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Length-weight relationship and condition factor of *Cyprinus carpio* var. *communis* in Manasbal lake, Kashmir

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Abstract
An investigative study was carried on the length-weight relationship and condition factor of *Cyprinus carpio* var. *communis*, in Manasbal Lake, Kashmir. A total of 360 samples were collected from July 2018 to June 2019. The length-weight relationship was established as W= 4.6033 $L^{2.9031}$. The study indicated a negative allometric growth. The condition factor ranged between 1.23 to 1.88 in females and 1.31 to 1.84 in males indicating good condition of the fish. The combined condition factor was found to be highest (1.87) in the month of November and lowest (1.27) in the month of March.

Keywords: Common carp, length-weight, condition factor, Manasbal Lake, Kashmir, *Cyprinus carpio*

Introduction
The common carp *Cyprinus carpio* is one of the most widely-distributed freshwater fishes in the world (Vilizzi, 2018) [37]. Common carp is a hardy fish and can withstand wide fluctuation in temperature. It has wide adaptability to varying climatic and environmental conditions as well as to divergent feed availability. It is omnivorous and feeds on food items as per availability. It can tolerate varying oxygen levels in the water (FAO, 2009) [8]. Apart from this, unlike other major carps, the common carp breeds in confinement. In view of these features, common carp is a best suited fish for culture in Kashmir waters. Carp and other cyprinids contribute the largest share in the total global aquaculture production (FAO, 2018) [9]. The common carp was introduced in Kashmir in 1956 and since then this fish has shown remarkable adaptation in various water bodies of the state, and constitutes a major fishery of flat land temperate waters of Kashmir (Fotedar and Qadri, 1974) [12]. *Cyprinus carpio* var. *communis*, commonly known as scale carp is one of the most commercially important fish species in the Manasbal lake and scientific knowledge about this fish is required for rational exploitation and management of the resource.

The determination of relationship between the length of the fish and its weight is of immense importance in fish biology, physiology and ecology. This relationship serves the purposes of determining the type of the mathematical relationship between two variables so that if one variable is known the other could be computed (Mir *et al.*, 2012) [23]. The relationship is also helpful for calculating the yield of exploited species in different age groups and may indicate some taxonomic differences, metamorphosis or onset of sexual maturity. These methods are also widely used for conversion of the growth in length equation to growth-in-weight for use in stock assessment models, estimation of the mortality rate and estimation of biomass from length observations (Weatherley and Gill, 1987) [40]. According to Bayhan *et al.* (2008) [4], the data on length and weight can also be used to compare fish life history between regions in species and populations. The relationship between length (L) and weight (W) typically takes the allometric form: $W=aL^b$ or in the linear form: Log W=Log a + b Log L, where 'a' and 'b' are constants estimated by regression analysis. The length-weight relationship provides an opportunity to calculate an index commonly used by fisheries biologists to compare the "well-being" of a fish (Sani *et al.*, 2010) [25]. This index is called condition factor (K). Fish condition, which is defined as the robustness or wellbeing of an individual fish (Blackwell *et al.*, 2000), is an essential component of fishery biology used to assess the general health of populations (Gulland, 1983) [15].

Material and Methods

Study area and Sampling Design

Manasbal lake is situated about 32 kilometers away towards north-west of Srinagar city in Ganderbal district of Kashmir valley. It lies between 34°15′N latitude and 34°39′-34°41′E longitude at an attitude of 1,583 meters above m.s.l. and covers an area of about 2.81 km^2 (Sarah *et al*., 2011) [26]. It is the deepest of all the fresh water lakes of Kashmir Valley (Sarah *et al.,* 2011) [26]. It is fed by ground water and has predominantly a rural ambience with three villages namely Gratabal, Kondbal and Jarokbal in its surroundings. mountains on its eastern and southern sides.

Fig 1: Map of the study area showing the three sampling sites

A total 360 specimen of *Cyprinus carpio* var. *Communis* were collected monthly during July, 2018 to June, 2019 from three sampling sites i.e. Manasbal, Jarokhbagh and Kondabal (Fig. 1). These samples were brought to the laboratory in order to calculate the length-weight relationship and condition factor.

Estimation of length-weight relationship

The length-weight relationship was estimated from the allometric formula proposed by Le-Cren (1951) separately for both sexes as well as for combined data.

