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Comparative Feeding Biology of the Minor Carp *Labeo gonius* (Hamilton, 1822) from the Burhi Gandak River and Birauli Oxbow Lake, India

Amit Singh Kshatri[1], Adita Sharma[2*], Prem Prakash Srivastava[2], Hs Mogalekar[2], Tanushri Ghorai[2], Shikha Ahalavat[3], Kavita Sharma[1], Nitish Bansal[1], Padmanabha A.[1], Arvind Sinha[1], Shruthi H U[1], Ambrish Singh[4], Ashutosh Lowanshi[5], Rupendra Kumar Meshram[2], Vadde Shyamala Devi[1]

College of Fisheries Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar (125001) Haryana, India[1]

College of Fisheries, Dholi, Dr. Rajendra Prasad Central Agricultural University, Pusa Samastipur (843121) Bihar, India[2]

College of Basic Sciences and Humanities, Chaudhary Charan Singh Haryana Agricultural University, Hisar (125001) Haryana, India[3]

College of Fisheries Science, DUVASU, Mathura (281001), Uttar Pradesh[4]

College of Fisheries Science and Research Centre, Etawah Campus, CSAUA&T Kanpur (206001) India[5]

Corresponding author: 2*

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Labeo gonius, Feeding Biology, Gut Content Analysis, RGL, GaSI, Oxbow Lake, Burhi Gandak River

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ABSTRACT

The present study investigated the feeding biology of the minor carp *Labeo gonius* collected from two different freshwater ecosystem the Burhi Gandak River and Birauli Oxbow Lake in North Bihar, India. From August 2022 to July 2023, a total of 120 specimens were collected by monthly sampling to use gut content analysis, Relative Gut Length (RGL) and Gastro-somatic Index (GaSI) to assess dietary composition, feeding intensity and trophic characteristics. Sand and mud made up the majority of *L. gonius* diet (48.82% in Burhi Gandak River and 38.14% in Birauli Oxbow Lake), followed by diatoms (18.27% and 22.36%), decayed organic matter (15.96% and 20.95%), green algae (8.81% and 6.50%), macrophytes (5.06% and 9.09%), and blue-green algae (3.06% and 2.83%). The majority of benthic detritus suggests that the species has detritivores bottom-feeding tendencies. GaSI measurements showed seasonal variation in feeding intensity, ranging from 1.5±0.10 to 4.6±0.08 in the Burhi Gandak River and from 1.28±0.07 to 4.89±0.07 in Birauli Oxbow Lake, with greater values in the winter and post-monsoon. An omnivorous to herbivorous feeding behavior was suggested by the RGL values, which varied from 4.7–7.8 in the river and 4.1–6.5 in the oxbow lake. Habitat-based variation in feeding behaviour and food availability is shown by a substantial difference in RGL ($P < 0.05$) between the two environments. The results show *L. gonius* ecological adaptability and its critical function in benthic energy transfer in freshwater environments. These findings provide important insights into trophic dynamics and the sustainable management of inland fisheries resources.

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1. Introduction

The Feeding ecology is a basic component of fish biology that gives vital insights into trophic interactions, energy transmission and ecosystem functioning in aquatic habitats. Fish species' ecological functions, suitable habitats and adaptation strategies within aquatic communities can be revealed through an understanding of their food composition and feeding habits. Additionally, feeding studies play a major role in evaluating fish survival, development and reproductive performance in natural environments. In addition, understanding feeding biology is crucial for regulating and preserving fisheries effectively, especially in freshwater habitats where supplies of food and climatic variables can change seasonally and geographically. The fish dietary requirements analysis is essential for understanding trophic dynamics and resource usage patterns in freshwater environments [15], [1]. In order to ensure the sustainable use of inland fishing resources and to establish effective management strategies, such knowledge is very crucial.

The minor carp *Labeo gonius* (Hamilton, 1822) is a member of the Cyprinidae family and it is found in many freshwater systems throughout South Asia, including Bangladesh, India, Nepal and Pakistan. The species can be observed in oxbow lakes, reservoirs, floodplain wetlands and rivers, where it makes a substantial contribution to inland capture fisheries. In many parts of the Indian sub-continent, *L. gonius* is regarded as a significant food fish because of its moderate growth rate, adaptation to various ecological conditions and high nutritional value. The species is typically classified as an omnivore or herbivorous feeder based on habitat conditions and food availability, and it is known to use a variety of natural food items. The ecological significance of minor carps in maintaining trophic balance and enhancing fish diversification in freshwater habitats has been emphasized in recent studies [3], [13]. Understanding the feeding ecology of such species is therefore vital for evaluating their ecological importance and possible contribution to fisheries productivity.

The fish feeding habits and food composition have been investigated through a variety of methods. Among them, gut content analysis is still one of the most used techniques for identifying the types of food that fish species eat in their natural environments. Additionally, trophic attributes and feeding intensity are frequently evaluated using indicators like the Gastro-somatic index (GaSI) and Relative gut length (RGL). Since herbivorous species typically have longer digestive tracts than carnivorous species, RGL is helpful in determining the trophic nature of fish. Similar to this, the Gastro-somatic index links gut weight to body weight to provide information on feeding activity and digestive processes. These indices are useful for understanding freshwater fish feeding habits and trophic strategies, based on recent study [2], [9]. Furthermore, fish species feeding habits and nutritional composition may be greatly impacted by environmental elements as habitat type, seasonal productivity and food availability.

