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Original Article

Food and feeding ecology of *Tor putitora* (Hamilton, 1822) from Rajouri River of Pir Panjal Himalayan Range, India

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Abstract
The present investigation provides the first comprehensive account of food and feeding habits of 375 Endangered putitor mahseer, *Tor putitora*, from Rajouri River of the Pir Panjal Himalayan region. Food items were grouped into eight categories, namely macroinvertebrates, zooplanktons, algal matter, unidentified plant matter, fish remains, detritus, unidentified-debris, and mud and sand, which were broadly classified into three major groups- plant matter, animal matter and miscellaneous materials. Quantitative and qualitative analyses revealed that plant matter constituted 38.97% of the diet, followed by miscellaneous materials 34.16% and animal matter 26.75%. The gastro somatic index and fullness index varied with sex, maturity stage and season owing to changes in food availability and reproductive activity. Both indices were the lowest during the spawning stage and highest during the pre-spawning stage. Feeding intensity increased during maturation and ripening (stages III and IV), but decreased significantly during the ripe stage (stage V). The relationship between total length and gut length indicated that gut was longer than the body, with body length-to-gut length ratios were 1:1.50 in females and 1:1.65 in males. Overall, relative length of gut, the index of preponderance, and predominance of algal matter throughout the year, together with the occurrence of animal matter in the gut indicate that the *T. putitora* is a column-feeding omnivore. These findings provide baseline information on the feeding ecology of this threatened species and will be valuable for the development of captive breeding, habitat management and conservation strategies.

Keywords: feeding habits; food; Himalayan region; putitor mahseer; Rajouri River; *Tor putitora*

1 | INTRODUCTION

The assessment of food and feeding habits of fish plays a vital role in the study of fish biology and also showed the requirements at different stages in their life cycles varies with time and space (Hardy *et al.* 1936, Allan and Castillo 2007). The availability of food is one of the critical aspects that influenced the survival of the fish and also plays an imperative role in growth, development and breeding of fish (Oronsaye and Nakpodia 2005). The abundance of fish in a particular habitat is also an indicator of food and feeding habits (Baijot and Moreau 1997; King and Akpan 2002). Besides, the composition of food present in the gut provides the information about the type of habitat and the quality of food (Sarkar *et al*. 2017). Fish shows a wide range of feeding habit due to the dynamic nature of aquatic ecosystem, then any other vertebrates (Olojo *et*

al. 2003). The versatility of feeding habits may differ in taxonomy, size, growth stage, sex or maturation even in the same species (Nikolskii 1963; Otieno *et al*. 2014). The gut of a fish species or any other animal reflects its diet and the percentage composition of food items present in the stomach indicates the feeding behaviour of the fish (Manon and Hossain 2011).

Based on the type of food they consumed, fishes are broadly classified as: herbivores, carnivores and omnivores (Nikolsky 1963; Wootton 1998). Therefore, investigations of the food and feeding habits of freshwater fish continue to be an important area of research because knowledge of their feeding ecology forms the basis for effective management and sustainable aquaculture (Oronsaye and Nakpodia 2005). Food and feeding habits also enable us to have a better understanding of dietary requirements with a view to formulate feed for them in aquaculture (Malami *et al*. 2004). Gut content analysis is a valuable tool for understanding the feeding ecology of fishes, as it provides information on diet composition, resource utilization, and trophic relationships. Such information helps assess the extent of intra- and interspecific competition through dietary overlap and resource partitioning (Pius and Benedicta 2002). Feeding ecology describes how fish exploit available food resources and adopt optimal foraging strategies to maximize energy intake while minimizing the costs associated with food acquisition. Food preferences and trophic selection vary with species, habitat, and life stage and play a crucial role in growth, development, survival, and reproductive success (Gerking 1994; Wootton 1998; Bone and Moore 2008). The entire life cycle of fish largely depends upon feeding activity (Royce 1972). The success of good scientific planning and management of fish species largely depends on the knowledge of their biological aspects, in which food and feeding habits constitutes valuable feature (Chakaborty *et al*. 2016). Apart from ecology and well-beings of the fish in natural environment, understanding the feeding habit of the fish also is useful in deciding the induction of species to culture system (Allan and Castillo 2007). All the biological activities of the fish like growth, development, migration and breeding mainly depends on the nutritional requirements of the feed (Khongngain *et al*. 2017; Sarkar *et al*. 2017).

