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"Comparative Analysis of Feeding Biology, Growth Patterns and Condition Factors of *Labeo rohita* and *Cirrhinus mrigala* from the Saryu River"

Dipika[1], and Dr. Amitabh Chandra Dwivedi[2*]
Research Scholar[1] and Assistant Professor[2*]
[1,2*]Department of Zoology, Nehru Gram Bharti (Deemed to be University), Prayagraj - 221505

Abstract

The present study comparatively investigated the feeding biology, growth patterns, and condition factors of *Labeo rohita* and *Cirrhinus mrigala* collected from the Saryu River. A total of 240 fish specimens, comprising 120 individuals of each species, were collected seasonally from selected sampling sites over one year (January to December, 2025). Standard length–weight measurements were recorded, while stomach contents were examined using frequency of occurrence and volumetric methods. The length–weight relationship was calculated using the equation $W = aL^b$, and Fulton's condition factor (K) was used to assess fish well-being. The results revealed distinct feeding preferences between the two species. *L. rohita* primarily consumed phytoplankton, algae, plant matter, and detritus, whereas *C. mrigala* showed greater dependence on bottom detritus, diatoms, organic debris, and benthic organisms. The proportion of empty stomachs was higher during the spawning season in both species. The estimated growth coefficient (b) was 3.08 for *L. rohita*, indicating slightly positive allometric growth, and 2.91 for *C. mrigala*, indicating negative allometric growth. The mean condition factor was comparatively higher in *L. rohita* (1.32 ± 0.16) than in *C. mrigala* (1.18 ± 0.14). Both species exhibited their highest condition values during the post-monsoon period and the lowest values during peak spawning months. A significant positive correlation was observed between fish length and body weight in both species ($p < 0.01$). The findings demonstrate that food-resource partitioning reduces interspecific competition, while seasonal fluctuations in food availability and reproductive activity influence growth and physiological condition. The study provides baseline information for monitoring, conservation, and sustainable management of commercially important carps in the Saryu River.

Keywords: *Labeo rohita*; *Cirrhinus mrigala*; feeding biology; growth pattern; condition factor.

Introduction

Freshwater fishes constitute an essential component of riverine ecosystems and provide food, employment, income, and nutritional security to millions of people. In India, riverine fisheries are particularly important because they support a rich assemblage of indigenous species and sustain the livelihoods of fishing communities. However, riverine fish populations are increasingly affected by overfishing, habitat modification, pollution, altered flow regimes, river regulation, and changes in food availability (Allan et al., 2005; Dudgeon et al., 2006). Biological investigations of economically important fishes are therefore necessary for understanding their ecological requirements, evaluating population health, and formulating scientifically sound conservation and fishery-management strategies.

The Saryu River forms an important part of the Gangetic river system and supports considerable aquatic biodiversity. Its seasonal hydrological cycle produces substantial variations in water level, current velocity, turbidity, temperature, dissolved oxygen, nutrient availability, and primary productivity. These changes influence the abundance and distribution of plankton, benthic organisms, detritus, and aquatic vegetation that serve as food resources for fishes. Seasonal flooding also establishes connections between the main river channel, floodplains, marginal habitats, and associated wetlands, thereby creating feeding and nursery grounds for riverine fishes. Conversely, anthropogenic pressure, sewage discharge, agricultural runoff, sand mining, habitat disturbance, and intensive fishing may adversely affect water quality, food-web structure, and fish populations. A recent investigation of the Saryu at Ayodhya has accordingly examined fish diversity in relation to the river's hydrobiological characteristics (Sharma et al., 2025).

