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Original Article

Morphometric relationships of length-weight and length-length of farmed *Ctenopharyngodon idella* from Muzaffar Garh, Southern Punjab, Pakistan

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Abstract

Various morphometric characters i.e. total length (TL) standard length (SL), head length (HL), head width (HW), body girth (BG), body depth (BD), Dorsal fin length (DFL), pectoral fin length (P_tFL), pelvic fin length (P_vFL), anal fin length (AFL), eye diameter (ED), caudal fin length (CFL), caudal fin width (CFW) of farmed collected *Ctenopharyngodon idella* were studied to know their correlation with reference to size (TL and W), and types of growth pattern. Correlation coefficient (r) value (0.984) shows high significant relationship between total length and wet body weight, while growth pattern was isometric as value of 'b' being 2.97 (95% confidence interval of b = 2.840 to 3.092) was very close to ideal slope value (b = 3). Highly significant correlationships ($P < 0.001$) were found between body weight versus various morphometric characters. The interrelationship of total length to SL, HL, HW, BG, BD, HW, BG, BD, DFL, P_tFL, P_vFL, AFL, ED, CFL and CFW were highly significant ($P < 0.001$).

Keywords: Length Weight relationship, length length relationship, farming system, Chinese carp

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INTRODUCTION

Morphometry deals with study of variety and change in the organisms form (size and shape) (Webster, 2006). There are various aspects of a living being, like feeding efficiency, locomotion capability, and defenselessness to predators, and reproduction performance which can be observed by body shape examination (Guill *et al.*, 2003). Fishes can adjust according the environmental condition by different adaptations to improve their suitability (Nacua *et al.*, 2010). From a pragmatic perspective, it is vital to observe noticeable morphological characters for use in recognizing species (Bannikov and Tyler, 2008). Fish are exceptionally touchy to natural changes and rapidly adjust by changing fundamental morphometrics (Hossain *et al.*, 2010). Data for the morphometric estimations of fishes and the investigation of factual relationship among them are keys for taxonomic work (Narejo, 2010). The use of phenotypic characters is especially imperative where the distinctions are credited to natural impacts as opposed to hereditary separation (Mir *et al.*, 2013). Morphometric estimations are for the most part displayed as an extent of total, standard and fork length, body weight and condition factor (K) (Naeem *et al.*, 2012; Pervaiz *et al*., 2012).

Talwar and Jhingran (1992) reported that morphometric can be portrayed as outer estimations of living being, a few scientists including Hoque (1984); Gosh *et al.* (1988), Narejo *et al.* (2000); Lashari, *et al.* (2004); Narejo (2010) played out their work on a few parts of morphometric characterization of different fish species from various water habitats of Asiatic region including Pakistan, India and Bangladesh. Length–weight relationships (LWR) are utilized for evaluating the weight relating to a given length, and condition factors are utilized for looking at the condition, heaviness, or prosperity (Tesch, 1968; Froese, 2006) of fish, in view of the suspicion that heavier fish of a given length are in better condition. Egbal *et al*., (2011) expressed that length-weight connections (LWR) give data on the natural surroundings where the fish lives. LWR is a vital device in fish science, physiology, environmental science and fisheries evaluation (Oscoz *et al.,* 2005). Fishbase (Froese and Pauly, 2016) has incorporated LWR parameters for a large

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number of fish species. Up to now, LWRs of 3584 species can be checked in fish base (Froese and Pauly, 2016). The weight (W) of fishes (and different life forms) is exponentially identified with their length (L) as indicated by the condition $W = aL^b$, where "a" denotes intercept while "b" shows slope of the log-transformed relation (Le Cren, 1951; Froese, 2006). A few studies on length-weight relationship have already been reported on different fish species (Talwar and Jhingran, 1991; Wootton, 1990; Naeem *et al.*, 1992; Salam and Naeem, 2004; Yousaf *et al.*, 2009; Naeem *et al.*, 2012; Pervaiz *et al*., 2012; Ishtiaq and Naeem, 2016). The fundamental supposition hidden the utilization of condition components is that fish in better "condition" (nutritious and wellbeing status) are all the more full-bodied and subsequently heavier at a given length.

The present study was conducted to evaluate the various external morphometrics relationships for *Ctenopharangodon idella* (Grass carp) from the farming system of Muzaffar Garh, Pakistan.

