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Research Article

Length-Weight relationships of *Cyprinus carpio* from the Indus River at Chashma Lake, District Mianwali, Punjab, Pakistan

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Abstract

Length-weight relationships (LWRs) and relative condition factors are of great importance in fishery assessment studies since they provide information about the growth of all fishes. The objective of the present study was to develop the model for predicting length-weight relationship (LWR) length relationship (LLR) and condition factor (K) of *Cyprinus carpio* at Chashma Lake District Mianwali, Punjab, Pakistan. In January 2017, Samples of 43 fish's range in size of 31.00 cm to 60.80 cm were taken to estimate the LWR and LLR. The length of the fish was ranged in size from 31.00 to 60.80 cm with a mean of 43.50 (± 1.98) in TL and from 25.00 to 50.00 cm with a mean range of 35.20 (± 1.87) in SL. The regressions result for LWR were found highly significant (r =0.943; P < 0.001) with coefficients of determination, r^2 = 0.889 showing a highly significant correlation between logs transformed data of TL and W. Slope value (b) of *C. carpio* was found 3.01, which is very close to 3.00, hence representing an isometric growth pattern. In LLR, the SL, BG, DFL, PvFL, and AFB were found isometric (b=1) with TL, HL, PtFL, PtFB, PvFB, AFL, CFL and CFW showed negative allometric growth, while DFB showed positive allometric growth with TL in *C. carpio.* Condition factor (K) remained insignificant with TL and BW.

Keywords: Body girth, condition factor, length-length relationship, length-weight relationship

Introduction

During 2003 - 2004, about 104937 tons of fish and fishery products valued at US$ 156 254 million were exported from Pakistan (FAO 2005). The fisheries and aquaculture sector of Pakistan contributed USD 232.5 million in the GDP (FAO 2008). Today, China accounts for the largest commercial production of *C. carpio*, with approximately 70% of total global production (FAO 2006, FAO 2008). In 2013 the world production of fish was 70 189 848 tons out of which 62 546 664 tons was produced by Asia in which China was at the top in inland fish production with an annual production of 24 817 311 tons of fish which was 60.1% of the total production of the world (FAO 2005). The present study was completed at Chashma Reservoir (Lat: 32° 26' 2 N, Long: 71° 22' 44 E). Chashma Barrage was constructed in 1971 on the River Indus near the village of Chashma. The barrage is 3,536 feet long, with 3,120 feet of the clear waterway, and with a maximum design discharge of 1.1 million cusecs. The maximum flood level height of Chashma Barrage is 37 feet. The barrage has 52 bays, each 60 feet wide. The length of the left and right guide bank is 4,302 ft. These reservoirs provide a huge macro-habitat containing diverse microhabitats occupied by a variety of fish fauna. They deliver shallow waters to the side streams, deep waters in the reservoir areas, stagnant clear waters in hands, fast-flowing waters, side waters with decomposing vegetation, seepage water on the sides, shallow waters with submerged vegetation, side pockets with typha and lotus (Rafique *et al*. 2003, Rafique 2005, Khan 2008).

Cyprinus carpio is also called common carp or Gulfam, which is the common name of *C. carpio* in Pakistan, is the inhabitant of China and Russia, transplanted in the middle ages to Europe and South East Asia. *C. carpio* was first introduced from Thailand to Pakistan in 1964 for aquaculture (Khan *et al*. 2016). It is the most cultured and most domesticated fish around the world. Fish farming of common carp has been carried out in Pakistan since 1970, and now a day it is playing an essential role in the economy of the country by employing more than 400,000 people (Ebrahim 2014, Khan *et al*. 2016). *C. carpio* is temperate water fish and hardy thrives in turbid waters (Kottelat 2007). Common carp fishes are omnivorous, live in the lower water level, and feed on small insects and water plants, benthic worms, crawfish, crustaceans, and zooplankton. Based on its scale's distribution, the fish has been categorized into three different varieties, e.g., the fish having fully covered with big scales are called Scaly Common Carp, the other variety having a single row of big shining scales from the posterior portion of operculum to caudal fin along the dorsal fin and rest of the body remains to scale less such Common Carp is called Mirror Carp. The variety of Common Carp which do not have a single scale on the body and such Common Carp variety is called Leather Carp. This fish is one of the hardest, and it is easy to transport from one place to another. Common carp fish can gain weight up to 0.6 to 1.0 kg within one growing season in the polyculture fish ponds of tropical and subtropical areas. The growth rate is much slower in the temperate zone, where the fish gain weight of 1 to 2 kg after 2 to 4 rearing seasons.