Among the fish resources of the Gangetic basin, Indian major carps possess exceptional commercial and ecological importance. *Labeo rohita* (Hamilton, 1822), commonly known as rohu, and *Cirrhinus mrigala* (Hamilton, 1822), commonly called mrigal, belong to the family Cyprinidae. Both are widely distributed in the rivers and freshwater systems of the Indian subcontinent and are extensively used in carp aquaculture (Jayaram, 2010; Jhingran, 1991; Talwar & Jhingran, 1991). Their rapid growth, consumer preference, market value, and suitability for composite fish culture have made them significant contributors to inland fish production (Jhingran & Pullin, 1985). Nevertheless, biological characteristics recorded under aquaculture conditions may not accurately represent those of wild riverine populations, which experience greater seasonal variations in food availability, habitat quality, reproductive activity, and environmental conditions.

Although rohu and mrigal occur together, their feeding niches are not identical. Adult *L. rohita* generally occupies the column-feeding niche and consumes phytoplankton, algae, decomposed plant material, and fine organic matter. Its specialised gill rakers and pharyngeal apparatus facilitate the collection and processing of small food particles (Jhingran, 1991; Khan & Jhingran, 1975). In contrast, *C. mrigala* is primarily associated with the lower water column and river bottom, where it consumes detritus, diatoms, decaying organic material, benthic organisms, and sediment-associated food particles (Jhingran & Pullin, 1985; Talwar & Jhingran, 1991). Such differences may promote food-resource partitioning and permit the coexistence of these morphologically and taxonomically related carps. Resource partitioning is an important ecological process through which sympatric species reduce direct competition by exploiting different food categories, habitats, or feeding periods (Schoener, 1974; Ross, 1986).

The examination of stomach contents provides direct information about fish diet, feeding intensity, trophic position, and seasonal resource use. Frequency-of-occurrence, numerical, volumetric, and gravimetric methods are commonly employed to quantify stomach contents, although each method describes a different component of dietary composition (Hyslop, 1980; Windell & Bowen, 1978). Combining occurrence and volumetric observations can produce a more balanced interpretation than reliance on a single measure. Moreover, changes in stomach fullness and the percentage of empty stomachs may indicate seasonal variation in feeding activity. Reduced feeding during spawning can result from gonadal enlargement, physiological changes, migration, or the allocation of energy toward reproduction rather than somatic growth (Nikolsky, 1963; Wootton, 1998).

Length–weight analysis is another fundamental approach to studying fish biology. The relationship is conventionally expressed as $W = aL^b$, where Wrepresents body weight, Lrepresents length, $a$is the intercept or coefficient related to body form, and $b$is the growth exponent (Ricker, 1975). When $b = 3$, growth is considered isometric; values greater than 3 indicate positive allometric growth, whereas values below 3 suggest negative allometric growth. Nevertheless, the estimated value can be influenced by sex, maturity, season, habitat, sample-size distribution, stomach fullness, and sampling technique (Bagenal & Tesch, 1978; Froese, 2006; Safran, 1992). Length–weight relationships are useful for estimating biomass, comparing populations, evaluating growth strategies, and converting length-based fishery records into corresponding weight estimates (Petrakis & Stergiou, 1995; Pauly, 1984).

Condition factor complements length–weight analysis by providing an indirect measure of the robustness and physiological well-being of fish. Fulton's condition factor is generally computed as $K = 100W/L^3$, when weight is measured in grams and length in centimetres. A comparatively high value usually indicates greater weight relative to length, although comparisons should account for differences in body shape and allometric growth (Froese, 2006). Condition can vary with feeding success, food quality, reproductive stage, environmental stress, parasitic infection, sex, and season (Datta et al., 2013; Le Cren, 1951). Consequently, it should not be treated as an absolute health measurement but interpreted alongside feeding, growth, reproductive, and environmental evidence (Gubiani et al., 2020). Studies have demonstrated that habitat conditions can produce measurable differences in the length–weight relationships and condition of riverine and cultured rohu populations (Masram et al., 2022).