The feeding habits of cyprinid fishes, including species from the genus Labeo, in various freshwater environments have been documented in a number of studies. According to these studies, phytoplankton, algae, detritus and plant materials are the main food sources for many Labeo species, while dietary composition may vary based on habitat conditions and the seasonality of food resources [10], [12]. The fish populations' feeding habits may be impacted by the flowing water, changing hydrological conditions and diverse food sources that are typical of riverine environments. On the other hand, oxbow lakes and floodplain wetlands are typically semi-lentic water bodies with higher nutrient concentrations and fairly secure environmental conditions, which result in higher plankton abundance and primary productivity. The variety and accessibility of food organisms for fish species that live in various environments may be impacted by these ecological

variations.

There are still few studies comparing the feeding ecology of *Labeo gonius* in various freshwater environments, despite its significant ecological and economic importance. Specifically, very little is known about how this species' dietary habits differ across riverine and oxbow lake habitats. Understanding these variations is crucial for assessing the trophic dynamics and ecological adaptation of fish populations in various environments. Therefore, the present study was undertaken to analyze and compare the feeding biology of *Labeo gonius* from the Burhi Gandak River and Birauli Oxbow Lake. In order to determine the food composition, trophic nature and feeding intensity of the species in these two different freshwater environments, the study focuses on the investigation of gut content composition, Relative Gut Length (RGL) and Gastro-somatic Index (GaSI).

2. Materials and method

2.1 Sampling Area

The current study was carried out at multiple sampling points along the Burhi Gandak River in North Bihar, India, specifically in the districts of Motihari, Muzaffarpur and Samastipur. As well as in Birauli Oxbow Lake (shown in fig.1), which was created by the river's meandering and channel shifting. In order to record seasonal variations in environmental conditions and feeding habits, monthly sampling was carried out throughout a twelve-month period, from August 2022 to July 2023. For the purpose of comparing the feeding biology of *Labeo gonius* in riverine and oxbow lake environments, the sampling sites were selected on the basis of accessibility, year-round water availability and regular fish landing catches by local fishermen.

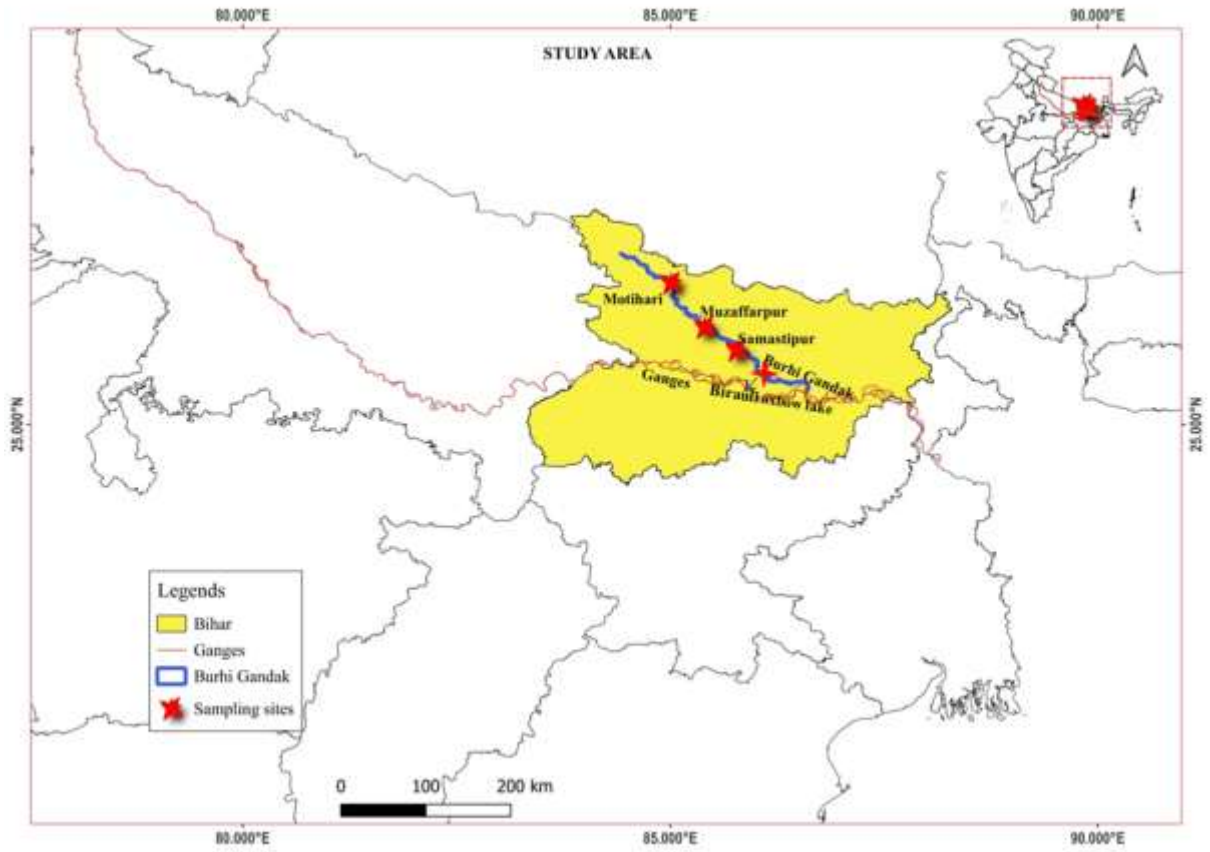

Figure 1. Map of sampling stations in the Burhi Gandak River and Birauli Oxbow Lake