$W = aL^b$

or Log W= Log a + b x Log L

Where, "W" is the total body weight in grams, "L" is the total length in mm, "a" and "b" are the coefficients of the functional regression.
To test 'b' value against the value of '3', Student's t-test was employed to predict any significant deviation. The t-statistic was calculated as follows:

The hypothesis given is,
H_0: Growth is isometric i.e. H0: b = 3
H_1: Growth is not isometric i.e. H1: b ≠ 3
The t statistics used are given by:

$t = |b-3|/Sb$

Where, Sb= Standard error of "b" and t has (n-2) degrees of freedom.

Condition Factor

The relationship between length and weight for individual fish is used to calculate Fulton's Condition Factor Index using the following equation (Fulton, 1904) [13]:

$K=W\backslash L^3 \times 10^5$

Where, K is the condition factor, W is the weight of the fish in grams (g) and L is the total length in mm.
The condition factor (K) was calculated month-wise and length-wise for both the sexes separately. The mode in the 'K' values can be taken to be an index of gonadal maturity and spawning season or better feeding conditions (Anderson and Gutreuter, 1983) [2].

Results

In the present study, the length-weight relationship of 360 specimen comprising of 198 males and 162 females of *Cyprinus carpio* var. *communis* was determined. The minimum length of 110 mm and a maximum of 319.6 mm was recorded. Similarly the minimum and maximum weight ranged from 22g to 470g respectively. The length- weight relationship equations were obtained are as follows:

Male: Log W = -4.980 + 3.067 Log L (R^2 = 0.826)
Female: Log W = -4.557 + 2.882 Log L (R^2 = 0.814)
Combined: Log W = -4.6033 + 2.9031 Log L (R^2 = 0.811)

The above regression equations, revealed that the there was significant differences between males and females in growth coefficient *b*. The values of '*b*' indicated that growth was more pronounced in case of males than females. In order to test whether length- weight relationship follows the isometric growth pattern or not, Student's t-test was applied.

t = |2.903-3|/0.03074
t= -3.1554

The calculated "t" value was found to be significantly different from 3 at 1% level indicating negative allometric growth for *Cyprinus carpio* var. *communis*

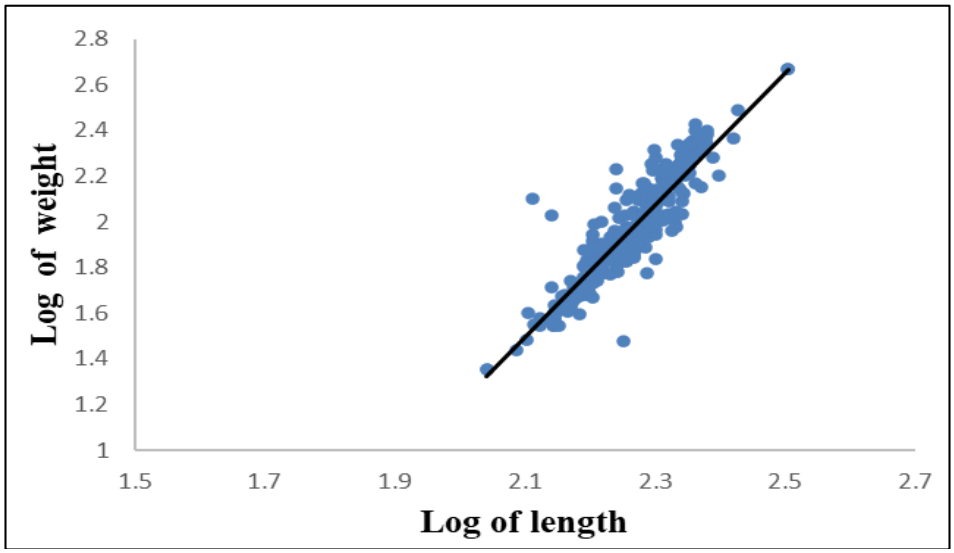

Fig 2: Logarithimic relationship between length and weight in *C.carpio* var. *communis* (Combined)

Condition Factor (K)

The condition factor (K) of *Cyprinus carpio* var. *communis* was higher in the month of October (1.88) and lowest in the month of March (1.23) in females and in case of males it was highest in the month of September (1.84) and lowest in the month of March (1.31). The graphical representation of month wise condition factor of *Cyprinus carpio var. communis* is given in Fig. 3

Table 1: Monthly average of Relative condition factor (K)

