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# Length-weight relationship and condition factor based assessment of growth pattern of a cold water fish *Schizothorax richardsonii* from different habitats of Himalayan region

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**Abstract**
*Schizothorax richardsonii* is the major fishery of the riverine ecosystems in Uttarakhand. The length–weight relationships and condition factor of *Schizothorax richardsonii* were estimated in the present study for which five sampling sites were selected which included four lotic water bodies and one farmed stock. The sites selected were river Kosi, river Alaknanda, Chirapani stream, river Gaula and one captive stock of DCFR farm. The results revealed that fish of river Alaknanda had an isometric growth pattern having a growth coefficient of 3.08 while the rest showed a negative allometric growth pattern. The growth coefficient (*b*) values varied between 2.40 to 3.08. The condition factor of river Alaknada was highest followed by river Kosi, Chirapani stream, river Gaula and farmed stock. The values of condition factor suggested that running water is better for the growth of this species. The values of condition factor are more than one in all the sites depicting good condition for dwelling the fish.

**Keywords:** Allometric, condition factor, length-weight relationship, lotic, isometric

## 1. Introduction
Uttarakhand state has plenty of water resources in the form of rivers, streams, springs, reservoirs & lakes. The major sources of the rivers in Uttarakhand are the glaciers of Western Himalayas that make rivers more sacred and eye-catching. The upper stretch of the river of the Uttarakhand is rich in cold water resources. *Schizothorax richardsonii* (Gray, 1832) is a coldwater fish, commonly known as Asala or Snowtrout belonging to the family Cyprinidae and forms the major fishery of the riverine ecosystems. An endemic fish species of the Himalayas, *Schizothorax richardsonii* is widely distributed in the streams, rivers and lakes all along the Himalayas from 750 to 2500 m above mean sea level. They prefer to dwell in the rivers, near submerged stones and rocks and feed mainly on algae and detritus [1]. *Schizothorax sp.* generally prefers to dwell in snow-fed rivers or streams with temperature ranging between 8-22 °C. The different anthropogenic activities like construction of a dam, illegal fishing, deforestation, and pollution have adversely affected the ecology of the riverine ecosystems, deterioration of the water quality ultimately affect the physiology and morphology of the fish species. For the management of fisheries, the study of morphometric parameters is quite useful such as growth, length-weight relationship, Condition Factor (CF) and mortality of fishes [2]. The study of the length-weight relationship helps to estimate the growth pattern and well being of the fish population and this variation depends on the condition of the ecosystem [3]. The length-weight relationship may vary during the developments stages like onset of maturity and growth [4]. The variability among the length-weight relationship of an aquatic organism depends on several factors such as food availability [5], water quality and the catchment area of the aquatic ecosystem where the fish dwells. The relationship is expressed with the help of mathematical expression between length and weight. This relationship is generally presented by the equation $W = aL^b$. The relationship helps to understand the growth pattern of the fishes which may be either isomeric or allometric [4, 6] by estimating the value of the regression coefficient (b). Fish can show isometric growth (b=3), positive allometric (b>3) and negative allometric growth (b<3). Isometric growth means fishes attain a uniform body shape, positive allometric shows the deeper body shape as length is increased as compared to weight while in negative allometry weight is increased as compared to the length and fish becomes more slender [7]. It can be used for the estimation of the biomass from the length data.

The relationship can be used for the comparison between the fish species or population dwelling in different habitats [8, 9]. Another important biological parameter which gives the information about the condition of the fish species and used for the management of the ecosystem is Fulton's condition factor [10, 11]. It is calculated from the relationship of length and weight of a fish [12] and can be used as the index of feeding intensity and the growth rate [13]. Condition factor (K) is widely used in fisheries and fish biology studies. The condition factor depends on various ecological and biological factors such as the gonadal development of the species, age, food availability, stress and suitability of the environment [14] [15]. The greater value of the condition factor indicates the wellness of the species as well as the ecosystem. The endeavor of this study is to give information on the length-weight relationship and the condition factor of *Schizothorax richardsonii* collected from different rivers of Uttarakhand and it can be quite helpful in stock assessment models and the management of the fisheries resources in the aquatic ecosystems.

