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Length-Weight Relationship of Snow Trout (*Schizothorax richardsonii*) Based on Linear and Nonlinear Models from Hill Stream of Uttarakhand, India

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Abstract: The present study attempts to develop a comprehensive length weight relationship of snow trout (*Schizothorax richardsonii*) in the tributary of Kosi River from the Ratighat region of Uttarakhand, India. Both linear and non linear regression equations were obtained. Non-linear model fitted to the dataset has shown appropriateness, which follows allometric growth. The condition of the fish is found to be better. In length weight relationship of Snow trout, weight increases in length. Thus it is clear that these fishes maintain its shape throughout its life.

Key words: Nonlinear Model · Condition Factor · Length Weight Relationship

INTRODUCTION

According to Le Cren [1], knowledge of the length-weight relationship of a fish is essential, since various important biological aspects, viz., general well being of fish, appearance of first maturity, onset of spawning, etc., can be assessed with the help of condition factor, a derivative of this relationship. Moreover, the length-weight relationship (LWR) of fish is an important fishery management tool because they allow the estimation of the average weight of the fish of a given length group by establishing a mathematical relationship between the two [2]. As length and weight of fish are among the important morphometric characters, they can be used for the purpose of taxonomy and ultimately in fish stock assessment. In fisheries science, the condition factor or K-factor is used in order to compare the ‘condition’, ‘fatness’ or well being of fish and it is based on the hypothesis that heavier fish of a given length are in better condition [3]. Condition factor is also a useful index for the monitoring of feeding intensity, age and growth rates in fish [4]. Condition factor has been used as an index of growth and feeding intensity [5]. An extensive research on length-weight relationship of commercial freshwater fishes from different water bodies in India is already reported [6-8]. This study reports the LWR of *Schizothorax richardsonii* of Kosi River in Uttarakhand, India.

MATERIALS AND METHODS

The present study was carried out in *Schizothorax richardsonii* taken by cast net fisheries in the tributary of Kosi River from the Ratighat region (29°27.488’N, 79°28.812’E, Altitude- 1033 m asl) located in Kumaun hills of Uttarakhand, India. In this study, a total of 78 fish specimens comprises of *S. richardsonii* ranged from 70-177 mm in length and 4.7-30.0 gm in weight were studied for the length weight relationship. The species were identified by using the key provided by Jhingran [9]. The total length of the fish was measured from the tip of the anterior part of the snout to the end of caudal fin. Fish weight was measured after blot drying. Weighing was done with a tabletop weighing balance, to the nearest gram. The dataset has been analyzed by using SPSS 12.0 Version.

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The relationship between the length (L) and weight (W) of fish is expressed by following equation [10]:

$$W = aL^b \quad (1)$$

Where 'a' and 'b' are the parameters of the above non-linear model. Also, by taking logarithmic transformation on both sides of the above equation, we get the linearized model:

$$\text{Log } W = \log a + b \log L \quad (2)$$

Levenberg- Marquardt method [11] is the most widely used and reliable procedure for computing nonlinear least square estimates and thus used in the present study. However, ordinary least squares method is employed for fitting of the linearized model.

Moreover, summary statistics like R- square are also calculated.

$$R^2 = 1 - \frac{\sum_{t=1}^{n}\left(W_t - \hat{W}_t\right)^2}{\sum_{t=1}^{n}\left(W_t - \bar{W}\right)^2}$$

Where:

W_t = Observed fish weight (in gm);
W = Predicted fish weight (in gm);
W = Average fish weight (in gm);
n = Number of observations & t = 1, 2..., n.

A better model has the larger value of R-square [12]. A change in 'condition factor' or 'K-factor' or 'Ponderal index' has been calculated as follows [13, 14]:

$$K = 10^5 \; W / L^3$$

The relative condition factor (Kn) of samples was also calculated as suggested by Le Cren [1] and the formula is given below:

$$Kn = W / aL^b$$

RESULTS AND DISSCUSION

The two different forms of model (non-linear and linearized forms) are fitted in the length weight relationship analysis of *S. richardsonii*. The estimates of parameter and goodness of fit statistics are presented in Table 1. A better model has the larger value of R-square. The R- square value for nonlinear model is more as compared to its corresponding linearized model. From the above results, we conclude that nonlinear model appears to describe more precisely the length-weight relationship of *S. richardsonii* than the corresponding linearised model, which is illustrated in Fig. 1 along with observed values. The average condition factor (K) and relative condition factor (Kn) for *S. richardsonii* is 0.732488 ± 0.154(K±SD) and 0.753727± 0.154 (Kn±SD) respectively.

