JOURNAL OF MARITIME RESEARCH

Vol XXII. No. III (2025) pp 339–345

ISSN: 1697-4840, www.jmr.unican.es

# Seasonal Feeding Activity, Gut Content Analysis and Morphometric Insights of *B. Bagarius* from the Indus River

Murak[1,*], Muhammad Sajjad Ahmad[2]

ARTICLE INFO

***Article history:***
Received 05 Jan 2025;
in revised from 24 Jan 2024;
accepted 05 Mar 2025.

***Keywords:***
Feeding activity, Morphometric Traits, Bagarius Bagarius, Stomach Fullness, Omnivorous, Gut Content.

ABSTRACT

This study examines the seasonal feeding patterns of *Bagarius bagarius* in the Indus River. It focuses on changes in feeding activity, gut content, and the length–weight relationship, to understand shifts in food availability influence feeding patterns throughout the year. The feeding activity was categorized into five levels: full stomach, three-quarters full stomach, half full stomach, one-quarter full stomach, and empty stomach. Monthly observations were made for each category. The highest number of empty stomachs was observed in January, while feeding activity increased during the summer and monsoon periods. August showed the highest proportion of full stomachs at 45%. Gut content analysis revealed a wide range of food items, including zooplankton, protozoans, crustaceans, insects, molluscs, detritus, plant material, fish larvae, eggs, and scales. Seasonal patterns revealed that *B. bagarius* predominantly follows a carnivorous diet but opportunistically shifts to omnivory when food is scarce. The morphometric analysis highlighted significant variation in length-weight relationships, showing negative allometric growth (b=1.59). Monthly data revealed differences in feeding intensity between mature and immature individuals, influenced by breeding cycles and seasonal food availability. This research explains the trophic ecology and seasonal adaptations of *B. bagarius*. It also clarifies its ecological role in the Indus River and supports the development of effective conservation strategies for this freshwater species.



## 1. Introduction.

The Tibetan Plateau is where the Indus River begins. Then it goes through India and Pakistan. It helps millions of people find jobs and is very important for agriculture, fishing, and biodiversity in Pakistan. Seasonal changes in river flow strongly affect plants and animals living in the river. When flow conditions change, fish alter their feeding, breeding, and growth patterns. The Upper Indus Basin receives water from different runoff sources, including glacial, nival pluvial, and pluvial systems. These runoff types directly control water availability and must be managed carefully[1]. Climate change also has changed when it rains and heavy streams flow. It makes farming harder and requires adaptive management [2-3]. Water management becomes more difficult because India and Pakistan have disagreements on sharing transboundary river flows. Long term sustainability depends on cooperation between both countries and compliance with international water laws[4]. Aquatic biodiversity in the Indus River is also vulnerable by pollution from transition metals and by habitat degradation. These threats necessitate targeted measures and enhanced water quality standards [5]. Additionally, the increased frequency of floods and droughts, driven by climate change, highlights the urgent need for suitable water management policies [6]. Addressing these challenges requires effective water management policies, regional cooperation, legal reforms, and the adoption of innovative solutions to protect the Indus River and the communities

[1]PhD Student, Institute of Tropical Aquaculture and Fisheries, University Malaysia Terengganu, 21030, Kuala Nerus, Terengganu, Malaysia.

[2]PhD Student, Marine Technology Center, Faculty of Mechanical Engineering, Universiti Teknologi Malaysia, 81300, Skudai, Johor Bahru, Johor, Malaysia.

*Corresponding author: Murak. E-mail Address: p6068@pps.umt.edu.my.

that depend on it.

*B. bagarius*, known as the goonch catfish, is a carnivorous freshwater fish from the family Sisoridae. It is found across South Asia and Southeast Asia. The species inhabits fast flowing rivers and streams. It acts as a top predator in aquatic ecosystems. In the Indus River, *B. bagarius* has both ecological and commercial value. It supports local fisheries due to its nutritional value and demand in regional markets [7]. Despite its importance, few studies have explored its feeding ecology, growth, and seasonal adaptation in the Indus River. It limits understanding of its ecological role [8]. The feeding behavior of *B. bagarius* responds to environmental conditions. Population changes often indicate habitat degradation and pollution, making the species a useful bioindicator of river health [9]. Human activities, including irrigation dam construction, have reduced suitable deep-water habitats. This decline has been observed in areas such as the Budhikhola River in Nepal[10]. Recent phylogenetic studies of the Sisoridae family show a complex evolutionary history. Therefore, a clear taxonomy is necessary to support effective biodiversity conservation [11].

