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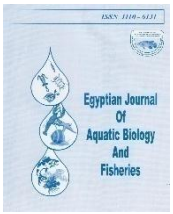

Morphometric and Length-Weight Relationship of the Nile tilapia (*Oreochromis niloticus* (Linnaeus, 1758) from Head Panjnad, Punjab, Pakistan

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ABSTRACT

Morphometric studies address the development, growth, variation, systematics and structure of the population of an organism. In the present study, samples of *Oreochromis niloticus* were collected from Head Panjnad Alipur, Punjab, Pakistan for the analysis of morphometric characteristics. Results showed that the wet weight of fish samples ranged from 4.33 to 9.45g, with a mean value of 7.08 ± 1.49g, while length ranged from 17.5 to 23.6cm, with a mean value of 20.72± 1.56. Correlations between log total length with a log of various morphological parameters, such as wet body weight, standard length, body girth, body depth, head length, pectoral fin length, anal fin length, dorsal fin length and caudal peduncle length were highly significant (P<0.001) and positively correlated. Moreover, the relationship between log total length and some other morphological parameters was found to be unique, such as log pelvic fin length was a significant positive correlation (P<0.01), log eye diameter showed a significant negative correlation (P<0.001), while a non-significant negative correlation was observed for condition factor. Furthermore, the log wet body weight showed a highly significant positive correlation (P<0.001) with standard length, body depth, head length, body girth, pectoral fin length, anal fin length and caudal peduncle length. The correlation among log wet body weight with log dorsal fin length and log eye diameter recorded a highly significant negative correlation (P<0.001). The correlation between log wet body weight and log pelvic fin length was significantly positive (P<0.01). The value of 'b' was 2.66 in a length-weight relationship, suggesting a negative allometric growth for *O. niloticus* and it is significantly lower than the ideal value (b=3.0). The present study provided useful information about the morphometric analysis of *O. niloticus* and the outcomes of the mathematical equation, with relationships of different morphometric relationships. These relationships have great importance in fish conservation.

INTRODUCTION

Morphometry is the type of quantitative analysis in which shape and size of overall body and parts are physically measured. Morphometric measurements are widely used to assess the variation between populations of various fish species. In fish morphometry, measurements of body length, depth, head length, fin length and eye diameter are the most commonly used morphological characters. These measurements provide a lot of important information that is usually described as total, fork and standard length **(Howe, 2002)**.

Furthermore, the morphometric measurements in fish provide useful information to assess the fish stock **(Turan*et al.*, 2004)**. It was reported that, the differences in morphology of fish has greater variability within the species than many other vertebrates **(Allendorf*et al.*, 1987; Wimberger, 1992)**. The identification of environmental and genetic stock in various fish populations through morphometric analysis provided useful information on the variation between the populations resulting from environmental factors and genetic variations. These differences are the ultimate source of natural selection initiated by geographical isolation for a long time period **(McHugh, 1954)**. The human activities, especially the usage of pesticides and fertilizers are exposing the aquatic environment to changes that ultimately boost the differences in fish morphology in various populations. The fish morphological characters respond greatly to changes in environmental factors. However, these responses vary with species.

Oreochromis is a large genus of Family Cichlidae that is mainly endemic to Middle East and Africa. However, some studies have shown that several *Oreochromis* species have been introduced to many new areas of the world. Many species from this genus have a key role in aquaculture. The common name of *O. niloticus* is also shared by the members of genus *Sarotherodon* **(Nagl *et al.*, 2001)**. The first ever fish raised for human consumption is believed to be *O. niloticus*, from about 2,500 years ago **(Chapman, 2000)**. Presently, *O. niloticus* is the third most cultivated fish in aquaculture after carps and salmonids throughout the world. In 2002, the estimated production of *O. niloticus* was 1,505,804 metric tons **(Fessehaye, 2006)**.

Given that morphometric characters of fish varies with location and species, thus this study was designed with the aim of analyzing the morphometric characters of fish species at Head PanjnadAlipur, Punjab, Pakistan since there is no literature available on fish morphometry in this location. In current study, only *O. niloticus* fish species was used.