2.2 Sample Collection, Biometric Measurements & preservation

During the study period, local fishermen helped to collect fish samples of *Labeo gonius* from the Burhi Gandak River and Birauli Oxbow Lake on a monthly basis using traditional fishing gear such cast nets, drag nets and gill nets. From the selected sampling locations, 120 specimens in total were gathered and transported immediately to the lab for in-depth biometric examination. A graduated measuring board was used to measure each specimen's total length (TL) to the nearest 0.1 cm and a digital electronic scale was used to record the specimen's body weight (W) to the nearest 0.01 g. Specimens were kept in a 5% formalin solution following measurements for later use in the lab.

2.3 Gut Content Analysis

To determine *Labeo gonius* feeding habits and dietary composition, gut content analysis was carried out. The preserved specimens were dissected in the lab after biometric measurements and the alimentary canal was carefully removed. After the gut were taken out and cut longitudinally, the contents were carefully cleaned with distilled water and placed in a Petri dish. A compound microscope was used to examine the gut or stomach contents o in order to identify various dietary items. Food components were identified using conventional identification keys and relevant literature based on their morphological features. The classification guidelines of [14] were used to categorize the food items, while the miscellaneous category was assigned to unidentified food materials. The major groups including phytoplankton, zooplankton, algae, plant materials, detritus and insect larvae, were used to broadly classify the detected food items. To assess the feeding habits and nutritional preferences of the species. Important details on the trophic nature and feeding ecology of *Labeo gonius* in the areas under study were revealed by this analysis.

2.4 Gastro-Somatic Index (GaSI)

The identification of prey items within the gut contents was the basis for the qualitative evaluation, which was an essential component of the study and the foundation for all subsequent quantitative assessments. The gravimetric method was used to examine the contents of the fish guts followed by [8]. The Gastro-Somatic Index (GaSI) is calculated as follows:

$$\text{GaSI} = \frac{\text{Weight of Gut}}{\text{Body Weight}} \text{x } 100$$

2.5 Relative Gut Length (RGL)

The fish feeding behaviour influences the length of the gut and the Relative Gut Length (RGL) is a measure of fish distinct feeding patterns. The ratio of the length of the gut or intestine to the length of the body is known as RGL. With RGL values ranging from 0.2 to 2.5 times the body length for carnivores, 0.6 to 8.0 times for omnivores and 0.8 to 15 times for herbivores, herbivorous fish often have longer digestive tracts than carnivorous ones. The formula proposed by [6] is used to calculate Relative Gut Length (RGL):

$$\text{RGL} = \frac{\text{Total Length of gut (cm)}}{\text{Total length of fish (cm)}}$$

2.6 Statistical Analysis

The GasI and Relative Gut Length (RGL) of *Labeo gonius* were measured using descriptive statistics like mean and standard deviation (Mean ± SD). The significant difference in RGL values between the two sampling locations, the Burhi Gandak River and Birauli Oxbow Lake were examined using a paired sample t-test, taking into account monthly observations as paired data. Standard statistical methods were used to

assess for statistical significance at $P < 0.05$.

3. Results and Discussion

3.1 Gut Content Analysis

An analysis of the gut contents of *Labeo gonius* Using the frequency of occurrence method, from Burhi Gandak River and Birauli Oxbow Lake (August 2022-July 2023) revealed that the diet was dominated by sand and mud at annual averages of 48.8% (Burhi Gandak) and 38.1% (Birauli), followed by diatoms 18.3% and 22.4%, decomposing organic matter 16.0% and 21.0%, green algae 8.8% and 6.5%, macrophytes 5.1% and 9.1% and blue-green algae 3.1% and 2.8% in Burhi Gandak River and Birauli Obow Lake respectively. While diatoms peaked in cooler/post-monsoon months (e.g., December-January: 27–31%) and green algae showed greater numbers in winter (up to 12.9%), sand and mud remained consistently high throughout the year. In comparison to the Burhi Gandak River, Birauli showed greater percentages of macrophytes and decomposing debris.

The *Labeo gonius* is a bottom-feeding detritivore that consumes benthic materials while grazing microphytobenthos like diatoms, as evidenced by the prevalence of sand and mud. Higher levels of detritus and macrophytes in the lentic Birauli lake indicate slower flow and richer littoral zones. These results correspond most closely to the findings reported by [4] from River Kali (sand/mud 35.4%, diatoms 18.6%, decayed matter 16.4%, green algae 8.6%), indicating that feeding habits are maintained across habitats, although local variations (e.g., elevated macrophytes) are due to site-specific vegetation and hydrology. In these habitats, *L. gonius* serves as a benthic omnivore that connects detrital pathways to higher trophic levels.

