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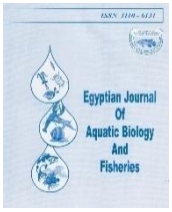

External Morphometric Analysis of Wild *Schizothorax plagiostomus* in Relation to Body Size and Condition Factor From Pakistan

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ABSTRACT

Schizothorax plagiostomus is an essential food and game fish source in Pakistan's mountainous regions, although the species' population has declined in recent years. Morphometric studies play important role in management of sustainable fisheries. 85 *Schizothorax plagiostomus* specimens gathered from the Suleman Mountain Range in the District Dera Ghazi Khan of Punjab, Pakistan, was studied for various external morphometric parameters. All weight-length and length-length relationships demonstrated significant correlation coefficient values following linear regression. However, condition factor reflects non-significant relation with total length and wet body weight ($P > 0.05$). Slope 'b' value indicated isometric growth pattern for majority of parameters.

INTRODUCTION

The fishes belong to the genus *Schizothorax* are usually known as Snow Carps. They belong to subfamily schizothorcinae of the family:Cyprinidae**(Mirza, 2004)**. These are distributed in Central Asia, Jammu and Kashmir, Tibet, Nepal, Iran and Pakistan. 68 species of this group have been recorded worldwide **(He and Chen, 2006)**, and approximately 12 species have been recorded from Pakistan **(Mirza, 2004)**. *Schizothorax plagiostomus* (Heckel, 1838) inhabits mountainous streams and rivers; and have been recorded from different localities of Northern Areas, Khyber Pakhtoon Khwa and Balochistan Provinces in Pakistan. In addition, it has also been found from River Indus and its tributaries. This is an important food and game fish **(Mirza, 2004)**. The population of

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Schizothorax plagiostomus has been reported to undergo decline and declared as vulnerable in Pakistan **(Rafique and Khan, 2012)**.

Morphometrics is the study of an organism's external body components **(Talwar and Jhingran, 1991)**. Morphometric characters are among the key factors for determining fish systematic and growth variability **(Kovac and Copp, 1999)**. Because fish growth differs from species to species and environment to environment, knowing the length-weight relationship of a fish species in a given location is important for fisheries management **(Kulkarni *et al.*, 2007)**. As mass verses length relationship, size of scales verses body length is helpful for calculating the age and growth of fish **(Weatherley, 1972)**. Thus, the two measurements in a fish catch i.e. weight which, in turn, is a role of its length, are more associated and indicate success of fishing industry.

According to our knowledge, no research has been done in Pakistan on *Schizothorax plagiostomus* morphometric analyses. However, morphometric studies of this species from India have been published by different researchers **(Bahuguna *et al.*, 2009; Mir *et al.*, 2013; Jan *et al.*, 2014)**.

The current study aimed to describe external morphometrics in relation to body size and condition factor of wild *Schizothorax plagiostomus* from hilly area of District Dera Ghazi Khan, Punjab, Pakistan.

MATERIALS AND METHODS

A total of 85 wild *Schizothorax plagiostomus* specimens (adults and immature) were gathered from the Suleman Mountain Range, Dera Ghazi Khan District of Punjab, Pakistan, employing a variety of fish gears, including scoop nets, drag nets, cast nets (approximate mesh size 2 cm^2). In plastic bags, the captured fishes were transferred to the Zoology Lab, Government Post Graduate College of Dera Ghazi Khan of Punjab province, Pakistan, where they were examined. The fish were wiped dry using a paper towel and weighed on an electronic balance to the nearest 0.1 g. Several body morphometric measures **(Table, 1)** were taken using a wooden measuring tray with vernier calliper and a millimetre scale.

By applying the formula; $W = aL^b$, length and weight relationships were calculated **(Ricker, 1975)**. Here; 'b' represents growth exponent (regression coefficient), L represents total length in centimeters (cm), 'a' represents as constant, and W represents weight in grams (g). Then, these parameters were changed into logarithmic form with the help of formula; log W = log a + b log L. The condition factor (K) was found by using the formula, $K = W \times 100/L^3$ following **Pauly (1983)**, Here, L = total length and W = wet body weight.

MS Exel with SPSS 20 was used to carry out statistical studies such as regression, correlation coefficients, and regression coefficient comparison.

RESULTS AND DISCUSSION

Table (1) shows the data of central tendency i.e., standard deviation (SD) and means, as well as the range of recorded morphometric values. Wet body weight (W) ranging from 7.06 to 68.02g, having a mean value of 32.00 g. Total length (TL) ranges from 8.09 to 17.21 cm having a mean value of 14.14 cm. Correlations ($P< 0.001$) between W and TL for all morphometric measures were highly significant.

Table 1. Data of central tendency i.e. means ± SD and range of various body measurements of *Schizothorax plagiostomus*.

