

Length–weight Relationship and Relative Condition Factor of *Cyprinus carpio* (Linnaeus, 1758) from Ottu Reservoir, Sirsa, Haryana

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Keywords:

Length–weight relationship, *Cyprinus carpio*, Relative condition factor, Ottu Reservoir

ABSTRACT

The length–weight relationship (LWR) and relative condition factor (Kn) of *Cyprinus carpio* from the Ottu Reservoir in Sirsa, Haryana, India, were studied in order to assess the species growth pattern and its physiological condition within the reservoir ecosystem. Using various fishing gear, fish samples (n = 260) have been collected from four sampling locations between January 2025 to December 2025. The body weight (g) and total length (cm) have been measured and evaluated using the cube law equation, $W=aL^b$. Both sexes' length and weight were strongly correlated, with high coefficients of determination ($R^2 = 0.96$) in the length–weight relationship. The female *C. carpio* showed positive allometric growth ($b = 3.1605$), indicating relatively larger weight gain relative to length, probably related to gonadal development, whereas males showed near-isometric growth ($b = 2.9833$), indicating proportional rise in weight with length. For both males (1.0055) and females (1.0192), the mean relative condition factor (Kn) was close to unity, reflecting generally good physiological condition and favourable conditions in the reservoir. There were seasonal differences in Kn, with relatively larger values in the spring and summer, possibly as a result of greater food availability and reproductive activity and slightly lower values in autumn and winter. Overall, the results reveal that *C. carpio* populations in the Ottu Reservoir maintain constant growth and a good condition of health, underscoring the reservoir's suitability and highlighting the significance of continuous monitoring for sustainable fisheries management and conservation.

DOI:

03.13802/Ama.11.03.2026.01



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1. Introduction

The common carp (*Cyprinus carpio* Linnaeus, 1758), also known as the European carp, is a prominent exotic cyprinid species that has become widely established across India's river systems, reservoirs and wetlands following its introduction for aquaculture purposes. The *C. carpio* is one of the most widely distributed freshwater fish species in the world, now established on every continent except Antarctica. In India, grows in diverse freshwater habitats including the Ganga, Yamuna, Brahmaputra, peninsular rivers and reservoirs. Ganga river dominates the catches in middle and lower stretch (up to 43% abundance) and exhibiting the high adaptability of changes in temperature, turbidity, nutrient availability and oxygen levels [13]. *C. carpio* is highly valued fish for its fast growth and suitability for aquaculture particularly in integrated and polyculture farming systems.

The study of length-weight relationships (LWRs) and condition factors in fish offers critical insights into population health and adaptive responses to environmental variability. It plays an important role in fisheries development, to know biological, physiological and ecological parameters and all the life history pattern of a fish population [2]. These metrics are particularly valuable for monitoring the impacts of natural and anthropogenic factors such as seasonal changes, habitat alterations and water quality fluctuations on fish populations. By using the available data, the LWR serves the purposes of determining the type of the mathematical relationship between two variables and approaches effectively considers fish biomass. It also estimates fish length based on the weight in a given environment, which ultimately results in estimates of biomass and population growth. In addition to ecological monitoring, length-weight data serve as a foundation for the development of predictive models in fisheries science. Such models assist in estimating biomass, projecting stock yields and informing sustainable harvest strategies. The ecosystem fish abundance is a key parameter in monitoring of fish populations [15]. There are various methods available to estimate fish abundance and species composition, with traditional approaches usually involving the selection of sites or sampling units in a water body, followed by counting the number of fish caught at those sites. Species composition and abundance are influenced by a variety of factors, including overfishing, dam construction, habitat destruction and biological pollution.