Table 1: Monthly Variation in food composition of *Labeo gonius* in Burhi Gandak River & Birauli Oxbow Lake

Food items	August		September		October		November		December		January	
	Burhi Gandak	Birauli	Burhi Gandak	Birauli	Burhi Gandak	Birauli	Burhi Gandak	Birauli	Burhi Gandak	Birauli	Burhi Gandak	Birauli
Green Algae	6.3	4.8	7.2	5.1	6.5	5.8	7.3	6.7	12.9	8.3	11.3	7.6
Diatoms	11.8	14.3	17.3	18.3	22.8	24.6	22.4	26.5	27.6	28.8	28.9	31.1
Blue green algae (BGA)	5.2	5.1	6.8	4.7	4.4	3.8	4.7	3.1	4.7	2.1	1.5	1.9
Macrophytes	5.9	9.1	4.1	7.8	2.1	8.8	5.3	9.1	3.1	6.2	10	11.4
Decayed Organi	13.7	21.8	18.7	20.6	21.2	24.2	23.1	26.7	23.2	24.5	13.6	17.8

c Matter												
Sand and mud	57.1	44.9	45.9	43.5	43	32	37.2	27.9	28.5	30.1	34.7	30.2

Food items	**February**		**March**		**April**		**May**		**June**		**July**		**Average %**	
	Burhi Gandak	**Birauli**	**Burhi Gandak**	**Birauli**	**Burhi Gandak**	**Biraili**	**Burhi Gandak**	**Birauli**	**Burhi Gandak**	**Birauli**	**Burhi Gandak**	**Birauli**	**Burhi Gandak**	**Biraili**
Green Algae	6.9	4.8	10.4	6.7	11.9	8.1	13.3	8.9	4.7	4.4	7.1	6.8	**8.81**	**6.5**
Diatoms	20.2	21.3	28.6	29.3	17.3	23.6	8.2	16.2	4.5	16.7	9.7	17.7	**18.27**	**22.36**
Blue green algae (BGA)	0.8	1.1	1.3	2.4	1.1	1.6	1.2	2.4	1	3.6	4.1	2.2	**3.06**	**2.83**
Macrophytes	1.1	3.7	2.7	6.3	6.2	9.9	7.1	11.1	5.7	9.4	7.4	16.3	**5.06**	**9.09**
Decayed Organic Matter	22.8	24.6	10.3	21.6	11.8	18.7	6.5	12.3	14.9	19.4	11.8	19.3	**15.96**	**20.95**
Sand and mud	48.2	44.5	46.7	33.7	51.7	38.1	63.7	49.1	69.7	46	59.9	37.7	**48.82**	**38.14**

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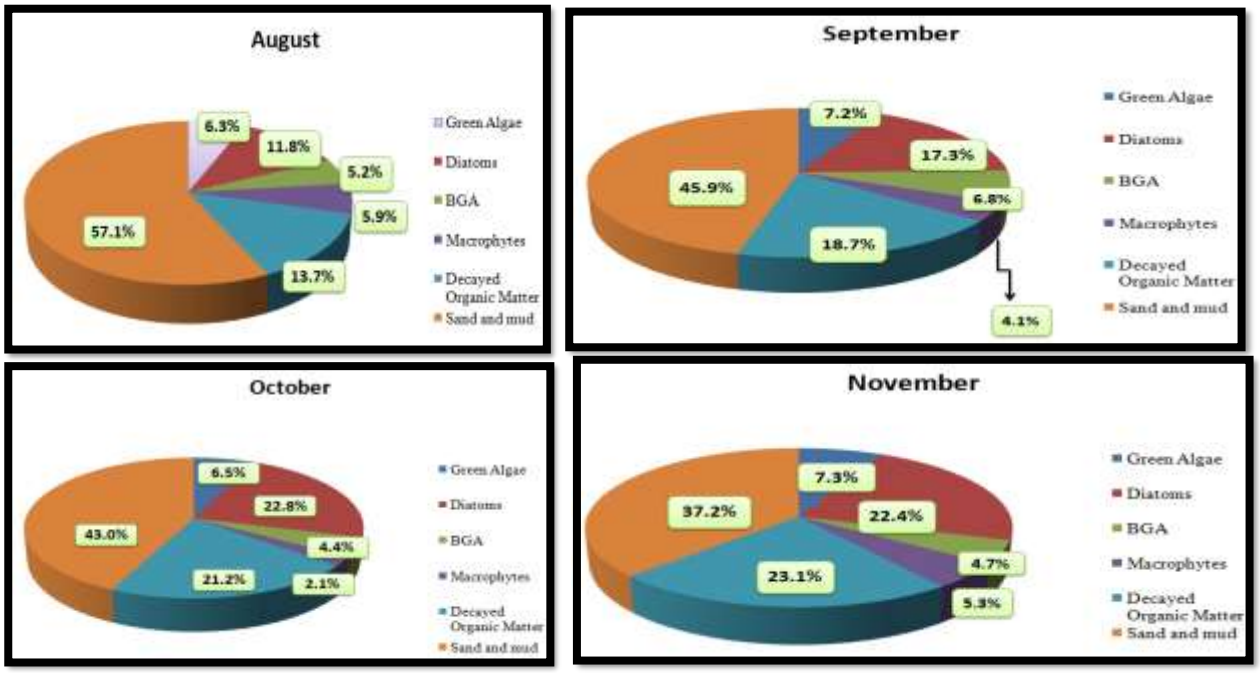

Figure 2: Monthly variation in food composition of *Labeo gonius* from August 2022 to November 2022 in Burhi Gandak River

