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Original Article

Length-weight relationships and condition factor for farmed *Catla catla* (Hamilton, 1822) from southern Punjab, Pakistan

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Abstract

The present study has been carried out to study length-weight relationships (LWRs) and condition factor (K) of renowned and highly commercial freshwater major carp, thaila (*Catla catla*) from farming system. Mean±S.E. total length (TL) and body weight (W) of studied samples have been calculated as 39.29±0.23 cm and 827.43±14.55 g, respectively. For LWRs, specimens of *C.catla* were collected from fish ponds and grouped into three categories on the basis of the feed offered to them which contained 15%, 20% and 25% crude protein (CP). The regression estimates for LWRs were highly significant (P <0.001) with coefficient of determination, r^2-values being >0.930 in the three studied groups and for overall data. The value of the regression coefficient (b) indicated negative allometric growth (b= 2.87), isometric growth (b= 2.95) and positive allometric growth (b= 3.22) for fish fed 15 %, 20 % and 25 % crude protein respectively, and 3.04 for overall data. The results of the present study will contribute to the proper management of this species in the farming system and can be used to fill a gap in the current knowledge in this area.

Key Words: Major carp, *Catla catla*, length-weight relationships, condition factor, farming system

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INTRODUCTION

Studies on morphological characters of fishes are imperative from various perspectives including behavior, ecology, conservation, evolution and water resource management (Başusta *et al*., 2014; Kalhoro *et al*., 2015). Morphometric information has an eminent role in fishery biology involving various trends with the life history of fishes (Ferdaushy and Alam, 2015). Statistical relationships among morphometric measurements of fishes are also very important for both taxonomists (Simon *et al*., 2010) and fishery biologists (Mustafa and Brooks, 2008).

In order to transform data collected in the field into appropriate indices, researchers frequently involve the use of biometric relations (Mendes *et al*., 2004). Length-weight relationships (LWRs) in fisheries management are dominant and widely employed techniques that are used to estimate the biomass (Adarsh and James, 2016). The relationship between length and weight of fish is a commonly used tool in fisheries sciences to estimate mean weight of the fish stock from known length of the group (Le Cren, 1951; Gupta and Banerjee, 2015) by establishing precise mathematical equation between length and weight.

LWR studies are often used to indicate the well being of a fish (Safran, 1992), aquatic habitat (Pauly, 1993) and ecosystem modeling (Kulbicki *et al*., 2005). It is a valuable technique that provides evidence on the spatial distribution of different fish species and reproductive history (Kara and Bayhan, 2008). Moreover, it is also an important prerequisite to determine some aspects of fish population dynamics like age structure and growth pattern *i.e.,* allometric or isometric (Le Cren, 1951; Quist *et al*., 2012). The log-transformed length fitted over weight provides linear growth indicating the three dimensional growth structures of most fish species (Lagler *et al*., 1977).

When the growth is isometric, this implies that the fish species did not increase in weight faster than the cube of their total length. However, when the weight of species increases faster than the cube of their total lengths (*i.e*. value of 'b' more than 3), this describes an increase in width or height of the fish more than its length. Conversely, when the value of 'b' is less than 3, this represents elongated body shape as in large specimens (Froese, 2006).

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Condition factor (K) is commonly used as an indirect morphological indicator for fish farmers and ichthyologists to estimate fish growth. It is an index of feeding intensity and growth (Fagade, 1979) which reveals information on the biological state of fish in relation to its well-being (Abowei, 2010). In terms of nutrition it shows a proper accumulation of fat due to proper feeding. Moreover, it also reveals the appropriateness of a specific water body for fish growth (Le Cren, 1951).

There is wealth knowledge on the LWR on wild *Catla catla* from various water bodies of different geographical regions. However, data is scarce from framed environment, which may be used for comparative growth assessment of this major carp among various habitats. Thus, the present research work was carried out to study LWRs and condition factor of farmed *C. catla*, from southern Punjab, Pakistan.

