Length Weight Relationship (LWR) and Condition Factor (K) of Brown Trout, *Salmo trutta fario*

Muddasir Jan, Neelofar Jan and Imtiaz Ahmed*

Fish Nutrition Research Laboratory, Department of Zoology, University of Kashmir, Hazratbal, Srinagar – 190006, Jammu and Kashmir, India; imtiazamu1@yahoo.com

Abstract

Length-weight relationships and condition factor of *Salmo trutta fario* (Brown trout) at Kokernag trout fish farm, Anantnag, Jammu and Kashmir was estimated for a period of one year. During the present study the fish samples was within the range of 30cm to 45.8cm in length and 250g to 750g in weight were originally used to provide information on the condition of fish and to determine whether somatic growth was isometric or allometric. The relationship was analysed using the formula W = a L^b which was further transformed into Log W = a + b log L. The equation obtained for females was log W = 1.61 + 3.33 log L and for males was log W = 1.81 + 3.22 log L. Females show 'b' value slight more than males. Studies on condition factor revealed that the fluctuations in K values can be attributed to the spawning cycle. The condition factor 'K' was above 1 indicating robustness or well being of the experimental fish.

Keywords: Condition Factor, Length-Weight Relationship, *Salmo trutta fario*

1. Introduction

*Salmo trutta fario* (brown trout) is one of the most important fish species which is a native of European waters and now it has become extensively distributed throughout many of the fresh waters of the world including Jammu and Kashmir. It was introduced in Jammu and Kashmir due to its high aquaculture potential, economic value, good taste and high nutritional value. Brown trout (*Salmo trutta fario*) and Rainbow trout (*Oncorhynchus mykiss*) constitute the trout fishery in the streams, Lakes and reservoirs in the Indian uplands[23]. Trout is highly nutritious and it contains omega-3 poly unsaturated fatty acid that is needed for the development of brain and retina in infants[4]. This fish prefers wild type of environment and accepts less amount of artificial feed which is a big challenge for its culture practice. Kokernag trout hatchery is doing lot of efforts for artificial propagation of this fish.

Length-weight relationship of fishes is an important aspect in fisheries and fish biology because it is used in estimation of the average weight of the fish of a given length group by establishing a mathematical relation between them[21,22,24]. The length weight data has two main purposes; it helps to express the relationships between length and weight, so that one of them can be converted into another. It helps to measure the variation of fish condition from the observed weight in relation to the length of the individual fish[14]. The length weight relationship can be extended for the estimation of fish condition assuming that heavier fish of a given length is in better condition[1].

The data on length-weight relationship of some fish species from Kashmir valley has also been reported by different workers[19,24,25,26,27]. Fulton's condition factor (K) is widely used in fisheries and fish biology studies. This factor is calculated from the relationship between the weight of a fish and its length, with the intention of describing the condition of that individual fish[10]. The condition factor is used for comparing the condition, fatness or wellbeing of fish, based on the assumption that heavier fish of a given length are in better condition[12]. As per existing literature, not so much work has been done on length-weight relationship and condition factor of a highly demanded fish *Salmo trutta fario*. Therefore, the study provides baseline...
information on this fish species, which may serve as a tool for management and culture practices.

2. Materials and Methods

2.1 Study Sites
Kokernag is located within geographical coordinates of 33.584721°N and 75.308601°E and is famous for its trout stream and trout hatchery where trout is reared. The study site was selected at Department of Fisheries Kokernag trout fish farm, Anantnag, Jammu and Kashmir. The species of trout fish which are bred as well as propagated are Rainbow trout \((Oncorhyncus mykiss)\) and Brown trout \(Salmo trutta fario\).

2.2 Collection and Identification of Specimens
The method for identification of fish was used as described earlier by Day 1878 and Kullander et al., 1999.

2.3 Collection of Fish for Measurement of Length-Weight Relationship (LWR)
The samples were randomly collected from the raceways. Total length (TL) was measured to the nearest 0.01 cm and the length of the fish was taken from the tip of snout (mouth closed) to the tip of the caudal fin and the weight was taken on digital electronic balance (Shimadzu UX320G) with 0.01g accuracy. The statistical relationship between these parameters of fishes was established using the parabolic equation as described by:

\[ W = aL^b \]

Where, \(W\) = weight of fish (g)
\(L\) = total length of fish (cm)
\(a\) = constant
\(b\) = an exponential expressing relation between length and weight

The relationship \((W=aL^b)\) when converted into the logarithmic form gives a straight line relationship graphically

\[ \log W = \log a + b \log L \]

Where \(b\) represents the slope of the line, \(\log a\) is a constant.

2.4 Condition Factor (K)
The coefficient of condition K was calculated by using Fulton\(^{10}\), equation:

\[ \text{Condition factor (K)} = \left(\frac{W}{L^3}\right) \times 100 \]

Where, \(W\) = weight in grams, \(L\) = length in cm and 100 is a factor to bring the value of K near unity\(^9\).