The length-weight relationship provides an opportunity to calculate an index commonly used by fisheries biologists to compare the “well-being” of a fish [5]. This index is called condition factor. Fish with a high condition factor (K) are heavier or in better physiological condition for their length, whereas fish with a low K value are comparatively lighter or in poorer condition [11]. The fish condition, which is defined as the robustness or wellbeing of an individual fish is an essential component of fishery biology used to assess the general health of populations. Additionally, the condition factor K provides information for comparing two populations depending on specific feeding, density and climatic conditions; identifying out when gonadal maturation occurs and monitoring a species level of feeding activity to make sure it is effectively utilizing its feeding source [7]. To maximize fishery production, it is crucial to identify environmental predictors of the variation in fish condition both within and among populations, and to extend this assessment to comparative studies across different river systems and geographic regions. Such comparisons help elucidate the influence of local environmental conditions and management practices on fish growth and health, thereby supporting the long-term resilience of both the species and the ecosystems they inhabit.

In Haryana, inland fisheries play an important role in rural livelihoods, particularly in districts such as Hisar, Sirsa, Karnal, Yamunanagar and Kaithal, where the ponds, canals, reservoirs and seasonal wetlands support freshwater fish production. The Ottu Reservoir created by the Ghaggar River-Hakra Ottu barrage near Sirsa provides important freshwater fishery habitats that support rural livelihoods and food security. In these lentic systems, *C. carpio* is one of the key fish species found alongside other cyprinids, contributing to reservoir catches and pond fisheries in the region. *C. carpio* adaptability to varied water conditions, ability to utilize a range of food resources and compatibility with mixed fish culture make it a reliable source of animal protein and micronutrients for local communities. Its presence enhances aquaculture productivity, especially in polyculture systems, adding value to integrated farming and reservoir-based fisheries in Haryana. Several factors threaten *Cyprinus carpio* populations despite their ecological and economic value. Overfishing from high demand, habitat loss via sand mining, siltation and flow alterations with dams blocking migration and pollution from effluents and runoff, drive declines.

In the Ottu Reservoir on the Ghaggar-Hakra River in Haryana, environmental stressors can impact the long-term viability and overall health of freshwater fish communities, including *Cyprinus carpio*. The reservoir also receives runoff surrounding and agricultural areas, which can contain sediments, fertilizers and pesticides that harm the water quality, stress fish and increase their susceptibility to diseases, particularly in warm weather. In order to sustain carp populations and overall fish biodiversity in the Ottu reservoir system, regular monitoring, pollution control and sustainable fisheries practices are essential. These factors include habitat alteration from impoundment, problems with water quality and persistent fishing pressure [12].

In this study, economically important fish species with a focus on *Cyprinus carpio* collected from the Ottu Reservoir in Haryana were evaluated for length–weight relationship (LWR) and condition factor. The improved knowledge of the *C. carpio* growth pattern, population structure, and health status within the reservoir ecosystem is anticipated as a result of the findings. As a result, the region's reservoir-based fisheries will be improved and conservation planning and sustainable fisheries management will be supported.

2. Materials and Methods

2.1 Sampling Area

The present study was conducted at 4 sampling sites in the Ottu reservoir, located near the Sirsa district in Haryana. The selection of sampling locations was based on criteria such as water depth variation, fish abundance, accessibility for regular monitoring and representation of different zones of the reservoir (inlet, central basin and marginal areas). The study was carried out over a period of 12 months, beginning in January 2025 and concluding in December 2025. During this period, systematic monthly sampling was conducted to collect data on fish species composition, with special emphasis on *Cyprinus carpio*.

2.2 Sample collection, laboratory analysis & preservation

During the study, a total of 260 fishes using various fishing gears such as drag nets, cast nets and gillnets. To obtain measurements, a graduated measuring board or scale was used to record total body length (in cm), while an electronic weighing balance with a precision of 0.01 grams was employed to measure body weight (in g). After these measurements were taken, fish specimens were subsequently preserved in separate glass jars containing 5% formalin. The data collected were then compiled and analysed on a monthly basis.