Morphometry of fish enables one to describe complex shapes rigorously and permits numerical comparison between different forms (Webster 2006). Variations in the shape, breed, and origin of any fish species create interest in the scientist to understand them within species and population (Shearer 1994). The length-weight relationship gives an idea about the mathematical relationship between length and weight. Length-Weight relationship (LWR) is also an essential tool in the fishery to study the discreteness and the relationship across various taxonomic categories. These LLR and LWRs are very important in fish management in fisheries for comparative growth studies (Moutopoulos and Stergiou 2002). The variation is influenced by fatness, feeding intensity, or gonadal development of the fish (Rishikanta *et al*. 2015). Length-weight relationships (LWRs) are used to estimate the weight corresponding to a given length, and condition factors are used to compare the condition, fatness, or well-being of fish, based on the assumption that heavier fish of a given length are in better condition (Froese 2006). Variations in environmental conditions and genetic structure lead to morphological variations among different geographical populations (Mirza *et al*. 2012, Sarkar *et al*. 2013). Like LWR and LLR, the size of scales and other calcified tissue of the body plays a vital role in the growth of fishes and by determining the age of fish (LeCren 1951). The LWR and condition factor (K) of a fish species are the parameters that provide the most appropriate information on growth level and on overall fish condition (Okgerman 2005) and help the learner to look at the health of a fish and its community more closely (Richter 2007). LWR of fish species has too many practical applications in fishery and fish management research (Luff and Bailey 2000, Zakaria *et al*. 2000). The regular calculation of the value of condition factor (K) can help assess the fish population's overall health, productivity, and physiology (Blackwell *et al*. 2000, Richter 2007). Condition factors also reflect the other characteristics of the fish, such as physiology, body morphology, lipid contents, and growth rate (Bister *et al*. 2000, Froese 2006, Stevenson and Woods 2006, Rypel and Richter 2008). The present study aimed to analyze the different external morphometric variables concerning body size and condition factor in common carp of *Cyprinus carpio*.

Material and methods

A total of 43 fish specimens were randomly collected from Chashma Lake located on the Indus River in District Mianwali on Dera Ismail Khan Road at an altitude of 32° 25’ N, 71° 22’ in Punjab province that covered an area of 33,109 hectares (Scott 1989). Fish samples were collected by different fishing gears such as drag nets, cast nets, and hand nets with local fishers' help. These fish samples were transported to The University of Lahore (Sargodha) laboratory in an icebox to prevent them from spoilage and then stored in a deep freezer at a temperature of -15 C°. The weight of all these fish specimens was measured using a digital balance (SF-400). Body length measurements such as Total length (TL), Standard length (SL), Head length (HL), and Body Girth (BG) were measured by using fish measuring wooden measuring board to the nearest 0.01cm. Total length (TL) was taken from the tip of the snout to the tip of the tail. The standard length (SL) was chosen as the length from the terminal mouth to the caudal fin's hidden base.