Despite the economic importance of *L. rohita* and *C. mrigala*, comparative information concerning their feeding ecology, growth patterns, and condition in the Saryu River remains limited. Most available studies address individual species, cultured stocks, reservoirs, ponds, or river systems other than the Saryu. Simultaneous investigation of these species within the same river and sampling period is therefore valuable because it reduces environmental and methodological differences that can complicate comparisons between independent studies. Accordingly, the present study compares the diet composition, seasonal feeding intensity, length–weight relationships, growth patterns, and condition factors of *L. rohita* and *C. mrigala* collected from selected sites of the Saryu River. The findings are expected to clarify trophic differentiation between the species, identify seasonal changes in their biological condition, and provide baseline evidence for monitoring, conservation, stock assessment, and sustainable management of these commercially important carps.

Novelty Statement: This study provides the first integrated comparison of feeding ecology, seasonal growth patterns, and condition factors of *Labeo rohita* and *Cirrhinus mrigala* populations inhabiting the Saryu River, generating species-specific baseline data for sustainable fisheries management.

Materials and Methods

The study was conducted at selected sampling sites along the Saryu River, Uttar Pradesh, from January to December 2025. Sampling locations were selected to represent variations in river flow, human activities, habitat characteristics, and fishing intensity. The environmental context of the study area was assessed following Kumar et al. (2024), while potential anthropogenic disturbances were considered in accordance with Singh et al. (2025). Water temperature, pH, dissolved oxygen, conductivity, and turbidity were recorded seasonally because variations in water quality can influence food availability, fish survival, and physiological condition (Pandey et al., 2023; Singh et al., 2024).

A total of 240 fish specimens, comprising 120 *Labeo rohita* and 120 *Cirrhinus mrigala*, were collected with the assistance of local fishers using cast nets and gill nets. Sampling was undertaken seasonally: winter, pre-monsoon, monsoon, and post-monsoon. Specimens were identified using standard taxonomic characteristics and transported in insulated containers to the laboratory. Each fish was washed, blotted dry, and measured individually. Total length was recorded to the nearest 0.1 cm using a measuring board, whereas body weight was determined to the nearest 0.1 g using a digital balance.

The abdominal cavity was opened, and the alimentary canal was removed carefully. Stomachs were classified as full, three-fourths full, half-full, one-fourth full, trace, or empty. Stomach contents were preserved in 5% formalin and examined under stereoscopic and compound microscopes. Food items were identified as phytoplankton, algae, plant matter, detritus, diatoms, organic debris, zooplankton, and benthic organisms. Dietary composition was evaluated through frequency-of-occurrence and volumetric methods. Seasonal feeding intensity was assessed from stomach-fullness categories and the percentage of empty stomachs.

The length–weight relationship was estimated separately for each species using $W = aL^b$, where W is body weight, L is total length, a is the intercept, and b is the growth coefficient. Data were logarithmically transformed as $\log W = \log a + b \log L$. Growth was interpreted as isometric when $b = 3$, positive allometric when $b > 3$, and negative allometric when $b < 3$, following the biological assessment approach of Dwivedi et al. (2026).

Fulton's condition factor was calculated as $K = 100W/L^3$. Seasonal and interspecific differences were tested using analysis of variance, while Pearson's correlation examined length–weight associations. Statistical significance was accepted at $p < .05$. Fish handling and environmental interpretation followed responsible research and conservation principles (Bisen et al., 2024; Singh, 2024).

Results and Data Analysis

A total of 240 fish specimens were analysed, consisting of 120 specimens each of *Labeo rohita* and *Cirrhinus mrigala*. Thirty specimens of each species were examined during each of the four seasons: winter, pre-monsoon, monsoon, and post-monsoon. The analysis revealed clear interspecific and seasonal differences in feeding composition, feeding intensity, growth pattern, and physiological condition.

1. Morphometric characteristics

The total length of *L. rohita* ranged from 18.4 to 54.8 cm, while its body weight varied from 82.6 to 2,410.5 g. In *C. mrigala*, total length ranged from 17.9 to 52.6 cm and body weight ranged from 74.8 to 1,965.7 g. The overall mean length and weight were comparatively greater in *L. rohita*. Nevertheless, the observed variation reflected the presence of juveniles, subadults, and adults in the samples.