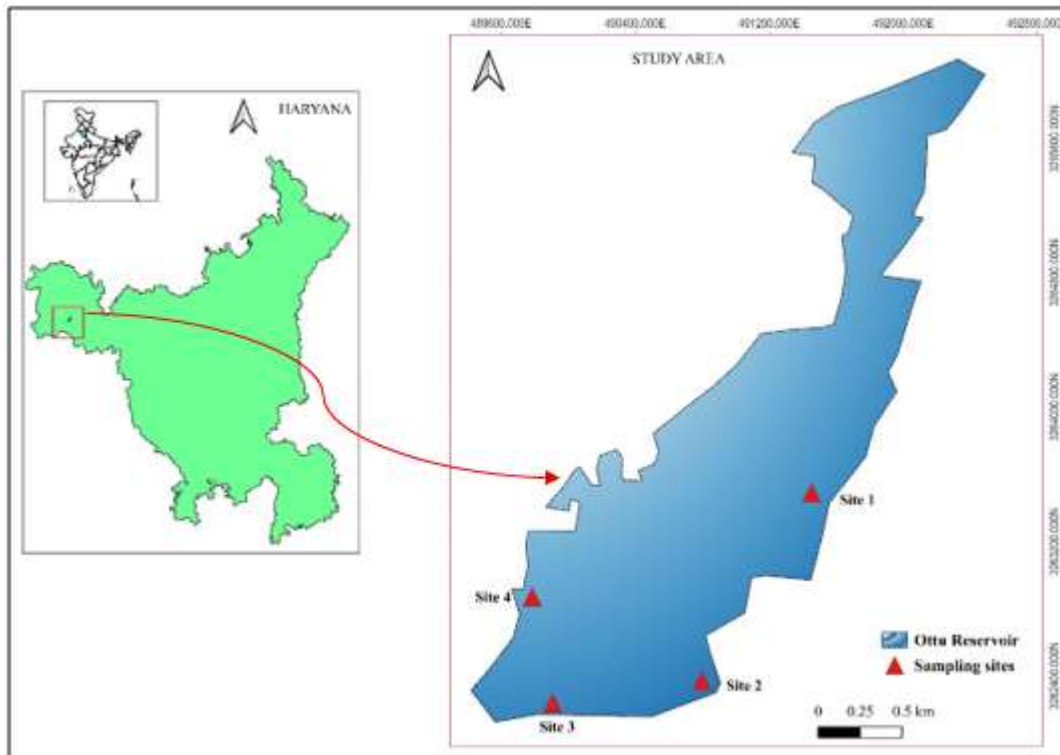


Figure 1. Map of sampling stations in the Ottu reservoir

2.3 Length-weight relationship

[6] the length-weight relationship of *Cyprinus carpio* was estimated by using cube law given by [10]

$$W = a L^b$$

where, W and L are weight (g) and length (cm) of the fish, a and b were estimated by linear regression equation based on natural logarithm:

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

Where, W is the weight of the fish in grams (g), L is the total length of fish in millimetres (mm), a and b are intercept and slope of regression line respectively. To assess for potential significant variations in the "b" value from the cube or isometric value of three, the t-test was utilized. When this formula is used to fish samples, b may deviate from the "ideal value" of 3, which indicates an isometric growth, due to particular environmental conditions or the fish themselves (Ricker, 1958). When b is less than 3, growth is negatively allometric and fish become thinner as they get longer. Fish gain more weight in relation to length when the b value is more than 3.0, signifying positive allometric growth and optimal growing conditions.

The length-weight relationship intercept (a), slope (b) and coefficient of determination (r^2), as well as their 95% confidence intervals, were also calculated. When the co-efficient of allometry (b) equals 3, the growth rates of weight and length are equal (Ricker 1975); in hypo-allometry or negative allometry growth, length increases greater than expected weight; in hyper-allometry or positive allometry growth, length increases less than predicted weight (Shingleton, 2010). To assess if each species' b value differed substantially from the isometric value ($H_0: b = 3$), a 95% confidence interval was calculated using the student t-test. Every statistical analysis was done at a significance level of 5%.

2.4 Relative Condition Factor (Kn)

The relative condition factor (Kn) was used to evaluate the fish species' growth and health. It has been calculated using the formula $Kn = W_o / W_c$, where W_o is the weight that was observed and W_c is the weight that was determined using the length–weight relationship [10]. A fish is in better growth condition if its Kn value is greater than 1; if it is less than 1, it is in a less favorable state than an average individual of the same length. The present study estimated monthly Kn values for males and females independently.