Figure 1: *B. bagarius*.

Source: Hamilton, 1822.

Food and feeding habits are central to understanding fish ecology and biology. Diet affects growth, reproduction, and survival. It also defines a species role in the ecosystem. Feeding behavior for *B. bagarius*, is closely linked to seasonal changes in food availability and river conditions. It acts as a top predator in the Indus River. It mainly feeds on fish and aquatic invertebrates, which helps maintain trophic balance [12]. Seasonal changes in water flow and temperature affect prey availability. These changes influence feeding intensity and diet composition [13]. Gut content analysis shows that *B. bagarius* can adjust its diet. It consumes a wide range of food items in response to environmental conditions [14-15]. This flexibility supports survival under changing river conditions, including pollution and habitat modification. Morphometric analysis also indicates that larger individuals consume more food. Seasonal patterns also show dietary shifts during breeding periods and times of limited resources [16]. Understanding these feeding patterns is important for conservation. As a bioindicator, *B. bagarius* reflects river health and supports sustainable management and biodiversity conservation [17-18].

*B. bagarius*, has significant ecological importance in the Indus River. However, research specific to its feeding activity, gut content composition, and length-weight relationship remains limited, particularly regarding seasonal feeding dynamics and prey availability[19-20]. Seasonal variations in food resources and environmental factors, as observed in other carnivorous fish like Hemibagrus nemurus, likely influence the feeding ecology and adaptive strategies of B. *bagarius*, justifying further study [21]. Limited morphometric and ecological data restrict understanding of how this species responds to habitat degradation and pollution. Human pressures such as overfishing and hydraulic structures further reduce fish diversity and abundance in river systems[22-23]. Low to moderate genetic diversity in *B. bagarius* reduces its ability to cope with environmental change[24]. Focused research on its ecology and adaptive strategies is therefore necessary. It will support conservation planning, help maintain genetic diversity, and improve long term survival of the species in the Indus River[25].

This study aims to fill the research gap by investigating the seasonal feeding activity, gut content composition, and length-weight relationship of *B. bagarius* in the Indus River. It focuses on examining seasonal variations in feeding intensity and exploring how dietary patterns correlate with the availability of natural food resources. The findings will provide critical insights into the species' ecological role, serve as baseline data for future research, and support the development of conservation and sustainable management strategies for the Indus River ecosystem. By shedding light on the seasonal adaptations of B. *bagarius*, this study contributes to the preservation of biodiversity and the ecological integrity of one of Asia's most vital freshwater systems. The structure of the article is as follows: Section 2 outlines the methodology used for the study, Section 3 presents the results and discusses their implications, and Section 4 concludes the study with key findings and recommendations.

## 2. Materials and Methods.

### *2.1. Study Area.*

The study was carried out in the Indus River, one of the major freshwater systems in Asia. The river supports high aquatic biodiversity. The sampling site shown in Figure 2 was selected to represent different ecological zones along the river. It includes habitats with varying environmental conditions. Site selection considered accessibility, fish abundance, and the level of human activity affecting the river. Fish specimens were collected from the Indus River. Additional samples were obtained from local fishers during routine fishing activities in the Indus River.

Figure 2: Google Maps location of the sampling area.


Source: Google Maps.

### 2.2. Sample Collection.

The samples of *B. bagarius* were collected in every season from January 2019 to December 2019, to see how their body shape and eating habits changed with the seasons. We got fish from some parts of the Indus River that have different types of habitats that are affected by both natural and man-made things. They fished with cast nets, gill nets, and hand nets, which are all old-fashioned ways to do it. The mesh size ranged from 15 to 40 mm. We chose this range so that it would appeal to a wide range of people, from kids to adults.