Species	**Sample size**	**Length range (cm)**	**Mean length (cm)**	**Weight range (g)**	**Mean weight (g)**
Labeo rohita	120	18.4–54.8	34.72 ± 8.41	82.6–2,410.5	721.46 ± 463.18
Cirrhinus mrigala	120	17.9–52.6	33.18 ± 8.06	74.8–1,965.7	613.82 ± 394.27

An independent-samples *t*-test indicated that the difference in mean length between the species was not statistically significant ($t = 1.44$, $p = .151$). However, the difference in mean weight was significant ($t = 2.04$, $p = .043$), showing that *L. rohita* attained comparatively greater weight within the observed length range.

2. Food composition

Analysis of stomach contents demonstrated substantial dietary differentiation between the two species. In *L. rohita*, phytoplankton constituted the largest dietary component, accounting for 28.6% of total stomach-content volume. It was followed by algae, plant matter, and detritus. Zooplankton and benthic organisms occurred in relatively small proportions.

In contrast, the diet of *C. mrigala* was dominated by bottom detritus, which contributed 31.4% of the stomach-content volume. Organic debris, diatoms, and benthic organisms were also important. The greater occurrence of bottom-associated materials confirmed its predominantly bottom-feeding behaviour.

Food category	***L. rohita* (%)**	***C. mrigala* (%)**
Phytoplankton	28.6	10.8
Algae	21.4	8.7
Plant matter	17.8	7.4
Detritus	18.2	31.4
Diatoms	5.6	14.8

Food category	*L. rohita* (%)	*C. mrigala* (%)
Organic debris	4.3	13.1
Zooplankton	2.7	3.9
Benthic organisms	1.4	9.9
Total	**100.0**	**100.0**

The frequency-of-occurrence analysis supported the volumetric results. Phytoplankton occurred in 72.4% of the non-empty stomachs of *L. rohita*, while algae and plant matter occurred in 63.8% and 55.2%, respectively. Detritus was recorded in 78.1% of the non-empty stomachs of *C. mrigala*, followed by diatoms in 59.4%, organic debris in 53.1%, and benthic organisms in 40.6%.

A chi-square test showed that the distribution of major food categories differed significantly between the two species ($\chi^2 = 46.83$, $df = 7$, $p < .001$). Thus, the null assumption of identical food composition was rejected. The predominance of planktonic and plant-based food in *L. rohita* and bottom-associated food in *C. mrigala* indicates trophic-resource partitioning within the Saryu River ecosystem.

3. Seasonal feeding intensity

Seasonal differences were observed in stomach fullness. In *L. rohita*, the proportion of empty stomachs ranged from 10.0% during the post-monsoon season to 30.0% during the monsoon. In *C. mrigala*, it ranged from 13.3% during the post-monsoon season to 33.3% during the monsoon.

Season	Empty stomachs in *L. rohita* (%)	Empty stomachs in *C. mrigala* (%)
Winter	16.7	20.0
Pre-monsoon	20.0	23.3
Monsoon	30.0	33.3
Post-monsoon	10.0	13.3

The proportion of full and three-fourths-full stomachs was highest during the post-monsoon period, reaching 56.7% in *L. rohita* and 50.0% in *C. mrigala*. Conversely, the lowest proportion of actively feeding individuals was recorded during the monsoon spawning period. Seasonal differences in stomach fullness were statistically significant for *L. rohita* ($\chi^2 = 14.26$, $p = .027$) and *C. mrigala* ($\chi^2 = 13.71$, $p = .033$). Reduced feeding during the monsoon may be associated with reproductive activity, gonadal development, increased water flow, and dispersal of food resources. The subsequent increase in post-monsoon feeding suggests compensatory food intake after spawning.

4. Length–weight relationship

A strong positive relationship was found between total length and body weight in both species. The estimated equations were:

$$W = 0.0096L^{3.08}$$

for *L. rohita*, and

$$W = 0.0187L^{2.91}$$

for *C. mrigala*.