3. Results

3.1 Length-Weight Relationship
The monthly data on length-weight relationship of female and male fish is given in Table 1 and Table 2, respectively. During the present study length weight relationship showed some variation throughout the year. The mean value of \((b)\) in both sexes showed positive allometric growth i.e. \(b>3\). In case of females the growth coefficient \((b)\) was minimum in May (3.12) and maximum in November (3.79). The coefficient of determination \((r^2)\) ranged from 0.72 in April to 0.96 in November in females. Whereas in case of males the growth coefficient \((b)\) was minimum in May (3.00) and maximum in November (3.76). The coefficient of determination \((r^2)\) ranged from 0.39 in October to 0.98 in January. The coefficients \(a\), \(r^2\) and \(b\) differs due to variations in the length classes. The values were obtained through SPSS statistical software by using linear regression. Length-weight relationship of females and males of \(Salmo trutta fario\) can be expressed by the equations: \(\log W = 1.61 + 3.33\log L\) and \(\log W = 1.81+ 3.22\log L\) respectively as shown in Table 1 and 2.

3.2 Condition Factor
The condition factor was calculated month-wise, it ranged from 0.99 ± 0.10 to 1.87 ± 0.08 in females. The highest condition factor (K) in case of females was reported in November i.e. 1.87 ± 0.08, while lowest condition factor was reported in January 0.99 ± 0.10 (Table 3). In case of males, it ranged from 0.98 ± 0.126 to 1.77 ± 0.40 with highest in the month of November 1.177 ± 0.40, whereas lowest was recorded in the month of January 0.98 ± 0.12.
| Months  | Total Length (cm) | Total Weight (g) | Regression Parameters W = aL^b | r^2  |
|--------|------------------|-----------------|-------------------------------|------|
|        | Min              | Max             | Min                          | Max  |
| January | 22.5             | 42.3            | 104                          | 760.3|
| February| 21.9             | 40              | 154                          | 650  |
| March  | 24.7             | 34.5            | 480                          | 417.2 |
| April  | 24.7             | 34.4            | 40                           | 440  |
| May    | 24.7             | 41.1            | 646.2                        | 3.22 |
| June   | 24.7             | 43.8            | 840.4                        | 3.24 |
| July   | 23.2             | 38.2            | 108                          | 341  |
| August | 26               | 38.1            | 140                          | 361  |
| September | 23               | 43.5            | 166.4                        | 3.33 |
| October | 23.5             | 39.5            | 120                          | 3.43 |
| November | 24.2             | 43              | 124                          | 3.79 |
| December| 26               | 42.8            | 182                          | 3.24 |

- **Table 1.** Monthly length-weight relationships of *Salmo trutta fario* female (Brown trout)

- **Mean±SD:** 23.90±1.35, 40.1±3.28, 129.98±35.41, 587.07±1210.96, 1.61±0.31, 3.33±0.20, 0.90±0.07
Table 2. Monthly length-weight relationships of *Salmo trutta fario* male (Brown trout)

| Months     | Total Length (cm) | Total Weight (g) | Regression Parameters $W = aL^b$ | $r^2$ |
|------------|-------------------|------------------|----------------------------------|-------|
|            | Min   | Max  | Min  | Max  | a     | b     |       |
| January    | 23    | 44.2 | 160  | 915.7| 1.63  | 3.21  | 0.98  |
| February   | 28    | 44   | 316  | 860  | 1.11  | 3.23  | 0.87  |
| March      | 28    | 44   | 166.4| 840.4| 1.22  | 3.12  | 0.92  |
| April      | 24.7  | 43.8 | 166.4| 840.4| 1.53  | 3.21  | 1.53  |
| May        | 24.5  | 43   | 164  | 800  | 2.11  | 3.00  | 0.96  |
| June       | 29.3  | 42.9 | 252  | 700  | 1.80  | 3.21  | 0.89  |
| July       | 26    | 38.1 | 140  | 410  | 1.58  | 3.16  | 0.89  |
| August     | 23    | 44.2 | 104  | 915.7| 2.85  | 3.13  | 0.97  |
| September  | 29.8  | 45   | 200  | 840  | 1.77  | 3.20  | 0.88  |
| October    | 29    | 44   | 230  | 830  | 1.68  | 3.01  | 0.39  |
| November   | 33    | 42   | 305  | 672  | 1.39  | 3.76  | 0.79  |
| December   | 33    | 47   | 305  | 1030 | 2.70  | 3.48  | 0.90  |
| Mean±SD    | 27.60±3.45 | 43.51±2.09 | 209.066±71.4 | 804.51±155.8 | 1.81±0.515 | 3.22±0.1 | 0.917±0.24 |
Figure 1. Showing regression line for (LWR) of female fish *Salmo trutta fario*.