Months	Female ± SEM	Male ±SEM	Combined ±SEM
July	1.48 ± 0.1269	1.52 ± 0.0152	1.50 ± 0.007
August	1.51 ± 0.0186	1.46 ± 0.0104	1.45 ± 0.004
September	1.49 ± 0.0192	1.84 ± 0.02338	1.46 ± 0.0130
October	1.88 ± 0.0332	1.64 ± 0.0372	1.82 ± 0.0155
November	1.64 ± 0.0330	1.65 ± 0.0126	1.87± 0.0284
December	1.72 ± 0.0155	1.68 ± 0.0481	1.82 ± 0.0203
January	1.80 ± 0.1155	1.83 ± 0.0258	1.77 ± 0.0023
February	1.64±0.0373	1.31 ± 0.0125	1.73 ± 0.0155
March	1.23 ± 0.0244	1.31 ± 0.0308	1.27 ± 0.0081
April	1.38 ± 0.0240	1.36 ± 0.0310	1.34 ± 0.0135
May	1.31 ± 0.2046	1.38 ± 0.0122	1.38 ± 0.0116
June	1.46 ± 0.0096	1.45 ± 0.0295	1.44 ± 0.006
Average	1.545± 0.0588	1.536 ±0.0234	1.57± 0.0131

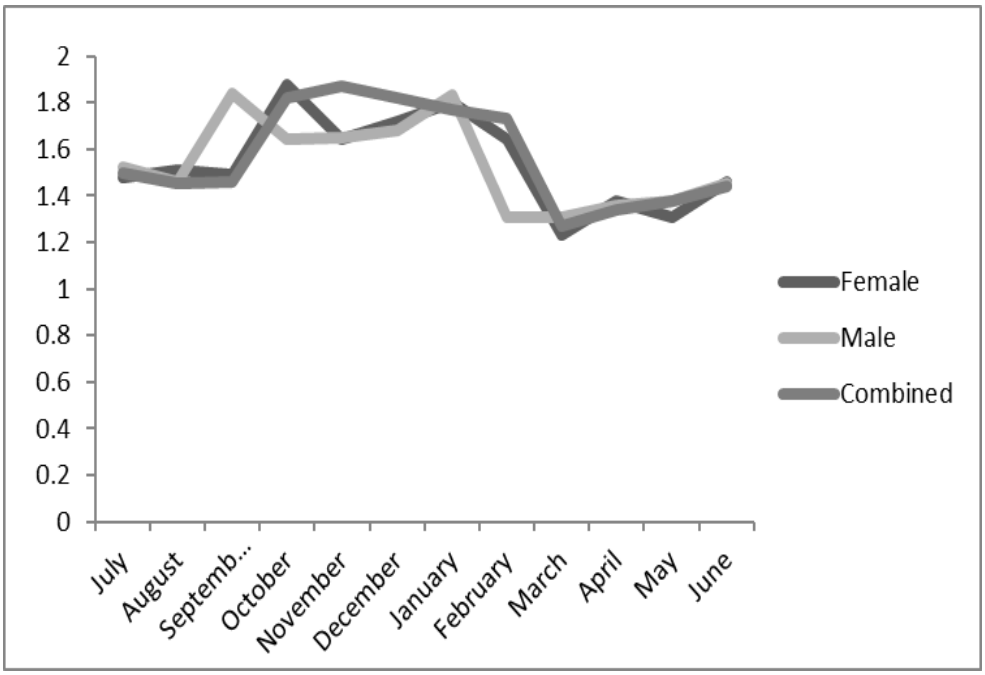

Fig 3: Monthly condition factor for *Cyprinus carpio* var. *communis* (Males, Females and Combined)

Discussion

Length-weight relationship

During the present study, the mean size of *Cyprinus carpio* var. *communis* reported was 184.4 mm which is considerably lower than that reported by Kindong *et al*. (2018) [19] for the same species in Dianshan Lake, Shanghai (241.4mm) and by Hashemi *et al.* (2014) [16] from Shadegan wetland, Iran (256 mm). In the present study, the correlation coefficient (R^2) was found to be 0.811 while for the same species, Fatemi *et al*. (2009) [11] and Singh *et al.* (2015) [33] recorded a correlation coefficient of 0.9828 in southern Caspian Sea and 0.903 in bheries of West Bengal respectively. Shah *et al*. (2011) [29] recorded a high correlation coefficient of 0.9751 for farmed female rainbow trout in Kashmir while as Wali *et al*. (2019) [39] found a much lower correlation coefficient of 0.608 in trout from Kashmir. In *Sardinella longiceps* found along the Ratnagiri coast of Maharashtra, Shah *et al.* (2014) reported the correlation coefficient to be 0.721, 0.739, 0.740 for males, females and pooled data respectively. In Kenya, Aera *et al*. (2014) [1] found the value of correlation coefficient for *Cyprinus carpio* var. *communis* to be much lower i.e 0.82 and 0.72 for males and females respectively. The higher correlation coefficient (r) for *C. carpio* indicated positive correlation between the two parameters of length and weight.

