J. Mountain Res. ISSN: 0974-3030
Vol. 12, (2017) 47-53

Observation on the length-weight relationship and relative condition factor of a hill stream fish, *Puntius conchonius* (Ham.-Buch.) from Garhwal Himalaya, India

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Received: 18.07.2017; Revised: 25.10.2017; Accepted: 12.11.2017

Abstract: The present contribution embodies the analysis of length weight relationship and relative condition factor in *Puntius conchonius* (Ham.-Buch.) a minor carp inhabiting Mandal river of Garhwal Himalaya. The study showed that the total length of *P. conchonius* was positively correlated to its weight (r = 0.9176) in case of pooled data. The correlation was also significant for male (r=0.9053) and female (r = 0.9238) sexes separately. The regression coefficient for sex wise and pooled data varied from a minimum of 1.91043 for male to a maximum of 1.99392 for the female. For pooled data it ranged from 1.2980 (r = 0.7875) during monsoon (minimum) to 2.8501 (r = 0.8809) during summer (maximum). The relative condition factor was minimum 0.970±0.001 during (August) in male, 0.911± 0.228 (August) in female and 0.996±0.059 (August) in pooled data. The maximum RCF value of 1.006±0.058 for male, 1.020±0.081 for the female and 1.012±0.069 for pooled data was observed in the month of May. The K_n value was constant during May to July in male and July to September in female fish. Season wise the K_n value was maximum in spring for male (1.0012±0.064) and summer for female (1.0091±0.071) and pooled data (1.0061±0.066).

Keywords: Length-weight relationship • hill stream fish • *Puntius conchonius* • Garhwal Himalaya

Introduction

Length and weight relationship is an important estimation in fish biologication estimation. It has been commonly used for two different purposes. Firstly, to describe the mathematical relationship between length and weight so as to derive one from the other. Secondly, length weight relationship is used to compute the departure from the expected weight for length of the individual fish or a group of fishes as indications of fatness or degree of well being of fish, this relationship is called "condition factor" (Woottan, 1990). This parameter helps to assess the experimental improvements in environment for an existing fish and for the purpose of new stocking. The study of length - weight relationship has its applied value in fish biology to assess the growth of fish in different environments. The length weight relationship also provides an opportunity to calculate an index commonly called

Relative Condition Factor (K_n). Fish with high value of K_n are heavy for its length, while fish with low K_n value are lighter which has been calculated as the ratio between the observed weight and that of the expected weight from the observed length

Various studies were carried out on the length weight relationship and Relative Condition Factor for fish species in India and abroad. The references include Sarojini (1957); Malhotra and Chauhan (1984); Ali et al. (2002); Zafar et al. (2003); Nagesh et al. (2004); Bahuguna et al. (2010); Bahuguna and Joshi (2012); Joshi et al. (2014); Behera et al. (2016).

The present study is a sequence of this chain and is deals with length weight relationship and relative condition factor of *P. conchonius*, which is one of the important aquarium fish of the region. It is for the first time that this species is being studied from Garhwal region.

Materials and Methods

The total length and weight of fish were recorded in fresh condition. However, the other parameters were measured within a fortnight of collection. The length-weight relationship of males and females were analysed separately by grouping them into sex-wise and season-wise. Analysis was also made for pooled data. The equations for the length-weight relationship were computed by using the formula for general parabola:

$$W = a L^n \text{ (Le Cren, 1951)}$$

Where, W = weight of fish, L = length of fish, a and n are the constants

The linearity of regression was tested by the analysis of variance. Based on the data collected and computed for length-weight relationship, the K_n factor was calculated for different sexes month wise and season wise to know the well being of the fish by the formula:

$$K_n = W / \bar{W}$$

Where, K_n = Relative condition factor,

W= observed weight, $\bar{W}$ = calculated weight

Results

Statistical analysis on length-weight relationship for *Puntius conchonius* sex wise, season wise and pooled data is presented in Table 1. The analysis showed that the total length of *P. conchonius* was positively correlated to its weight (r = 0.9176) in case of pooled data. The correlation was also high for male (r = 0.9053) and female (r = 0.9238) sexes separately. The fish samples were also grouped for different seasons and sex wise which showed close relationships between their length and weight. The regression coefficient for sex wise and pooled data varied from a minimum of 1.91043 for male to a maximum of 1.99392 for the female. For season and sex wise it ranged from a minimum 1.3867 (r = 0.7966) during monsoon to 2.7859 (r = 0.9233) during summer (maximum) for male and from 1.2397 (r = 0.7829) in monsoon (minimum) to 2.9260 (r = 0.9612) in spring (maximum) for female fish. For pooled data it ranged from 1.2980 (r = 0.7875) during monsoon (minimum) to 2.8501 (r = 0.8809) during summer (maximum).