MATERIALS AND METHODS

The 72 specimen of experimental fish were collected randomly with the help of cast net from fish ponds in which *Ctenopharangodon idella* (Grass carp) showed increased growth in response to diets having various protein levels from Muzaffar Garh, Southern Punjab, Pakistan. These fishes were transported to Fisheries Research Lab., Institute of Pure and Applied Biology, Bahauddin Zakariya University, Multan.

Morphometric characters were measured with the help of wooden measuring board and measuring scales to the closest 0.01cm.

All the fish samples were weighed on an electronic advanced digital balance closest to 0.01g. Before measuring wet body weight, the fish samples were blotted dry and debris was removed from the surface of fish body.

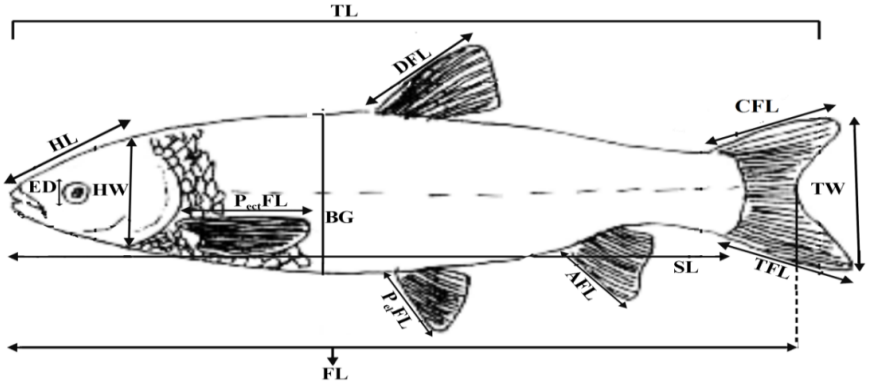

Figure 1: Grass carp: external morphometry and measurements

External morphometry was measured as given in Fig. 1. Their total length (TL) was measured beginning from snout tip to the longest part of caudal blade. Like total length by using wooden measuring board, forked length (FL) was measured from the snout tip to the point of bifurcation of caudal fin. Standard length (SL) is the length of a fish from the tip of the snout to the inception caudal blade. Eye diameter (ED) was taken as separation between the edges of the cartilaginous eye ball over the cornea. Head length (HL) is the length from the nostril tip of nose to the back end of the opercular bone. Head width (HW) is a distance along the broadest part of the head in ventral position. Pectoral find length (PtFL) is the length of the longest find ray of pectoral balance. Body depth (BD) is the most swollen bit of the body and was measured with the assistance of a wooden measuring scale. Body girth (BG) was found by drawing a string around the fish at its widest point stamping where the string covers. After that the separation was measured between the overlapping points on a ruler. Pelvic fin length (PvFL) is the length from anterior of intersection with body to the foremost tip of the blade. Dorsal fin length (DFL) is the length of the longest dorsal fin, fin ray length. Anal fin length (AFL) is the length of the longest fin ray of anal fin. Caudal (tail fin) fin length (CFL) was measured beginning from base of caudal blade to the stature of caudal balance of fish. Caudal/tail fin width (CFW) is the greatest vertical length of tail. Statistical analyses including regression analyses were carried out by using Microsoft Excel.

RESULTS

A total of 72 specimens of *C. idella* were collected and analyzed. The range of wet body weight (g) and total length (cm) was 67.00–722.00, 19.00 – 39.70 respectively. The mean value of weight and total length with standard deviation was 207.66 ± 140.95 and 30.98 ± 35.28. The general form which shows the relationship between wet body weight and total length is exponential and is expressed as

$W = aL^b$ or $Y = a X^b$

Y and X are independent and dependent variable respectively although a and b are intercepts & power. The above expression can be transformed logarithmically as suggested by Le Cren (1951) to:Log W = log a + b log TL

The regression equation for wet body weight (w) and total length (TL) is expressed as:

$W = 1.8766TL^{2.97}$ (Table II; Fig 2) andLogW = 1.8766+2.97 log TL (r=0.984)(Table III; Fig 3).

