ISSN: 2347-5129
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.352
IJFAS 2016; 4(3): 513-517

www.fisheriesjournal.com
Received: 13-03-2016
Accepted: 14-04-2016

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Length-weight relationship, condition factor and sex-ratio of snow trout (*Schizothorax plagiostomus*, Heckel, 1938) from Neelum and Jhelum rivers, Muzaffarabad, Azad Kashmir

Tasleem Akhtar, Nuzhat Shafi and Ghazanfar Ali

Abstract
This study was the first effort to illustrate the length-weight relationship (LWR), condition factor and sex ratio of an economically important Snow trout, *Schizothorax plagiostomus* collected from Neelum and Jhelum Rivers, Muzaffarabad, Azad Kashmir. The LWR of *S. plagiostomus* was analyzed for both sexes with formula Log W = Log a + b Log L. A total of 330 specimens were collected during January to December, 2012 by using conventional fishing tools. The allometric coefficient *b* of LWR was found to be negative (b<3) all over the year. A trend line graph disclosed the declination in growth condition. The sex ratio of *S. plagiostomus* was calculated as 0.15: 6.4 (male: female) which strongly favors the dominance of the female sex over male in the natural population throughout the year. It is concluded that LWR, condition factor and sex ratio of *S. plagiostomus* demonstrated significant variation with environmental and physiological factors. This study would be useful to handle the adequate regulations and conservation of sustainable fishery management.

Keywords: *Schizothorax plagiostomus*, Neelum and Jhelum River, length-weight relationship, co-efficient of correlation, condition factor, sex ratio

1. Introduction
As the world population is increasing, there is enormous increase in the demand of animal proteins. It is very difficult to fulfill the increasing demands without exploiting all natural and captivity options including natural and artificial rearing and breeding of animals such as fisheries and integrated aquaculture practices similar to poultry. Therefore, in developing countries like Pakistan and especially in Azad Jammu & Kashmir (AJ&K), where traditional fish consuming was totally rely on capture fisheries or fish from the wild, the management and improvement of fisheries is only possible when their life cycles are fully understood.
Fishes have a vital role inside the economic advancement of any country. Apart from being an economical source of extremely nutritive protein, it also contain desirable amount of nutrients, minerals and vitamins considered necessary for the body [1]. The length-weight relationship is fundamental for proper exploitation and management of the population of fish species [2]. Assessment of the relationship between total length and body weight is also indispensable to level out the taxonomic characters of the species [3]. Standard result obtained from length and weight data are a useful for fish sampling programs. These data are also needed for the estimation of growth rates, maturation and age structures, and other components of fish population dynamics [1, 4]. In stock assessment models, length-weight relationships allow ichthyologist to convert growth-in-length equation to growth-in-weight appraisal [1, 5] and estimate biomass from length frequency distributions [6], comparison of life history and morphological characteristics of populations dwelling in different regions [7] and determine fish condition [6]. The statistical relationship between these two parameters has great significance with regard to their morphology, biology, nutrition, and growth rate conditions.
In fisheries science, the condition factor is applied in order to measure up the fatness or welfare of fish. It is supposed that heavier fish of a particular length are in better physiological condition [8]. Condition factor is also a constructive index for examining the feeding intensity of fish its growth rates and age [9]. Both biotic and abiotic environmental factors strongly influenced conditions factor of fish and also assess the status of the aquatic ecosystem [2].

Sex ratio on the other hand, is a comparison of the number of males and females in any population. The sex ratio is a sign of population behavior and fecundity and observation of the sex ratio of a fish at different times in the year is essential for obtaining information on seasonal segregation of the sexes and also their differential growth [10].

Schizothorax plagiostomus commonly known as Snow trout is an endemic carp fishery of Neelum and Jhelum Rivers of Kashmir valley. It is highly preferred by the local masses because of its food value and taste that fetches high price market [11]. However, the important biological data such as LWR, condition factor and sex ratio aspects of *S. plagiostomus* in AJK have never been studied, this study was an effort to bridge the knowledge gap on these parameters in natural waters of the area.

2. Materials and Methods

2.1 Ethical Statement

All animal experimental procedures were conducted in accordance with local and international regulations. The international regulation is the Wet op de dierproeven (Article 9) of Dutch Law (International).