Body measurements	Means ± SD	Range
Wet body weight (g)	32.00 ± 12.04	7.06-68.02
Total length (cm)	14.14 ± 1.91	8.09-17.21
Standard length (cm)	11.16 ± 1.65	6.09-14.10
Fork length (cm)	12.89 ± 1.80	7.09-15.80
Eye diameter (cm)	0.48 ± 0.04	0.40-0.60
Pre-orbital length (cm)	1.07 ± 0.14	0.75-1.40
Post-orbital length (cm)	1.16 ± 0.15	0.80-1.60
Head depth (cm)	1.96 ± 0.26	1.35-2.60
Head length (cm)	2.72 ± 0.34	1.86-3.60
Pectoral fin base (cm)	0.49 ± 0.05	0.38-0.65
Pectoral fin length (cm)	1.97 ± 0.28	1.36-2.60
Girth length (cm)	7.50 ± 1.22	4.00-10.40
Body depth (cm)	2.66 ± 0.44	1.62-3.59
Pelvic fin base (cm)	0.48 ± 0.08	0.31-0.71
Pelvic fin length (cm)	1.57 ± 0.15	1.25-20.00
Dorsal fin base (cm)	1.36 ± 0.21	0.85-1.90
Dorsal fin length (cm)	1.96 ± 0.24	1.34-2.50
Anal fin base (cm)	0.98 ± 0.18	0.55-1.40
Anal fin length (cm)	2.58 ± 0.46	1.48-3.80
Caudal peduncle width (cm)	1.02 ± 0.14	0.66-1.35
Caudal peduncle length (cm)	1.56 ± 0.24	1.00-2.18
Caudal fin length (cm)	2.90 ± 0.35	2.00-3.7.00

By keeping TL on x-axis along with other morphometric measurements on y-axis, the maximum correlation had been observed for TL vs SL (standard length) ($r = 0.965$, $P < 0.001$) and minimum for TL vs GL (girth length) ($r = 0.853$, $P < 0.001$) **(Table, 2)**. The slope 'b' for TL vs W was obserbed to be 2.90, which indicate optimal fish growth. For

length and weight relationships, the usual range of slope 'b' has been described from 2.5 to 3.5 **(Froese, 2006; Carlander, 1969)**. For various morphometric measures, the slope'b' value ranged from 0.420 to 1.220. For the majority of the parameters, it demonstrated either an isometric (b = 1) or a negative allometric (b<1) growth pattern. But, TL vs AFL (anal fin length) and TL vs AFB (anal fin base) showed positive allometric growth pattern (b > 1).

Table2. Descriptive statistical analysis and regression parameters of total length (cm) with varios morphometrics for *Schizothorax plagiostomus*

Equation	a	b	95 % CL of a	95 % CL of b	R
W = a + b TL	0.014	2.900	0.008-0.023	2.707-3.093	0.957
K = a + b TL	1.393	-0.100	0.838-2.323	-0.293-0.093	0.113
FL = a + b TL	1.009	0.961	0.805-1.265	0.876-1.047	0.926
SL = a + b TL	0.690	1.050	0.586-0.813	0.988-1.112	0.965
PreOL = a + b TL	0.136	0.781	0.108-170	0.694-0.868	0.891
ED = a + b TL	0.160	0.420	0.137-0.185	0.363-0.477	0.849
PostOL = a + b TL	0.149	0.775	0.119-0.186	0.690-0.860	0.894
HL = a + b TL	0.314	0.814	0.264-0.374	0.749-0.880	0.938
HD = a + b TL	0.202	0.858	0.163-0.251	0.776-0.939	0.917
PecFL = a + b TL	0.187	0.888	0.144-0.242	0.790-0.986	0.893
PecFB = a + b TL	0.090	0.645	0.074-0.109	0.572-0.719	0.886
BD = a + b TL	0.169	1.038	0.125-0.229	0.925-1.152	0.894
GL = a + b TL	0.533	0.997	0.376-0.759	0.864-1.130	0.853
PelFL = a + b TL	0.349	0.567	0.288-0.423	0.495-0.639	0.864
PelFB = a + b TL	0.034	1.002	0.026-0.044	0.904-1.101	0.912
DFL = a + b TL	0.265	0.755	0.211-0.331	0.670-0.840	0.889
DFB = a + b TL	0.102	0.976	0.077-0.135	0.870-1.082	0.896
AFL = a + b TL	0.107	1.201	0.078-0.146	1.084-1.318	0.913
AFB = a + b TL	0.039	1.220	0.028-0.054	1.094-1.345	0.905
CPW = a + b TL	0.119	0.081	0.094-0.152	0.718-0.901	0.888
CPL = a + b TL	0.118	0.973	0.088-0.158	0.862-1.084	0.887
CFL = a + b TL	0.388	0.760	0.316-0.475	0.682-0.838	0.906

a = intercept, **b**= slope, **CL**= confidence limits, **r**= correlation coefficient, **K**= condition factor, **W**= wet body weight, **TL**= total length, **SL**= standard length, **FL**= fork length, **PreOL**= pre-orbital length, **PostOL**= post-orbital length, **ED**= eye diameter, **HL**= head length, **PecFL**= pectoral fin length, **HD**= head depth, **PecFB**= pectoral fin base, **GL**= girth length, **BD**= body depth, **PelFL**= pelvic fin length, **DFL**= dorsal fin length,**DFB**= dorsal fin base, **PelFB**= pelvic fin base, **AFL**= anal fin length, **CPW**= caudal peduncle width, **AFB**= anal fin base, **CPL**= caudal peduncle length, **CFL**= caudal fin length