Table I: Mean (±SD) values and ranges of weight and various external morphology parameters of *Ctenopharyngodon idella.*

Parameters	Mean ± S.D	Range
Wet Body Weight (W)	207.60±140.95	67.00 to 722.00
Total length (TL)	30.98±35.28	19.00 to 39.70.00
Standard length (SL)	20.75 ± 3.86	15.50 to 32.90
Head length (HL)	5.45 ± 1.06	2.90 to 8.40
Head Width (HW)	3.80 ± 0.70	2.80 to 6.00
Body girth (BG)	13.95 ± 2.64	9.00 to 22.00
Body Depth (BD)	6.98 ± 1.36	4.50 to 11.00
Dorsal fin length (DFL)	3.90 ± 0.97	2.50 to 7.00
Pectoral fin length (PtFL)	3.5 8 ± 0.90	2.50 to 6.40
Pelvic fin length (PvFL)	2.96 ± 0.83	1.90 to 5.00
Anal fin length (AFL)	3.07 ± 0.80	1.90 to 5.40
Eye Diameter (ED)	0.99±0.18	0.7 to 1.5
Caudal Fin Length (CFL)	4.64±0.90	3.40 to 7.00
Caudal Fin Width (CFW)	5.76±1.97	3.50 to 12.50

Table II: Descriptive statistics and regression parameters of total length (TL, cm) with weight for farmed *C. idelle* collected from Muzaffar Garh, Southern Punjab, Pakistan.

Equation	Relationship Parameters		95% CI of a	95% CI of b	r	r^2
	a	b				
W = a + b TL	-551.75	30.290	-593.6 to -509.9	28.6 to 31.9	0.975***	0.951
SL = a + b TL	-0.387	0.843	0.843 to 0.292	0.817 to 0.870	0.991***	0.983
HL = a + b TL	0.097	0.213	-0.469 to 0.664	0.191 to 0.236	0.916***	0.839
HW = a + b TL	0.393	0.136	-0.042 to 0.828	0.119 to 0.153	0.885***	0.782
BG = a + b TL	0.010	0.556	-1.038 to 1.059	0.515 to 0.597	0.955***	0.912
BD = a+ b TL	-0.213	0.287	-0.743 to 0.318	0.266 to 0.308	0.957***	0.915
DFL = a + b TL	-0.240	0.165	-1.066 to 0.586	0.133 to 0.198	0.772***	0.596
PtFL = a + b TL	-0.874	0.178	-1.395 to -0.352	0.157 to 0.198	0.901***	0.811
PvFL = a + b TL	-0.761	0.148	-1.413 to -0.109	0.123 to 0.174	0.810***	0.656
AFL = a + b TL	-0.630	0.148	-1.216 to -0.044	0.125 to 0.171	0.837***	0.701
ED = a+ b TL	0.224	0.030	0.071 to 0.378	0.024 to 0.037	0.770***	0.593
CFL = a+ b TL	1.510	0.125	0.576 to 2.444	0.088 to 0.161	0.630***	0.397
CFW= a+b TL	-4.104	0.394	-5.206 to -3.003	0.350 to 0.437	0.908***	0.825

Correlation coefficient (r), coefficient of determination (r^2), intercept (a), regression coefficient (b), CI: confidence intervals, *** $p < 0.001$

Table III: Descriptive statistics and log transformed regression parameters of total length (TL, cm) with weight and different morphometrics for farmed *C. idelle* collected from Muzaffar Garh, Southern Punjab, Pakistan.

Equation	Relationship Parameters		95% CI of a	95% CI of b	r	r^2
	a	b				
Log W = a + b Log TL	-1.88	2.966	-2.05 to -1.70	2.84 to 3.09	0.984***	0.969
Log SL = a + b Log TL	-0.104	1.016	-0.16 to -0.05	0.98 to 1.05	0.989***	0.977
Log HL = a + b Log TL	-0.705	1.029	-0.87 to -0.54	0.91 to 1.15	0.899***	0.808
Log HW = a + b Log TL	-0.703	0.915	-0.884 to -0.521	0.785 to 1.045	0.859***	0.738
Log BG = a + b Log TL	-0.292	1.026	-0.412 to -0.172	0.940 to 1.112	0.943***	0.890
Log BD = a+ b Log TL	-0.625	1.049	-0.746 to -0.504	0.963 to 1.136	0.945***	0.893
Log DFL = a + Log b TL	-0.910	1.069	-1.204 to -0.615	0.858 to 1.280	0.770***	0.593
Log PtFL = a + b Log TL	-1.123	1.196	-1.348 to -0.898	1.035 to 1.357	0.870***	0.758
Log PvFL = a + b Log TL	-1.342	1.291	-1.652 to -1.032	1.069 to 1.513	0.811***	0.657
Log AFL = a + b Log TL	-1.179	1.187	-1.469 to -0.890	0.980 to 1.395	0.806***	0.650
Log ED=a +b Log TL	-1.156	0.821	-1.395 to -0.917	0.650 to 0.993	0.752***	0.566
Log CFL = a+ b Log TL	-0.317	0.700	-0.612 to -0.021	0.488 to 0.912	0.619***	0.383
Log CFW= a+ b Log TL	-1.448	1.571	-1.726 to -1.171	1.372 to 1.770	0.883***	0.780

Table IV: Descriptive statistics and regression parameters of wet body weight and different morphometrics for farmed *C. idelle* collected from Muzaffar Garh, Southern Punjab, Pakistan.