## 2. Materials and methods

### 2.1 Study area

The fish species were sampled from five different sampling sites i.e River Kosi, River Alaknanda, Chirapani stream, River Gaula and one farm stocked respectively.

#### 2.1.1 River Kosi

In the Kumaon region, it is one of the major rivers and a tributary of the Ganga river system. It originates near Kausani, district Almora and flows from valleys, towns and enter into the Tarai region of Uttar Pradesh, where it meets Ramganga.

#### 2.1.2 River Alaknanda

It is the headstream of river Ganga. The source of Alaknanda is Satopanth glacier and Bhagirathi Kharak glacier. The five main tributaries joining with Alaknanda in order includes Dhauliganga at Vishnuprayag, Nandakini at Nandaprayag, Pindar at Karnaprayag, Mandakini at Rudraprayag and Bhagirathi at Devprayag where it becomes finally the Ganga river. The draining part of Alaknanda is Chamoli, Tehri and Pauri district.

#### 2.1.3 Chirapani stream

The stream flows in district Champawat of Uttarakhand which originates from the southern extremity of the Kranteswar range of the hills at an elevation of 1860 m asl. The stream is perennial and receives water from the springs. The stream has religious value due to north flowing nature. The stream which is of primary and secondary order originates from Kranteswar, Banlekh and Hingla hill are also emerging in the stream.

#### 2.1.4 River Gaula

The river is originating from the Lesser Himalayas range in sattal lake of Uttarakhand state and flow through Ranibag, Kathgodam, Haldwani, Kichha and Shahi and finally drains into the Ramganga in Uttar Pradesh. It is a spring fed river and it is the source of drinking water for Haldwani city.

#### 2.1.5 Farmed stock

The farmed stock was collected from the Fish farm of Directorate of Coldwater Fisheries Research, Bhimtal district Nainital of Uttarakhand which was established in 1987. The institute has a well-furnished infrastructure, hatchery and cemented tanks.

### 2.2 Sample collection

Live specimens of the fish *Schizothorax richardsonii* were sampled from the different lotic water bodies either by fishing or from commercial catches. The different sampling sites were Kosi at the elevation of 1,642m above sea level and from the coordinates 29°38'N, 79°37' E, Alaknanda, at the elevation of 1,814 m above sea level and from the coordinates 30° 9′ N, 78° 46′ E Chirapani stream at the elevation of 1,615 m above sea level and from the coordinates 29° 19′ N, 80° 6′ E, Gaula, at the elevation of 554 m above sea level and from the coordinates 29° 16′ N, 79° 32′ E and farmed stock at the elevation of 1370 meters above sea level and from the coordinates 29°21'N and 79°33'E. A total of 135 individuals were collected from these sites for the analysis throughout the sampling period from September 2017 to August 2018.

### 2.3 Length-weight relationship

The mathematical relationship between the two variables, length and weight is established by the study of length-weight relationship of a fish which helps in assessing the variations from the expected weight for the known length groups. Length of fish was taken with a marked ruler and a digital balance to the nearest 0.01 g accuracy was used to know the weight of collected samples. The relationship was calculated by using the equation

$W = a L^b$ [4].

The constants (a and b) were calculated by transforming data as

$\log W = \log a + b \log L$ [16].

Where,
W=Weight of fish (g),
'*a*' is the regression intercept,
L is total length of fish (cm),
'*b*' is the slope of regression.

Deviations of growth coefficient *b* from the isometric value of 3 were tested using student *t*-test. The '*t'* value was calculated as follows:

$t = (b - 3) / S_b$

Where,
$S_b$ is the standard error of *b.*

### 2.4 Condition factor

The well-being or relative robustness of the fish is expressed by 'coefficient of condition' (also known as condition factor). The variation in the length-weight relationship is an indicator of overall condition and such changes generally analyzed with the help of condition factor. Fulton's condition factor (K) was analyzed by

$K = 100*W/L^3$ [12].

Where K is condition factor, Where,
W is total body weight of fish measured in grams,
L is the total length of fish measured in centimeters

100 factors are used to bring the condition factor close to unity. All the statistical analysis was performed by using MS Excel.

