locations by Discriminant analysis using 19 morphometric characters and 6 meristic counts confirmed the identity of the species.

**Keywords:** Discriminant analysis, characterization, *Oreochromis niloticus*.

## INTRODUCTION

For more than a century, the state-of-the art in fish taxonomy relied largely on external and sometimes on internal morphology in defining and organizing fish into subspecies, species and genera. Advances in numerical taxonomy posted questions about the quality of the results based on the tedious ratio indices [1]. The growing demand on *Oreochromis niloticus* as stable food boosts up interest in its aquaculture [2]. These necessitate proper differentiation of *O. niloticus* from different localities to help in choosing candidate specimens to be used in aquaculture. The objective of this study is to quantify the credibility of morphometric measurement and meristic counts in characterization of *O. niloticus* using discriminant analysis.

## MATERIAL AND METHODS

*Oreochromis niloticus* used in this study were morphologically identified following Abu Gideiri [3]. Live specimens were randomly collected from the commercial fisheries operating at Kosti (White Nile); Sinnar (Blue Nile); Khashm El Girba (Atbara River); and Al Sabaloga (River Nile). 15 meristic counts and 21 morphometric measurements were taken from each specimen (Table 1, Fig. 1). Out of the 15 meristic counts Canonical discriminant analysis selected the number of dorsal fin spines, dorsal fin rays, anal fin rays, pectoral fin rays; the number of scales along the LLS and TRA scale as discriminant characters.

The posterior part of fins was examined carefully for the any thin small fin rays. Morphometric measurements were taken from each fish using a measuring board, a tape and a vernier caliper. Measurements (Table 1) followed Barel *et al.* [4].

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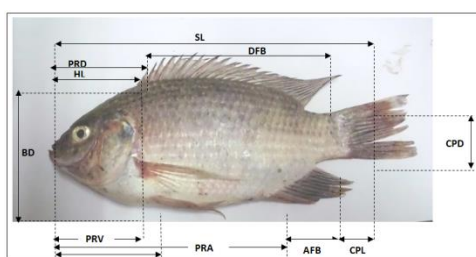
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**Table-1: Description of meristic and morphometric measurements and their abbreviations**

Description	Abbreviation
<b>Meristic counts</b>	
Longitudinal line scale: No. of scales on upper lateral line plus those on the lower lateral line	LLS
Transverse line scales: No. of scale starting from the dorsal fin origin towards the mid ventral line.	TRA
<b>Morphometric measurements</b>	
Standard Length: from the nostral lip of the upper jaw to the midpoint of the origin of the caudal fin (cm).	SL
Body weight (gm)	W
Head Length: from the rostral lip of the upper jaw to the most posterior point of the gill cover margin.	HL
Eye diameter: maximum eye length from the most anterior point to the most posterior point of the orbit.	ED
Head width: with the opercula in a normally adducted position.	HW
Snout Length: from the rostral tip of the upper jaw to the nostral point of the bony border of the orbit.	SNL
Premaxillary Pedical Length: from the nostril tip of the upper jaw to the tip of the ascending process of premaxilla.	PPL
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
Anal fin base length: distance between the most rostral and the most caudal point to the anal fin base.	AFB
Lachrymal depth: from the rostral corner of the bony orbit to the rostral corner of the lachrymal.	LAD
Cheek depth: from the ventral point of the bony margin of the orbit to the dorsal corner of the lower jaw.	CD
Caudal peduncle depth: minimum depth of caudal peduncle.	CPD
Body Depth : maximum depth of the body in front of the pelvic fin, starting from the dorsal fin base in a vertical plain	BD
Inter Orbital Width (IOW): minimum width of the dorsal margin of the bony orbits.	IOW
Prepectoral distance: from the rostral tip of the upper jaw to the most rostral point of the pectoral fin base.	PRV
Preanal distance: from the rostral tip of the upper jaw to the most rostral point of the anal fine base.	PRA
Predorsal distance: from the rostral tip of the upper jaw to the most rostral point of the dorsal fin base.	PRD
Prepelvic distance: from the rostral tip of the upper jaw to the most rostral point of the pelvic fin base.	PRP
Dorsal fin base: distance between the most rostral to the most caudal point of the dorsal fin base.	DFB



**Fig-1: Morphometrics measurements of various body parts**

## RESULTS

It is apparent from (Table 1 and Fig. 2) that:

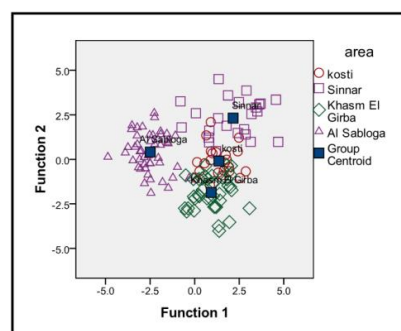
- There is a clear overlap between *O. niloticus* samples from Kosti, Sinnar, and Khashm El Girba. Al Sabloga samples were clearly separated from the rest of localities as indicated by the negative value (-2.453) of function 1 (Table 1).
- Function 2 separated Kosti and Khashm El Girba samples from Sinnar and Al Sabloga samples.
- Function 3 separated Kosti samples from samples from other collection sites.