Similarly, head length (HL) was measured as the distance from the most anterior part of the snout to the opercular bones' posterior edge. Body girth was measured by using fiber tape around the most fate area of the body in a circular way. The fin length of fish specimens like dorsal Fin Length (DFL), Dorsal Fin Base (DFB), Pectoral Fin Length (PtFL), Pectoral Fin Base (PtFB), Pelvic Fin Length (PvFL), Pelvic Fin Base (PvFB), Anal fin Length (AFL), Anal Fin Base (AFB), Caudal Fin Length (CFL), and Caudal Fin Width (CFW) were measured by using vernier caliper to nearest 0.01cm. A log-log plot of data was done for all species; outliners were identified and removed (Froese 2006), and redoing of regressions was made. A total of 14 morphometric and meristic variables namely, TL (Total Length), SL (Standard Length), HL (Head Length), BG (Body Girth), DFL (Dorsal Fin Length), DFB (Dorsal Fin Base), PtFL (Pectoral Fin Length), PtFB (Pectoral Fin Base), PvFL (Pelvic Fin Length), PvFB (Pelvic Fin Base), AFL (Anal fin Length), AFB (Anal Fin Base), CFL (Caudal Fin Length), CFW (Caudal Fin Width) are used here to demonstrate the features of Common carp (Naeem *et al*. 2011). The statistical relationship between total length (TL) and total body weight (W) of the fish was derived using the formula (Froese 2006).

$$\text{Log } W = \log a + b \log TL$$

Where W is the weight of fish (g), a is the intercept (constant); TL is the total length of fish (cm), and b is the regression coefficient (slope). Moreover, length-length relationships of different body parts were also calculated by linear regression. The condition factor was calculated with the following formula (Froese 2006).

$$\text{Condition factor } (K) = W/TL^3 \times 100$$

Results

The results of the measurements of body parts, ranges, and indexes of the *Cyprinus carpio* were indicated as a mean (± S.D) as shown in Table 1. Samples of *Cyprinus carpio* were ranged in size from 31.00 to 60.80 cm with a mean of 43.50 (± 1.98) in total length and from 25.00 to 50.00 cm 35.20 (± 1.87) in standard length. The result for the logarithmic relationship of *Cyprinus carpio* between total length (TL) and body weight (W) has been described in Table 2 and Fig. 1 and 2. Regressions of length-weight relationship were highly significant (r = 0.943; P < 0.001) with coefficients of determination, r^2 = 0.889. Slope (b) value was found b=3.01, which is close to 3.00, indicating an isometric growth pattern (Table 2). Morphometric characters, that is, standard length (SL), head length (HL), dorsal fin length (DFL), dorsal fin base (DFB), pectoral fin length (PtFL), pelvic fin length (PvFL), anal fin length (AFL), anal fin base (AFB), caudal fin length (CFL) and caudal fin width (CFW), and Body girth (BG) were found to be highly significant with body weight and total length. Pelvic fin base (PvFB) and Pectoral fin base (PtFB) were to be found least significant with total length. (Tables 2 and 3). In length-length relationships, SL, BG, DFL, PvFL, and AFB were found isometric (b=1) with TL for *Cyprinus carpio.* HL, PtFL, PtFB, PvFB, AFL, CFL, and CFW showed negative allometric growth, while DFB showed positive allometric growth with TL in *C. carpio.* In length-length relationships, SL, BG, DFL, PvFL, and AFB were found isometric (b=1) with TL for *Cyprinus carpio.* HL, PtFL, PtFB, PvFB, AFL, CFL, and CFW showed negative allometric growth, while DFB showed positive allometric growth with TL in *C. carpio.* Condition factor (K) remained insignificant with total length and least significant body weight in *C. carpio* (Tables 2 and 3).

Table 1. Biometric profile of sampled *Cyprinus carpio* from Chasma lake

Body Measurements	**Mean ± SD**	**Range**
Total length (TL)	43.50 ± 1.98	31.00 -60.80
Condition factor (K)	1.61 ± 0.28	0.99 - 2.62
Standard length (SL)	35.20 ± 1.87	25.00 -50.00
Head length (HL)	9.15 ± 1.35	7.10 -12.20
Body girth (BG)	29.97 ± 1.93	22.00 -46.50
Dorsal fin length (DFL)	6.27 ± 1.49	3.30 -9.90
Dorsal fin base (DFB)	13.57 ± 0.61	9.70 -20.00
Pectoral fin length (PtFL)	7.33 ± 1.30	5.10 -10.20
Pectoral fin Base (PtFB)	2.34 ± 0.93	1.10 -4.50
Pelvic fin length (PvFL)	6.44 ± 1.30	4.50 -10.30
Pelvic fin base (PvFB)	2.02 ± 0.68	0.90 -3.10
Anal fin length (AFL)	6.10 ± 1.06	4.00 -8.20
Anal fin base (AFB)	3.07 ± 0.61	1.90 -4.70
Caudal fin length (CFL)	8.61 ± 1.12	7.00 -13.00
Caudal fin width (CFW)	6.50 ± 1.53	4.20 -10.50