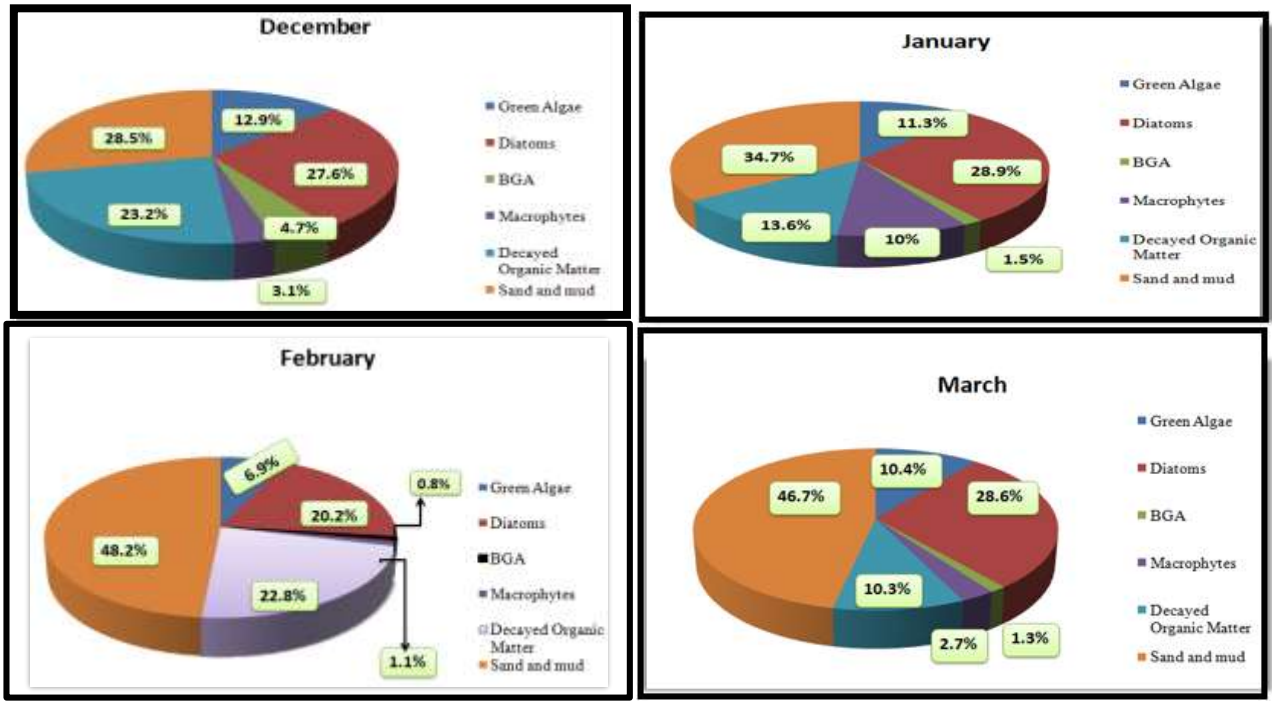

Figure 3: Monthly variation in food composition of *Labeo gonius* from December 2022 to March 2023 in Burhi Gandak river

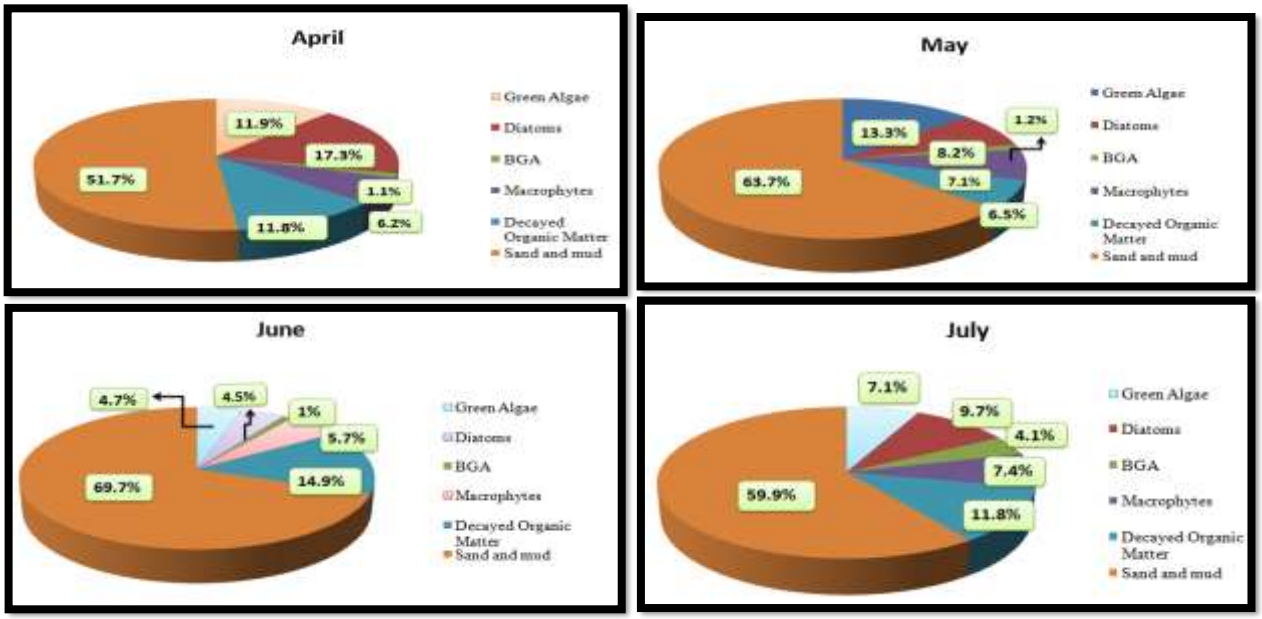

Figure 4: Monthly variation in food composition of *Labeo gonius* from April 2023 to July 2023 in Burhi Gandak river