A total of 360 specimens of *B. bagarius* were collected. Sampling averaged 30 fish per month. Immediately after collection, a 10 percent formalin solution was injected into the gut of each specimen. This step stopped digestion and preserved gut contents. The fish were sealed in plastic bags and stored in ice boxes. Samples were then transported to the Department of Fresh Water Biology and Fisheries, University of Sindh, Jamshoro. In the laboratory, specimens were defrosted before analysis. Each fish was weighed using a digital balance with 0.1 g accuracy. Total length was measured on a wooden measuring board to the nearest 0.1 cm, as shown in Figure 3.

Figure 3: Dissections and measurements of *B. bagarius*.

Source: Authors.

### 2.3. Morphometric Measurements.

The morphometric measurements of each fish included total length (TL, cm) and body weight (BW, g). The measurements were taken with a precision of 0.1 cm and an electronic weighing scale with an accuracy of 0.1 g, as shown in figure 4. The identification of the specimens was conducted following Mirza and Sharif [26]. The relationship between TL and alimentary canal length (ACL) TL, and stomach length was analyzed using the formula:

$$Y = a + bX \tag{1}$$

where $Y$ is the alimentary canal length, $X$ is the total length, $a$ is the intercept, and $b$ is the regression coefficient.

Figure 4: Dissection of *B. bagarius* for stomach removal and measurement of length.

Source: Authors.

The length weight relationship (LWR) was used to examine growth in the species. It also provided information on body condition and overall health. The relationship was expressed using the equation:

$$W = aL^b \tag{2}$$

where $W$ is the body weight (g), $L$ is the total length (cm), $a$ is the intercept (representing the initial growth factor), and $b$ is the growth coefficient (indicating the type of growth).

To determine the parameters $a$ and $b$, the logarithmic transformation of the equation was applied:

$$log(W) = log(a) + blog(L) \tag{3}$$

This transformation allowed for a linear regression analysis to be performed, where $b$ values near 3 indicate isometric growth (proportional increase in length and weight), while deviations suggest allometric growth (disproportionate growth). The relationship was analyzed separately for each season to identify potential seasonal variations in growth patterns, reflecting changes in environmental conditions or resource availability.

All measurements were conducted within 24 hours of sample collection to minimize potential biases from post-mortem changes in body weight or length. Data from the length-weight relationship analysis served as a foundation for understanding the ecological adaptations and growth strategies of B. *bagarius* in the dynamic conditions of the Indus River.

### 2.4. Gut Content Analysis.

The gastrointestinal tracts of collected specimens were carefully dissected under controlled laboratory conditions, to investigate the dietary composition of B. *bagarius*, as suggested by Mahesh et al. [27]. Sterilized surgical tools were used to avoid contamination and ensure accuracy, as shown in Figure 5. The extracted gut contents were then preserved in a 10 % formalin solution for further analysis.

Figure 5: Analysing the Digestive Tract.

Source: Authors.

In the laboratory, preserved gut contents were examined under a dissecting microscope. Prey items were identified to the lowest possible taxonomic level using standard taxonomic keys, regional guides, and published references on aquatic fauna. Identification focused on accuracy and consistency across samples. Prey items were grouped into fish, crustaceans, insects, mollusks, and plant material. Further identification to family, genus, or species level was carried out where possible. Diet composition was analyzed using three indices. Frequency of occurrence (%FO) represented the percentage of stomachs containing a given prey type. Numerical abundance (%N) indicated the proportion of each prey item by count. Gravimetric analysis (%W) measured the weight contribution of each prey type to total gut content.

To synthesize these metrics into a single measure of dietary importance, the Index of Relative Importance (IRI) was calculated using the formula below:

$$IRI = (\%FO) \times (\%N + \%W) \quad (4)$$

The IRI values were then expressed as percentages to facilitate comparisons across prey categories. This comprehensive analysis provided a robust understanding of the dietary habits and trophic role of B. *bagarius*, revealing seasonal variations in feeding behavior and prey selection, which are critical for understanding its ecological adaptations and predator-prey dynamics within the Indus River ecosystem.

