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Morphometry and length-weight relationship of rainbow trout *Oncorhynchus mykiss* Walbaum, 1792 (Salmoniformes: Salmonidae) from Kashmir

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Abstract
The present study involves analysis of morphometric characters and length-weight relationship of *Oncorhynchus mykiss* collected on monthly basis from three state owned trout fish farms. Eleven morphometric characters studied showed high level of interdependence (R^2 = 0.502 to 0.876) among which standard length and pre-anal length were found to have highly significant relationship with total length (R^2 = 0.876 and 0.807 respectively), reflecting thereby that the morphometric characters of fish were highly correlated. The length-weight relationship was established as $W=1.957L^{3.028}$. The correlation coefficient (R^2) for length-weight relationship was found to be 0.608, indicating a positive relationship between the two parameters.

Keywords: Rainbow trout, morphometry, *Oncorhynchus mykiss*, length- weight, Kashmir

Introduction

Trout is the common name for a number of species of freshwater fish belonging to the genera *Oncorhynchus*, *Salmo* and *Salvelinus*, all of sub-family Salmoninae of family Salmonidae. The word trout is also used as part of the name of some non-salmonid fish as *Cynoscion nebulosus*, the spotted sea trout or speckled trout. Trout are closely related to salmon and char (or charr): species termed salmon and char occur in the genera as do trout (*Oncorhynchus* – Pacific salmon and trout, *Salmo*-Atlantic salmon and various trout, *Salvelinus*- char and trout). Most trout such as lake trout live in freshwater lakes and/ or rivers exclusively, while there are others such as the rainbow trout which may either live in freshwater, or spend two or three years to spawn. A rainbow trout that spends time in the ocean is called steelhead. Trout is important food source for humans and wildlife including brown bear, birds of prey such as eagles and other animals. They are classified as oily fish.

Behnke (1992) [3] provides a thorough discussion of the description and taxonomy of rainbow trout and other salmonids. The body coloration of stream-resident forms of rainbow trout is typically silvery-gray to greenish brown on the back and sides with a white belly. Rainbow trout have a pink or reddish lateral stripe, sometimes with lavender or orange overtones, from the gill cover running the entire length of the fish to the tail. The spotting patterns and body coloration of rainbow trout are diverse. In general, their caudal fins have rows of small dark spots with spots on the dorsal and adipose fins. The lower fins are pale-pink without spots. There are often small blackish spots sprinkled on the head and sides. At spawning time, males become deeply colored with an intensely red side stripe.

The hot-spot of ichthyological studies is fish morphometrics for many decades, but the pioneer steps date back to the time of Galileo Galilei (Froese 2006) [9]. Fulton (1906) set the scientific basis for morphometry in fishes, and especially the mathematical way which correlate the weight to length and introduced fisheries science into 'allometry'. Nowadays, most common relationships that have been established and used for the majority of fishes are those which are relating weight to body length (in the majority of cases, total body length (TL), and in some, the standard (SL) and fork (FL) length. Weight (W) - length (TL) relationships are of power type, i.e., $W=a L^b$. (Binohlan & Pauly, 2000; Froese & Pauly, 2011) [10],

The primary step in any research work is identification of fish species which had a greater impact and key role for the behavioral studies. The authentic methods for the identification of specimen which is termed as morphological systematics (Nayman, 1965) [19] are morphometric

measurements and meristic counts that are considered as easiest methods for the identification. Morphometric measurements, meristic counts, shape and size provide data useful for taxonomic status (Ihssen *et al.*, 1981) [14].

The credit for transplantation of rainbow trout in Kashmir goes to F.J. Mitchell, a carpet dealer, also known as "the father of Kashmir trout fishery". Mitchell in 1912 succeeded in hatching and rearing rainbow trout eggs from a consignment presented by the Bristol Waterworks from their head works at Blagdon, England (Mitchell 1918) [17]. The eggs successfully hatched in a small trout hatchery at Harwan, Srinagar Kashmir.

Jammu and Kashmir State Fisheries Department has achieved remarkable success in trout and at present 32 trout rearing units are functioning in various districts of the state. The Department collects huge revenue from sale of trout fish at various parts of the state. The environment, topography, climate etc. of Kashmir valley is well suited for breeding, rearing and production of trout fish. The snow-fed and glacier-fed streams, mountains, lakes and springs of the state boost the healthy environment of the trout fish. The physico-chemical parameters of the cold waters of Kashmir Valley are beneficial and productive for trout fishes. The survival rate of trout eggs in Kashmir has been estimated to be about 10% higher than the western average of 46% (Hassan and Pandey, 2012) [13].