Figure 5: Monthly variation in food composition of *Labeo gonius* from August 2022 to January 2023 in Birauli Oxbow Lake

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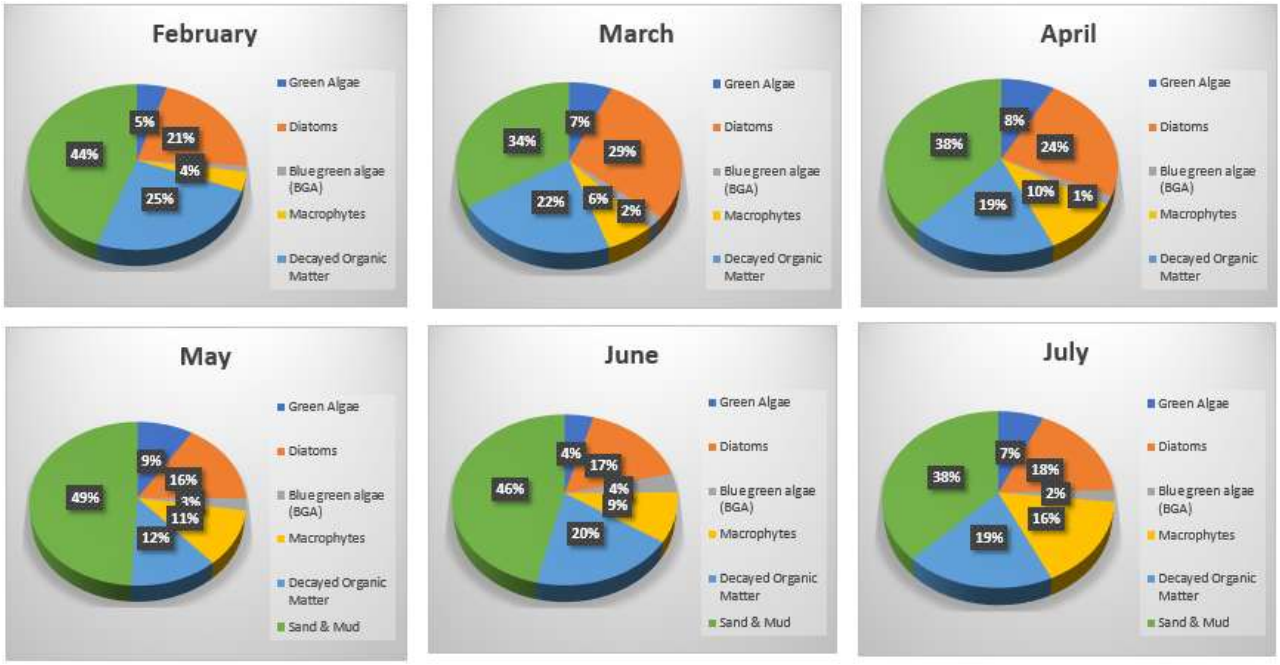


Figure 6: Monthly variation in food composition of *Labeo gonius* from February 2023 to July 2023 in Birauli Oxbow Lake