2.2 Fish Sampling

Total of 330 fish specimen of *S. plagiostomus* (with average of 25- 28 samples/month) were randomly sampled during January to December 2012, from Jhelum and Neelum Rivers of District Muzaffarabad, Azad Kashmir (34°21'13.10"N, 73°28'12.68"E) with the help of local anglers (fishermen) using cast net and collected in a hand-held seine and dip net. The specimens were identified by counting the fin rays and barbells at the collecting site and then sent back to the Fisheries Laboratory, Department of Zoology, The University of Azad Jammu and Kashmir, Muzaffarabad. The weight and length measurements were taken at the site using measuring scale (accuracy of 0.01mm) and digital weighing balance (accuracy of 0.01g), respectively.

2.3 Length-Weight Relationship

The length –weight relationship of fish was calculated by the following parabolic equation

$W = aL^b$ or Log W = Log a+ b Log L [12]

Where, W = Weight (grams) of fish, L =Length (cm) of fish, *a is* constant and *b* denotes an exponential relationship between length-weight.

2.4 Condition Factor (K): The coefficient of condition, K was calculated by following the Falton [13]

$$\text{Condition Factor (K)} = \frac{100W}{L^3}$$

Where, 100 is a factor to bring the value of K near unity. The significance of the LWR and K were judged by analysis of variance (ANOVA) then the t-test were applied for the verification of its significance level in different months of a year. Excel 2007 was used for all statistical analysis.

2.5 Dissection and Sex Ratio Determination

Each specimen was dissected and the gonads were observed morphologically to check the different stages of maturity. After the differentiation of male and female, the sex ratio was recorded by direct counting of number of male and female in whole study period.

3. Results and Discussions

3.1 Length-Weight Relationship

Weight-length relationship of *S. plagiostomus* showed variation throughout the year, Data of 330 specimens showed the average size ranged between 10 to 39 cm and its weight ranged between 26 to 534 g (Table 1). The value of *b* showed deviation from Cube law during the whole study period and negative allometric growth was observed as *b* was less than 3. Table (2) depicts the variation in *a* (intercept) and *b* (slope) for different months, indicating a clear picture of the average growth condition. The graph plotted to illuminate the growth of the fish showing asymmetrical declining trend in the growth pattern in the year (Fig 1).

Table 1: Length and weight characteristics (mean, minimum and maximum) for the *S. plagiostomus* caught from Neelum and Jhelum Rivers Muzaffarabad in January to December 2012. (SE = Standard error)

	Length characters					Weight characters			
Months	**n**	**Mean**	**S.E**	**Min.**	**Max.**	**Mean**	**S.E**	**Min.**	**Max.**
Jan.	24	15.70	0.66	10	20	71.81	3.55	50	209
Feb.	35	19.94	0.56	15	27	129.92	4.71	50	270
Mar.	20	27.02	0.47	24	30.5	280.97	12.27	125	350
Apr.	30	27.41	1.23	15	37	229.8	28.07	26	460
May	25	28.72	0.63	25	36	274.12	12.82	144.5	454.5
Jun.	36	30.41	0.54	25	38	263.26	15.54	160	452
Jul.	40	30.13	0.51	23.5	39	255.00	9.38	150	534
Aug.	27	22.35	0.82	15	33	159.80	5.91	50	400
Sep.	32	28.5	0.429	24	34	287.95	8.77	155	381
Oct.	22	30.59	1.01	20	37	317.15	24.91	170	460
Nov.	29	31.81	0.62	27	34	310.4	18.21	150	400
Dec.	10	33.25	1.160	27	35	364.45	34.36	230	350

Table 2: Statistical details showing number of fish studied (n), intercept (log a), regression coefficient (b) and results of t-test on correlation coefficient (r), ($P<0.01$).

Months	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**
n	24	35	20	30	25	36	40	27	32	22	29	10
Log a	-0.46	0.75	-0.35	-0.34	0.07	-1.61	-0.39	-0.41	1.12	-0.06	0.46	0.94
Log b	2.03	1.05	1.95	1.87	1.61	2.70	1.89	1.94	0.92	1.72	1.30	1.09
r	0.80	0.61	0.61	0.93	0.75	0.91	0.83	0.89	0.53	0.78	0.82	0.55
p	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09

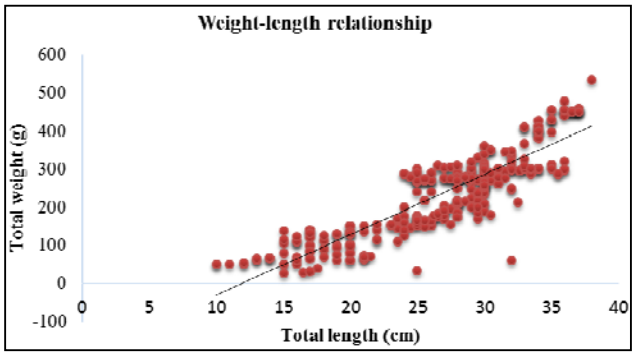

Fig 1: Length-weight relationship of both male and female *S. plagiostomus* during January to December 2012 from Neelum and Jhelum Rivers Muzaffarabad.