**Table-1: Discriminant function evaluated at group means (Group Centroids) used to differentiate *O. niloticus* collected from four locations**

Location	Function		
	1	2	3
Kosti	1.363	-0.086	1.714
Sinnar	2.283	2.142	-0.694
Khashm El Girba	0.827	-1.867	-0.551
Al Sabloga	-2.453	0.469	-0.027

Discriminant analysis showed high degree of purity of *O. niloticus* with an overall average of 85.1%. This high purity was attributed to low sharing of characters between specimens from one location with other specimens from different locations as given below:

- One specimen from Kosti samples shared character with Sinnar samples.
- Three specimens from Sinnar samples shared character with Kosti samples and Khashm el Girba samples.
- Three specimens from Sinnar samples shared characters with Khashm El Girba samples.
- Six specimens from Khashm El Girba samples shared character with Kosti samples.
- One specimen from Al Sabloga samples shared characters with Kosti samples and three specimens shared characters with Khashm El Girba samples.



**Fig-2: Scatter plot of discriminant of *O. niloticus* from four location using 19 morphometric characters**

Wilks lambda analysis (Table 2) showed extremely highly significant differences ( $p < 0.000$ ) between the three functions. This analysis selected 12 morphometric characters out of 21, to be used with high accuracy to discriminate between *O. niloticus* from the four sampling locations. These characters are: head

length (HL); head width (HW); eye diameter (ED); premaxillary pedical length (PPI); interorbital width (IOW); anal fin base (AFB); check depth (CD); lacrimal depth (LAD); snout length (SNL); caudal peduncle length (CPL); caudal peduncle depth (CPD) and prepectoral distance (PRP) Fig. 1.

**Table-2: The CDF and SCDF from discriminate analysis of *O. niloticus* from four locations**

Factor	CDF			SCDF			Loading		
	1	2	3	1	2	3	1	2	3
PRV	23.263	-7.854	-12.366	0.410	-0.138	-0.218	0.508*	0.048	-0.215
BD	9.216	17.274	21.993	0.162	0.303	0.386	0.383*	0.229	0.358
W	0.320	-0.183	0.093	0.571	-0.326	0.165	0.365*	-0.073	0.205
PRA	9.621	-15.546	-1.855	0.254	-0.410	-0.049	0.318*	-0.037	-0.161
PRD	13.329	34.880	18.649	0.226	0.591	0.316	0.280	0.486*	-0.030
SL	6.657	24.513	22.541	0.095	0.351	0.323	0.267	0.381*	0.189
DFB	-11.782	28.043	1.446	-0.152	0.361	0.019	-0.214	0.307*	0.134
PP	-0.821	-6.005	9.261	-0.041	-0.298	0.459	-0.127	-0.419	0.478*
HL	-8.863	22.636	-6.027	-0.163	0.415	-0.111	0.134	0.355	-0.467*
HW	23.219	7.296	-36.068	0.305	0.096	-0.473	0.337	0.199	-0.398*
IOW	7.321	0.854	9.750	0.303	0.035	0.403	0.130	-0.082	0.373*
AFB	-5.383	0.836	1.654	-0.426	0.066	0.131	-0.261	0.069	0.323*
CD	-2.208	4.663	1.615	-0.074	0.157	0.054	-0.030	0.157	0.258*
LAD	-6.719	3.813	5.152	-0.218	0.124	0.167	-0.168	-0.011	0.241*
SNL	7.236	-2.459	2.191	0.385	-0.131	0.116	0.044	-0.135	0.228*
CPL	-1.544	5.108	0.272	-0.090	0.299	0.016	-0.093	0.005	0.126*
ED	7.051	-5.985	-2.198	0.329	-0.279	-0.102	0.084	-0.056	0.118*
CPD	-3.764	11.429	-4.310	-0.156	0.474	-0.179	-0.012	0.024	0.107*
PRP	-15.037	-4.953	-8.954	-0.360	-0.119	-0.214	0.028	-0.034	-0.072*
Significance of function 1, 2 and 3 based on Wilks Lambda									
Function	Wilks lambda		Chi-square	DF	Significant				
1	0.040		39.098	57	p<0.000				
2	0.190		202.014	36	p<0.000				
3	0.587		64.748	17	p<0.000				

Leave-one-out cross validation reclassified 82.6%, 75%, 84.6% and 91.6% of Kosti, Sinnar, Khashm El Girba and Al Sabloga specimens, respectively at an average of 85.1% (Table 3).