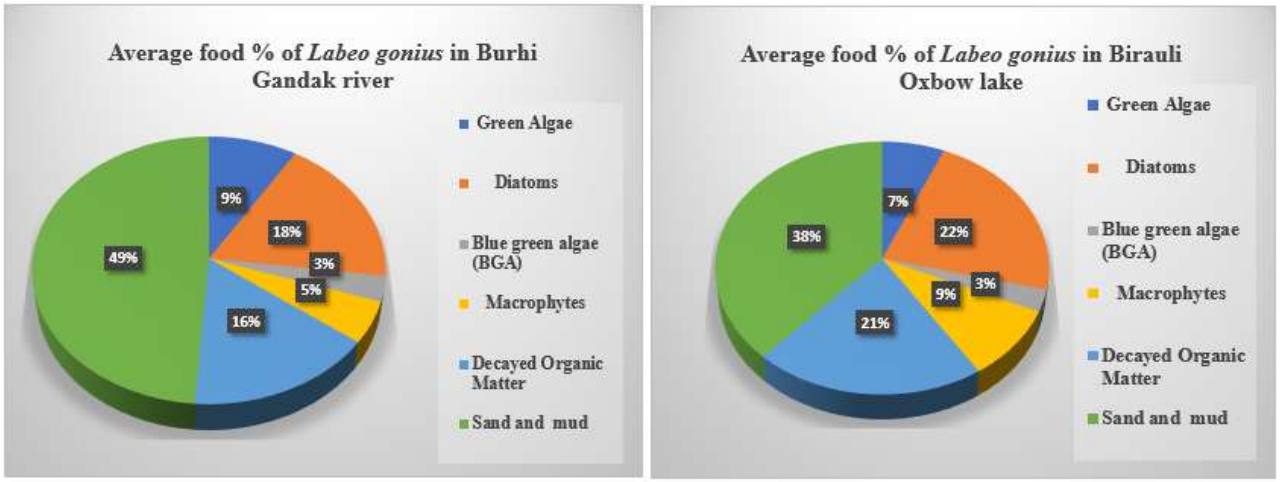
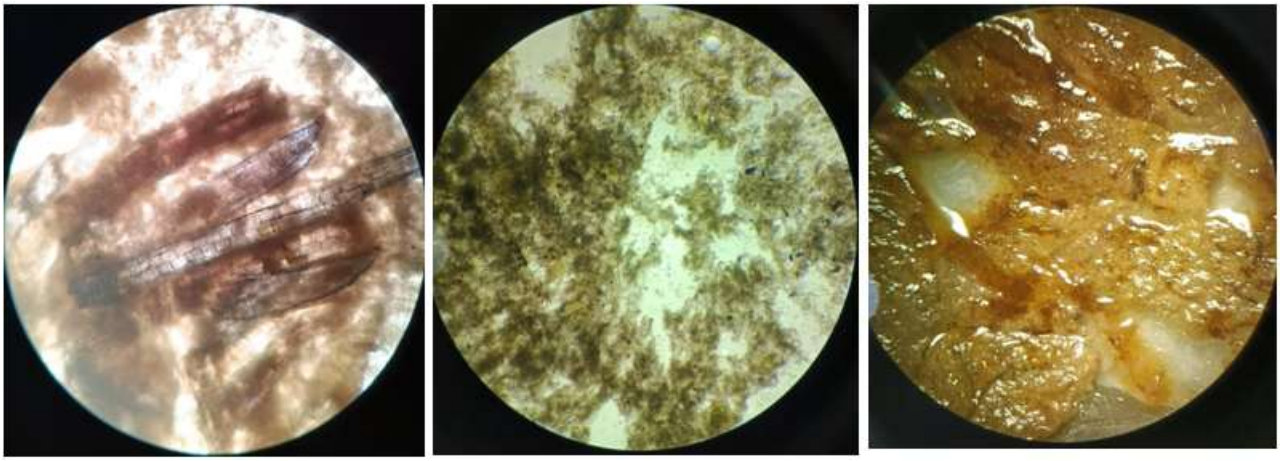


Figure 7: Average percentage of total food items of *Labeo gonius* in Burhi Gandak River and Birauli Oxbow Lake



Macrophytes | Decayed organic matter | Sand and mud

Plate 17: Gut content of *Labeo gonius*

3.2 Gastro-somatic Index (GaSI)

In the duration of study period (August 2022-July 2023), there was a noticeable monthly variation in Gastro-somatic Index (GaSI) of *Labeo gonius* in the Burhi Gandak River and Birauli Oxbow Lake are presented in Fig. 8. The monthly mean GaSI values for *L. gonius* in the Burhi Gandak River ranged from 1.5±0.10% to 4.6±0.08%, with the highest value in January and the lowest in July. Similarly, the monthly mean GaSI values in the Birauli Oxbow Lake varied from 1.28±0.07% to 4.89±0.07%, with the highest value observed in January and the lowest in July. Seasonal variation in feeding intensity can be determined by the overall trend, which showed higher GaSI values during the post-monsoon and winter months (October–February) and comparatively lower values during the summer and monsoon months (March–August).