It is evident from the results that the 'b' value of length - weight relationship was found 2.68, represents fish that becomes less rotund as length increases, indicating the allometric pattern of growth in the fish. Some of this variation from isometry may be due to the very small specimens that had not yet reached adult body properties being included in the regression. According to Hile [13] and Martin [15], the value of 'b' usually ranges between 2.5 and 4.0. Allen [16] suggested that the value of 'b' remains constant for ideal fish. Hence, *Schizothorax richardsonii* can be considered as 'ideal' (b = 2.68) as per the suggestion of Allen [16]. On plotting the observed average weight of the species against the observed length with a predicted data, a parabolic curve has been obtained (Fig. 1) and a logarithmic graph prepared with the observed data of log l and log w with a predicted data showed a straight line relationship (Fig. 2).

The length weight relationship of *S. richardsonii* (Snow trout) was analyzed in present study. Both linear (R^2=0.92) and non-linear (R^2=0.95) regression equation were obtained. The exponential value for Snow trout is the hypothetical value (3), b value was '2.68' and the correlation coefficient was (>0.9). In length weight relationship of Snow trout, weight increases in length. Thus it is clear that these fishes maintain its shape throughout its life.

Table 1: Summary statistics of the models fitted to length-weight dataset of snow trout (*S. richardsonii*)

	Linearized model: Log W = log a +b log L	Non-linear model: $W = aL^b$
Parameters Estimates		
log a or, a	-4.440 (0.172)	3.11×10^{-5} (0.000)*
b	2.653 (0.085)	2.688 (0.0770)
Goodness of fit Statistics		
R^2	0.92	0.95

*The corresponding asymptotic standard errors are shown in the parentheses

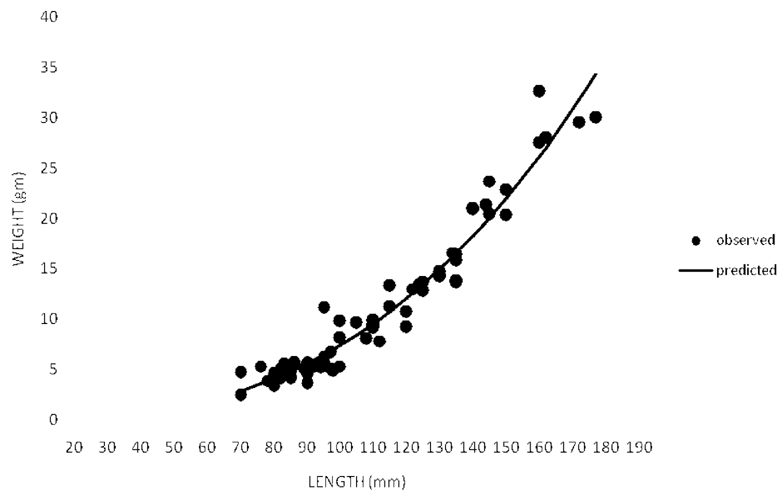

Fig. 1: Fitted Non-linear length - weight model of snow trout (*S. richardsonii*)

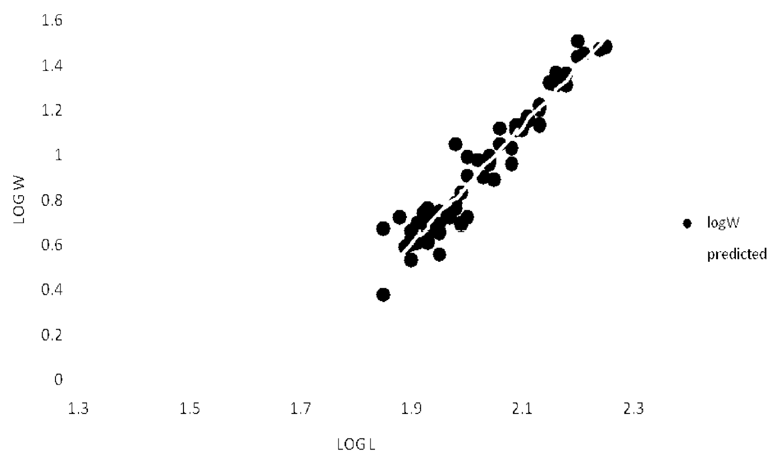

Fig. 2: Fitted Linearized length-weight model of snow trout (*S. richardsonii*)

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