MATERIALS AND METHODS

A total of 40 samples of *O. niloticus* were used to assess their body sizes. The specimens were collected from Head PunjadAliPur, using a hand net during summer in October 2017. Collected samples of *O. niloticus* were immediately transported live to the Fisheries Research Laboratory, Department of Zoology, Govt. Emerson College, Bosan road, Multan and were killed with a sharp knife below the head. The following parameters were assessed for this study.

Total body length (TL). Total body length was measured for the longest distance in length of fish body from tip of snout to the end of caudal fin. This measurement started from the anterior tip to the posterior tip and included the filamentous prolongations. Notably, measurement is a straight line and did not deviate along the curvature of the body.

Standard length (SL). Standard length is like the total body length i.e. it also includes the shortest distance from snout's tip to caudal fin's base. Furthermore, it starts from most interior part of fish body and end at the last of vertebral column.

Head length (HL). Head length is the longest region from top of head to the most far point of opercular membrane.

Body depth (BD). Depth of body is the deepest region of the fish's body along the vertical line. It is the measurement from the highest region in the back to the strait and deepest region in the body in vertical surface.

Body girth (BG). The widest part of the fish determined via wrapping the measuring tape around the fish.

Eye diameter (ED). Eye diameter is the diameter of eye cup measured with scale.

Dorsal fin length (DFL). Dorsal fin length is the largest length measurement of the fin.

Pectoral fin length (PFL). Pectoral fin length is the length of the longest fin ray of pectoral fin.

Pelvic fin length (PvFL). Pelvic fin length was also measured using a measuring scale.

Anal fin length (AFL). Anal fin length was another parameter to support this study. It stands for the largest length of the anal fin.

Caudal peduncle length (CPL). In fish, the tail refers to the part of body which corresponds to the caudal vertebrae after which the caudal fin is present. Simply, it is the part of the fish body from the vent posteriorly to, but not including the caudal fin. It is also measured and included in this study.

Statistical analysis

The statistical analysis was done using the regression analysis via the following formula:

$$\mathbf{Y= a+bx}$$

Where, a= constant and b= slope, calculation of correlation coefficient standard error of coefficient was carried out by using SPSS (9.2). However, graphics were designed using MS Excel 2013.

RESULTS

External morphometric parameter

Results in Table (1) show that the total length of *O. niloticus* fish, measuring the mean value of 20.72cm and it ranged between 17.5 and 23.6cm. The wet weight had a mean value of 7.08,g and it ranged between 4.33 and 9.45g. Similarly, the mean value of condition factor was 0.08. The standard length of fish had a mean value of 16.85cm, and it ranged from 14.50 to 19.50cm. The pelvic fin length was determined with a mean of 2.66cm, and it ranged between 2.10 and 25.40cm. *O. niloticus* samples were also used to get the head length that was noted with a mean value of 5.45cm, and it ranged between 4.20 and 6.60cm.The mean body girth was recorded with a value of 17.99cm, and it ranged from 15.30 to 20.40cm. For the dorsal fin length, its mean value was 1.81cm ranging from 1.20 to 3.80cm. The pectoral fin length in *O. niloticus* fish was 3.49cm in average, and the mean anal fin length was 1.43 cm. Moreover, the mean value of caudal peduncle length was 4.20cm, ranging between 3.90 and 4.90cm. Body depth of *O. niloticus* samples collected in current study was 8.99cm in mean but it ranged between 7.65 and 10.20cm. Eye diameter was another important parameter of morphometry covered in current study, outcomes showed mean value of0.94cm and ranged between 0.8 and 1.1cm.

The body characters such as; wet weight, head length, standard length, caudal peduncle length, body girth, body depth, eye diameter and condition factor showed the relationship with the total length (TL) of the fish **(Table 2)**.These results showed a strong relationship between total body length in fish with length of various fins including; length of pelvic fin, dorsal fin, pectoral fin and anal fin. In morphometric analysis, the regression analysis showed a positive correlation between all characters to the total length.