3. Results and discussion

3.1 Length-weight relationship of male *Cyprinus carpio* from the Ottu reservoir

The length–weight relationship of male *Cyprinus carpio* from the Ottu reservoir was expressed as:

$$W = 0.0166L^{2.9833} \quad , \quad R^2 = 0.9595$$

Where W is the body weight (g) and L is the total length (cm). The regression analysis revealed a strong relationship between length and weight, as indicated by the high coefficient of determination ($R^2 = 0.9595$) for *Cyprinus carpio*. The estimated slope ($b = 2.9833$) was very close to the isometric value of 3, indicating that male *Cyprinus carpio* demonstrated isometric growth, with body weight increasing proportionally as length increased. It indicates that the species maintains proportional body shape during growth, with weight increasing nearly cubically with length.

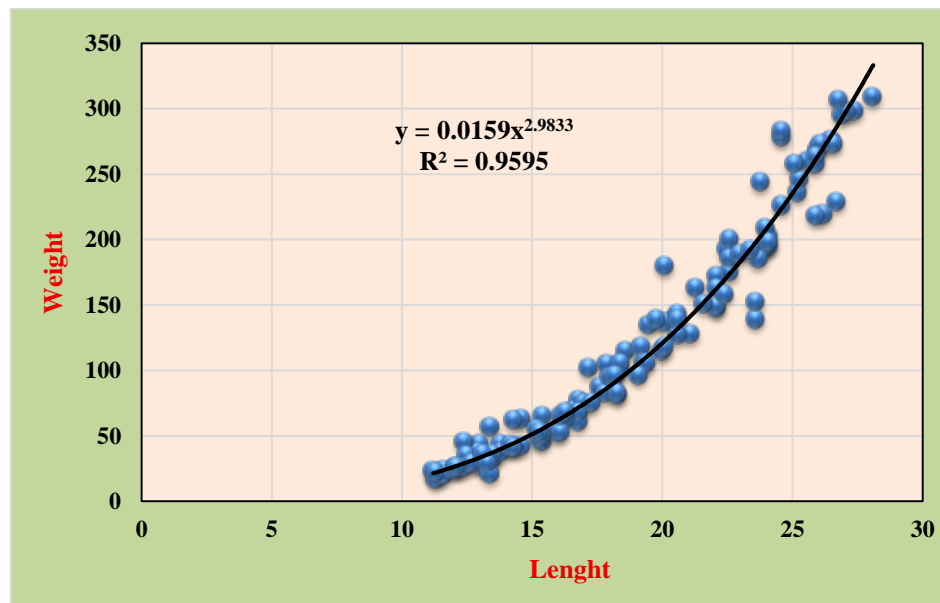


Figure 2: Length-weight relationship in male *Cyprinus carpio*

Similar findings have been reported in earlier studies where *Cyprinus carpio* exhibited near-isometric growth, such as the male b value of 3.062 reported in a polyculture pond system and a pooled b value of 2.903 observed in Manasbal lake, Kashmir [4]. Most fish species have b values between 2.5 and 3.5, according to [6] and the present result is within this estimated range. The strong relationship between the current finding and earlier research indicates that, under the right ecological conditions, *C. carpio* typically maintains proportional growth rate throughout several freshwater habitats. The seasonal effects, variations in feeding intensity, reproductive condition, population structure and environmental variability may all be cause of minor variations from the actual isometric value. As a result, the study's near-isometric growth trend suggests

that the *Cyprinus carpio* population under study is stable and well-suited to the local environment.

3.2 Length-weight relationship of female *Cyprinus carpio* from the Ottu reservoir

The length–weight relationship of female *Cyprinus carpio* from the Ottu reservoir was expressed as:

$$W=0.0094L^{3.1605} \quad , \quad R^2=0.9673$$

Where W is the body weight (g) and L is the total length (cm). The regression analysis showed a strong correlation between length and weight, with a high co-efficient of determination ($R^2 = 0.9673$). The estimated slope ($b = 3.1605$) was slightly higher than the ideal isometric value of 3, indicating positive allometric growth in female *Cyprinus carpio*. This suggests that females tend to gain proportionally more weight relative to length. Such growth patterns are often linked with reproductive physiology, as females generally develop heavier gonads during maturation, which contributes to weight gain.