Data related to the analysis of variance (F- test) between length and weight relationship for different sexes, different seasons and pooled data presented in Table 2. The values were observed always insignificant at 5% level for different sexes, season and pooled data (sex wise : Male –$F_{0.05}$ = 0.132, Female- $F_{0.05}$ =0.093, pooled data - $F_{0.05}$ = 1.32, season and sex wise: Male - $F_{0.05}$ ranging from $F_{0.05}$ = 0.008 in summer to 0.979 in monsoon, Female - $F_{0.05}$ = 0.012 in spring to 0.632 in summer; pooled data- $F_{0.05}$ = 0.088 in summer to 0.578 in monsoon).

The value of relative condition factor (K_n) was calculated for each fish and finally the average K_n value for different sexes and pooled data during each month was calculated and presented in Table 3. It showed that the relative condition factor was minimum 0.970±0.001 during (August) in male, 0.911± 0.228 (August) in female and 0.996±0.059 (August) in pooled data. The maximum value of 1.006±0.058 for male, 1.020±0.081 for the female and 1.012±0.069 for pooled data were observed in the month of May. The K_n value was constant during May to July in male and July to September in female fish. The average K_n values for male, female and pooled data during different seasons were also calculated (Table 4). The values were maximum during spring (1.0012±0.064) for males and during summer for females (1.0091±0.071) and pooled data (1.0061±0.066). It might be due to sexual maturity. The values were also quite high during autumn and winter, which again indicate the suitability of environment for food availability in the river Mandal.

Table 1 Regression analysis and coefficient of Correlation on length weight relationship of *P. conchonius* based on the fish collected from July 2003 to June 2005.

S. No.	Condition		Parabolic Equation	Correlation Coefficient (R)
1.	Sex wise and Pooled data			
	Male		$W = -7.0487 \ L^{1.91043}$	0.9053
	Female		$W = -7.5444 \ L^{1.99392}$	0.9238
	Pooled data		$W = -7.4088 \ L^{1.96886}$	0.9176
2.	Season and Sex wise			
			Male	
	Winter	(Dec.– Feb.)	$W = -8.0714 \ L^{2.0590}$	0.9002
	Spring	(Mar.–Apr.)	$W = -10.0339 \ L^{2.396\ 9}$	0.9702
	Summer	(May –Jun.)	$W = -12.8099 \ L^{2.7859}$	0.9233
	Monsoon	(Jul. – Aug.)	$W = -3.5792 \ L^{1.3867}$	0.7966
	Autumn	(Sep.–Nov.)	$W = -5.9484 \ L^{1.6792}$	0.9406
			Female	
	Winter	(Dec. – Feb.)	$W = -9.4104 \ L^{2.2382}$	0.9030
	Spring	(Mar. –Apr.)	$W = -13.6629 \ L^{2.9260}$	0.9612
	Summer	(May – Jun.)	$W = -13.5770 \ L^{2.8629}$	0.8298
	Monsoon	(Jul. – Aug.)	$W = -2.6715 \ L^{1.2397}$	0.7829
	Autumn	(Sep. – Nov)	$W = -6.1325 \ L^{1.7528}$	0.9666
			Pooled data	
	Winter	(Dec.– Feb.)	$W = -8.6381 \ L^{2.1354}$	0.9041
	Spring	(Mar.–Apr.)	$W = -11.8399 \ L^{2.6663}$	0.9622
	Summer	(May– Jun.)	$W = -13.3686 \ L^{2.8501}$	0.8809
	Monsoon	(Jul. – Aug.)	$W = -3.0225 \ L^{1.2980}$	0.7875
	Autumn	(Sep.–Nov.)	$W = -6.0236 \ L^{1.7138}$	0.9555