Similarly, by keeping weight (W) on x-axis along with other morphometric measures on y-axis, maximum correlation had been observed for W vs SL ($r = 0.978$, $P < 0.001$) and minimum for W vs FL (fork length) ($r = 0.901$, $P < 0.001$). For the majority of the relationships, slope 'b' values demonstrated either an isometric ($b = 0.33$) or a negative allometric ($b>0.33$) growth pattern. But, W vs BD (body depth), W vs GL, W vs AFL and W vs AFB exhibited positive allometric growth patterns ($b < 0.33$), **(Table,3)**. The value of condition factor (K) had been observed to be 1.08 in the present study, which indicates optimum fish growth. Weight has traditionally been regarded being a function of length in fish **(Hussain *et al.*, 2016)**. A relative 'k' value more than one shows that fish weighs greater than predictable for its length; a relative 'k' value less than one shows that fish weighs less than predictable for its length. The correlation values among K and W ($r = 0.181$) and between K and TL ($r = 0.113$) were non-significant ($P > 0.05$).

Table 3. The descriptive statistical analysis and regression parameters of body weight (g) with various morphometrics for *Schizothorax plagiostomus*.

Equation	a	B	95 % CL of a	95 % CL of b	r
K = a + b W	0.893	0.054	0.721-1.109	-0.009-0.116	0.181
FL = a + b W	4.498	0.308	4.027-5.023	0.276-0.341	0.901
TL = a + b W	4.819	0.315	4.487-5.176	0.294-0.336	0.957
SL = a + b W	3.373	0.351	3.184-3.565	0.334-0.367	0.978
PreOL = a + b W	0.422	0.274	0.394-0.452	0.253-0.294	0.947
ED = a + b W	0.291	0.150	0.277-0.305	0.136-0.164	0.921
PostOL = a + b W	0.468	0.269	0.432-0.498	0.247-0.290	0.939
HL = a + b W	1.054	0.278	1.000-1.109	0.263-0.293	0.970
HD = a + b W	0.705	0.300	0.668-0.743	0.285-0.316	0.973
PecFL = a + b W	0.684	0.310	0.631-0.741	0.286-0.333	0.943
PecFB = a + b W	0.230	0.225	0.216-0.244	0.207-0.243	0.938
BD = a + b W	0.750	0.370	0.697-0.807	0.349-0.392	0.966
GL = a + b W	2.153	0.366	1.968-2.355	0.339-0.392	0.949
PelFL = a + b W	0.794	0.199	0.746-0.847	0.181-0.218	0.920
PelFB = a + b W	0.150	0.343	0.138-0.164	0.318-0.369	0.947
DFL = a + b W	0.794	0.264	0.741-0.853	0.244-0.285	0.943
DFB = a + b W	0.439	0.331	0.394-0.486	0.300-0.362	0.921
AFL = a + b W	0.637	0.410	0.571-0.708	0.378-0.441	0.944
AFB = a + b W	0.236	0.416	0.210-0.265	0.382-0.450	0.936
CPW = a + b W	0.394	0.278	0.362-0.430	0.253-0.303	0.924
CFL = a + b W	1.186	0.263	1.112-1.265	0.244-0.281	0.950
CPL = a + b W	0.499	0.334	0.450-0.553	0.304-0.365	0.923

a = intercept, **b**= slope, **r**= correlation coefficient, **CL**= confidence limits, **K**= condition factor, **W**= wet body weight, **SL**= standard length, **TL**= total length, **FL**= fork length, **PreOL**= pre-orbital length, **ED**= eye diameter, **HD**= head depth, **HL**= head length, **PostOL**= post-orbital length, **PecFL**= pectoral fin length, **PecFB**= pectoral fin base, **BD**= body depth,**GL**= girth length, **PelFB**= pelvic fin base, **PelFL**= pelvic fin length,**DFB**= dorsal fin base, **DFL**= dorsal fin length, **AFL**= anal fin length, **AFB**= anal fin base, **CPW**= caudal peduncle width, **CFL**= caudal fin length, **CPL**= caudal peduncle length

The present information gathered about morphometric measurements and condition factor of *Schizothoraxplagiostomus*will be useful for fisheries and aquaculture management in this area. However, more research on the morphometrics of *Schizothorax plagiostomus* in relation to different habitats, size groups, and gender is needed.

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