Equation	Relationship Parameters		95% CI of a	95% CI Of b	r	r^2
	a	b				
SL = a + b W	15.231	0.027	14.841 to 15.620	0.025 to 0.028	0.971***	0.943
HL = a + b W	4.081	0.007	3.866 to 4.296	0.006 to 0.007	0.877***	0.769
HW = a + b W	2.903	0.004	2.758 to 3.048	0.004 to 0.005	0.871***	0.758
BG = a + b W	10.306	0.018	9.914 to 10.698	0.016 to 0.019	0.937***	0.877
BD = a+ b W	0.734	0.000	0.719 to 0.748	0.000 to 0.001	0.897***	0.804
DFL = a + b W	2.831	0.005	2.558 to 3.104	0.004 to 0.006	0.748***	0.560
PtFL = a + b W	2.407	0.006	2.236 to 2.579	0.005 to 0.006	0.892***	0.796
PvFL = a + b W	2.016	0.005	1.792 to 2.240	0.004 to 0.005	0.771***	0.594
AFL = a + b W	2.097	0.005	1.906 to 2.287	0.004 to 0.005	0.827***	0.683
ED = a+ b W	0.794	0.001	0.743 to 0.846	0.001 to 0.001	0.736***	0.542
CFL = a+ b W	3.879	0.004	3.567 to 4.191	0.002 to 0.005	0.573***	0.328
CFW= a+ b W	3.152	0.013	2.791 to 3.514	0.011 to 0.014	0.901***	0.812

Correlation coefficient (0.984) is highly significant ($P < 0.001$) between W & TL in both untransformed and transformed (Log) data. The b value (regression coefficient) is 2.97 which is very close to 3.00 and thus matches with an ideal slope value (b=3). Therefore growth was seen to be isometric in farmed collected *C. idella*.The relationship of total length versus standard length (SL) head length (HL) head width (HW), body girth (BG) body depth (BD), dorsal fin length (DFL), pectoral fin length (P_tFL), pelvic fin length (P_VFL), anal fin length (AFL), eye diameter (ED), caudal fin length (CFL), caudal fin width (CFW) were found to be highly significant ($P < 0.01$). The respective coefficient correlation (r) value and b-values are shown in Table II and III**.**All studied morphometric characters showed highly significant relationship ($P < 0.001$) with wet body weight. The values of 'r' with regression coefficient (b) are shown in Table IV and V**.**

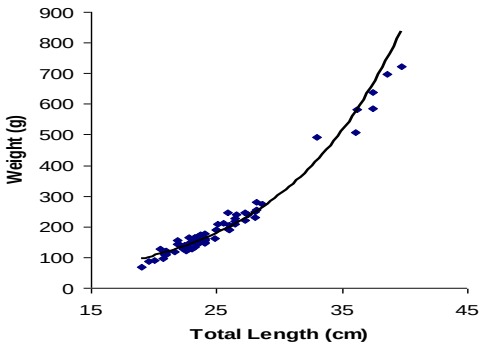

Figure 2: Relationship between total length and wet weight of farmed *C. idella*.

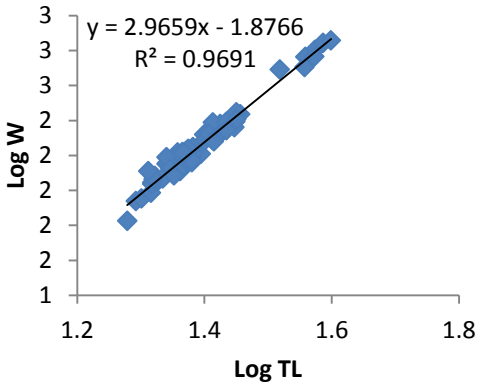

Figure 3: Relationship between log total length and log wet body weight of farmed *C. idella*.

Table V: Descriptive statistics and regression parameters of log transformed wet body weight and different morphometrics for farmed *C. idelle* collected from Muzaffar Garh, Southern Punjab, Pakistan.