Relationship between log total length and log external morphometric parameter

The relationship between log total lengthswith various external morphometric parameters was assessed in this study **(Table 3)**.Currently, ‘b’ was found to be 2.662 for log wet weight against log total length that is significantly lowerthan the ideal value (b=3.0).Therefore, *O. niloticus* fish is supposed to be with negative allometric growth.Moreover, many of the morphometric parameters such as; log wet weight, log head length, log caudal peduncle length, log body girth, log standard length, log body depth, length of log dorsal, pectoral, anal fin length of *O. niloticus* fish were observed to be significantly positive correlated ($p<0.001$) with log total length. However, the log pelvic fin length was significantly positively correlated at ($p<0.01$). Furthermore, the correlation between log total length and log eye diameter was observed to be highly negatively significant ($p<0.001$). The log condition factor was the only factor that remained non-significant and negative when correlated withlog total length in *O. niloticus* fish.

Relationship between log wet body weight and log external Morphometric parameter

The correlation analysis was also done for the analysis of relationship between wet body weight or log wet body weight and many morphometric parameters**(Tables 4 & 5)**. The wet body weight was observed to be highly positively significantly correlated ($p<0.001$) with

log head length, log body girth, log standard length, log pectoral fin length, log body depth, log anal fin length, log caudal peduncle length. Moreover, the correlation among log wet weight with log dorsal fin length and log eye diameter is highly significant negative correlation ($p<0.001$). The correlation among log wet weight with log pelvic fin length was significant positive correlation ($p<0.01$). The correlation between log body weight and log condition factor were non- significant and negative correlation.

Table (1): Measurements of various external morphological structures of *O. niloticus*

Measurements	Mean ± S.D	Range
Total length (TL)	20.72±1.56	17.5 – 23.6
Wet weight (Wet-W)	7.08± 1.49	4.33 – 9.45
Condition factor	0.08 ± 0.01	0.05- 0.10
Standard length (SL)	16.85±1.33	14.50– 19.50
Pelvic fin length (PvFL)	2.66± 0.55	2.10 – 25.40
Head length (HL)	5.45± 0.51	4.20– 6.60
Body girth (BG) cm	17.99±1.38	15.30– 20.40
Dorsal fin length (DFL)	1.81± 0.46	1.20– 3.80
Pectoralfinlength(PFL)	3.49± 0.33	2.90 – 4.20
Anal fin length (AFL)	1.43 ± 0.23	1.00- 2.00
Caudal peduncle length (CPL)	4.20± 0.42	3.90 – 4.90
Body depth (BD)	8.99 ± 0.69	7.65– 10.20
Eye diameter(ED)	0.94 ± 0.07	0.8– 1.1

S.D = Standard Deviation

Table (2): Relationship of total fish length (cm) with various morphometrics of *O. niloticus*

Equation	Parameters a	b	95% CI of a	95% CI of b	R	r^2
Wet wt.=a+b TL	-9.983	0.82	-13.30	0.67	0.861***	0.741
PvFL=a+b TL	3.046	0.059	1.847	0.024	0.449**	0.449
SL=a+b TL	0.271	0.852	-2.362	0.776	0.958***	0.917
K=a+b TL	1.666	-0.014	1.187	-0.027	0.280^{ns}	0.079
HL=a+b TL	0.464	0.188	-1.138	0.142	0.770***	0.592
BG=a+b TL	6.127	0.428	2.168	0.314	0.743***	0.553
DFL=a+b TL	1.691	0.113	0.463	0.463	0.688***	0.473
PFL=a+b TL	2.415	0.080	1.238	0.046	0.575***	0.330
AFL=a+b TL	1.850	0.088	0.567	0.051	0.578***	0.334
CPL=a+b TL	-2.379	0.260	-4.322	0.203	0.808***	0.653
BD=a+b TL	3.064	0.214	1.084	0.157	0.743***	0.553
ED=a+b TL	0.481	0.029	0.099	0.018	0.610***	0.373

a: intercept;b: regression coefficient; Cl: confidence intervals; r: correlationcoefficient; r^2: coefficient of determination; ***: $p < 0.001$; **: $p < 0.01$; ns: $p > 0.05$

Table (3): Relationship of total fish length (cm) with various morphometrics of *O. niloticus*