### *2.5. Seasonal Feeding Activity.*

Feeding intensity was assessed by calculating the gastrosomatic index (GaSI) using the formula:

$$GaSI = \left(\frac{Weight\ of\ gut\ contents\ (g)}{Total\ body\ weight\ (g)}\right) \times 100 \quad (5)$$

This index provides a quantitative measure of feeding activity relative to body weight. Seasonal variations in *GaSI* were analyzed to identify patterns of feeding intensity across spring, summer, autumn, and winter. This approach identified periods of high feeding activity and low food intake. It also clarified seasonal feeding patterns in *B. bagarius*.

### *2.6. Data Analysis.*

Data was analyzed using Microsoft Excel to explore the relationships between various biological and ecological variables. The length-weight relationship of *B. bagarius* was assessed through regression analysis, which provided insights into the growth patterns of the species. Seasonal variations in feeding intensity and dietary composition were evaluated using regression analysis to test for significant differences between the four seasons. It helped identify periods of high or low feeding activity and shifts in dietary preferences across different environmental conditions. Correlation analysis was used to examine the link between fish size and diet. It verified whether gut content composition changed with fish size. All results were expressed as mean ± standard deviation to quantify variability, and statistical significance was determined at a level of $p < 0.05$. The statistical approach ensured that the findings were good and reliable, allowing for meaningful conclusions regarding the ecological dynamics of *B. bagarius*.

### *2.7. Ethical Considerations.*

All fish handling and sampling followed established ethical guidelines for animal research. Required permits were obtained from local fisheries and environmental authorities before the study. Care was taken to reduce stress and harm the fish. Sampling methods were designed to limit impacts on non-target species and the river ecosystem. All activities were conducted with a focus on environmental responsibility and conservation of aquatic life in the Indus River.

## 3. Results.

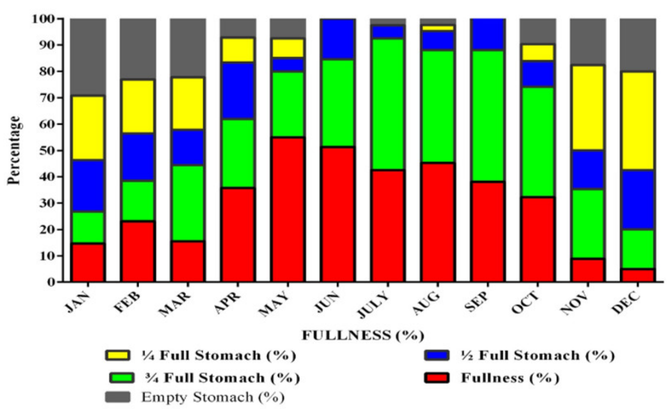
### *3.1. Seasonal Feeding Activity of B. bagarius.*

The seasonal variation in feeding activity of *B. bagarius* shows clear links with river conditions, prey availability, and physiology, as described in Figure 6. Feeding was lowest during winter. In January, 29.2% of specimens had empty stomachs, followed by 23.7% in February and 22.2% in March. Lower water temperature during this period likely reduced metabolic rate and prey activity, leading to reduced food intake. Feeding activity increased from early spring. In April, 35.71% of fish showed full stomachs, indicating improved feeding conditions. Rising temperature and moderate flow may have increased the availability of prey such as fish larvae, insects, and benthic invertebrates. High feeding intensity was recorded during summer and monsoon months. In June, 51.28% of fish had full stomachs, while July showed 42.5%. Feeding remained high at 45.23% in August and 38.09% in September. Increased discharge during this period likely enhanced nutrient input and habitat connectivity, supporting higher prey abundance and foraging opportunities. A slight decline in feeding activity was observed during October and November, although around 40%

of specimens still had full stomachs. This reduction may be linked to gradual cooling and changing flow conditions, which can affect prey availability and distribution.

Statistical analysis of stomach fullness categories in Table 1 shows significant seasonal variation in feeding activity. The goodness of fit test produced non-zero slopes for all stomach fullness classes, with P values less than 0.05, confirming that feeding activity varies significantly with season and is not random. Feeding intensity was higher during warmer months and declined during colder months. The increased proportion of empty stomachs in winter indicates reduced food intake during this period. These results demonstrate a direct link between seasonal food availability and feeding behavior of *B. bagarius* in the Indus River.

Figure 6: Seasonal variation in the Stomach Fullness categories of *B. bagarius* from the Indus River.