Equation	Relationship Parameters a	b	95% CI of a	95% CI of b	r	r^2
LogSL = a + b LogW	0.556	0.335	0.520 to 0.590	0.319 to 0.350	0.981***	0.963
LogHL = a + b LogW	-0.031	0.337	-0.126 to 0.064	0.295 to 0.379	0.887***	0.786
LogHW = a + b LogW	-0.107	0.301	-0.207 to -0.007	0.257 to 0.346	0.852***	0.726
LogBG = a + b LogW	0.357	0.346	0.302 to 0.413	0.321 to 0.371	0.959***	0.919
LogBD = a+ b LogW	0.041	0.353	-0.016 to 0.098	0.328 to 0.378	0.958***	0.917
LogDFL = a + b LogW	-0.191	0.342	-0.358 to -0.024	0.268 to 0.415	0.742***	0.550
LogPtFL = a + b LogW	-0.326	0.385	-0.458 to -0.195	0.327 to 0.444	0.845***	0.715
LogPvFL = a + b LogW	-0.474	0.413	-0.653 to -0.296	0.334 to 0.491	0.781***	0.610
LogAFL = a + b Log W	-0.402	0.389	-0.562 to -0.242	0.318 to 0.459	0.795***	0.633
Log ED = a+ b Log W	-0.616	0.268	-0.748 to -0.485	0.210 to 0.326	0.740***	0.547
Log CFL = a+b Log W	0.169	0.217	0.003 to 0.334	0.144 to 0.290	0.579***	0.335
Log CFW= a+b Log W	-0.415	0.513	-0.574 to -0.257	0.443 to 0.583	0.868***	0.754

DISCUSSION

Morphometric study is fundamental tool for knowing about ontogeny, growth, systematic, variation & demographic characteristics of fish (Kov and Copp, 1999). Morphometric analysis plays a key role to estimate relationship between various parts of body (Carpenter *et al.*, 1996). Coefficient correlation (r) values indicates that all relations of TL with SL, HL, HW, BG, BD, DFL, P_tFL, P_vFL, AFL, ED, CFL and CFW, are highly significance ($P < 0.001$) which show that all length–length relationships (LLRs) are significantly correlated. These highly significant correlations in this study for LLRs are in general agreement with other studies reported on *Oreochromis mossambicus* (Naeem *et al*. 2011a), *Tor putitora* (Naeem *et al*., 2011b) and *Tor macrolepis* (Pervaiz *et al*., 2012). Value of "b" = 1.0 shows an isometric pattern of growth between length to length of various parts of fish body, b > 1 shows allometric growth (positive) while b < 1 for allometric growth (negative). PtFL, PvFL, AFL and CFW indicated b-value more than unity, with TL, representing positive allometric growth. SL, HL, BG, BD and DFL were found to have isometric growth, while negative allometric growth was indicated in HW, ED and CFL in length-length relationships.

The study of length weight relationship (LWR) is also very helpful in knowing the well being growth of fish with their gonadal development (Le Cren, 1951; Pauly, 1993) along with comparative study of fish life histories belonging to various habitats (Petrakis and Stergion, 1995). Regression coefficient between

total length andwet weight in LWR helps to understand type of growth. Fish showing ideal growth having the value of 'b' range 2 – 4, mostly lie close to 3. The b = 3 value of b above or below 3 shows positive and negative allometric growth. In case of positive allometric growth (b greater than 3) fish becomes heavier for its length as fish increase in size, while negative allometric growth (b less or than 3) indicates that fish becomes lighter for r its length as it grows (Tesch, 1968). In the present study the value of b (2.97) being very close to 3.00, shows isometric growth pattern.

The calculated value 'b' (2.97) in LWRs of present study closely matched to the reported value of 'b' by other studies on *Esox Lucius (*b=2.97) by Mann, 1976; *Oreochromis nilotica (*b = 2.99) by Naeem *et al.* (1992); *Puntius cola (*2.82) by Salam *et al.* (2005) and on*Terapon puta* (3.00) by Ahmed and Benzer (2015). However it is different from Lal and Dwivedi (1965); Jhingran (1968); Chatierji *et al.* (1977); Naeem *et al.* (2012), who reported b-value more or less than 3.00. This variation in 'b' value is due to the fact that it is influence of other various factors such as sex, breed, health, seasons, salinity, time of year and maturity, geography, biological factors, pH and DO (Bagenal and Tesch 1978; Muchlisin *et al.*, 2010) and food availability (Ishtiaq and Naeem, 2016).

The results of this study would be helpful for ichthyologists and taxonomists to compare morphometric relationships of farmed and wild captured *Ctenopharyngodon idella.*

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