## 3. Results and discussion

### 3.1 Length-weight relationship

A total of 135 species were analyzed for the estimation of the length-weight relationship. The mean length (cm), mean weight (g), length-weight relationship parameters ('*a*' and '*b*'), correlation coefficient (r) and the coefficient of determination ($R^2$) are presented in Table 1. The length weight relationship of different ecosystem was represented in figures 1 to 5. The value of '*b*' showed deviation from cube law. In this study, the values of estimates of parameter *b* ranged from 2.40 to 3.08. The maximum value was shown by river Alaknanda and the minimum value was represented by river Gaula. The value of regression coefficient '*b*' usually may range between 2 to 4 [17, 18, 19] also observed that the '*b*' ranges between 2.5 to 4. The value of regression coefficient '*b'* of river Alaknanda was 3.08, showed isometric growth pattern. The value of b of river Kosi, Chirapani stream, river Gaula and captive stock were 2.82, 2.72, 2.40 and 2.63 respectively and exhibit the negative allometric growth pattern [20]. also found the *b* value of *Tor putitora* dwelling in Uttarakhand ranged from 2.021 to 3.013 during their study. Similar results were observed by [21] when they studied the length-weight relationship of *Schizothorax richrsonii* from different rivers. The similar type of results also reported in S. *plagiostomus* from Jammu region [22, 23] and in *Schizothorax niger* from Dal lake Kashmir [24, 25] studied length weight relationship of different species of Kosi River and observed the *b* value for *Schizothorax richardsonii* was 2.811. The b value less than 3 may be the small specimens have better nutrition or due to non availability of the food for the large specimen and better nutrition [26]. The statistical analysis of length-weight relationships showed that the value of exponent (*b* value) of the length-weight relationships was significantly different from the cube value and this indicates that fish species follows an allometric growth pattern.

**Table 1:** Length-weight relationship and condition factor of *Schizothorax richardsonii* collected from five different ecosystems

| Parameters | Sampling sites | | | | |
|---|---|---|---|---|---|
| | River Kosi | River Alaknanda | Chirapani stream | River Gaula | Farmed stock |
| Mean length (cm) | 18.70 | 21.01 | 16.25 | 17.56 | 19.80 |
| Mean weight (g) | 105.68 | 168.03 | 66.25 | 70.35 | 93.02 |
| Growth coefficient '*b'* | 2.82 | 3.08 | 2.72 | 2.40 | 2.63 |
| Correlation coefficient 'r' | 0.85 | 0.90 | 0.97 | 0.86 | 0.89 |
| Coefficient of determination '$R^2$' | 0.75 | 0.82 | 0.93 | 0.73 | 0.86 |
| Condition factor 'K' | 1.61 | 1.81 | 1.55 | 1.29 | 1.19 |
| Growth type | Negative Allometric growth | Isometric growth | Negative allometric growth | Negative allometric growth | Negative allometric growth |

The regression graphs of length-weight relationship of *Schizothorax richardsonii* collected from river Kosi, river Alaknanda, Chirapani stream, river Gaula and captive stock are depicted from Figure 1 to 5. The growth of the fish increases with increasing length and is interrelated to each other. The highest 'b' value of *Schizothorax richardsonii* in the sample collected from river Alaknanda showed that it provided a better and conducive environment for the growth and survival as compared to the other rivers. The lowest value of b observed in river Gaula depicted the condition of the river is not in well and conducive for the species as compared to other sampling sites. The variation in the length-weight relationship between different rivers and captive stock may be due to differences in the ecology, body size, habitat condition, life stages, nutritive condition of the environment, differences in the length ranges of the specimen caught and maturity. The dissimilarity may be due to their inherited body shape and according to the condition of the individual fish. High values of b are an indication of the general condition of desire for food and gonad content of the fish [26]. In addition *'b'* values are also affecting by the different factors such as biological condition, environmental conditions, geographical location, temporal and sampling factors [27, 12]. The correlation coefficient (r) values ranged from 0.85 to 0.97 indicated the significant positive correlation between total length and the total weight of the fish species [28]. The coefficient of determination ($R^2$) indicates the fitness of the regression model. Linear regressions were significant for all the species ($p$<0.05) with $R^2$ values ranged from 0.75 to 0.93. The higher values of $R^2$ indicate the relationship to be good fitted.