Source: Authors.

Table 1: Statistical analysis of stomach fullness categories in B. *bagarius* from the Indus River.

| *Statistical analysis* | *Fullness* | *¾ Full* | *½ Full* | *¼ Full* | *Empty* |
|---|---|---|---|---|---|
| *Best-fit values* | | | | | |
| *Slope* | 3.561 ± 0.9253 | 3.989 ± 0.6281 | 1.579 ± 0.3768 | 1.678 ± 0.5589 | 1.193 ± 0.5130 |
| *1/slope* | 0.2808 | 0.2507 | 0.6334 | 0.5961 | 0.8381 |
| *95% Confidence Intervals* | | | | | |
| *Slope* | 1.525 to 5.598 | 2.606 to 5.371 | 0.7495 to 2.408 | 0.4475 to 2.908 | 0.06408 to 2.322 |
| *Goodness of Fit* | | | | | |
| *Sy.x* | 23.59 | 16.01 | 9.606 | 14.25 | 13.08 |
| *Is slope significantly non-zero?* | | | | | |
| *T* | 3.849 | 6.351 | 4.19 | 3.002 | 2.326 |
| *DF* | 11 | 11 | 11 | 11 | 11 |
| *P value* | 0.0027 | < 0.0001 | 0.0015 | 0.012 | 0.0402 |
| *Number of X values* | 12 | 12 | 12 | 12 | 12 |
| *Maximum number of Y replicates* | 1 | 1 | 1 | 1 | 1 |
| *Total number of values* | 12 | 12 | 12 | 12 | 12 |
| *Number of missing values* | 0 | 0 | 0 | 0 | 0 |
| *Points above line* | 9 | 10 | 6 | 6 | 7 |
| *Points below line* | 3 | 2 | 6 | 6 | 5 |
| *Number of runs* | 2 | 2 | 5 | 3 | 3 |
| *P value (runs test)* | 0.0091 | 0.0303 | 0.1753 | 0.013 | 0.0152 |
| *Deviation from linearity* | Significant | Significant | Not Significant | Significant | Significant |

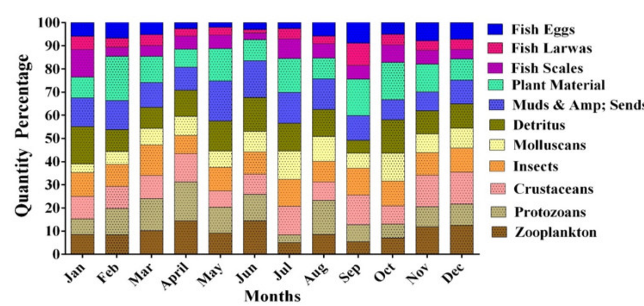
Source: Authors.

### *3.2. Qualitative and Quantitative Analysis of the Dietary Composition of B. bagarius.*

The feeding activity of *B. bagarius* was analyzed through both qualitative and quantitative methods to examine the variety and availability of food items in its diet. The qualitative analysis focused on identifying the different types of food items consumed by the species, while the quantitative approach evaluated the relative abundance of these items in the natural environment. This dual approach provides insights into the seasonal feeding patterns and the availability of food resources along both upstream and downstream areas of the Indus River.

The data were categorized by food types and grouped by month to identify seasonal variations in prey availability. The gut contents of *B. bagarius* were found to include a diverse range of food items, such as zooplankton, protozoans, crustaceans, insects, mollusks, detritus, mud and sand, plant material, fish scales, fish larvae, and fish eggs shown in figure 7. This detailed analysis sheds light on the seasonal food phenomena, contributing to a better understanding of the species' trophic role in the dynamic ecosystem of the Indus River.

Figure 7: Yearly collected and identified food items in the gut of *B. bagarius*.




Source: Authors.

### *3.3. Length-Weight Relationship of B. bagarius.*

The length-weight relationship of *B. bagarius* was analyzed to understand the growth pattern and body condition of the species throughout the year. The data, shown in Table 2, presents the average length in centimetres (cm) and corresponding weight in grams (gm) for each month. In addition, the coefficient of variation (CV) and the mean values for both length and weight were calculated for each month, providing further insights into the variability and trends in the species' growth over the year.