Figure 2. Showing regression line for (LWR) of male fish *Salmo trutta fario*.

Table 3. Month wise condition factor of female and male of *salmo trutta fario* (Brown trout)

| Months   | Females K±SD | Males K±SD |
|----------|--------------|------------|
| January  | 0.99±0.10    | 0.98±0.12  |
| February | 1.02±0.06    | 1.16±0.12  |
| March    | 1.05±0.14    | 1.14±0.40  |
| April    | 1.07±0.14    | 1.08±0.12  |
| May      | 1.08±0.09    | 1.04±0.11  |
4. Discussion

Studies on the length weight relation of fishes constitutes an important tool in fishery biology and it helps to determine whether somatic growth was isometric or allometric\(^{15,13}\). It is useful in fish stock and population assessment\(^1\). The parameter length-weight relationships (LWR) is affected by a series of factors viz. season, habitat, gonad maturity, sex, diet, stomach fullness, and health\(^{22,3,7}\). The length-weight relationship (LWR) is obtained monthly throughout a complete annual cycle and hence was followed same way in present study for appropriate results. The growth coefficient (b) estimated in the present study was within the range of 3.12-3.79 in case of females, whereas in case of males it was found to be in range of 3.00-3.76. The b value was found slightly higher in females as compared to males. The higher b value in female implies that the females gain weight at a faster rate in relation to its length\(^{15}\).

Similar results were also reported by Rawat et al. (2014) on *Salmo trutta fario* from river Asiganga and found b value 3.04 in females and 3.09 in case of males. Whereas Bagenal and Tesch (1978) also reported that the ‘b’ value fluctuates between 2 to 4. Similar results were observed by Dar et al. (2012) in *Schizopyg esocinus*. According to Le Cren (1951) ecological conditions of the habitat, temperature, food supply, spawning, sex, age or variation in the physiology of the animals are responsible for growth rate variations in the same species in different months of a year. The b values observed in the present study were above 3 which mean that *Salmo trutta fario* in Kokernag trout fish farm exhibit positive allometric growth.

Condition indices have been widely used as indicators of relative health and robustness (Brown and Murphy, 1991). The condition factor is also used for comparing the condition, fatness, or well being of fish, based on the assumption that heavier fishes of given length are in better condition\(^1\). It is strongly influenced by both biotic and abiotic environmental conditions and can be used as an index to assess the status of the aquatic ecosystem. Condition factor can also be affected by factors like sex, season, age and maturity stages of fish\(^8\).

In the present study the condition factor of *Salmo trutta fario* showed variation in different months. In case of females it ranged from 0.99 ± 0.10 to 1.87 ± 0.08, with its peak value in November and minimum in the month of January. Similarly in case of males it ranged from 0.98 ± 0.126 to 1.77 ± 0.40, and the highest value of K was recorded in the month of November and the lowest value was again recorded in the month of January. Finally, the length weight relationship and condition factor presented here will prove useful information for fisheries management, research and fish population dynamic studies.

5. Acknowledgements

The authors are grateful to the Head, Department of Zoology, University of Kashmir, Hazratbal, Srinagar, India for providing necessary laboratory facilities and project officer, trout fish farm Kokernag for his kind approval and help to carry out this work and also gratefully acknowledge the Department of Science and Technology (DST), Govt of India, New Delhi for providing the financial support for the establishment of Fish

| Month   | June       | July       | August     | September  | October    | November   | December   |
|---------|------------|------------|------------|------------|------------|------------|------------|
|         | 1.09±0.06  | 1.03±0.13  | 1.10±0.08  | 1.09±0.41  | 1.21±0.13  | 1.11±0.31  | 1.41±0.12  |
|         | 1.62±0.10  | 1.51±0.21  | 1.87±0.08  | 1.77±0.40  | 1.72±0.11  | 1.62±0.12  | 1.09±0.08  |
|         |            |            |            |            |            |            | 1.09±0.08  |
6. References

1. Abowie JFN. The condition factor, length-weight relationship and abundance of Elops senegalensis (Regan, 1909) from Nkoro river, Niger Delta, Nigeria. Advance Journal of Food Science and Technology. 2010; 2:16-21.

2. Ackman RG. Nutritional composition of fats in sea food. Progress in Food and Nutrition Science. 1989; 13:161-241. PMid:2699043

3. Bagenal TB and Tesch FW. Conditions and growth patterns in fresh water habitats. Blackwell Scientific Publications, Oxford, UK. 1978; p. 75-89.

4. Bhagath MJ and Sunder S. A preliminary notes on length-weight relationship and condition factor Schizothorax plagiostomus (Heckel, 1883) from Jammu region. Journal of Inland Fisheries Society of India. 1983; 15:73-4.