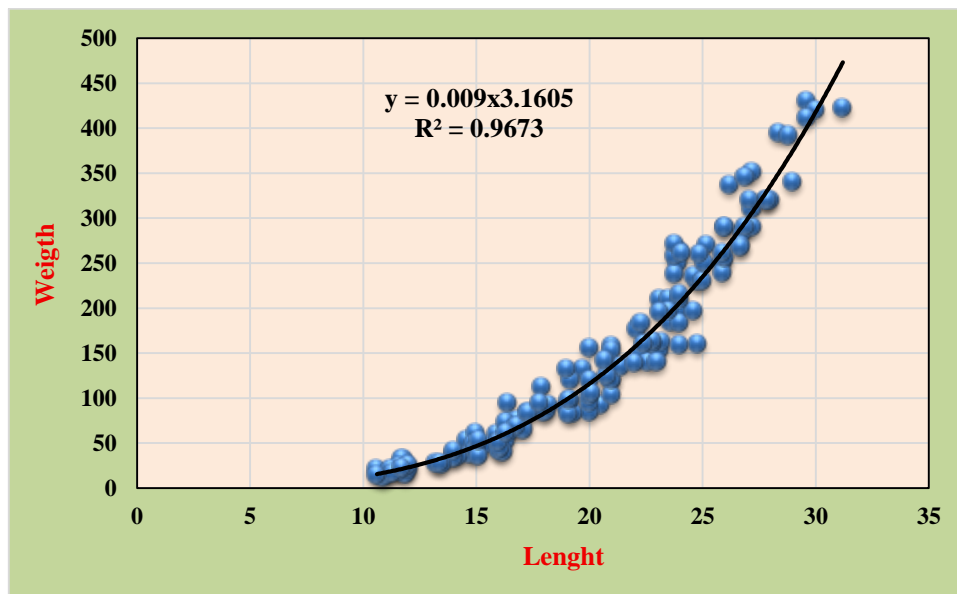


Figure 3: Length-weight relationship in female *Cyprinus carpio*

The several aquatic environments have shown similar results of positive allometric growth in *Cyprinus carpio*. Similar positive allometry was observed by [14], who observed b values greater than 3 (about 3.097 for pooled samples). Similarly, increased b values from Omerli Reservoir [9] ($b \approx 3.140$) have been documented, providing additional evidence that weight-dominant growth occurs in particular carp populations. These regional differences show how habitat conditions, reproductive status and environmental productivity affect growth dynamics. Gonadal development during maturity is probably a contributing factor to the female population of *Cyprinus carpio* from the Ottu reservoir positive allometric growth, which indicates an increase in weight compared to length. In addition to differentiating females from males in terms of energy allocation, this growth propensity highlights how crucial it is to consider sex-specific patterns of development into account when establishing conservation and fisheries management strategies.

The statistical analysis offered further confirmation that the calculated length-weight relationship parameters were accurate. The regression parameters and their 95% confidence intervals were calculated, including the intercept (a), slope (b) and coefficient of determination (R^2). The theoretical isometric value ($b = 3$) and the estimated b values were compared using Student's t -test at a 5% significance level. Near-isometric population

growth was verified by the analysis, which showed that the male *Cyprinus carpio* b value ($b = 2.9833$) did not significantly deviation from the isometric value. On the other hand, females' b value ($b = 3.1605$) indicated a tendency toward positive allometric growth, suggesting a comparatively larger rise in weight than in length. According to [6], these statistical results show that the predicted length-weight parameters are accurate and fall within the typically defined biological range (2.5–3.5) for the majority of fish species. The observed differences between males and females could be explained by changes in the Ottu Reservoir's conditions, Feeding habits and reproductive development.