Discussion

In the natural habitat, the weight of a fish increases as the length increases thereby showing that the weight of a fish is a function of its length. Since length is a linear measurement and weight a measure of volume, it was generally found that, for fishes the relation between length and weight could be expressed by the hypothetical cube law, $W=CL^3$. This cubic relationship holds good only in the ideal fish where the specific gravity and form remains unaltered as they grow. According to Le Cren (1951) the fishes normally do not remain of the same shape or body outline throughout their life time and also the specific gravity of the tissues also may not remain constant, hence the actual relationship may sometimes deviate significantly from this cubic relationship. In such fishes it is better to fit general parabolic equation, $W=aL^n$. The study of length–weight relationship have been made by Le Cren (1951) in *Preca fluviatilis* who reviewed the cubic parabola into a general parabola.

Table 2 Analysis of variance (ANOVA) between Length and weight Relationship for different sexes and different seasons in *Puntius conchonius* (Ham-Buch) F Test.

Parameter	S^2B	S^2W	Observed "F"	Table "F"	Remark
For Sexes					
Male	0.156	1.181	0.132	$F_{0.05} = 3.84$; ndf = 1, ddf = 198	NS
Female	0.146	1.559	0.093	$F_{0.05} = 3.84$; ndf = 1, ddf = 233	NS
Pooled Data	0.180	1.361	1.322	$F_{0.05} = 3.84$; ndf = 1, ddf = 433	NS
For Seasons Male					
Monsoon	0.520	0.531	0.979	$F_{0.05} = 4.24$; ndf = 1, ddf = 25	NS
Autumn	0.766	3.014	0.254	$F_{0.05} = 4.00$; ndf = 1, ddf = 47	NS
Winter	0.178	0.783	0.227	$F_{0.05} = 4.00$; ndf = 1, ddf = 47	NS
Spring	0.052	1.941	0.027	$F_{0.05} = 4.08$; ndf = 1, ddf = 38	NS
Summer	0.004	0.491	0.008	$F_{0.05} = 4.08$; ndf = 1, ddf = 33	NS
For seasons Female					
Monsoon	0.423	0.705	0.600	$F_{0.05} = 4.00$; ndf = 1, ddf = 41	NS
Autumn	0.672	4.991	0.134	$F_{0.05} = 4.00$; ndf = 1, ddf = 51	NS
Winter	0.066	2.545	0.026	$F_{0.05} = 4.00$; ndf = 1, ddf = 50	NS
Spring	0.032	2.694	0.012	$F_{0.05} = 4.08$; ndf = 1, ddf = 35	NS
Summer	0.259	0.410	0.632	$F_{0.05} = 4.00$; ndf = 1, ddf = 48	NS
For Pooled data					
Monsoon	0.336	0.581	0.578	$F_{0.05} = 3.92$; ndf = 1, ddf = 68	NS
Autumn	0.794	3.725	0.213	$F_{0.05} = 3.92$; ndf = 1, ddf = 100	NS
Winter	0.116	0.791	0.147	$F_{0.05} = 3.92$; ndf = 1, ddf = 99	NS
Spring	0.020	2.281	0.009	$F_{0.05} = 3.92$; ndf = 1, ddf = 75	NS
Summer	0.080	0.904	0.088	$F_{0.05} = 3.92$; ndf = 1, ddf = 83	NS

NS = Non significant, ndf = numerator degree of freedom (K-1), ddf = denominator degree of freedom. S^2 B and S^2W are two independent estimates of population

Table 3 Monthly fluctuation in Relative condition factor (K_n) for different Sexes and Pooled data of *Puntius conchonius* (Ham-Buch) during July 2003 to June 2005.