Discussion

The estimate of parameter b (3.01) was found within an acceptable range for fish (2.50 to 3.50), as various authors described. Slope value (b) of common carp was found 3.01, which is very close to 3.00, hence representing an isometric growth pattern. Regression slope showed isometric growth (close to 3), indicating that the small specimens have the same form and probably the same condition as large specimens (Froese 2006, Percin and Akyol 2009). The slop value of 'b' for LLR of Common carp was found 1.06, which is very close to one hence representing isometric length (Table 1). The value of slope (b) of Cyprinus carpio is compared with those reported by other investigators for other this species in different regions, as shown in table 4. The correlation coefficient (r) was found to be 0.943, indicating a significant correlation between log-transformed data of total length and weight.

Table 2. Descriptive statistics and regression parameters of total length (TL, cm) with different morphometrics for *Cyprinus carpio*

Equation	Relationship Parameters a	Relationship Parameters b	95% CI of a	95% CI Of b	r	r^2
Log W = a + b Log TL	-1.827	3.017359	-2.37641 to -1.2772	2.68 To 3.35	0.943***	0.889
Log K= a + b Log TL	0.173172	0.017359	-0.37641 to 0.7227	-0.3188 To 0.35359	0.016281	0.000265
Log SL = a + b Log TL	-0.19219	1.06545	-0.26351 to -0.12087	1.02181 To 1.10908	0.991675***	0.98342
Log HL = a + b Log TL	-0.427	0.847381	-0.60403 to -0.24996	0.739071 To 0.955691	0.926787***	0.858935
Log BG = a + b Log TL	-0.23726	1.044751	-0.52436 to 0.049833	0.869106 To 1.220396	0.882459***	0.778734
Log DFL = a + b Log TL	-0.93902	1.055489	-1.53176 to -0.34627	0.692847 To 1.41813	0.676253***	0.457318
Log DFB = a + b Log TL	-0.74434	1.144587	-0.92367 to -0.56502	1.034875 To 1.254298	0.956791***	0.915448
Log PtFL = a + b Log TL	-0.65833	0.928629	-0.99053 to -0.32614	0.725391 To 1.13186	0.821577***	0.674989
Log PtFB = a + b Log TL	-1.20036	0.941256	-2.36519 to -0.03552	0.228608 To 1.653904	0.384543**	0.147874
Log PvFL = a + b Log TL	-0.85302	1.012713	-1.22086 to -0.48518	0.787666 To 1.23776	0.817472***	0.66826
Log PvFB = a + b Log TL	-0.91711	0.732871	-1.99099 to 0.156777	0.075868 To 1.389875	0.33188*	0.110144
Log AFL = a + b Log TL	-0.74559	0.933332	-1.05797 to -0.43321	0.742217 To 1.12444	0.838739***	0.703482
Log AFB = a + b Log TL	-1.15583	1.000726	-1.51301 to -0.79865	0.782204 To 1.219248	0.82218***	0.67598
Log CFL = a + b Log TL	-0.05308	0.603076	-0.30018 to 0.194019	0.451899 To 0.75425	0.782854***	0.612861
Log CFW = a + b Log TL	-0.74621	0.947308	-1.33686 to -0.15555	0.585942 To 1.30867	0.637212***	0.406039

(*=Least significance, **=Significant, ***= Highly significant)

Table 3. Descriptive statistics and regression parameters of total length (W, g) with different morphometrics for *Cyprinus carpio*