In the past, the food and feeding habits of fish have been the subject of extensive research, with numerous studies employing a variety of methodological approaches (Hyslop 1980). Mookerjee *et al*. (1946) reported that no fish species is exclusively carnivorous or herbivorous; rather feeding habits are determined by the relative proportions of different food items present in the gut. Later on, various studies have been conducted to understand the food and feeding of various fish species such as; Alderton (2008) stated that the digestive system of fish is typically similar to that of other vertebrate. However, herbivorous fishes generally possess longer intestines than omnivores and carnivorous fish species because plant matter is rough, fibrous and not easily to break-down. Fish feeds on wide range of food material and get their nutrients from plant as well as animal matter (Vahneichong *et al*. 2017). In omnivores and carnivorous hill stream fishes, stomach and intestine distinction is clear but in herbivorous fishes' true stomach is not present and the anterior part of alimentary canal is swollen to form a sac behind the esophagus which serves for storing the food and is known as intestinal bulb (Khanna and Bhatt 1975; Bhakta *et al*. 2019). The food and feeding habits of fish shows changes on monthly basis due to the variation in the composition of food items occurring at different seasons of the year (Bhuiyan *et al*. 1997, 1999).

Although numerous studies have investigated the food and feeding habits of fish species from Indian water bodies (Saikia *et al*. 2012; Chaturvedi and Saksena 2013; Chaturvedi and Parihar 2014; Naik *et al*. 2015; Jyrwa and Bhuyan 2016; Sabha *et al*. 2017; Kurbah and Bhuyan 2018). However, no information on feeding ecology of *Tor putitora* from the Rajouri River of Pir Panjal Himalayan range. This species, also known as putitor mahseer or golden mahseer, is an important food and game fish of mid-Himalayan regions of northern India. Due to its good taste and high nutritional values, the fish fetch high demand in the market and thrives well in cold and clear water. However, recently it has been observed that the species is struggling to cope with the issues in its habitat and fall under the criteria of Endangered species (Jha *et al.* 2018). Moreover, in order to fulfil the growing demand of fish eaters, indiscriminate fishing has been taken place over the last few decades, which has declined the natural population of both *T. putitora* in the region. Thus, the abundance of *T. putitora* is decreasing, and if preventive measures for its conservation are not taken, this fish may become Critically Endangered or even Extinct. Therefore, it is necessary to study the food and feeding habits of *T. putitora* which requires a dietary analysis in their natural habitat. Therefore, an attempt was made during the present investigation to analyze different aspects of food and feeding of *T. putitora* from the Rajouri River of Pir Panjal Himalayan Range in northern India.

2 | METHODOLOGY

2.1 Study area

The union territory of Jammu and Kashmir is one of the most important parts of Himalayan region and has remarkable potential in terms of resources in the inland sector swarming with fish diversity. It provides vast and diverse resources holding river ecological heritage and enrich biodiversity. Jammu region is located on Shivalik's Hills and Pir Panjal Range at an altitude of 1073 feet above the sea level. However, the climatic condition of

the region varies from sub-tropical to tropical. Rajouri River (33°10′N 74°16′E) is one of the famous and important tributaries of the region. It is a snow fed river originated from the Rattan Pir Panjal Range of North Eastern Himalayan Range and flows through a unique topography along a varying climatic condition and after passing a stretch of more than 100 km and finally drains into Chenab River in Pakistan. The total area of the river is about 2060 km^2 with a total length of about 100 km and altitude of about 915 m above the sea level. The water bodies of the region have variety of freshwater fauna including fish. Due to rich ichthyofaunal, state has attracted by the large number of zoologists beginning with Heckel (1938). Thereafter, many others studied ichthyofaunal diversity in the region (Day 1878; Sunder *et al*. 1978; Kullander 1999; Dutta 2003; Mishra *et al*. 2013; Gandotra and Sharma 2015; Bhat *et al*. 2020).

