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Length-weight relationship and relative condition factor of some hill stream fishes, India

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Abstract
Knowledge of some quantitative aspects such as length-weight relationship is important in fishery science. During present study four fish species were studied from different streams for length-weight relationship and relative condition factor. The regression coefficient (b) was unique for each species in each stream. It was lower in the streams of smaller dimensions and higher in the streams of larger dimension; *P. conchonius* low in Suswa Mothoronwala, high in Asan Chakmansa, *B. bendelisis* low in Henwal at Khadi, high in Asan at Dharmawala, and *T. putitora* low in Shyampur Khadri Nala, high in Khoh at Kotdwar. However, low and high 'b' values for *S. rupecola* could not be explained on similar grounds because the dimensions of the brooks did not differ. The b value helped to determine allometric or isometric growth in these fishes. *B. bendelisis* shows isometric growth in all streams while *P. conchonius, T. putitora* and *S. rupecola* shows both isometric and allometric growth in different streams. In most of the cases the relationship followed cube law. The Kn values ranged from 0.790 to 1.447 for *B. bendelisis,* 0.713 to 1.627 for *T. putitora*, 0.366 to 1.868 for *P. conchonius* and 0.211 to 1.754 for *S. rupecola.* The highest variation in the Kn value was observed for *P. conchonius* at SuM and *S. rupecola* at Dhundseer Teen Chhade which may be attributed to varied environmental conditions of the streams inhabited by them.

Keywords: Stream dimension, Cube law, Allometric growth, Kn factor, Springfed

1. Introduction
Length-weight relationship is of great importance in fishery assessments as it facilitates conversion of one measure into another [1]. Fisheries management and research often require the use of biometric relationships in order to transform data collected in the field into appropriate indices [2] Length-weight relationship of fishes are important in fisheries and fish biology because they allow the estimation of the average weight of the fish of a given length group by establishing a mathematical relation between them [3,4].
The length-weight relationships study assumes an important prerequisite in fishery biological investigations. It is mainly dealt with to know the variations in expected weight from the known length groups, which are, in turn, the indications of fatness, breeding and feeding state and their suitability to the environment. It also perceived to establish precise mathematical equations between the length and weight. So that if one is measured the other could be computed. This relationship also gives information on the condition of the species, which is a measure of the variation from the expected weight for the particular length of an individual fish. There have been many investigations on length-weight relationship of fishes. Thus the aim of this study was designed to determine the length-weight relationship and the relative condition factor of some hill stream fishes, and compare this relationship for each species obtained from different streams.

2. Materials and Methods
2.1 Sample Collection: Four fish species were collected from 7 streams at 10 stations in lower, middle and upper elevations. The geographical locations of the study area are given in Table1. Each water body was sampled in two seasons; pre monsoon and post monsoon. The samples could not be collected in the monsoon season as high water flow prevents the use of cast nets. The samples were collected with the help of local fishermen by using cast nets and other indigenous traps. The collected samples were preserved in 10% formalin and brought to the laboratory for identification to species level.

Table 1: Geographical co-ordinate of the locations on the rivers/streams of Uttarakhand for sampling fish. The streams are arranged in the order of their gross size, the Dhundseer Gad smallest in size, subsequent ones of increased size, the Asan being the largest.

River	Stations		Latitude (ºN)	Longitude (ºE)	Altitude m (asl)	Fish species
Dhundseer Gad	Teen Chhade	DTc	30º20'	78º45'	1609	*S. rupecola*
	Tapra	DT	30º20'	78º46'	1595	*S. rupecola*
	Udgadu	DU	30º19'	78º46'	1601	*S. rupecola*
Shyampur Khadri Nallah	Shyampur Khadri	SKNS	30º03'	78º13'	350	*T. putitora*
Burhi Tons	Guchupani	BT	30º22'	78º03'	766	*B. bendelisis*
Suswa	Mothoronwala	SuM	30º15'	78º01'	593	*B. bendelisis, P. conchonius*
Khoh	Kotdwar	KhK	29º45'	78º32'	484	*T. putitora*
Henwal	Khadi	HK	30º18'	78º20'	1007	*B. bendelisis*
Asan	Chakmansa	AC	30º20'	77º52'	521	*P. conchonius*
	Dharmawala	AD	30º25'	77º43'	421	*B. bendelisis*