Equation	Parameters a	b	95% CI of a	95% CI of b	R	r^2
Log Wet wt.=a+b LogTL	-1.415	2.662	-2.031	2.259	0.891***	0.794
Log SL=a+b LogTL	-0.052	0.991	-0.184	0.906	0.960***	0.922
Log PvFL=a+b LogTL	0.122	0.377	-0.226	0.149	0.441**	0.194
Log K=a+b LogTL	0.585	-0.338	-0.031	0.741	0.242^{ns}	0.059
Log HL=a+b LogTL	-0.650	0.968	-0.974	0.756	0.805***	0.647
Log BG=a+b LogTL	0.184	0.738	-0.107	0.547	0.754***	0.569
Log DFL=a+b LogTL	-0.320	0.693	-0.630	0.490	0.712***	0.712
Log PFL=a+b LogTL	-0.092	0.524	-0.432	0.302	0.574***	0.329
Log AFL=a+b LogTL	-0.239	0.602	-0.651	0.333	0.553***	0.306
Log CPL=a+b LogTL	-1.452	1.470	-1.941	1.150	0.806***	0.650
Log BD=a+b LogTL	-0.117	0.738	-0.408	0.547	0.754***	0.569
Log ED=a+b LogTL	-0.834	0.649	-1.223	0.395	0.604***	0.364

Table 4: Relationship of body weigt with various morphometrics of *O. niloticus*

Equation	Parameters a	b	a (95% CI)	b (95% CI)	R	r^2
TL=a+b W	3.014	0.007	2.265	0.006	0.831***	0.691
SL=a+b W	19.452	0.020	17.532	0.016	0.858***	0.736
PvFL=a+b W	4.348	0.001	3.849	0.0005	0.413**	0.171
K=a+b W	1.094	0.0002	0.893	-0.0002	0.170^{ns}	0.029
HL=a+ b W	4.427	0.005	3.777	0.004	0.773***	0.598
BG=a+b W	15.221	0.011	13.591	0.008	0.739***	0.546
DFL=a+b W	3.982	0.003	3.514	0.002	0.737***	0.543
PFL=a+b W	4.085	0.002	3.611	0.001	0.591***	0.350
AFL=a+b W	3.714	0.002	3.191	0.001	0.582***	0.338
CPL=a+b W	3.014	3.014	2.265	0.006	0.831***	0.691
BD=a+b W	7.611	0.006	0.006	0.004	0.739***	0.546
ED=a+b W	0.998	0.001	0.869	0.001	0.756***	0.572

Table 5: Relationship of body weight (g) with various morphometrics of *O. niloticus*

Equation	Parameters a	b	A (95%CI)	B (95% CI)	R	r^2
Log TL=a+b Log Wet-Wt.	-0.553	0.508	-0.820	0.407	0.832***	0.692
Log SL=a+b Log Wet-Wt.	0.669	0.299	0.532	0.248	0.866***	0.750
Log PvFL=a+b Log Wet-Wt.	0.379	0.121	0.174	0.044	0.421**	0.177
Log K=a+b Log Wet-Wt.	-0.211	0.105	-0.571	-0.030	0.225^{ns}	0.051
Log HL=a+b Log Wet-Wt.	-0.021	0.321	-0.213	0.248	0.796***	0.634
Log BG=a+b Log Wet-Wt.	0.664	0.244	0.492	0.180	0.746***	0.557
Log DFL=a+b Log Wet-Wt.	0.083	0.248	-0.085	0.185	0.760***	0.577
Log PFL=a+b Log Wet-Wt.	0.215	0.186	0.023	0.114	0.608***	0.370
Log AFL=a+b Log Wet-Wt.	0.130	0.208	-0.107	0.119	0.570***	0.325
Log CPL=a+b Log Wet-Wt.	-0.553	0.508	-0.820	0.407	0.832***	0.692
Log BD=a+b Log Wet-Wt.	0.363	0.244	0.191	0.180	0.746***	0.557
Log ED=a+b Log Wet-Wt.	-0.559	0.270	-0.747	0.200	0.751***	0.564

DISCUSSION

Current study was conducted on *O. niloticus* fish, collected from Head PanjnadAlipur to observe the most important morphometric characteristics. The morphometric analysis in fisheries is important to observe the fish diversity, distribution and inter-relationship. **Dean *et al.* (2004)** stated that the morphological analysis has key role in taxonomy of organisms and the species diversity. Moreover, it also plays a vital role in identification of systematics, growth variability, ontogeny and population statistics **(Kovac &Copp, 1999; Verep*et al.*, 2006)**. The morphological and phenotypic variations are under the influence of more environmental variations as compared to genetic factors **(Clayton, 1981)**.