Material and Methods

During the present study, 90 samples of *O. mykiss* ranging from 220-350mm in total length and 85-505.5g in total weight were collected from three state owned trout farms namely, Mammar Trout Fish Farm, Ganderbal, Dachigam Trout Fish Farm, Srinagar and Achabal Trout Fish Farm, Anantnag on monthly basis from August 2015 to January 2016. The weight of the fish was measured to the nearest 0.1g by using a digital weighing balance (Shimadzu), while the morphometric characters were measured using Digital Venier Caliper (Truesize) to the nearest mm. The eleven measurements taken were total length (TL), standard length (SL), pre-dorsal length (PDL), pre-pectoral length (PPcL), pre-pelvic length (PPvl), pre-anal length (PAL), head length (HL), snout length (SnL), body depth (BD), eye diameter (ED) and caudal fin length (CFL). The relationship of various morphometric characters with total length and head length were established. Scatter diagrams were plotted and least square method was used to fit regression equation (Laevastu, 1965; Snecdecor and Cochron, 1967). The relationships were presented as:

$$Y = a + bx$$

Where, 'Y' is dependent variable, 'a' is intercept (constant), 'b' is regression coefficient (slope) and 'X'is independent variable The length-weight relationship was estimated by using allometric formula of Le Cren (1951) as:

$$\text{Log } W = \text{Log } a + b \times \text{Log } L$$

Where 'W' = weight of fish in g, 'L' is length of fish in mm, 'a' is the intercept and 'b' is the slope or regression coefficient

Results and Discussion

The statistical analysis of the collected data revealed that the coefficient of variation was maximum for body depth (13.32%) followed by snout length (13.16%) while minimum value of CV was obtained for pre-pelvic length (7.85%) followed by head length (8.03%). In this study, a straight-line regression was obtained for the various morphometric characters (Figure 1). The statistical estimates of morphometric characters are presented in table 1. The correlation coefficient 'r' for morphometric characters indicate a high degree of correlation, (0.571 to 0.879) (Table 2). Similar results have been obtained by various authors. Shah *et al.*, (2011) [22] worked on farmed rainbow trout from Dachigam, Kashmir and reported a high level of interdependence between the morphometric characters. Bhat *et al.*, (2013) [5] studied the morphometric characteristics of Schizothoracines from Lidder waters in Kashmir and reported a positive correlation coefficient of total length with other parameters.

The length-weight relationship was estimated as $W = 1.957L^{3.028}$ (Figure 3). The correlation coefficient (R^2) for length-weight relationship was found to be 0.608, indicating a positive relationship between the two parameters. The value of b (growth coefficient) was estimated at 3.028 which suggest an isometric growth pattern of the fish, indicating that the fish grows with equal proportions in all dimensions. Shah *et al*., 2013 has also reported isometric growth for rainbow trout from Kashmir. Site-wise comparison of length and weight of fish revealed a non-significant difference at the three sites ($p>0.05$) (Table 3). The information on condition and growth patterns of fish can be obtained specifically by length-weight relationships (Bagenal and Tesch, 1978) [2]. The growth of fishes is regarded as isometric when length grows similar in equal proportions of weight keeping specific gravity constant (Mortuza and Al-Misned, 2013) [18]. Qadri *et al.*, (2016) [21] studied morphometry and length-weigth relationship in *S. curvifrons* and reported that morphometric characters are highly correlated with each other. Brraich and Akhter (2015) [7] studied morphometrics of *Crossocheilus latius latius* from Ranjit Sagar and reported positive correlation between total length and external body parts and population appeared to be relatively uniform as revealed by morphometric characters, thus considered as isometric growth. Abowei *et al* (2009) [1] investigated length-weight relationship of five fish species from Nkoro River in the Niger delta region of Nigeria and reported that all species studied exhibited isometric growth (b=3) except *S. maderensis* and *C. senegalensis* with 'b' equal to 3.6 and 3.5 respectively that exhibited positive allometric growth. Dali *et al* (2015) [8] described length-weight relationship in *Clarias gariepinus*, in Kiri reservoir and reported 'b' value at 3.80 and documented that it differed significantly ($p<0.05$) from 3, which indicates that fish species exhibited allometric growth. Parmar and Bhatia (2014) [20] studied length-weight relationship of *Cirrhinus mrigala* from Pong reservoir of the Kangra district of Himachal Pradesh and established length weight relationship as $\text{Log } W = -0.401745082\ L^{3.2848}$. Gupta and Banerjee, 2013 studied length-weight relationships (LWR) of Nile tilapia, *Oreochromis niloticus* in Wadi Hanifah, Riyadh, Saudi Arabia and reported values of regression coefficient (b) for length-weight relationship as 3.16, 2.98 and 3.01 for male, female and combined sex respectively and documented that this indicated positive allometric growth for all sexes.