Month	Male		Female		Pooled Data	
	Range Min. – Max.	Aver. ± S.D	Range Min. – Max.	Aver. ± S.D	Range Min. – Max.	Aver. ± S.D
Jul.	0.931 -1.056	0.992 ± 0.055	0.913 - 1.048	0.999 ± 0.055	0.942 - 1.097	0.998 ± 0.054
Aug.	0.920 - 0.999	0.970 ± 0.001	0.600 - 1.176	0.911 ± 0.228	0.935 - 1.123	0.996 ± 0.059
Sep.	0.976 - 1.021	0.999 ± 0.022	0.925 - 1.112	0.998 ± 0.079	0.974 - 1.035	0.999 ± 0.028
Oct.	0.861 - 1.342	0.999 ± 0.115	0.769 - 1.112	0.997 ± 0.086	0.718 - 1.517	0.998 ± 0.501
Nov.	0.907 - 1.159	1.000 ± 0.082	0.983 - 1.011	0.999 ± 0.012	0.657 - 1.088	0.998 ± 0.128
Dec.	0.887 - 1.177	1.000 ± 0.078	0.883 - 1.128	0.999 ± 0.069	0.875 - 1.181	1.000 ± 0.072
Jan.	0.869 - 1.128	1.001 ± 0.058	0.887 - 1.118	1.002 ± 0.059	0.863 - 1.124	1.000 ± 0.058
Feb.	0.922 - 1.123	0.999 ± 0.065	0.871 - 1.087	1.002 ± 0.067	0.826 - 1.161	1.001 ± 0.083
Mar.	0.916 - 1.119	1.000 ± 0.075	0.899 - 1.140	1.006 ± 0.060	0.877 - 1.158	1.002 ± 0.078
Apr.	0.881 - 1.059	1.002 ± 0.054	0.890 - 1.105	1.011 ± 0.084	0.848 - 1.150	1.007 ± 0.068
May	0.904 - 1.071	1.006 ± 0.058	0.883 - 1.106	1.020 ± 0.081	0.868 - 1.131	1.012 ± 0.069
Jun.	0.973 - 1.043	0.994 ± 0.029	0.926 - 1.066	1.000 ± 0.050	0.880 - 1.085	1.000 ± 0.062

Min.= Minimum , Max.= Maximum, Aver.= Average, S.D.= Standard Deviation

Table 4 Seasonal fluctuation in Relative condition factor (K_n) for different Sexes and Pooled data in *Puntius conchonius* (Ham – Buch) during July 2003 to June 2005.

Season	Relative Condition Factor (K_n)					
	Range [Male]		Range[Female]		Range [Pooled Data]	
	Min. Max.	Average ± S.D.	Min. Max.	Average ± S.D.	Min. Max.	Average ± S.D.
Monsoon (Jul - Aug)	0.920-1.056	0.9750 ± 0.043	0.600-1.178	0.9572±0.041	0.935-1.123	0.9970±0.049
Autumn (Sep - Nov)	0.861-1.342	1.0010± 0.096	0.769-1.112	0.9891± 0.147	0.657-1.517	0.9985±0.145
Winter (Dec - Feb)	0.869-1.177	0.9999±0.067	0.871-1.128	0.9999±0.064	0.826-1.181	0.9997 ±0.065
Spring (Mar- Apr)	0.881-1.119	1.0012±0.064	0.890-1.140	1.0042±0.070	0.848-1.158	1.0046± 0.081
Summer (May-June)	0.904-1.071	0.9927±0.048	0.883-1.106	1.0091± 0.071	0.868-1.131	1.006 ±0.066

According to Hile (1936) and Martin (1949) the value of "b" may vary from 2.5 to 4.0. If fish retains the same shape it grows isometrically and length exponent "b" has the value 3.0. A value significantly larger or smaller than three shows that fish becomes heavier or lighter for its length as it grows. According to Huxley (1932) and Frost (1945) the changes in the value of "b" may be due to metamorphosis and onset of maturity.

In the present investigation it was observed that regression coefficient (b) of female (1.99392) is found to be slightly higher when compared to that of male (1.91043). From this trend it may be presumed that female gained more weight with increase in length, indicating a better well-being. The "b" values were seasonally high in *Puntius conchonius* as 2.7859 for male, 2.8629 for female and 2.8501 for pooled ta. These higher values were either due to maturation of gonads or due to favorable feeding environment. Sarojini (1957) observed no significant difference in between the two sexes of *Mugil parsia*. Malhotra and Chauhan (1984) while studying the length weight relationship of *Labeo dero* observed that the values of b were 2.4905 for female, 2.0101 for male and 2.2377 for the pooled data.