MATERIALS AND METHODS

A major carp species of native origin, namely, *Catla catla,* was selected for determination of length-weight relationships (LWRs) and condition factor. Fish specimens were collected from fish farms of three different localities of southern Punjab Pakistan, which were Multan (*Latitude*: 30°16'02.19" N; *Longitude*: 71°30'05.76 E), Mianchannu (*Latitude*: 30°25'24.83" N; *Longitude*: 72°18'00.09 E) and Peerowaal (*Latitude*: 30°21'28.25" N; *Longitude*: 72°01'49.78 E). Samples of fish were collected by using drag net. Total length (cm) and wet body weight (g) was measured, on arrival to laboratory, to the nearest 0.1cm and 0.01g, by using wooden measuring tray with centimeter scale and electronic weight balance, respectively.

Studies on length-weight relationship were carried out on three groups of *C.catla* fed on feed containing 15%, 20% and 25% crude protein (CP). Parabolic Cube law equation [Weight (W) = a x Total Length (TL) ^{b}] is mostly used to depict the LWR (Le Cren, 1951). Linear regression [Log W = a + b Log TL] of this cube law equation was adopted to estimate LWRs. Where:

a = intercept of the regression

b = slope or regression coefficient

Moreover, for LWRs, outliers were detected by plotting a straight line graph of log (a) against (b), and regression analyses were redone after excluding outliers. Fulton's condition factor (K) of *C. catla* was calculated using the formula $K= 100 \times W/(TL)^3$. Multiple regression analysis was also performed for total length, weight and condition factor. Data were treated statistically by using MS-Excel and MINITAB for Windows-7.

RESULTS

The length-weight relationships (LWRs) of farmed *Catla catla,* were determined from the log transformed data of total length and body weight (W) for different groups of fish fed three different types of crude protein (CP).

The range and mean with standard error values of total length (TL), body weight (W) and condition factor (K) for a total number of 90 individuals of *C. catla* from three studied groups and overall data are presented in Table I.

Table I: Descriptive statistics for length, weight and condition factor of farmed *C. catla*

Group	Length (cm)		Weight (g)		Condition Factor	
	Range	Mean±SE	Range	Mean±SE	Range	Mean±SE
1	35.00 - 41.90	38.57±0.36	560.55 - 1003.94	775.60±20.71	1.29 - 1.41	1.34±0.01
2	35.00 - 41.70	38.82±0.41	553.48 - 999.04	794.76±24.40	1.27 - 1.42	1.35±0.01
3	37.10 - 42.00	40.48±0.32	681.75 - 1105.77	911.92±23.42	1.28 - 1.50	1.37±0.01
Overall	35.00 - 42.00	39.29±0.23	553.48 - 1105.77	827.43±14.55	1.27 - 1.50	1.35±0.005

The results showed that the highest value of mean TL, W and K for *C. catla* was observed for group-3 in which the fish were fed a diet containing with 25% crude protein (CP). The regression parameters of the length-weight relationships (LWRs) of the farmed *C catla* were analyzed and summarized in Table II. Slope (b-values) for LWRs of *C. catla* were estimated as 2.87, 2.95 and 3.22 for the three groups, respectively and 3.04 for overall data of the

three groups. Coefficient of determination (r^2) was > 0.930 in all LWRs, representing existence of strong correlation. The value of condition factor (K) ranged from 1.27 to 1.50 for groups 1, 2, and 3 with Mean (±S.E) values of 1.34±0.01, 1.35±0.01 and 1.37±0.01 for the three groups respectively, and 1.35±0.005 for overall data.

Multiple regression analysis among total length (cm), weight (g) and condition factor (K) for farmed *C. catla*, was also performed and described in Table III. Highly significant correlation was observed with values of r^2 = 0.928. The value of variance inflation factor (VIF) remained 0.072.

Table II: Descriptive statistics, parameters 'a' and 'b', confidence limits and coefficients of determination of farmed *C. catla*

Group	n	Relationship Parameters		95% CI of *a*	95% CI of *b*	r^2
		a	b			
1	30	-1.6667	2.87	-1.9658 to -1.3676	2.68 - 3.06	0.972
2	30	-1.7878	2.95	-2.1382 to -1.4374	2.73 - 3.17	0.964
3	30	-2.2132	3.22	-2.7578 to -1.6686	2.88 - 3.56	0.931
Overall	90	-1.9333	3.04	-2.1389 to -1.7276	2.91 - 3.17	0.961

n: sample size; a: intercept; b: slope; CI: confidence intervals; r^2: coefficient of determination