Equation	Relationship Parameters a	Relationship Parameters b	95% CI of a	95% CI Of b	R	r^2
Log TL = a + b Log W	0.719485	0.294636	0.617426 to 0.821544	0.261804 to 0.327469	0.942881***	0.889024
Log K= a + b Log W	-0.15845	0.116091	-0.46463 to 0.147723	0.017593 to 0.214589	0.348438*	0.121409
Log SL = a + b Log W	0.59034	0.308774	0.46111 to 0.71957	0.267201 to 0.350348	0.919704***	0.845855
Log HL = a + b Log W	0.129913	0.266687	0.0294 to 0.230419	0.234354 to 0.29902	0.933413***	0.87126
Log BG = a + b Log W	0.360768	0.357374	0.26698 to 0.45455	0.327204 to 0.387543	0.965995***	0.933147
Log DFL = a + b Log W	-0.21668	0.322941	-0.57501 to 0.14165	0.207665 to 0.438216	0.662138***	0.438426
Log DFB = a + b Log W	0.040115	0.349831	-0.08906 to 0.169286	0.308277 to 0.391386	0.935831***	0.87578
Log PtFL = a + b Log W	-0.03505	0.288072	-0.23541 to 0.165316	0.223614 to 0.35253	0.815601***	0.665204
Log PtFB = a + b Log W	-0.85682	0.384938	-1.50482 to -0.20881	0.176473 to 0.593403	0.503267***	0.253278
Log PvFL = a + b Log W	-0.1571	0.308933	-0.38581 to 0.07161	0.235356 to 0.38251	0.798033***	0.636856
Log PvFB = a + b LogW	-0.68711	0.311808	-1.29063 to -0.0836	0.117655 to 0.505961	0.451867**	0.204184
Log AFL = a + b Log W	-0.06591	0.27236	-0.27785 to 0.146038	0.204177 to 0.340544	0.783257***	0.613492
Log AFB = a + b Log W	-0.49613	0.314298	-0.70612 to -0.28613	0.246742 to 0.381855	0.82635***	0.682854
Log CFL = a + b Log W	0.325839	0.19542	0.188025 to 0.463652	0.151085 to 0.239755	0.8118***	0.659019
Log CFW = a + b Log W	-0.32682	0.363667	-0.61022 to -0.04342	0.272496 to 0.454837	0.782828***	0.61282