3.3 Relative Condition Factor (Kn) of Male *Cyprinus carpio*

The results of the present investigation revealed that male *Cyprinus carpio* have a mean relative condition factor ($Kn = 1.0055$), which is quite near to unity. This indicates that the observed body weights were almost the same as those anticipated by the length-weight relationship ($W = 0.0166L^{2.9833}$). Near-isometric growth was confirmed by the regression coefficient ($b = 2.9833$), which was similarly close to the isometric value ($b = 3$). Stable physiological condition and balanced energy allocation between growth and maintenance are often indicated by a Kn value of around 1.0. Similar results from tropical freshwater systems and Indian reservoirs indicate near-isometric growth and Kn values close to unity in common carp, indicating favorable conditions for growth and sufficient food availability [1], [4]. As per recent studies, population-specific length-weight characteristics are helpful tools for monitoring stocks and evaluating the health of ecosystems, and they offer accurate estimations of fish condition [8].

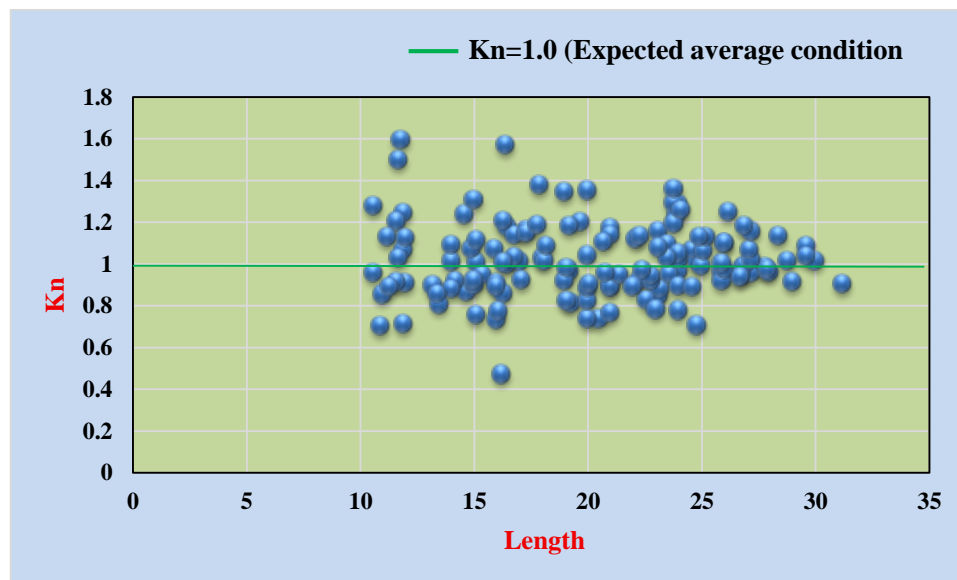


Figure 4: Relative condition factor (Kn) vs. total length for male *Cyprinus carpio*

However, the present study's unusually large range of Kn values (0.47–1.59) indicate intra-population variability, especially across juvenile size classes. Higher values (>1.3) in certain juveniles may suggest superior nutritional status or compensatory growth, while lower values (<0.8) in some smaller individuals may reflect feeding competition, environmental stress or seasonal variations in productivity. Carp populations from reservoir and wetland habitats, where trophic dynamics and hydrological regime have a significant impact on growth performance, have also shown this kind of variability. Overall, the mean Kn near one indicates that the water body under study offers comparatively favourable ecological circumstances for male *C. carpio*, underscoring the significance of ongoing monitoring to comprehend size-specific responses and environmental influences on fish health.

3.4 Relative Condition Factor (Kn) of Female *Cyprinus carpio*

The analysis of relative condition factor for female *Cyprinus carpio* observed Kn value is 1.01924, which is also close to one like male common carp fishes. The investigated female fishes, average observed body weights were slightly higher than the weights predicted by the established length–weight relationship ($W=0.0094L^{3.1646}$), as indicated by the mean Kn value slightly more than unity. The exponent value b value of 3.1646 suggests positive allometric growth. Indicating that females grew slightly heavier for their length as they increased in size. The higher mean Kn compared to the male sample (1.0083) may reflect the energetic demands and somatic changes associated with female maturity and potentially the presence of developing gonads, which typically inflate the condition factor.