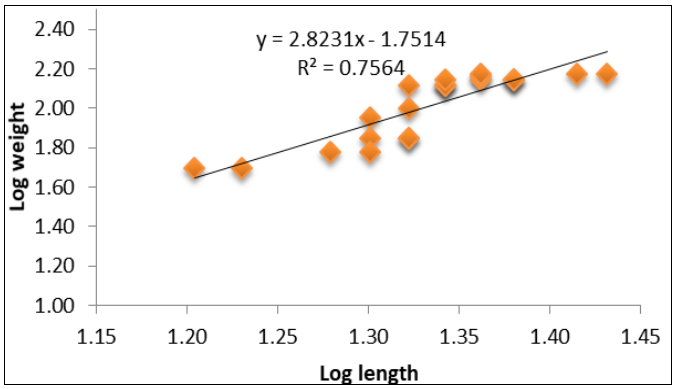


**Fig 1:** Length-weight relationship of *Schizothorax richardsonii* individuals collected from river Kosi

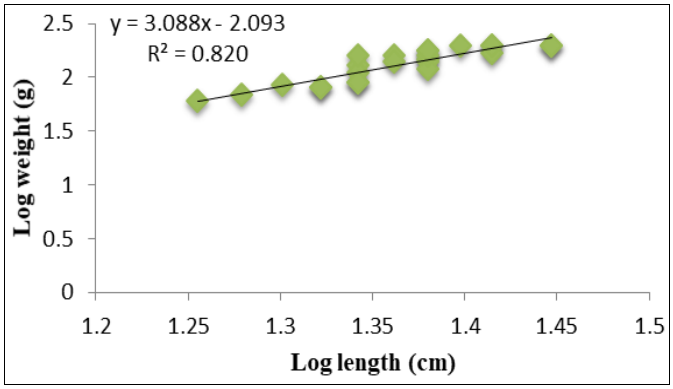


**Fig 2:** Length-weight relationship of *Schizothorax richardsonii* individuals collected from river Alaknanda

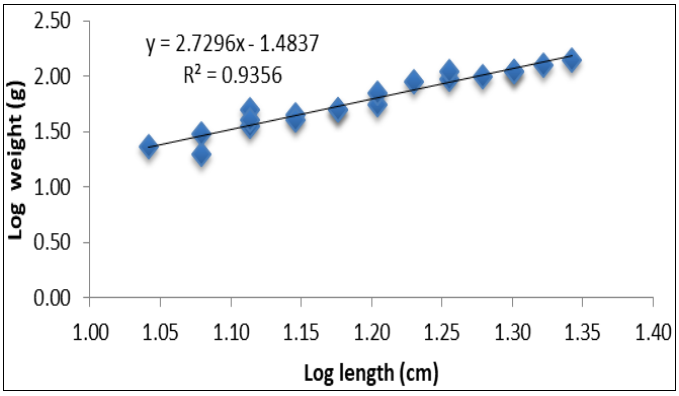


**Fig 3**: Length-weight relationship of *Schizothorax richardsonii* individuals collected from Chirapani stream

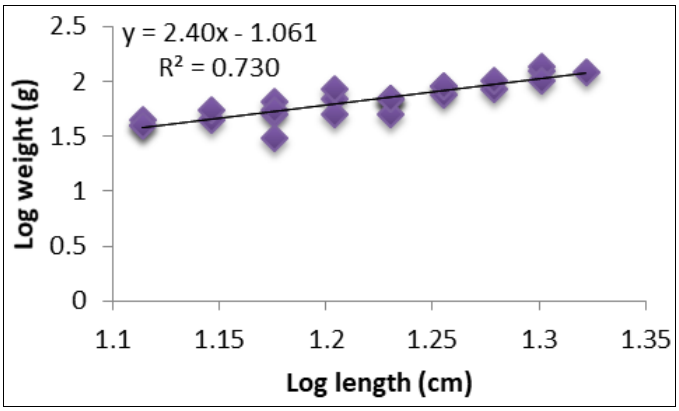


**Fig 4**: Length-weight relationship of *Schizothorax richardsonii* individuals collected from river Gaula

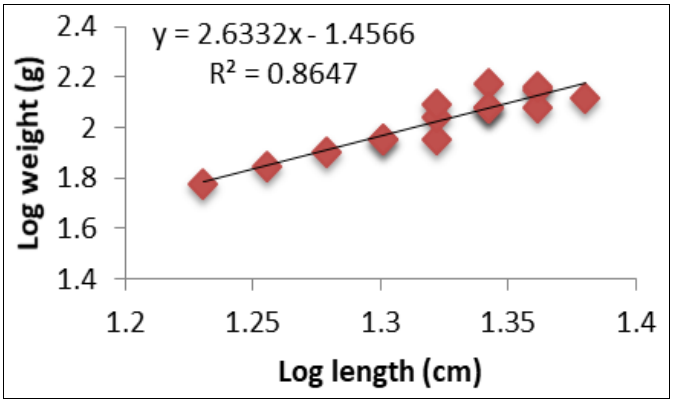


**Fig 5:** Length-weight relationship of *Schizothorax richardsonii* individuals collected from Farm

### 3.2 Condition factor

The condition factor or ponderal index is calculated on the basis of length and weight of the species. Fulton's condition factor estimates the wellness of the environment and the species. It is an index of interaction between the biotic and abiotic factors in the physiological condition of fishes. Condition factor (K) is also a useful index for monitoring of feeding intensity, age, relative robustness, and growth rates of fish [29]. The values of the condition factor of fish samples of different habitats were given in Table 1. The values of condition factor ranged from 1.19 to 1.81. The value of K in Kosi, Alaknanda, Chirapani, Gaula and farmed stock were 1.61, 1.81, 1.55, 1.29 and 1.19 respectively [30]. said if the K value is greater than one, fish would be in good condition. According to [31] if the K value is 1, the fish in poor condition, 1.20, the fish is in moderate condition and a value is approximately 1.4 indicate a well proportionate fish. The value of all the selected sites indicated the good condition for the fish species. The highest value of K was observed in river Alaknanda (1.81) and lowest in river Gaula (1.29) among the selected lotic ecosystem. The reason could be that river Alaknanda originates from glaciers that help to maintain the river well suited physico-chemical water quality parameters and the advantageous environment for the growth of the fish species as it is a cold water fish species. The catchment area is also covered with forest which provides better allocthonous nutrients to the river that maintains the natural food in the ecosystem. The sedimentation load in river Gaula is more as compared to other rivers due to deforestation and urbanization in the catchment area of the river. Sedimentation load may affect the water quality, food availability and provide the unfavorable environment to the fish species dwelling in [32]. The