2.2 Collection of fish samples

During the present study, a total of 375 specimens of *T. putitora* were collected from four sampling sites of the Rajouri river at monthly intervals between January 2019 and December 2020. The fish were collected with the assistance of local fishermen using cast nets of different mesh sizes. Fishing was usually carried out during morning hours. After collection, the specimens were wiped with tissue paper and transported to laboratory for identification and further analyses. The identification was done with the help of standard keys given by (Talwar and Jhingran 1991; Kullander *et al*. 1999; Jayaram 1999, 2010; Froese and Pauly 2020). All 375 specimens were measured for total length (nearest 0.1 cm) and body weight (nearest 0.01 g), dissected, and examined for gut content analysis, gastro-somatic index (GaSI), feeding intensity (FI), relative length of gut (RLG) and sex determination. The sex ratio deviation from 1:1 was tested statistically by chi-squared analysis (Sokal and Rohlf 1981; Jega *et al*. 2017).

2.3 Gut content analysis

For gut contents analysis of fishes, guts were cut open and weighed with and without food materials. Afterwards, gut contents were spread in Petridish to enable their macroscopic observation. For further study gut contents was preserved in 5% formaldehyde in labelled vials. Large food items were easily recognized with the naked eye, while as microscopic ones were teased to disperse their aggregates on cleaned slide for examination under binocular microscope (Model TCM-400), which is connected to the photomicrograph to enhance proper viewing and identification of organisms at different magnifications (100X, 200X and 400X). All recognized food items were identified according to Edmondson (1959); Natarajan and Jhingran (1961); Nikolsky (1963); Desai (1970); Hyslop (1980); Jordan and Verma (1996).

The gut contents were visually classified as empty guts, medium filled guts and full filled guts. The fishes were then classified based on the assumption that the fishes with full stomachs were considered as active feeders and with medium filled guts as moderate feeders and trace filled food particles as poor feeders found in the stomach represents (Rao and Rao 2002). The methods employed for the quantitative and qualitative analysis of gut contents of the different fish species were based on frequency of occurrence and volumetric methods. Volumetric method was employed for quantitative analysis of gut content. As recommended that volume forms a very suitable form of assessment of feeding, especially in the case of herbivorous and mud feeding fishes (Hynes 1950). There are various methods recognised for volumetric gut content analysis in fishes. However, it is suggested that any single method does not provide complete information of feed items found in fishes. Therefore, and hence more than one method should be preferred when analysed gut content analysis of fish. Therefore, in the present study both methods were used in combination so as to get exact picture of dietary importance in fishes (Shrivastava *et al*. 1999). Finally index of preponderance was followed (Natarajan and Jhingran 1969). The following methods were used during the study:

2.3.1 Frequency of occurrence method: After collection, fishes were dissected and stomach contents were removed and placed on Petri dish. The individual food organisms were sorted and identified. The number of stomachs in which each item occurs is recorded and expressed as percentage of the total number of the stomachs examined (Hynes 1950):

$$\text{Frequency of occurrence (Oi)} = (Ni / N) \times 100$$

Where, Ni is number of fishes containing prey i and N is the number of fishes with food in their stomach.

2.3.2 Displacement method: The displacement method is probably the most accurate one for assessing the volume. The volume of entire food in the stomach was determined through displacement method by using a graduated cylinder. After this the food items were separated and the volume of each food item is determined by the same method. The percentage of each food item out of the total volume was calculated following Hynes (1950).

2.3.3 Index of preponderance: The grading of food items was calculated by the methods of index of preponderance given by Natarajan and Jhingran (1969); Sreeraj *et al.* (2006). This method represents the combination of both occurrence (qualitative method) and volume (quantitative method) of food contents found in the gut of fish that determined the grading of different food items which can

be expressed with following equation:

Index of preponderance (Ii) = (ViOi / ΣViOi) × 100

Where, Ii represents the index of preponderance. Vi represents the percentage of volume of a particular food and Oi is the percentage of occurrence of particular food.

2.3.4 Relative length of gut (RLG): In order to study the feeding habit of *T. putitora* a thorough study was made on the relative length of gut in relation to total body length. The length of gut was measured carefully along with the total length of body to calculate RLG (Al-Hussaini 1949). RLG was calculated as the ratio of the gut length and total fish length by using following formula:

RLG = Total length of gut / Total length of fish

2.3.5 Gastro-somatic index (GaSI): The GaSI was calculated by using the method as described by Biswas (1993) and the following formula was employed:

GaSI = (Total weight of full gut / Total weight of fish) × 100

2.3.6 Feeding intensity (FI): The FI was calculated by using the method suggested by Khan *et al*. (1988), and the following formula was used:

FI = (Weight of the gut content / Weight of fish) × 100

2.4 Data analysis

Water temperature was also measured with the help of digital thermometer at the time of sampling in order to determine the relationship between temperature and gonad growth. The data were subjected to statistical analysis for Pearson correlation analysis by using statistical software SPSS (version 11.5) and Microsoft Excel- (version 2016).