**Table-3: Leave-one-out cross validation for *O. niloticus* from four locations by Discriminant analysis using 19 morphometric characters**

Data	Site	Predicted Group Membership count and (%)			
		Kosti	Sinnar	Khashm El Girba	Al Sabloga
Cross-validated	Kosti	19 (82.6)	1 (4.3)	3 (13)	0 (0)
	Sinnar	3 (12.5)	18 (75)	0 (0)	3 (12.5)
	Khashm El Girba	6 (15.4)	0 (0)	3 (84.6)	0 (0)
	Al Sabloga	1 (2.1)	0 (0)	3 (6.3)	44 (91.7)

## DISCUSSION

Morphometry in fish taxonomy stemmed from general statements such as the ratio of the upper jaw length to the head length, or the eye diameter is slightly longer than “snout” as can be seen in the work of Sandon [5, 3, 6] to precise measurements between well-defined, mostly bony, reference points [4, 7, 1]. The importance of accurate measuring is to detect the slight morphological differences found between highly similar-looking species [4, 7]. This has practical value in cross breeding for aquaculture purposes.

For descriptive purposes, all measurements are usually expressed as ratio indices of the standard length [7] but sometimes to other measurements [5, 3].

Galman and Aytalion [8] used morphological description and analysis of morphometric measurements and meristic counts to differentiate between *Tilapia* spp. But according to El-Serafy *et al.* [9] morphometric data showed striking similarities and overlapping among *Tilapia* spp., making it impossible to differentiate those species on basis of morphometrics. El-Serafy *et al.* [9] found that meristic counts are more precise in differentiating *O. niloticus*, *O. aureus*, *S. galilaeus* and *T. zilli* from each other. They reported that the lateral line scales differed significantly between these four spp., while the number of rays in the dorsal and anal fins differed significantly ( $p < 0.05$ ) between *S. galilaeus* and *T. zilli*.

The morphological characters of *O. niloticus* in the present study showed typical characteristics to those reported by Sandon [5], Abu Gideiri [3] and Bailey [6]. Due to characters overlap and inter-population variation and small differences among species, Fryer and Eles [10] and Trewavas [11] based their Cichlid classification on variation on dentition, bone structures and general body morphology. The current study provided multivariate data on 21 morphometric measurements and 14 meristic counts and discriminant analysis to outline parameters that are truly important in separating the *O. niloticus* in each location. Discriminant analysis successfully separated *O. niloticus* from Kosti, based on LAD, HW, CPD, PPL and RRD out of 21 morphometric characters. This validity is in line with the results of Murta [12] on *Trachurus irachurus*; Pinheiro *et al.* [13] on *Solea lascaris*; Silva [13] on *Sardina bilchardus*; Saborido-Rey and Nedreaas [14] on *Sebastes mentella* and Vidalis [15] on *Spicara smaris*. In Kosti sample the discriminant characters (dorsal fin spine, dorsal fin soft, lateral scale, TRA scale, anal soft rays and pectoral soft rays) selected by canonical discriminant analysis gave good separation accounting up to 80% classification. The quantification of meristic (a discrete data type set) through discriminant analysis yielded meaningful results unlike correlation run by Ihssen *et al.* [16], Hermida *et al.* [17] and Turan *et al.* [18] which resulted in a low association between meristic characters and standard length.

Gad Kareem [19] compared morphometric characters of *O. niloticus* from Sinnar and Al Sabloga, but made no effort to discriminate these measurements to pinpoint the appropriate characters to be measured. Mohamed [20] studied the taxonomy of *O. niloticus*, *S. galilaeus* and *T. zilli* from Khartoum area using 16 morphometrics and 4 meristic characters, chromosomal number and DNA molecular pattern. The analysis of the morphometric data was based on ratio indices and meristic counts given as non-quantified descriptive data. Mohamed [20] confirmed earlier reports of Sandon [5] but lacked currently accepted approaches based on discriminant analysis; therefore the comparison between her findings and the current work is only possible through classical description.

The present study showed that morphometric studies can successfully discriminate the fish populations from different sampling areas. This is in agreement with the findings of Bailey [21] on flat fish populations; Saborido-Rey and Nedreaas [14] on *Sebastes mentella* and Palma and Andrade [22] on *Diplodus sargus*, *Diplodus punntazo* and *Lithognathus mornurus*.

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