It was determined that the Cubes law is appropriate only for those fish species, which keep up their specific gravity and form all over their lifetimes. But the form and shape of fishes might be changed with time; consequently the weight- length relationship of the majority of the fishes may depart from cubes law. Additionally, the cubes law doesn't grip well all over the life period and the gain of weight in a fish may not be for all time cubed of its gain of length [15]. It was investigated that the 'b' value might be ranged between 2.5 and 4.0 [14], while the differences in value of 'b' is due to food availability, and environmental factors which in turn effect, sex and life stages [6].

Reports on the length-weight relationship of cyprinid fishes showed that many of them strictly follow cube law while there are many in which the weights of fishes either tend to increase or decrease in proportion to the cube of length. Isometric growth pattern has been reported in *S. plagiostomus* [16] from Jammu Region, female *S. esocinus* [17] from river Jhelum Kashmir in which the 'b' value was very close to the isometric value of 3. All these earlier reports are not in compliance with the present findings on the length-weight relationship in *S. plagiostomus* in which the 'b' values were deviated from isometric value of 3.

In this study isometric growth (b=3) was not observed in the whole year rather it was negatively allometric (b<3) at highest significant level (p=000). Such changes in the value of *b* might be recognized to certain environmental factors such as food competition, overfishing, habitat degradation and nutritional potential of the rivers. Considering the *b* values, despite of large or the small, specimens were in good health status at the sampling time [18]. Similar kind of observation were noticed in *S. richardsonii* from hill streams of Uttarakhand [19], in male *S. esocinus* from Jhelum River in Kashmir [17] and in *S. niger* from world famous Dal Lake of Kashmir [11]. They all attributed these inferences to size, their feeding strength and sex, and gonadal development of fish. The present study makes it quite clear that the weight-length relationship was affected by environmental factors like physico-chemical factors (Table 3), habitat destruction due to construction of dams and roads, pollution, floods, shortage of food and physiological stress.

Table 3: Ecological study of spawning ground of *S. plagiostomus* sampling spot Neelum and Jhelum Rivers at Muzaffarabad during January to December 2012.

Months	Water Color	Weather	Air temp. (ºC)	Water temp. (ºC)	pH	Dissolved Oxygen (mg/l)	Turbidity (NTU)
Jan.	Muddy	Clear	25	10	7.5	13.6	120
Feb.	Muddy	-	25.5	10.5	7.8	13.4	118
Mar.	transparent	-	26.5	11.5	7.9	14.7	115
Apr.	transparent	-	26	11.8	7.8	14.9	110
May	transparent	-	29.8	14.2	7.8	15	101
Jun.	Muddy	Cloudy	35	14	7.5	15.8	208
Jul.	Muddy	-	36	15	7.7	13.5	210
Aug.	Muddy	-	34	13.5	7.7	13.2	209
Sep.	transparent	-	30	12	7.6	12.7	200
Oct.	transparent	-	25	11.8	7.8	12	110
Nov.	transparent	Clear	24.5	11.3	7.9	11.8	100
Dec.	Muddy	Cloudy	20	10	7.5	10.9	150

3.2 Condition Factor

The condition factor of *S. plagiostomus* was studied in every month round the year and it varied from 0.92-1.85, with an average value of 1.239±0.084. Which pointed out that fish is in a good condition in these water bodies. The lowest level of "Kn" was observed in the month of June and July, which might be attributed to the increased spawning strain in them [20]. Thus it appears that reproductive cycle in *S. plagiostomus* is related to the variation in the condition factor, while it was highest in the rest of all the months (Fig 2). It was revealed that the condition factor (Kn) is a sign of broad vigorous life form of the fish. Condition factor greater than one is the indication of good health of fish, while, its value lower than one (1) indicates that fish is not in good condition [12].