Narasimha (1970) reported that the value of b was 3.4169 and 3.4369 for male and female of *Trichiurus lepturus.* Chondar (1972) observed the exponent value as 3.1586 in case of *Labeo gonius.* Soni and Kathal (1979) reported the higher value of b as 4.36 for *Cirrhina mrigala* and concluded that it was due to the presence of large quantities of sand and mud in the stomach that resulted in an increase in the total weight. Reddy and Rao (1992), observed a 'n' value (3.028509) more than '3' indicating a good growth of weight in relation to length of *Puntius sophore* from Hussainsagar lake. Zafar et al. (2003), worked on *Catla catla* and observed that weight of fish increases as the cube of length. The value of b=3.02 showed that the fish is growing isometrically in relation to length. The analysis of variance (ANOVA) between length and weight relationship for *Puntius conchonius* was observed as non-significant for sex wise (Male – $F_{0.05}$ =3.84, ddf =198; Female - $F_{0.05}$ =3.84, ddf =233; Pooled data $F_{0.05}$ =3.84, ddf = 433) and season wise data ($F_{0.05}$ ranges from 4.00 to 4.24 in Male, 4.00 to 4.08 for Female and 3.92 in Pooled data).

The condition factor is affected by length as well as several other factors like environment, food supply and degree of parasitism. Le Cren (1951) suggested that the effect of length and its correlated factors may be eliminated by using a relative condition factor (k_n) which is based on the empirical (observed) and calculated length weight relationship. The value of Kn>1 indicates good health of the fish and Kn<1 opposite. In his work on *Percea fluviatilis* he indicated that k_n was function of fatness and condition of gonads. In the present investigation on *Puntius conchonius*, the relative condition factor for male fish was maximum in the month of May (1.006±0.058) and minimum in the month of August (0.970±0.001). For female fish value of RCF was recorded also high in May (1.0020±0.081) and minimum in August (0.911±0.228). In the pooled data maximum value of RCF was also recorded in May (1.012±0.069) and minimum in August (0.0996±0.059). Season wise the K_n value was maximum in spring for male (1.0012±0.064) and summer for female (1.0091±0.071) and pooled data (1.0061±0.066). RCF calculated seasonally highest during Mar-April in male and May-June in female due to the highest maturity of fish. The second peak value was observed during Sept to Nov in male and March to April in female probably due to better feeding period. The lowest K_n value during Monsoon (0.9750±0.043 in male, 0.9572±0.041 for female and 0.9970±0.049 for pooled data) might be due to the fact that during this period mostly the spent or immature fish were available and also the food was rare in nature.

According to Hart (1946), the inflexion point on the K_n value curve is good indicator of size at first sexual maturity. Pillay (1958) reported in *Hilsa ilisha,* that the curve of K_n for females showed a steady increase from July onwards reading the maximum in November thereafter registered a sudden fall. According to Khan et. al (2001) the K_n value was 1.0091 for all the groups in *Hilsa ilisha*. Anibeze (1995) observed that females had higher mean K_n value than males (mean 1.29±0.19 and mean 1.07±0.18, respectively) in *Heterobranchus longifilis*. K_n values were higher in both sexes during the rainy season than the dry season showing that the fish were in better condition during the rainy season. Increased K_n values during the rains have been attributed to food availability and gonadal development in the fish.

Ali et al. (2002) reported that condition factor (K) remains constant with increasing body size for *Channa punctatus* from both sites studied showing that condition factor is not effected at all by increasing body length and mass of fish. They concluded that better living conditions led to improve the condition factor of the fish. According to Nagesh et al. (2004), the average K_n values for *Rohu* , *Catla* and *Mrigal* were found to be 1.02, 1.022 and 1.03 respectively. The K_n values for three species indicate that all three species exhibit healthy and robust condition showing good compatibility with the environment. Raizada et al (2005) also stated that the condition factor (K) and relative condition factor (K_n) showed value around 0.9 to1.0 respectively in the milk fish. They also concluded that though the growth of *Chanos chanos* at various length group intervals is allometric but it seemed to grow well in the in landsline waters with reasonable good plumpness.

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