Table III: Multiple regression parameters, coefficient of determination and variance inflation factor of farmed *C. catla*

Relationship	*a*	b_1 ± *S.E*	b_2 ± *S.E*	r^2	VIF
$K = a + b_1 W + b_2 TL$	3.51	- 0.084±0.003	0.001±0.00004	0.928	0.072

DISCUSSION

In the present study, a total number of 90 specimens of farmed *Catla catla* with a weight ranging from 553.48-1105.77 g were used for the assessment of LWRs and condition factor. Fish farming in Pakistan is performed with various types of feed inputs containing different levels of crude protein (CP) in the diet. It can be observed from the results that total length and weight for farmed *C. catla* and their mean values were lowest in fishes in group 1 and highest in group 3 due to the presence of higher crude protein level (25%) in the fish diet. These results are in general agreement with the study of Ramaswamy *et al*. (2013) who worked on the same species, *Catla catla* and reported the highest weight of fish fed with a feed containing 25% CP. In the present study, LWRs showed significantly positive correlation in all three groups and for the overall data. Also, the values of coefficient of determination (r^2) in LWRs were greater than 0.930 revealing that these relationships were linear over the observed range of values. In this study the values of the slope (b) were estimated for all three groups and for the overall data. It was found that they were all within the expected range of 2.5 - 3.5 (Froese, 2006). However, the value of (b) was lower than 3.0, very close to 3.0 and higher than 3.0 in the three groups respectively. The variation in the three studied groups may be due to composition of the fish diet (Henderson, 2005). However, slope (b) remained close to 3.0 for overall data revealing isometric growth pattern in farmed *C. catla.* Kartha and Rao (1990) reported similar results describing an isometric growth in *C. catla*. On the other hand, Singh and Lakhwinder (2015) reported positive allometric growth pattern, with a value of (b) of 3.20 for *C. catla* from a Ramsar site of India. Shakir *et al*. (2010) have also mentioned similar growth pattern with a value of (b) 3.18 for this species. These observations clearly show that that value of (b) may vary with the species and habitat suitability (Nieto-

Navarro *et al*., 2010), sample size, the length interval (Morey *et al*., 2003), gonad maturity (Le Cren,1951), sex (Naeem *et al*., 2010) and season (Yeasmin *et al*., 2015).

Condition factor (K) is extensively used to evaluate the living and feeding conditions of fish (Mozsar *et al*., 2015). Fish in better condition commonly have higher (K) value than those in deprived condition. Applicability of (K) factor arises from the assumption that a heavier fish of a specific length contains better energy reserves and accordingly is in a better condition (Bolger and Connolly, 1989). Shakir *et al*. (2010) has also stated that adequately fed fish would have value of condition factor equal to or greater than 1.0, whereas a value of less than 1.0 is attributed to undernourished fish. However, the value of this factor may fluctuate due to different size of fish, feeding intensity (Le Cren, 1951; Thakur, 1975) state of sexual maturity, age and sex of fish (Gomiero 2005) and environmental conditions (Blackwell *et al*. 2000). A study on carps by Shakir *et al*. (2010) indicated mean K value in farmed *C. catla* as 1.20. In the present work, K value found greater than 1.0 which was attributed to adequate supply of food, having good feeding habit and favorable environmental conditions for *C. catla*.

Highly significant value of coefficient of determination for multiple regression analysis (MRA) described positive relationships among weight, total length and condition factor of farmed *C. catla*. *VIF* (Variance inflation factor) are used as an indicator of multi-colinearity. The *VIF* measures how much the variance of an estimated regression coefficient increases if your predictors are correlated (Heckman, 2015). Hence, small value of VIF indicated precise estimates in MRA of the present study.

Conclusion

Results indicated that *Catla catla* attained more weight when fed a higher level of crude protein in its artificial diet in farmed conditions. Furthermore, *C. catla* responded as negative allometric, isometric and positive allometric growth pattern to 15%, 20% and 25% crude protein levels in its diet, respectively, showing a definite effect of diet composition on the fish. The present work provides baseline information on the length weight relationships of farmed *Catla catla* which will be helpful for future management of this major carp in fish farming systems. Moreover, further studies on LWRs of farmed *C. catla* are recommended to provide more comprehensive picture of this species under farming systems.

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