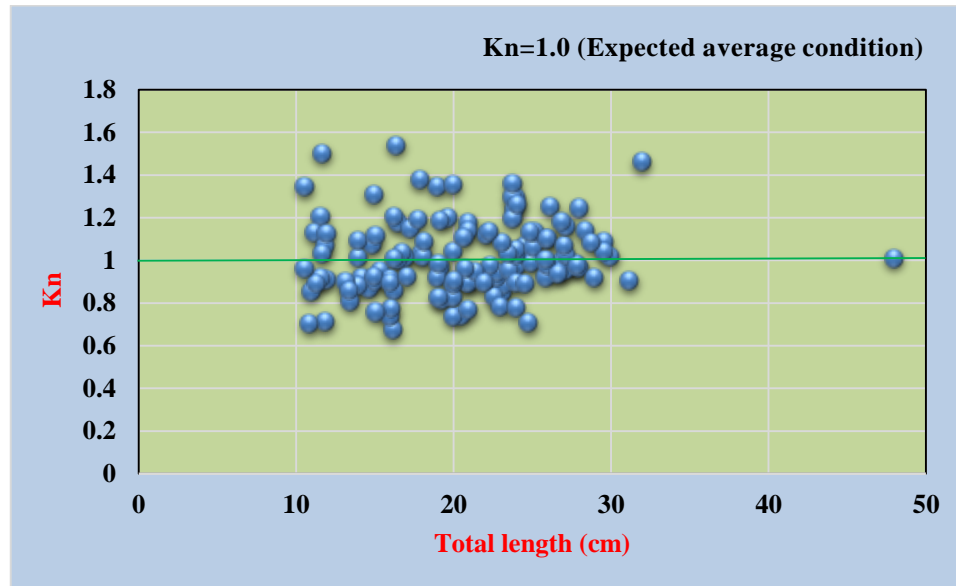


Figure 5: Relative condition factor (Kn) vs. total length for female *Cyprinus carpio*

The very large range of Kn values suggests significant individual variability even though the overall condition of the female population appears to be adequate. For example, several individuals (e.g., L = 29.0 cm; Kn = 0.3958) exhibited relatively poor condition, which may have resulted from environmental stress, limited food availability or post-spawning loss of energy. Other samples, on the other hand, showed comparatively high Kn values (>1.5), indicating improved growing conditions or nutritional status.

This pattern is similar to several previous studies that obtained b value higher than 3 in female *Cyprinus carpio*, such as 3.143 found in polyculture Bheries by [14]. However, negative allometric growth ($b < 3$) or growth near isometric patterns have been reported in other studies conducted in the Indian waters. Positive allometric growth in females is frequently linked to somatic and physiological changes during maturation. In addition, the results of [14], [3] are similar to the relative condition factor (Kn) observed in the present study, which is near unity.

3.5 Seasonal variation in Relative Condition Factor (Kn) of Male & Female *Cyprinus carpio*

During the period of the study, there were observable seasonal variations in the relative condition factor (Kn) of female *Cyprinus carpio*. The graphical representation shows that the condition factor peaked in the summer, indicating that females possessed comparatively higher body weight relative to length during this time. The development of energy reserves during the reproductive phase, higher food availability and good environmental conditions may all contribute to this better condition. The Kn values may be linked to decreased feeding activity, lower metabolic rates and environmental stress caused by decreasing water

temperatures. These gradually decreased in autumn and peaked in the winter. However, the condition factor improved again in the spring, suggesting that the start of reproductive activity and better environmental condition were probably responsible for the body's recovery. Overall, the seasonal pattern suggests that seasonal variations in food availability, environmental conditions and reproductive cycles have an impact on the physiological state of female *C. carpio*.