5. Bhat FA, Yousuf AR, Balkhi MH, Mahdi MD and Shah FA. Length-weight relationship and morphometric characteristics of Schizothorax spp. in the river Lidder of Kashmir. Indian Journal of Fisheries. 2010; 57:73-6.

6. Brown ML and Murphy BR. Standard weight (WS) development for striped bass, white bass and hybrid bass. North American Journal of Fisheries Management. 1991; 11: 451–467.

7. Dav SA, Najar AM, Balkhi MH, Rather MA and Sharma R. Length weight relationship and relative condition factor of Schizopyge escocinus (Heckel 1838) from Thelum river Kashmir. International Journal of Aquatic Science. 2012; 3; 29–36.

8. Day F. The fishes of India, being a natural history of the fishes known to inhabit the seas and fresh waters of India, Burma and Ceylon reproduced in 1958. London: Willaim Dowen and sons. 1878; p. 778.

9. Demirel N and Dalkara EM. Weight-length relationships of 28 fish species in the Sea of Marmara. Turkish Journal of Zoology. 2012; 36:785-91.

10. Edah BA, Akande AO, Ayo-Olalusi C and Olusola A. Computed weight-dry weight relationship of Oreochromis niloticus, Tilapia. International Journal of Food and Safety. 2010; 12:109-16.

11. Froese R. Cube law, condition factor and weight-length relationship: history, meta-analysis and recommendations. Journal of Applied Ichthyology. 2006; 22:241-53. https://doi.org/10.1111/j.1439-0426.2006.00805.x

12. Fulton TW. The rate of growth of fishes. Twenty-second Annual Report Part III. Fisheries Board of Scotland, Edinburgh. 1904; 3:141-241.

13. Gumanao GS, Saceda-Cardoza MM, Mueller B and Bos AR. Length-weight and length-height relationships of 139 Indo-Pacific fish species (Teleostei) from the Davao Gulf, Philippines. Journal of Applied Ichthyology. 2016; 32:377-85. https://doi.org/10.1111/jai.12993

14. Khan MA and Sabah. Length-weight and length-length relationships for five fish species from Kashmir valley. Journal of Applied Ichthyology. 2013; 29:283-4. https://doi.org/10.1111/j.1439-0426.2012.02061.x

15. Koutrakis ET and Tsikliras AC. Short communication on length-weight relationships of fishes from three northern Aegean estuarine systems (Greece). Journal of Applied Ichthyology, 2003; 19:258-60. https://doi.org/10.1046/j.1439-0426.2003.00456.x

16. Kullander SO, Fang F, Delling B and Ahlander E. The fishes of the Kashmir valley, River Jhelum, Kashmir valley. Impacts on the aquatic environment. Nyman L ed. Swedmar, Goteborgs, Lanstrycker AB, Swedmar. 1999: p. 99-162.

17. Le Cren ED. The length-weight relationship and seasonal cycle in gonad weight and condition in the pearch (Perca fluviatilis). Journal of Animal Ecology. 1951; 20:201-19. https://doi.org/10.2307/1540

18. Mir FA, Mir JI, Patiyal RS and Kumar P. Length-weight relationships of four snow trout species from the Kashmir Valley in India. Journal of Applied Ichthyology. 2014; 30:1103-4. https://doi.org/10.1111/jai.12482

19. Mir JI, Shabir R and Mir FA. Length-weight relationship and condition factor of Schizopyge curvifrons (Heckel, 1838) from river Jhelum, Kashmir, India. World Journal of Fish and Marine Sciences. 2012; 4:325-9.

20. Ndiaye W, Diouf K, Samba O, Ndiaye P and Panfili J. The length-weight relationship and condition factor of white grouper (Epinephelusanaeus, Geoffroy saint Hilaire, 1817) at the south-west coast of Senegal, west Africa. International Journal of Advanced Research. 2015; 3:145-53.

21. Qadri MY and Mir S. Length-weight relationship of Orienus plagiostomus (McCl). Geobios. 1980; 7:158-9.

22. Rawat MS, Bantwan B, Singh D and Gusain OP. Length-weight relationship and condition factor of Brown trout (Salmo trutta fario) from river Asiganga, Uttarakhand (India). Journal of Environmental Conservation. 2014; 15:41-6.

23. Sarkar UK, Deepak PK and Negi RS. Length-weight relationship of clown knife fish Chitala chitala (Hamilton, 1822) from the Ganga basin. Journal of Applied Ichthyology. 2008; 25:232-3. https://doi.org/10.1111/j.1439-0426.2008.01206.x

24. Tesch FW. Age and growth. Methods for Assessment of Fish Production in Fresh waters. Ricker WE ed. Blackwell Scientific Publication, Oxford. 1971; p. 98-130.

25. Vass KK. Breeding biology of trout: Cold water aquaculture and fisheries, Narendra publishing house, Delhi. 2000; p. 155-68.