2.2 Length-Weight Relationship: The length-weight relationship was calculated by the method of least square employing the equation of [1]: $W = a. L^b$

Where, W= weight of fish, L= length of fish and 'a' and 'b' are exponents. The same in the logarithmic from is written as: Log W=log a+ b Log L. The equation was log transformed to estimate the parameters 'a' and 'b'. When b is equal to three (3), isometric pattern of growth occurs but when b is not equal to 3, allometric pattern of growth occurs.

2.3 Relative Condition Factor (Kn): The relative condition factor was computed based on empirical length-weight relationship and was calculated by the formula that eliminates the effect of length on Kn.

Kn = W/Wc; where, Kn represents relative condition factor, W observed weight and Wc calculated weight.

3. Results and Discussion: The study of length weight relationship is paramount in fishery science, as it assists in understanding the general well being and growth pattern in fish population. Four fish species collected from different streams and different stations on same stream (Table1) were examined for length-weight relationship and relative condition factor. The 'b' value was unique for each species in each stream. The value of 'b' for *P. conchonius* was lower (2.080) in the small sized stream Suswa at Mothoronwala compared with 3.499 in relatively larger stream Asan at Chakmansa. Similarly, the 'b' values for *B. bendelisis* were lower in the streams of smaller dimensions (3.014 in Henwal Khadi, 3.044 in Suswa Mothoronwala, 3.098 in Burhi Tons at Tapkeshwar) and higher in the stream of larger dimension, (3.320 in Asan Dharmawala). Similarly, in case of *T. putitora* the value of 'b' was low (2.872) in small sized Shyampur Khadri Nala and higher (3.501) in larger Khoh Kotdwar. In case of *S. rupecola* 'b' value was 3.177 in Dhundseer at Udgadu, 3.244 in Dhunseer teen Chhede and 3.936 in Dhunseer at Tapra (Table 2), all branches of Dhundseer Gad in the headwaters. Here, the differences cannot be attributed to stream size as the brooks are similar in dimension and may be attributed to better state of nutrition. However, the observations suggest that the weight of the fish in respect of its length increases at lower rate in streams of smaller dimension and increases with increase in the dimensions of the streams in *P. conchonius B. bendelisis* and *T. putitora*.

Table: 2 Parameters of the relationship (W=aLb) between total length (cm) and total weight (g) of four fish species. Acronyms: DTc- Dhundseer Teen Chhade, DT- Dhundseer Tapra, DU- Dhundseer Udgadu, HK- Henwal Khadi, KhK- Khoh Kotdwar, SuM- Suswa Mothoronwala, AC- Asan Chakmansa, AD- Asan Dharmawala, BT- Burhi Tons Tapkeshwar, SKN- Shyampur Khadri Nala.

Fish	River/ station	Sample size	Length Weight		F	Intercept	b-value	Kn
			Mini-Max	Mini-Max				
B. bendelisis	HK	38	10.8-15	12.9-38.8	399.44	-2.0120	3.014	0.910-1.043
	AD	21	7.5-13	4.3-26.46	915.22	-2.2841	3.320*	0.944-1.065
	SuM	46	6.9-13	3.5-23.9	569.29	-2.0208	3.044	0.916-1.447
	BT	52	5-11.9	14-21.9	5027.85	-2.0457	3.098*	0.790-1.224
T. putitora	KhK	16	5.6-7.3	1.2-3.3	137.81	-2.5647	3.501*	0.713-1.627
	SKN	18	5.8-8.9	1.6-7.1	176.94	-1.9137	2.872	0.730-1.156
P. conchonius	SuM	23	2.9-5.8	0.6-2.3	111.12	-1.2104	2.080*	0.366-1.868
	AC	46	2.5-6.1	0.1-3.9	913.04	-2.1442	3.499*	0.397-1.567
S. rupecola	DTc	42	2.4-6.5	0.1-1.94	529.38	-2.2379	3.251*	0.211-1.754
	DT	27	2.8-7.2	0.2-3.64	2417.32	-2.0235	2.936	0.238-1.179
	DU	26	3.5-7.2	.15-3.64	228.51	-2.2182	3.177*	0.510-1.681