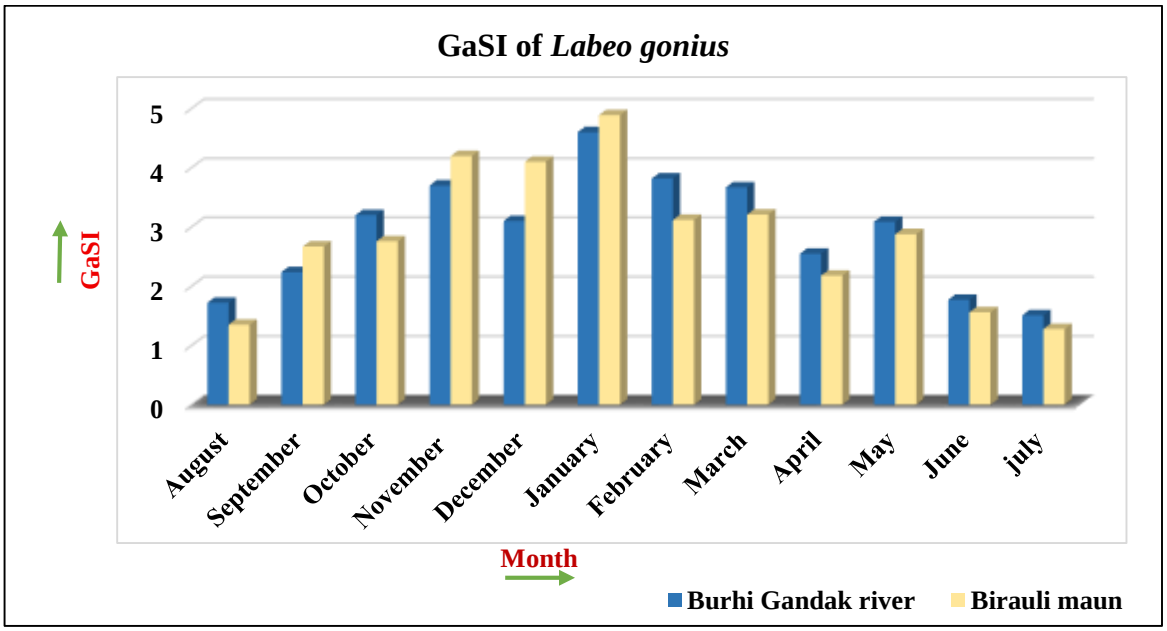


Figure 8: GaSI of *Labeo gonius* in Burhi Gandak and Birauli Oxbow Lake

The observed GaSI pattern in *Labeo gonius* indicates intense feeding during cooler months for energy storage, peaking at ~4.7-4.85% in January (post-monsoon/winter) and decreasing at ~1.15-1.3% in July (monsoon), in contrast to decreased feeding during the monsoon, which is probably caused by high turbidity, flooding and spawning energy diversion. This exactly corresponds with the findings of [4] from River Kali, where feeding

intensity and GaSI maximized October–February (post-monsoon/winter) and decreased March–August (post-winter/monsoon). [11] also reported maximum GaSI (5.874 ± 0.145) during the post-monsoon season and its lowest value (3.425 ± 0.152) during the monsoon season in *Labeo calbasu*. This suggests that the fish actively feeds after the breeding period to replenish the energy lost during spawning.

3.3 Relative Gut Length (RGL)

During the study period (August 2022–July 2023), the Relative Gut Length (RGL) of *Labeo gonius* showed evident monthly variation at both sampling sites. The Burhi Gandak River's RGL values varied from 4.7 to 7.8, with August having the greatest value and November having the lowest. Similarly, RGL values at the Birauli Oxbow Lake ranged from 4.1 to 6.5, peaking in August and lowering in February. The Birauli Oxbow Lake (5.13) had a lower mean RGL than the Burhi Gandak River (5.83). A significant difference in RGL between the two sites was found using a paired t-test ($t = 3.09$, $df = 11$, $P < 0.05$), suggesting that fish inhabiting the river ecosystem are feeding at a comparatively greater intensity.

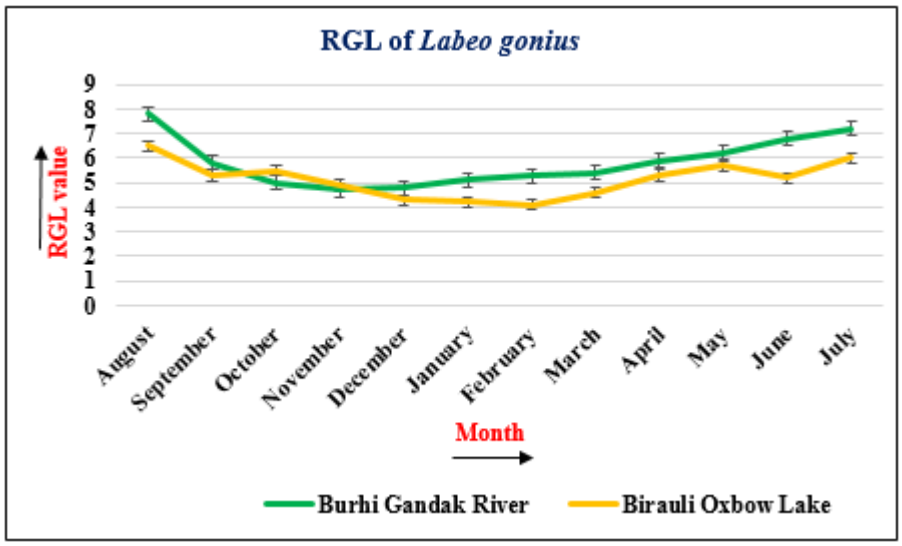


Figure 9: RGL of *Labeo gonius* in Burhi Gandak and Birauli Oxbow Lake

The variations in ecological parameters, including as nutrient availability, plankton abundance and organic matter, may be the reason of the partial variances between the river and Oxbow Lake RGL values. Riverine systems usually receive constant nutrient inputs and support a variety of food sources, which may increase feeding activity which can affect feeding indices and gut length. Therefore, variations in food supply and habitat productivity are probably reflected in the observed differences in RGL between the two environments. Relative gut length (RGL) and fish food type have been shown to be closely related in earlier research [7]. The RGL of *Labeo gonius* in the present research varied from 4.10 to 7.80, which is similar to the value of 9.42 that [5] observed.

4. Conclusion

The feeding biology of *Labeo gonius* in the Burhi Gandak River and Birauli Oxbow Lake in two distinct freshwater habitats is compared in study. The gut content analyses, the species has a bottom-feeding detritivores feeding pattern and mostly consumes benthic materials like sand, mud, detritus, diatoms, and algae. The Gastro-somatic Index clearly indicates seasonal differences in feeding intensity with lower feeding during the monsoon season and higher feeding activity during the post-monsoon and winter months. The species omnivore to herbivorous feeding habits were further supported by the relative gut length results. Significant variations in RGL in the habitats of the river and oxbow lake indicate that feeding behaviour and

digestive morphology are influenced by environmental factors, food availability and habitat productivity. In freshwater habitats, *Labeo gonius* plays a significant role in connecting detrital resources to higher trophic levels and generally has significant ecological flexibility. The results of this study advance our knowledge of trophic ecology and could help create sustainable inland fisheries management plans.

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