Table 1: Seasonal variation in condition factors of *Cyprinus carpio* in Ottu reservoir

Season	Sex	Relative condition Factor (Kn)		
		Min	Max	Mean \pm SD
Spring	Males	0.799	1.463	1.020 \pm 0.16
	Females	1.048	2.010	1.067 \pm 0.25
Summer	Males	0.759	1.526	1.063 \pm 0.16
	Females	0.702	1.352	0.999 \pm 0.14
Autumn	Males	0.566	1.537	0.967 \pm 0.16
	Females	0.673	1.499	0.975 \pm 0.17
Winter	Males	0.768	1.265	0.970 \pm 0.08
	Females	0.755	1.538	1.057 \pm 0.15

(Min=Minimum; Max=Maximum; SD=Standard Deviation)

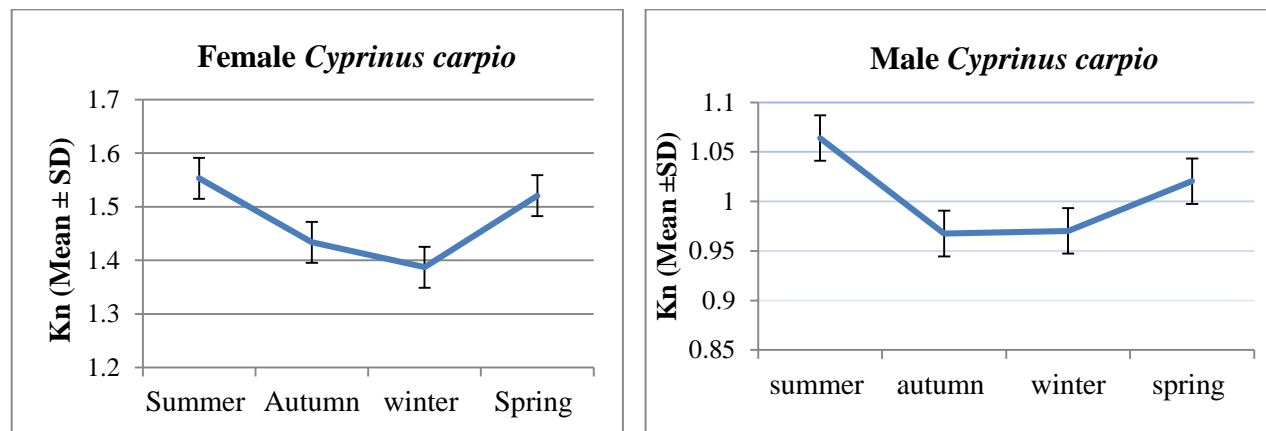


Figure 6: Seasonal Variation in relative condition factor (Kn) of females and males of *Cyprinus carpio* in Ottu reservoir condition

The relative condition factor (Kn) of male *Cyprinus carpio* showed significant seasonal variation during the duration of the study. The condition factor was comparatively greater during the summer, based to the graphical trend, suggesting improved physiological condition and body weight relative to length during this time. This better state might be linked to a plentiful supply of food and favourable environmental conditions that encourage development and energy storage. Due to decreased feeding activity, environmental stress and lower metabolic activity throughout the colder months, the Kn values decreased in autumn and remained comparatively lower in the winter. The condition increased again in the spring, indicating that if environmental condition improve and feeding activity increases, body condition will recover. The population typically maintained a stable and healthy condition with seasonal variations influenced by changes in environmental conditions and biological processes, as indicated by the Kn values of male *C. carpio* remaining close to unity throughout the seasons.

4. Conclusion

In order to understand the growth pattern and physiological state of *Cyprinus carpio* in the Ottu Reservoir in Sirsa, Haryana, the present study studied the length–weight relationship (LWR) and relative condition factor (Kn). The findings revealed a significant relationship between weight and length for both sexes. Female *C. carpio* exhibited positive allometric growth, indicating somewhat higher weight gain that may be associated with reproductive development, whereas males showed near-isometric growth, indicating an equivalent increase in weight with length. The population's generally healthy physiological state was reflected in the mean relative condition factor values for males and females, which were near unity. Seasonal variations in Kn revealed comparatively better conditions in the spring and summer, probably as a result of favourable environmental conditions, increased food availability and reproductive activity. In contrast, slightly lower values in the fall and winter may be related to decreased feeding and environmental stress. Overall, the results show that *C. carpio* in the Ottu Reservoir maintains steady growth and a satisfactory health status, indicating that the reservoir offers favourable ecological conditions. Nevertheless, ongoing observation of growth parameters and environmental factors is crucial for the region's fish biodiversity conservation and sustainable fisheries management.

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