From the data presented in Table 2, it is evident that the length and weight of *B. bagarius* show significant growth during the first half of the year, reaching a peak in June with a length of 58.86 cm and a weight of 950.42 gm. In contrast, the fish showed a notable reduction in length and weight during the months of July and August, likely due to lower food availability or changes in environmental conditions. After August, there was a gradual recovery in size, with measurements reaching their second-highest values in December (length: 42.45 cm, weight: 362.6 gm). The coefficient of variation (CV) for length and weight fluctuates throughout the year, indicating some degree of variability in the growth patterns. The highest CV val-

Table 2: Length-weight relationship, Coefficient of Variation, and Mean of *B. bagarius* (January - December).

| *Month* | *Length (cm)* | *Weight (gm)* | *% c v* | *Mean* |
|---|---|---|---|---|
| *January* | 45.52 | 353.038 | 109.1174 | 199.279 |
| *February* | 48.62 | 464.63 | 114.6278 | 256.625 |
| *March* | 51 | 628 | 120.1769 | 339.5 |
| *April* | 53.85 | 716.034 | 121.6378 | 384.942 |
| *May* | 56.07 | 816.02 | 123.2363 | 436.045 |
| *June* | 58.86 | 950.42 | 124.9263 | 504.64 |
| *July* | 30.44 | 105.268 | 77.97829 | 67.854 |
| *August* | 35.05 | 156.038 | 89.5414 | 95.544 |
| *September* | 40.25 | 256.032 | 102.9971 | 148.141 |
| *October* | 40.44 | 325.624 | 110.175 | 183.032 |
| *November* | 41.25 | 354.418 | 111.9339 | 197.834 |
| *December* | 42.446 | 362.6 | 111.7814 | 202.523 |

Source: Authors.

ues were observed in July, where the length and weight were significantly lower, possibly due to adverse environmental conditions. Conversely, the lowest CV values occurred in the months with higher growth rates, such as in June.

## 4. Discussion.

The seasonal feeding activity of *B. bagarius* was analyzed over the complete year. The analysis aimed to understand patterns and trends in the feeding behavior of this species. The feeding activity was analyzed using both qualitative and quantitative methods. The qualitative analysis revealed that *B. bagarius* is primarily carnivorous, feeding mainly on small fish, crustaceans, and insects. This diet is consistent with its role as a top predator in the Indus River. The species also showed some omnivorous tendencies, especially in periods of food scarcity, foraging in benthopelagic, surface, and sub-surface zones, and feeding both during the day and night. This adaptability is crucial for survival in varying environmental conditions.

Seasonal differences in food availability strongly influenced feeding intensity. Summer and monsoon periods supported higher prey abundance due to increased discharge and nutrient input. During these seasons, feeding activity increased across most size classes. In contrast, winter conditions reduced prey availability and feeding intensity. Immature fish fed more actively during non-breeding periods, likely to support growth. Mature individuals reduced feeding during the breeding season, indicating energy allocation toward reproduction rather than somatic growth.

Gut content analysis showed a wide range of food items, including zooplankton, protozoans, crustaceans, mollusks, fish larvae, eggs, and scales. The presence of mud, sand, and detritus suggests bottom feeding during periods of low prey density. This pattern supports opportunistic feeding driven by resource availability rather than prey selectivity.

Morphological traits further explain observed feeding behavior. The mouth structure and dentition favor prey capture, especially small fish and crustaceans. Short gut length and low gut mass are consistent with carnivorous feeding and rapid digestion of protein rich food. Length weight analysis showed negative allometric growth with b = 1.59. This indicates faster increase in length than weight. Such growth is typical for active predators and reflects feeding efficiency and energy use. These findings highlight the species sensitivity to changes in river flow, habitat structure, and food supply. Continued habitat degradation and flow regulation may therefore disrupt feeding efficiency and growth, with direct consequences for population stability.