***** 'b' differs significantly from 3.

The comparison of 'b' values obtained for each species from respective locations revealed significant differences at 5% level for *B. bendelisis, T. putitora* and *S. rupecola* for most of the locations (Table 3). The b value was also used to determine whether the fish is growing allometrically or isometrically. The examination revealed isometric and allometric growth in Asan chakmansa and Suswa Mothoronwala respectively for *P. conchonius*, while isometric growth in *B bendelisis* for all streams. In case of *T. putitora* isometric growth was observed for Khoh Kotdwar while allometric growth for Shyampur Khadri Nala. Pandy and Lala [5] also reported isometric growth in *B. bendelisis* from Garhwal region. Nautiyal [6] observed isometric growth for *T. putitora* from Garhwal region. In case of *S. rupecola* the growth was allometeric in Dhunseer at Tapra while isometric in Dhunseer Teen Chhade and Dhunseer Udgadu.

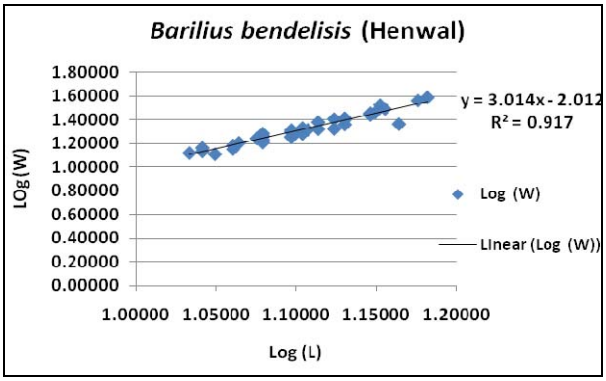
Table 3: Difference in 'b" value of same species between two different streams/stations.

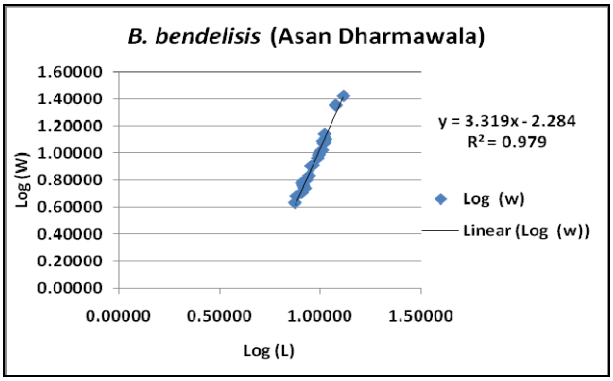
Fishes	Stations	AD	SuM	BT	SKN	AC	DT	DU
B. bendelisis	HK	3.38*	3.26*	1.275				
	AD		2.272	2.517*				
	SuM			6.60*				
	BT							
T. putitora	KhK				3.49*			
	SKN							
P. Conchonius	SuM					1.63		
	AC							
S. rupecola	DTc						1.08	2.27*
	DT							8.92*
	DU							

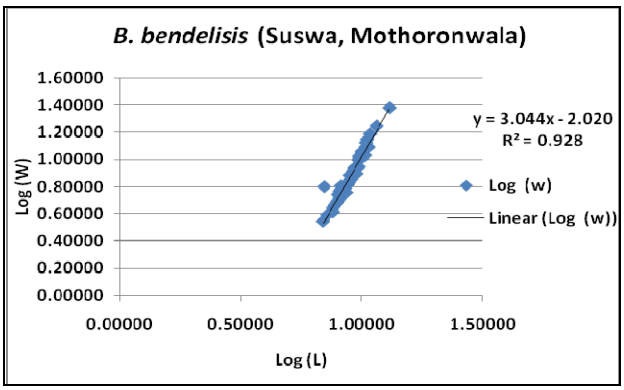
*Significant difference between two streams/stations at 5% level of significance