3 | RESULTS

3.1 Monthly variation in the food composition

The variations in composition of food items observed in *T. putitora* during different months of the year are presented in Table 1. The result on feeding habits of *T. putitora* indicates that the fish is a column omnivore. This is sustained by its modified anatomical features having thick and a fleshy lip with upper lip keratinized as well as protrudes outside, well adapted for rasping and scooping the prey and algae attached on the surface of rocks and stones. The food items present in the examined guts have mainly been grouped into eight categories namely algal matter, unidentified plant matter, zooplankton, macroinvertebrates, fish remains, detritus, mud and sand, and debris, which were further classified into 18 sub categories (Table 1).

3.1.1 Algal matter (benthic): The algal matter mainly consists of Cyanophyceae (blue green algae), Bacillariophyceae (diatoms), Chlorophyceae (green algae), Filamentous algae (spirogyra) as well as some unidentified other algae. Among them the maximum percentage of Cyanophyceae was found in the month of October 12.3% and minimum 2.51% in the month of July. Also, the maximum percentage of Bacillariophyceae was noted in the month of November 7.21% and minimum 0.27% in the month of July. While as the contribution of green algae (Chlorophyceae) was reported highest 1.73% in the month of June and lowest 0.21% in the month of January. Overall, the filamentous algae were represented the most abundant group among the contribution of phytoplankton in the gut of the fishes. The maximum percentage of filamentous algae (Spirogyra) was recorded in the month of May 23% and minimum 13.3% in the month of November. Other types of algae were reported highest in January 0.51% and lowest 0.07% in the month of September. Among the filamentous algae the dominated form is *Spirogyra*, *Pithophora*, *Cladophora*, *Oedogonium* and were found throughout the year. While as the blue green algae consisted of *Anabaena*, *Nostoc* and *Oscillatoria*. Bacillariophyceae has also found throughout the year and formed one among the favored component of *T. putitora* food. In addition, diatom is the most abundant contributors found during the present study include *Fragillaria*, *Navicula* and *Nitzschia*.

3.1.2 Unidentified plant matters: Apart from above identified food items, some other unidentified plant materials were also found in the gut of *T. putitora* collected from different sites in the present study with the highest percentage was recorded in the month of July 18%, whereas the lowest percentage was obtained in the month of September 3.41%. However, their occurrence was noted throughout the year.

3.1.3 Zooplankton: Zooplankton are found as a major constituent of food for *T. putitora*, which represents Rotifera, Copepoda, Cladocera, and protozoa, which makes a majority of the organisms that found in the gut of fish during the study. Rotifers represent the most abundant organisms in the gut having maximum percentage 10.75% in the month of November and minimum 2.32% in the month of July. Copepods were reported throughout the year with maximum 3.78% in the month of May and minimum 0.07% in the month of July. Cladocera was not found in the gut throughout the year and was reported maximum 2.65% in January and minimum 0.52% in November and October respectively. Among animal matter,

protozoa found during the study showed low percentage throughout the year, except in the month of July, August and October, where no food items related to protozoa were found. While as the maximum 0.88% food items related to protozoa were reported in the month of December and minimum 0.21% in the month of March and May.

Table 1 Mean percentage of month wise variation in contribution of different food components in the gut of *Tor putitora* from the Rajouri River of Pir Panjal Himalayan Range, India.