river Kosi and Chirapani stream also provide a good condition to the fish species as their value is more than 1.4. Since K is calculated by length and weight parameters so it also influences by the same factor that affects the length-weight relationship [4]. reported that physico-chemical parameters of the ecosystem, availability of food and parasitism influence the health of the fish dwelling in that ecosystem. The condition factor of farmed species was 1.19 which is the lowest among all the selected sampling sites depicted that the selected fish species condition is better in the lotic ecosystem as compare to the captive ecosystem [21]. also reported that captive ecosystem has lowered K value as compared to the natural ecosystem. According to [33] from nutritional point of view the higher value of condition factor may be due to deposition of fat and from a reproductive point of view, the higher value depicted that fish is fully mature, and have higher reproductive potentiality [34]. The variation in the values of condition factor may be due to the difference in the location of sampling sites as they are in different elevation [35]. Suggested that the variation in the values of condition factors may be due to the different locations of selected sites, availability of food and a difference in gonad development. The aquatic ecology of the Himalayan rivers have changed due to natural and anthropogenic activities such as the construction of dam, illegal fishing which ultimately affects the abiotic and biotic components of the ecosystem. As a result, these factors have an adverse effect on the morphology and physiology of the aquatic organism.

### 4. Conclusion

The present study observed the length-weight relationship and condition factor of *Schizothorax richardsonii* collected from the river Alaknanda, Kosi, Chirapani stream, Gaula and DCFR farm. The results revealed that the relationship varies among all the sites. The fish species of river Alaknanda showed an isometric growth pattern while the rest showed negative allometry growth pattern. The variation in the growth pattern of different ecosystem may be due to food availability, gonadal maturation, different geographical conditions and catchment area of the ecosystem. The value of the condition factor revealed that the natural ecosystem provides the better and conducive environment for the growth of the fish species as compared to the captive conditions. Therefore this study may help the fishery biologists for the conservation and the management of the fishery of the candidate species in these rivers/streams of Himalayan regime.

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