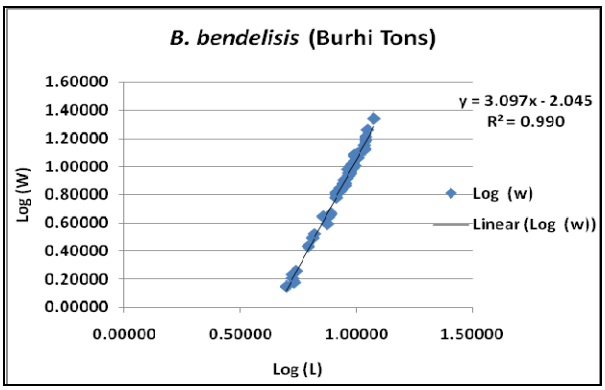
In most of the cases the relationship followed cube law. Yousuf and Firdous [7] recorded different 'b' value for *P. conchonius* in different rivers. Rao and Sreeramullu [8] recorded different b value for different sex of *P. conchonius* in same river. Dhasmana [9] also reported different 'b' value in different rivers for *T. putitora*. Earlier, Surendra *et al* [10] demonstrated different 'b' value for same species in different river. Qasim[11] indicated that the values of 'b' differed not only between different species but also within the same species depending on sex, stage of maturity and food habits. Shaheena and Yousuf [12] opined that regression coefficient 'b' of fish varies depending upon the condition of life in aquatic environment. Difference in 'b' value can be attributed to many factors such as river habitat, food source, gonad maturity and seasonal effects [13] however all of these are not accounted in this study.

The relative condition factor Kn is an indicator of general well-being of the fish [1, 14]. Kn greater than one (1) is indicative of the general well being of fish, whereas its value less than one (1) indicates that fish is not in a good condition. Salam *et al* [15] pointed out that 'K' remained constant with increase in length and weight of fish. In present study the Kn values ranged from 0.790 to 1.447 for *B. bendelisis*, 0.713 to 1.627 for *T. putitora*, 0.366 to 1.868 for *P. conchonius* and 0.211 to 1.754 for *S. rupecola* (Table 2). Though the highest Kn value was observed for *P. conchonius* at SuM (0.366-1.868) followed by *S. montanus* at Dhunseer Teen Chhade (0.211-1.754), the least Kn was also observed for these two species only. Consequently, Kn varies considerably in these two species. Comparably, the Kn exhibited far less variation for *B. bendelisis* and *T. putitora*. In *B. bendelisis* the Kn varied more in Burhi Tons at Tapkeshwar (0.790-1.224) and Suswa Mothoronwala (0.916-1.447). For this species, the variation in Kn was very low in Henwal Khadi (0.910-1.043) and Asan Dharmawala (0.944-1.065). Similarly, in *T. putitora* the Kn is higher in Khoh Kotdwar (0.713-1.627) and lower in Syampur Khadri Nala (0.730-1.156), but exhibits relatively more variation than Kn for *B. bendelisis*. However, in contrast to *B. bendelisis* and *T. putitora* the lower limit of Kn is much lower in *P. conchonius* and *S. montanus* (Table2) thus exhibiting stable Kn in former two species. The condition factor of fishes has been reported to be influenced by a number of factors such as the onset of maturity [16], spawning [17, 18], sex and maturity [19, 20, 21] pollution [22].