*=Least significance, **=Significant, ***= Highly significant

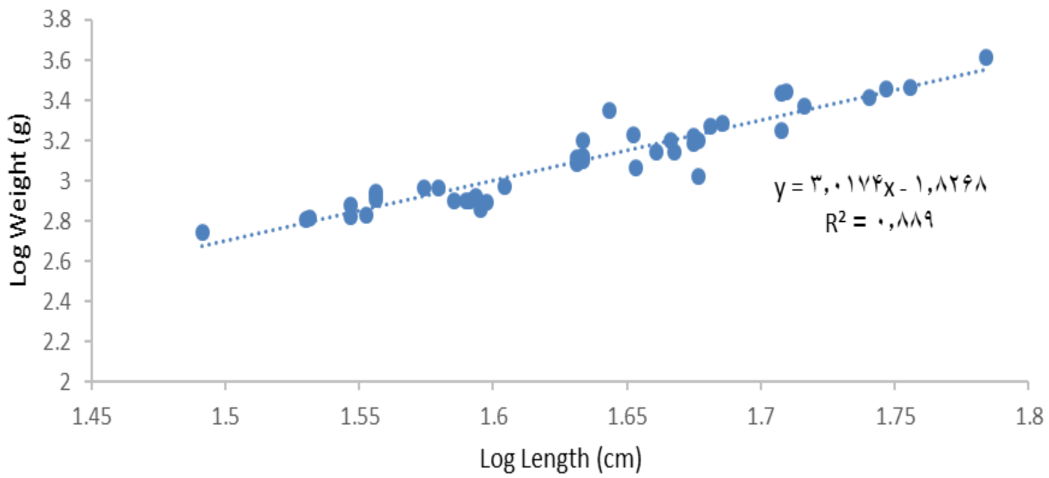

Figure 1. Log length weight relation of *Cyprinus carpio*

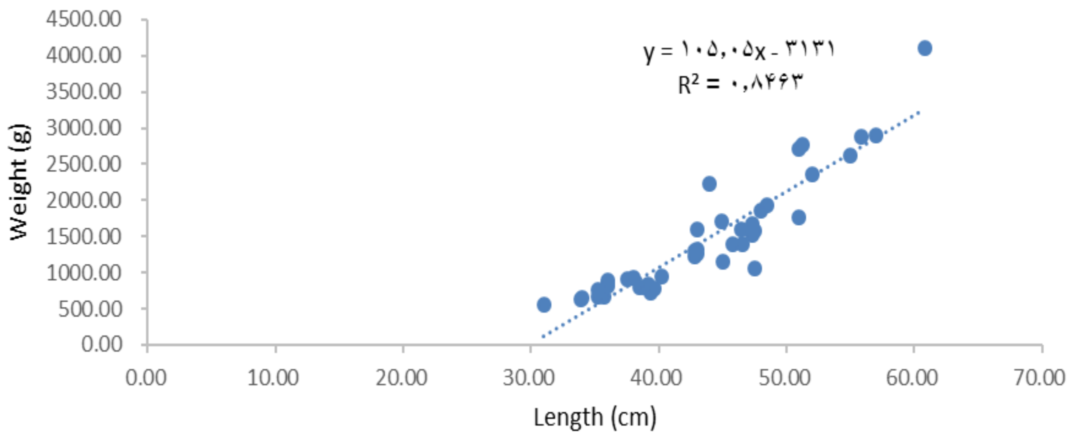

Figure 2 . Length weight relationship of Cyprinus carpio

The variation in the slope value of b may be because the length-weight relationship in fish is affected by a number of factors including biological and environmental conditions, geographical, temporal, and sampling factors (Begenal and Tesch 1978, Froese 2006). Isometric growth was observed in TL, SL, HL, BG,DFL, DFB, PvFL, PvFB, DFL, PtFL, AFL, AFB, CFL and CFW with increasing total length (b = 1). This indicated a proportional growth in these morphometric characters with an increase in total length or body weight. Condition factor (K) has remained non-significant with increasing weight and least significant with total length. When the value of b = 3.0, then the K would remain constant without any change. If, however, the weight increases more rapidly than the cube length, the condition factor would increase with an increase in length (Naeem *et al.* 2011).

Further studies are recommended with a larger sample size from the same and different habitats to the same and different species to validate these results. Table 4 shows the comparison of value 'b' for *Cyprinus carpio* in different localities of the world. The value 'b' in the present study is 3.0, indicating isometric growth for Cyprinus *carpio*, which stated that fish in the Chashma reservoir is in good condition, and a suitable ecosystem is necessary for the isometric growth.

Table 4. Comparison of value of 'b' with the same specie value of b in different localaties

Fish	Location	B	References
Cyprinus carpio	Altınkaya Dam (Turkey)	2.825	Yılmaz *et al.* 2010
Cyprinus carpio	Southern Caspian Sea	3.23	Amouei *et al.* 2013
Cyprinus carpio	Lake Naivasha Kenya	2.3484	Aera *et al.* 2014
Cyprinus carpio	Govindgarh Lake, India.	2.8372	Patel *et al*. 2014
Cyprinus carpio	Lake Ziway, Ethiopia	2.93	Abera *et al.* 2015
Cyprinus carpio	Marmara Lake (Turkey)	2.796	İlhan and Sarı (2015)
Cyprinus carpio	Bheries of South in West Bengal	3.097	Rishikanta *et al.* 2015
Cyprinus carpio	Kızılırmak River Basin (Turkey)	3.138	Sungur Birecikligil *et al.* 2016

Conclusion

This study provided the first data on LWRs and K for *Cyprinus carpio* collected from Chashma Barrage District Mianwali, Pakistan. Almost all LWRs showed an isometric growth, while some samples showed negative growth in HL, PtFL, PtFB, PvFB, AFL, CFL, and CFW, which might be attributed to environmental conditions or linked to morphological characteristic. This study fulfilled the aims set for it, and the data presented might constitute a valuable guideline for establishing future biometric studies for fish collected from Chashma Barrage, Pakistan.

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