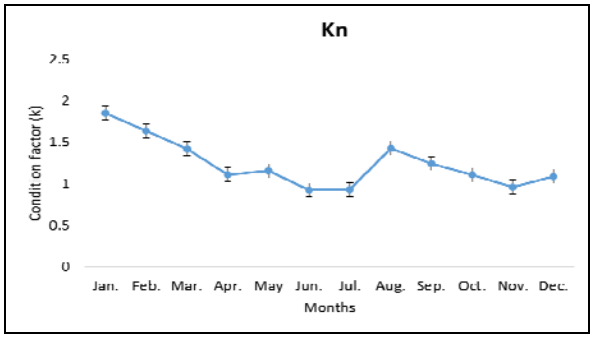

Fig 2: Month-wise disparity in condition factor of *S. plagiostomus* collected from Neelum and Jhelum Rivers, Muzaffarabad.

Fish health is greatly affected by environmental factors, availability of food and infection causes by different parasites [12]. Condition factor's variability in different seasons pointing towards a lower accessibility of feed and relapse of ovaries during chilled months and lofty feed availability in summer months fully develop gonads. Comparatively higher values of K could be credited to the deposition of fats as grounding for the coming breeding season. Similarly. *S. curvifrons* showed the highest value in the condition factor during the breeding season [21]. Similar kind of observation was noticed in *S. niger* collected from Dal Lake of Indian held Kashmir [11]. The fluctuation in condition factor have related with age and feeding intensity [22].

It can be concluded that in *S. plagiostomus*, though the condition of fish is more related to gonado somatic index, there exists some relationship between condition factor and other environmental and physiological factors.

3.3 Sex Ratio

Percentage comparison of sexes showed that the female sex take over the natural population over the year (Table 4). Out of 330 fish, 30 were male and 193 were females by the ratio of 0.15: 6.4. While the rest (77) of them were undifferentiated or under aged.

Results of sex ratio obtained during the study is deviated from expected ratio i.e., 1:1 in nature for all type of fish. Therefore, deviation from the ratio may be evidence for the dominant behavior of one sex over the other. This take places because of differential activities of sexes, environmental circumstances and overfishing [23]. The ratio of both sexes in *S. plagiostomus* illustrated a significant difference all through the year with female supremacy (Fig 3).

Table 4: Month-wise distribution of males and females of *S. plagiostomus* during January to December 2012.

Months	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Grand total
Male	1	4	2	1	3	3	7	2	2	3	2	0	30
Female	2	19	14	17	18	28	25	15	26	9	10	10	193
Total	3	23	26	18	21	31	32	17	28	12	12	10	223
% of male	4.1	11.4	10	6.66	12	8.33	17.5	7.40	6.25	13.63	6.89	0	9.09
% of female	8.3	54.2	70	56.6	72	77.7	62.5	55.55	81.25	40.90	34.48	100	58.4
Sex-ratio	0.5:2	0.2:4.7	0.1:7	0.05:17	0.16:6	0.10:9.3	0.2:3.5	0.1:7.5	0.07:13	0.3:3	0.2:5	0:10	0.15: 6.4

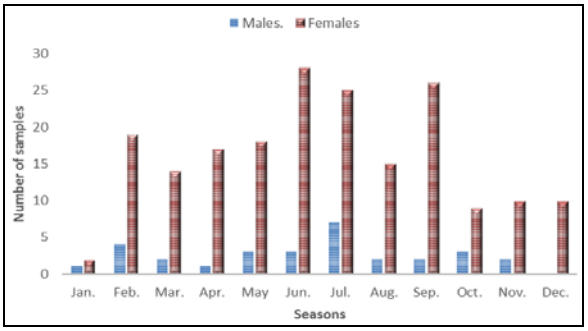

Fig 3: The variation in sex ratio of *S. plagiostomus* from January to December 2012 from Neelum and Jhelum Rivers Muzaffarabad.

Nevertheless it is not clear which factors might be responsible for discrepancy from standard sex ratio (1:1) of *S. plagiostomus* in the region. Further study will be needed to understand this phenomenon to conserve this species. In contrary, it was reported that in *S. richardsonii*, the percentage of sex ratio was 1: 1.09 [24]. The study enlighten about the growth condition of *S. plagiostomus* in wild habitation. This study will provide its status intensification and health condition in natural waters and will be constructive for conservationist and Ichthyologists, for successful administration, production and influential conservation.

The study showed that the environmental condition cause a significant impact on the status of the fish. It is recommended that these physiological limitations can be suitably put into fish culturing practices as health scrutinizing tools. This study is a base line towards future economically important ecological study, conservation and management of fisheries. This study will be helpful for the fish farmers to get the maximum yield by providing optimum breeding environment. It will also provide information about the growth condition of *S. plagiostomus* in wild condition.

4. Acknowledgements

We thank Muhammad Mubarak Ali for expert technical assistance and fish collection.

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