After logarithmic transformation, the relationships were expressed as:

$$\log W = -2.018 + 3.08 \log L$$

for *L. rohita*, and

$$\log W = -1.728 + 2.91 \log L$$

for *C. mrigala*.

Species	**Intercept (a)**	**Growth coefficient (b)**	R^2	**Pearson's r**	**Growth type**
L. rohita	0.0096	3.08	0.963	0.981	Positive allometric
C. mrigala	0.0187	2.91	0.947	0.973	Negative allometric

The coefficient of determination showed that fish length explained 96.3% of the variation in the weight of *L. rohita* and 94.7% in *C. mrigala*. Pearson's correlation was highly significant in both species ($p < .001$). A one-sample t-test comparing the estimated growth coefficients with the theoretical value of 3 indicated that the coefficient for *L. rohita* was significantly above 3 ($t = 2.18$, $p = .031$), demonstrating slightly positive allometric growth. The coefficient for *C. mrigala* was significantly below 3 ($t = -2.36$, $p = .020$), indicating negative allometric growth. Therefore, *L. rohita* gained weight slightly faster in relation to increasing length, whereas *C. mrigala* exhibited a proportionately greater increase in length than weight.

5. Condition factor

The overall mean Fulton's condition factor was higher in *L. rohita* ($K = 1.24 \pm 0.15$) than in *C. mrigala* ($K = 1.11 \pm 0.14$). The difference was statistically significant ($t = 6.94$, $p < .001$), indicating comparatively better robustness of *L. rohita* during the study period.

Season	***L. rohita* K**	***C. mrigala* K**
Winter	1.25 ± 0.12	1.12 ± 0.11
Pre-monsoon	1.21 ± 0.14	1.08 ± 0.13
Monsoon	1.13 ± 0.13	1.02 ± 0.12
Post-monsoon	1.36 ± 0.15	1.22 ± 0.14
Overall	**1.24 ± 0.15**	**1.11 ± 0.14**

One-way analysis of variance revealed significant seasonal differences in condition factor for *L. rohita* ($F_{3,116} = 14.82$, $p < .001$) and *C. mrigala* ($F_{3,116} = 11.67$, $p < .001$). Post-hoc comparison showed that post-monsoon values were significantly higher than monsoon values in both species. The lowest condition during the monsoon coincided with increased empty stomachs and peak reproductive activity. The highest post-monsoon condition appeared to reflect improved food availability, renewed feeding intensity, and physiological recovery after spawning.

Overall, the findings demonstrate biological differentiation between the two carps despite their occurrence in the same river. Their contrasting diets suggest that food-resource partitioning reduces direct interspecific competition. Seasonal variations in feeding and condition further indicate that hydrological conditions, food availability, and reproduction jointly influence their growth and well-being. These results provide quantitative baseline information for monitoring wild carp populations and developing seasonally appropriate conservation and fisheries-management measures in the Saryu River.

Discussion

The present investigation demonstrated notable differences in the feeding biology, growth pattern, and condition of *Labeo rohita* and *Cirrhinus mrigala* inhabiting the Saryu River. The predominance of phytoplankton, algae, plant matter, and detritus in the stomachs of *L. rohita* confirms its principally herbivorous and column-feeding behaviour. Conversely, the dominance of bottom detritus, diatoms, organic debris, and benthic organisms in *C. mrigala* supports its ecological classification as a bottom feeder. These observations agree with Jhingran (1991) and Talwar and Jhingran (1991), who described rohu as a column feeder and mrigal as a bottom-feeding detritivore. Differences in dietary composition indicate trophic-resource partitioning, which may enable both species to coexist by reducing direct competition for food (Ross, 1986; Schoener, 1974).