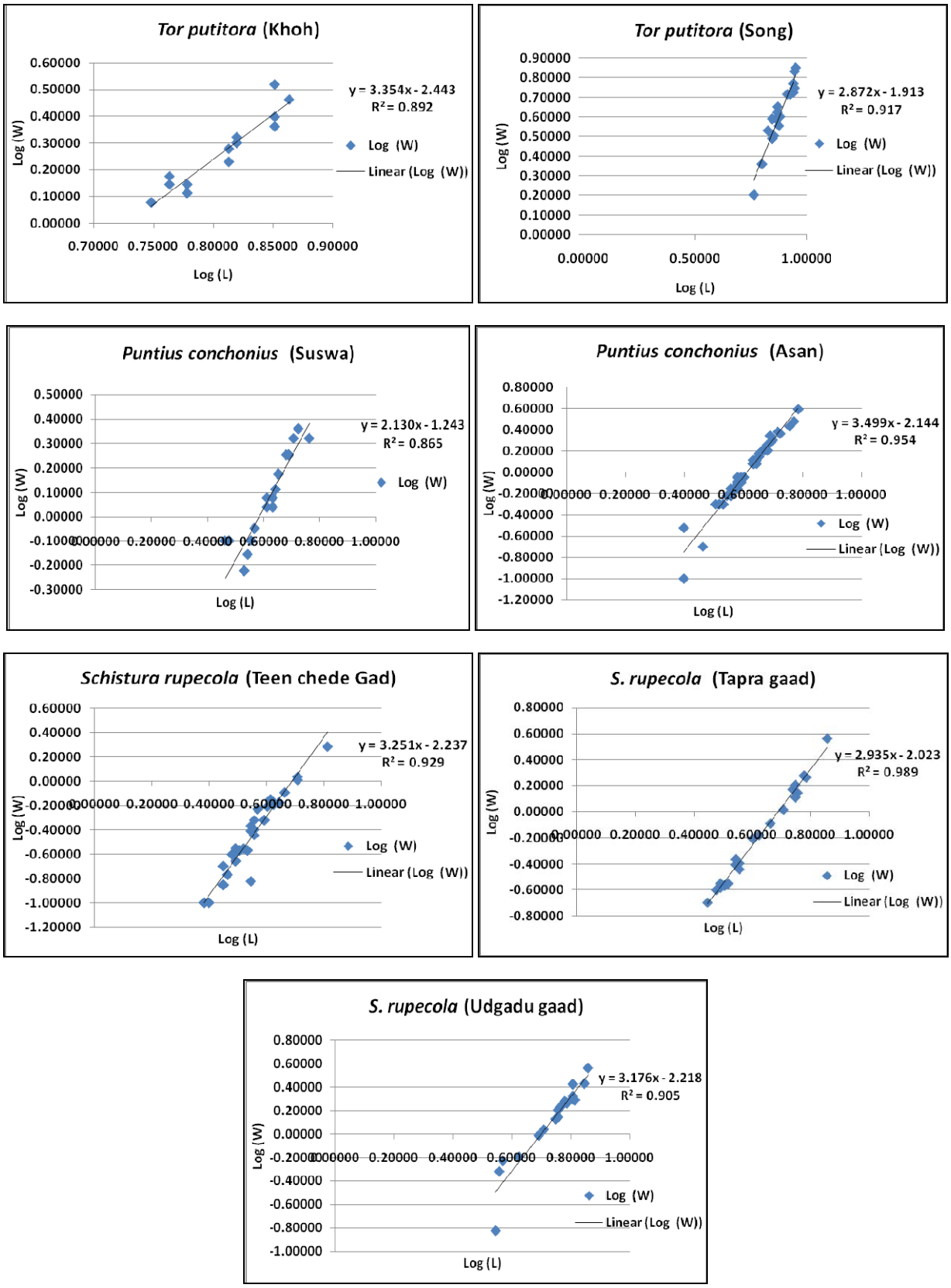


Fig 1: Length-weight relationships for four fish species.

4. Conclusion

In conclusion, this study provides the basic information on the length weight relationship and Kn factor of four indigenous fishes of the selected streams. The stream size plays vital role for fish growth i.e. weight gain. The observations on Kn support this opinion as fishes of smaller streams had highly variable condition compared to less variable condition in stream of larger dimension. The present study thus provides valuable information useful for the management of capture fishery resources.

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