## Conclusions.

This study presents a detailed analysis of seasonal feeding patterns, food availability, and morphological traits of *B. bagarius* in the Indus River. The species follows a mainly carnivorous diet but can shift toward omnivorous feeding when food availability changes. Seasonal variation in food resources strongly influenced feeding behavior. Immature fish fed more actively throughout the year, while mature individuals reduced feeding during the breeding season. Gut content analysis showed that *B. bagarius* consumes a wide range of prey, including zooplankton, crustaceans, mollusks, and small fish. This confirms its opportunistic feeding strategy under varying environmental conditions. Morphological features such as a short digestive tract, tooth arrangement, and gill rakers support a carnivorous feeding mode. The length weight relationship showed negative allometric growth, indicating faster increase in length than weight, which is typical of carnivorous fishes. These results clarify the ecological role of *B. bagarius* in the Indus River and provide useful information for conservation planning. Future research may evaluate changes in water temperature, flow, and habitat structure affect feeding behavior, growth, and long-term population stability.

## References.

[1] F. Meng, F. Su, H. Sun, J. Huang, and C. Li, “Divergent runoff regime revealed by hydrological simulations with corrected precipitation in the upper Indus,” J. Hydrol., vol. 626, p. 130315, 2023.

[2] S. Ali, B.-H. Kim, T. Akhtar, and J. Kam, “Past and future changes toward earlier timing of streamflow over Pakistan from bias-corrected regional climate projections (1962–2099),” J. Hydrol., vol. 617, p. 128959, 2023.

[3] M. Adnan, S. Liu, M. Saifullah, M. Iqbal, A. F. Ali, and M. A. Mukhtar, “Spatiotemporal variations in runoff and runoff components in response to climate change in a glacierized subbasin of the Upper Indus Basin, Pakistan,” Front. Earth Sci., vol. 10, p. 970349, 2022.

[4] B. BIBI, K. Jian, A. Hussain, and A. Sohail, "Environmental threats to South Asia's Basins (Indus and Ganga); treaties analysis," J. Peace Dev. Commun., vol. 7, no. 01, 2023.

[5] A. Hira, M. Arif, N. Zarif, Z. Gul, X. Liu, and Y. Cao, "Impacts of stressors on riparian health indicators in the upper and lower Indus river basins in Pakistan," Int. J. Environ. Res. Public. Health, vol. 19, no. 20, p. 13239, 2022.

[6] A. Inam et al., "The Geographic, Geological, and Oceanographic Setting of the Indus River – An Update," in Large Rivers, 1st ed., A. Gupta, Ed., Wiley, 2022, pp. 488–520. doi: 10.1002/-9781119412632.ch17.

[7] J. Ferdous Jerin, S. Akther, J. Debnath, and D. Saha, "Length-Weight Relationships and Condition Factor of Four Threatened Riverine Catfish Species in the Meghna River Estuary, Bangladesh," J. Appl. Ichthyol., vol. 2023, pp. 1–4, Oct. 2023, doi: 10.1155/2023/6651843.

[8] M. Choudhary et al., "Status of fish assemblage structure in the Ganga and Indus riverine systems of the western Himalaya," World Water Policy, vol. 9, no. 3, pp. 613–638, Aug. 2023, doi: 10.1002/wwp2.12116.

[9] B. R. Chaudhari, "Impact of Irrigation Dams on Fish Diversity of Budhikhola in Bardiya, Lumbini Province of Nepal," Acad. Res. J., vol. 3, no. 1, pp. 116–127, 2024.

[10] M. Choudhary et al., "Status of fish assemblage structure in the Ganga and Indus riverine systems of the western Himalaya," World Water Policy, vol. 9, no. 3, pp. 613–638, Aug. 2023, doi: 10.1002/wwp2.12116.

[11] Y. Wang et al., "Comparative Analysis of the Complete Mitochondrial Genomes of Three Sisoridae (Osteichthyes, Siluriformes) and the Phylogenetic Relationships of Sisoridae," Biochem. Genet., Apr. 2024, doi: 10.1007/s10528-024-10793-7.

[12] M. Mahamood, F. R. Khan, F. Zahir, M. Javed, and S. S. Alhewairini, "Bagarius bagarius, and Eichhornia crassipes are suitable bioindicators of heavy metal pollution, toxicity, and risk assessment," Sci. Rep., vol. 13, no. 1, p. 1824, 2023.