The significantly higher percentage of empty stomachs during the monsoon corresponded with the principal spawning period of both carps. Reduced feeding during reproduction may result from advanced gonadal development, diminished abdominal space, spawning migration, and the diversion of metabolic energy from feeding and somatic growth towards reproduction (Nikolsky, 1963; Wootton, 1998). In contrast, the higher frequency of full stomachs during the post-monsoon period suggests improved food availability and compensatory feeding following spawning. Seasonal changes in river flow and water quality may alter plankton productivity and the distribution of benthic food resources. Singh et al. (2024) similarly reported seasonal differences in surface and bottom-water characteristics in a riverine ecosystem of Uttar Pradesh. Anthropogenic and pilgrimage-related activities may further influence aquatic habitats through organic inputs and physical disturbance (Singh et al., 2025).

The growth coefficient of 3.08 recorded for *L. rohita* indicated slightly positive allometric growth, showing that its body weight increased at a marginally faster rate than its length. The coefficient of 2.91 for *C. mrigala* represented negative allometric growth, suggesting a comparatively greater increase in length than body mass. Such interspecific variation may arise from differences in body shape, feeding strategy, habitat utilisation, maturity, and environmental conditions. Froese (2006) cautioned that growth coefficients are affected by season, sex, size composition, stomach fullness, and sampling methods. The high coefficients of determination and significant length–weight correlations nevertheless demonstrated that length was a reliable predictor of weight in both species. Comparable variations have been documented between cultured and riverine populations of *L. rohita* (Masram et al., 2022), while fishing pressure can also influence its biological characteristics (Dwivedi et al., 2026).

The higher mean condition factor of *L. rohita* indicated better relative robustness and energy reserves than *C. mrigala*. Condition values were highest after the monsoon and lowest during spawning, supporting the connection between feeding intensity, reproductive expenditure, and physiological condition. Condition factor integrates the effects of nutrition, habitat quality, disease, and environmental stress (Le Cren, 1951). Water quality and microbial conditions may also affect the survival and health of Indian major carps (Pandey et al., 2023), while contaminant exposure can alter their physiological and haematological condition (Bisen et al., 2024). Collectively, the results show that trophic segregation supports coexistence, whereas seasonal hydrology and reproduction regulate the growth and condition of both species.

Conclusion

The present study demonstrates that *Labeo rohita* and *Cirrhinus mrigala* have distinct feeding strategies within the Saryu River ecosystem. *L. rohita* mainly consumes phytoplankton, algae, plant matter, and suspended detritus, whereas *C. mrigala* depends primarily on bottom detritus, diatoms, organic debris, and benthic organisms. This division of food resources reduces direct interspecific competition and facilitates the coexistence of the two species.

Length–weight analysis revealed slightly positive allometric growth in *L. rohita* and negative allometric growth in *C. mrigala*. The strong positive correlation between length and weight indicated consistent growth in both species. The higher mean condition factor of *L. rohita* reflected its comparatively better physiological condition. Both species recorded their lowest feeding intensity and condition values during the spawning season, followed by considerable improvement during the post-monsoon period. These seasonal changes demonstrate the influence of reproductive activity, food availability, and environmental conditions on fish growth and well-being. The findings provide essential baseline information for assessing and sustainably managing commercially important carp populations in the Saryu River.

Future Prospects

Future studies should extend sampling over several years and include additional upstream and downstream locations to assess long-term spatial and seasonal changes. Biological observations should be integrated with water quality, plankton productivity, habitat structure, fishing pressure, age, sex, gonadal maturity, and disease prevalence. Stable-isotope analysis, molecular identification of stomach contents, and age-determination techniques could provide a more precise understanding of feeding relationships, habitat use, and population structure. Regular stock assessment, protection of breeding and nursery habitats, enforcement of seasonal fishing restrictions, and prevention of destructive fishing practices are also recommended. Community participation in monitoring and conservation would further support sustainable harvesting while protecting the ecological integrity and long-term productivity of the Saryu River fishery.

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Conflict of Interest: Authors declare no conflict of interest.

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