Table 1: Statistical estimates of various morphometric characters of *Oncorhynchus mykiss*

Statistical Estimates	Range (mm)		Mean (mm)	Median (mm)	Standard deviation	Standard error	Coef of Variation (%)
	Min	Max					
Total Length	220.00	350.00	291.61	293.00	23.88	2.75	8.19
Standard Length	189.00	10.00	241.53	240.00	20.47	2.36	8.47
Pre-dorsal Length	95.00	155.00	126.60	127.00	11.60	1.34	9.16
Pre-pectoral Length	43.00	63.00	54.16	54.00	4.38	0.50	8.10
Pre-pelvic Length	110.00	180.00	141.96	142.00	11.15	1.28	7.85
Pre-anal Length	148.00	238.00	192.10	193.00	16.65	1.92	8.67
Head Length	47.00	69.00	60.22	61.00	4.83	0.55	8.03
Snout Length	10.00	23.00	15.74	16.00	2.07	0.23	13.16
Body depth	50.00	86.00	72.13	74.00	9.61	1.10	13.32
Eye diameter	11.00	18.00	14.68	14.00	1.68	0.19	11.48
Caudal fin Length	39.00	62.00	50.38	51.00	4.41	0.50	8.76

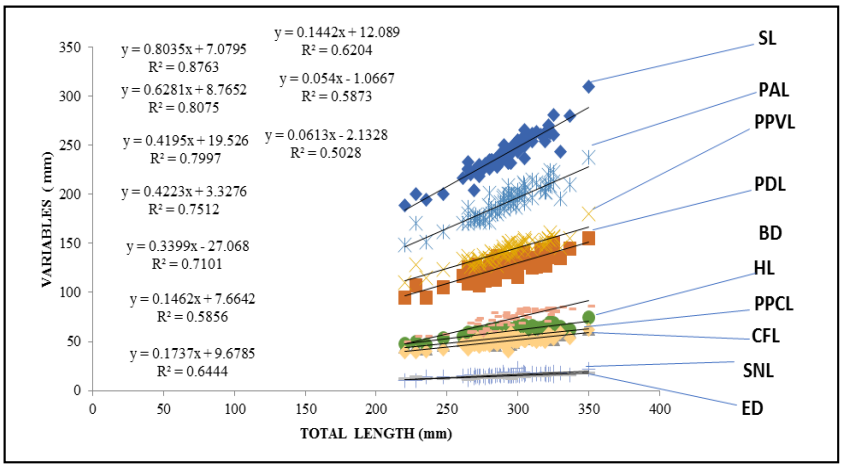

Fig 1: Logarithmic relationship of different morphometric characters with total length in *Oncorhynchus mykiss.*

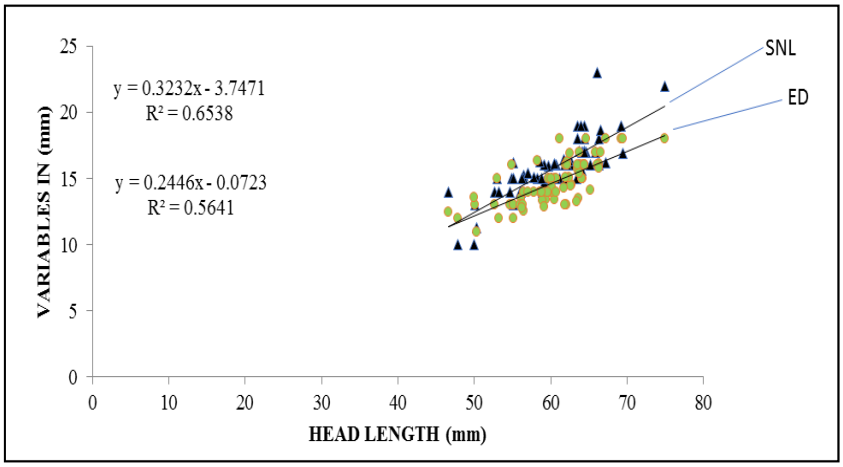

Fig 2: Logrithmic relationship of different morphometric characters with head length in *O. mykiss*

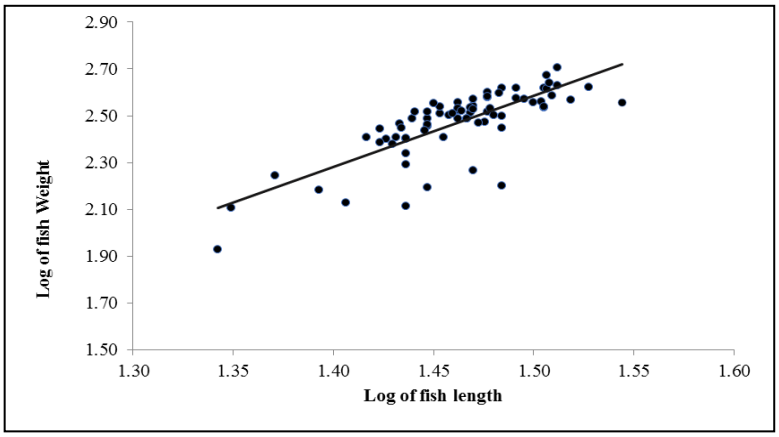

Fig 3: Logrithmic relationship of fish length with fish weight in *Oncorhynchus mykiss*

Table 3: Comparison of length and weight of *O. mykiss* (female) at various sites (Mean±SD) in mm**.**

Source	Site I (Mammar)	Site II (Dachigam)	Site III (Achabal)	F Value	*P* Value
Length	28.98±2.65	29.07±2.53	29.23±2.23	0.06546	>0.05
Weight	306.35±69.46	296.99±95.38	326.31±82.84	0.86	>0.05

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