The value of growth coefficient (b) was estimated as 2.903 which differed significantly from value of 3, indicating a negative allometric growth for the fish. Aera *et al*. (2014) [1] reported b value of 2.3 for males and 1.9 for females. Shukla and Mishra (2017) [32] reported a b value of 2.715 in Govindgarh lake, Madhya Pradesh for *Cyprinus carpio* var. *communis*. Kingdong *et al*. (2018) [19] reported a b value of 2.75 from Dianshan lake, Shanghai depicting an allometric growth pattern. Mert and Bulut (2014) [22], Saylar and Samra (2014) [28] have reported negative allometric growth for *Cyprinus carpio*, with b values 2.9 and 2.8 respectively. However, positive allometric growth for the fish has also been reported by Kartas *et al*. (2007) [18] and Kirankaya and Ekmeki (2004) [20] who reported b value of 3.21 and 3.022 respectively. Wali *et al*. (2019) [39] reported an isometric growth in trout with a b value of 3.028. Shah *et al.* (2011) [29] found a positive allometric growth of farmed female rainbow trout in Kashmir with a b value of 2.683. Hossain (2010) reported that the calculated coefficient b varied among the species from a minimum of 3.004 for *A. morar*, to a maximum of 3.758 for *A. mola*. The study also indicated positive allometric growth for the combined sexes. Shah *et al.*. (2014) [31] reported a negative allometric growth for *Sardinella longiceps* with a b value of 2.645 along Ratnagiri coast of Maharashtra. Solomon *et al.* (2016) [35] recorded negative allometric growth pattern with a growth exponent (b) value of 2.18 for periwinkile (*Tympanotonous fuscatus*) from Okrika estuary, Nigeria**.** Farooq *et al*., 2017 [10] also reported a negative allometric growth (b=2.578) in *Schizothorax labiatus* in River Jhelum, Kashmir. Qadri *et al*. (2017) [24] recorded a b value of 2.6138 for *Schizothorax curvifrons* in River Jhelum, Kashmir According to Gerritsen *et al*. (2003) [14], the variations in 'b' values between males and females may depend on various factors such as number of specimen examined, and the sampling season. However the change of b values may also depend primarily on the shape and fatness of the species as well as physical factors such as temperature, salinity, food, sex and stage of maturity (Wootton, 1998 and Sarkar *et al*., 2013) [27].

Condition factor

In the present study, the combined condition factor (K) varied from 1.27 to 1.87 with maximum value in females (1.88) in October and minimum value (1.23) in March while in males, the maximum (1.84) and the minimum (1.31) values were obtained in September and March respectively. Sinha (1972) [34] reported that monthly condition values are known to be influenced by mainly three factors viz. maturity of gonads, amount of undigested food in the alimentary canal and changes in the amount of fat stored in body tissue. A mean condition factor of 1.5 in males and 1.4 in females was reported in *Schizothorax labiatus* by Farooq *et al*. (2017) [10] from River Jhelum. Aera *et al.* (2014) [1] reported the condition factor of both males and females was greater than 1. This shows that the fish is above average condition in the lake (Wade 1992) [38]. Singh *et al*. (2015) [33] reported that the relative condition factor (K) of *Cyprinus carpio* from bheries of West Bengal varied from 0.93 to 1.10 in male and 0.95 to 1.19 in female. Shah *et al.* (2013) [30] recorded a condition factor of 1.15 of *Onchorynchus mykiss* from Dachigam stream in Kashmir. Ekpo (2013) [6] has reported a high condition factor (1.24) for *E. aeneus* in the Qua Iboe River estuary, Akwa Ibom State, southeastern Nigeria. In Alexandria region and Salloum Bay region (Egypt), Ezzat (1982) [7] found K values of 1.123 and 1.114 respectively. Le Cren (1951) [21] reported that environmental factors, food supply and parasitism have great influence on the health of the fish. Condition factor also gives information when comparing two populations living in certain feeding, density, climate and other conditions; when determining the period of gonadal maturation and when following up the degree of feeding activity of a species to verify whether it is making good use of its feeding source (Bagenal and Tesch, 1978). Furthermore, Vazzoler (1996) [36] confirmed that lowest K values during the more developed gonadal stages might mean resource transfer to the gonads during the reproductive period.

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