Fish phonological changes allow the animal to adopt in environment having environmental variation by modification in behavior and physiology in them. These changes in animal will lead to modification in morphology, survival pattern and reproductive capabilities **(Stearns, 1983; Meyer, 1987)**. These environmentally induced changes will ultimately lead to permanent morphological changes, simply become the genetic of that animal but these changes may need a little bit larger timescale to become fixed in species.

Current study covered some important morphological parameters such as; Total length, Standard length, Wet Weight, Body depth, Body girth, Head length, Eye diameter, length of Pectoral fin length, Length of dorsal fin, length of Pelvic fin, Length of anal fin, and Tail length.Currently, growth rate of various morphological fish body parts as mentioned aboveagainst its total length were also studied. The mean value of total length was 20.72 ± 1.56 that ranged from 17.50 to 23.60 cm in *O. niloticus* fish that were studied in current study. Moreover, total wet weight of *O. niloticus*was observed with mean value 7.08 ± 1.49 and ranged from 4.33 to 9.45g.The results were found to not obey the normal cube law for length and weight relationship in which the value of b must be 3.0 but here in current study the value of b was 2.662 that suggested negative allometric growth in *O. niloticus*. These results were in accordance to the outcomes of many previous studies conducted in different regions of Pakistan in *O. niloticus* species **(Zubia& Rehana, 2011; Nazeer *et al.*, 2015)**.

Various other morphological parameters were also analyzed in present study for analyzing the correlation among them with log total length. These parameters includes; log wet body weight, log standard length, log head length, log body girth, log body depth, log dorsal fin length, log pectoral fin length, log anal fin length, and log tail length. However, all of these parameters were found to be significantly associated ($p<0.001$) with log total length of *O. niloticus* fish. Similar results were also observed in *O. niloticus* species analyzed in study conducted by **Nazeer *et al.* (2015)**. However, they observed a weak correlation between total length of fish and eye diameter but in current study, we observed a strong relation between these parameters. This contrast might be due to variation in species of *O. niloticus*. Furthermore, the location and environmental conditions also influence the morphology of fish greatly.

In current study, we observed a positive correlation between log total length and log pelvic fin length at significant level $p<0.01$. These results were opposite to the observations of some previous studies **(Muhammad *et al.*, 2011; Nazeer *et al.*, 2015)**. Furthermore, the

correlation was also observed for log total fish length and condition factors that wereobserved to be non-significant and negatively associated in *O. niloticus* fish. Likely, the condition factor in relation to body weight was also non-significant in present study. Similar results for relationship of condition factors with total length and body weight were also observed in research conducted by **Hussain *et al*. (2022)**.

Various other morphological parameters such as; log head length, log standard length, log body girth, log body depth, log pectoral, anal fin length, ad caudal fin length were observed to be highly significant ($p<0.001$) and positively correlated with body weight. Body weight has traditionally been regarded as function of length in most of organism especially fish **(Hussain*et al.*, 2016)**. Furthermore, the Correlation among log wet weight along with log dorsal fin length and log eye diameter was highly significant negative correlation ($p<0.001$). The correlation among log pelvic fin length with wet weight was significantly positive correlation ($p<0.01$).

CONCLUSION

Thus the current study has great importance in aquaculture as its outcomes provide the basic and key knowledge in the form of mathematical equation for morphometric measurements of various body parts of *O. niloticus* fish. These outcomes can be used to make conservation laws for *O. niloticus* fish in their natural environment in future. Therefore, this study has importance in fisheries and aquaculture especially its conservation in Panjnad area of Punjab, Pakistan. However, some further studies are needed for the confirmation of our outcomes, especially on other species of *O. niloticus* fish in similar area.

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