[13] S. I. Paul, B. C. Majumdar, M. Hasan, A. K. Sarker, A. Baidya, and M. A. Hakim, "Biodiversity, Threat and Conservation of Fish Species Important to The Jamuna River, Bangladesh," Croat. J. Fish. Ribar., vol. 79, no. 4, pp. 173–186, 2021.

[14] A. Biswas, K. F. Kanon, M. A. Rahman, M. S. Alam, S. Ghosh, and M. A. Farid, "Assessment of human health hazard associated with heavy metal accumulation in popular freshwater, coastal and marine fishes from south-west region, Bangladesh," Heliyon, vol. 9, no. 10, 2023.

[15] W. Jiang, Y. Guo, K. Yang, Q. Shi, and J. Yang, "Insights into body size evolution: a comparative transcriptome study on three species of Asian Sisoridae catfish," Int. J. Mol. Sci., vol. 20, no. 4, p. 944, 2019.

[16] M. A. Haque et al., "Seasonal analysis of food items and feeding habits of endangered riverine catfish Rita rita (Hamilton, 1822)," Braz. J. Biol., vol. 82, p. e237040, 2021.

[17] N. Macías-Hernández, K. Athey, V. Tonzo, O. S. Wangensteen, M. Arnedo, and J. D. Harwood, "Molecular gut content analysis of different spider body parts," PloS One, vol. 13, no. 5, p. e0196589, 2018.

[18] J. Issara-Amphorn, C. P. Dang, W. Saisorn, K. Limbutara, and A. Leelahavanichkul, "Candida administration in bilateral nephrectomy mice elevates serum (1→ 3)-β-D-glucan that enhances systemic inflammation through energy augmentation in macrophages," Int. J. Mol. Sci., vol. 22, no. 9, p. 5031, 2021.

[19] S. Modeel et al., "A comprehensive DNA barcoding of Indian freshwater fishes of the Indus River system, Beas," Sci. Rep., vol. 14, no. 1, p. 2763, 2024.

[20] H. Muhammad and Q. Bashir, "Kloniranje, Sekvenciranje I Ekspresija Hormona Rasta Soma Bagarius bagarius (Hamilton, 1822.)," Croat. J. Fish. Ribar., vol. 81, no. 4, pp. 173–181, 2023.

[21] D. N. Wibowo, S. Sukmaningrum, A. Widyastuti, P. H. T. Soedibya, and N. L. Rahayu, "Feeding ecology study of Asian redtail catfish, Hemibagrus nemurus (Teleostei: Bagridae), post-sediment flushing in Jenderal Soedirman Reservoir Central Java, Indonesia," Biodiversitas J. Biol. Divers., vol. 25, no. 5, 2024.

[22] M. Olivares, P. Tiselius, A. Calbet, and E. Saiz, "Nonlethal effects of the predator Meganyctiphanes norvegica and influence of seasonal photoperiod and food availability on the diel feeding behaviour of the copepod Centropages typicus," J. Plankton Res., vol. 42, no. 6, pp. 742–751, 2020.

[23] M. W. Boota et al., "Distribution and bioaccumulation of trace elements in two Cyprinidae fish species in the Indus river, Pakistan, including the impact of hydraulic structure on macroinvertebrates' biodiversity," Environ. Res., vol. 252, p. 118882, 2024.

[24] S. Rabbani et al., "Genetic status of Bagarius bagarius in Indus River and its implications for conservation.," Pak. J. Agric. Sci., vol. 60, no. 3, 2023.

[25] S. Zafar, F. Jabeen, M. Ali, and A. Sajjad, "Assessment of genetic diversity of freshwater genus Labeo through DNA barcoding and phylogenetic analysis inhabited in the River Indus," J. King Saud Univ.-Sci., vol. 36, no. 4, p. 103123, 2024.

[26] M. R. Mirza and H. M. Sharif, "A key to the fishes of Punjab," Ilmi Katab Ghar Urdu Bazar Lahore, 1996.

[27] V. Mahesh, G. Ambarish, and N. J. Rekha, "Stomach content analysis techniques in fishes," ICAR Spons. Winter Sch. Recent Adv. Fish. Biol. Tech. Biodivers. Eval. Conserv., pp. 104–115, 2018.