Food items	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean±SD
Algal matter													
Cyanophyceae	7.61	5.74	8.12	5.51	3.12	3.87	2.51	2.88	5.17	12.3	6.37	8.7	5.99±2.80
Bacillariophyceae	5.9	6.7	3.8	2.07	1.8	0.43	0.27	2.67	7.02	5.1	7.2	1.07	3.66±2.62
Chlorophyceae	0.21	0.71	0.89	0.72	0.86	1.73	1.08	1.71	0.67	0	1.11	0.41	0.84±.52
Filamentous algae	18.6	16	17.3	18.3	23	18	20	17.2	17.4	15.2	13.3	18.7	17.7±2.22
Other algae	0.51	0.17	0.23	0.07	0	0.07	0.07	0.21	0.08	0	0.31	0.43	0.17±0.14
Unidentified-plant matter	7.03	14.1	18	12.4	7.72	12.2	18	8.21	3.41	9.57	8.7	7.23	10.5±4.48
Zooplankton													
Rotifers	8.21	5.21	7.33	5.71	7.81	3.42	2.32	5.2	7.21	3.3	10.75	8.83	6.27±2.51
Copepoda	3.32	2.24	2.43	1.8	3.78	0.83	0.07	1.21	2.8	0.87	3.44	1.01	1.98±2.22
Cladocera	2.65	2.3	1.08	1.71	0.73	0	0.82	1.3	0	0.91	0.52	1.41	1.11±0.87
Protozoa	0.81	0.71	0.21	0.5	0.2	0.4	0	0	0.54	0	0.71	0.88	0.41±0.31
Macroinvertebrates													
Crustacea	3.21	4.33	2.78	4.1	2.03	0	5.6	5.11	3.14	2.36	1.78	2.16	3.05±1.52
Insects larvae	9.11	7.3	9.4	12.1	3.4	5.54	7.8	10.74	17.2	8.23	7.87	5.51	8.68±3.53
Insect adults	5.02	3.36	3.24	3.4	1.35	0.83	4.5	2.78	1.66	3.34	4.21	2.07	2.98±1.27
Molluscs	3.12	2.71	0.78	2.78	1.31	0.68	0	1.86	0	2.6	1.04	1.87	1.56±1.04
Fish remains	0.23	0.13	0.51	0	1.14	1.02	0	0	2.11	1.05	0.56	0.87	0.69±0.62
Detritus	18.4	17.5	21.3	14	15.3	18.2	17.1	14.7	25.2	18.2	14.5	13.3	17.3±3.15
Mud and sand	17.4	16.8	14.2	16	17.1	18.5	10.4	13.6	14	17	20.2	15.3	15.8±2.25
Unidentified-debris	0.89	1.9	1.5	1.5	0.7	0.3	0	0.7	2.5	0.7	1.3	0.83	1.06±0.70

3.1.4 Macroinvertebrates: The animal food matters of *T. putitora* analyzed during the present study primarily comprises of benthic fauna, mostly insect larvae, insect adults, crustacea, annelids and mollusks etc. Crustacea was found throughout the year, except in the month of June, with maximum 5.6% was observed in the month of July and minimum 1.78% in the month of November. The insect larvae represented the highest percentage in the food composition and its presence was noted throughout the year with maximum 17.2% in the month of September and August, whereas minimum 3.4% in the month of May. Adults form of insects was also observed with maximum percentage 3.5% was recorded in the month of March and the minimum percentage 0.4% were recorded in the month of May and October, respectively. Whereas, in case of mollusks maximum 3.12% was recorded in the month of January and minimum 0.68% in the month of June.

3.1.5 Fish remains: In the present study, it was observed that apart from insects, the fish also feed on small fishes, larvae, scales, eggs and their fins which was clearly been seen in the gut of *T. putitora* during the study. Many undigested parts of fish were noted several times with maximum 2.11% in the month of September and May, whereas, minimum 0.14% in the month of January and February, respectively.

3.1.6 Detritus: The food components present in the gut of *T. putitora* during the present study represents highest percentage of detritus throughout the year. However, the maximum percentages were noted in the month of September 25.2%, while minimum in the month of December 13.3%.

3.1.7 Mud and sand particles: Another most abundant food component analyzed throughout the year in the gut of *T. putitora* was represented by sand and mud particles. The occurrence of both sand and mud in the gut seems to be related with the scraping behavior of the fish. The highest percentage was noted in the month of November 20.2% and lowest in the month of July i.e. 10.4%.

3.1.8 Unidentified debris: Some amounts of debris were also found in the gut of fish during the present study. The content of debris was recorded maximum 1.9% during the

month of February and March and minimum 0.3% in the month of June and October, respectively.

During the investigation of food and feeding habits of *T. putitora* it was observed that the fish is highly benthic omnivores in nature. The food mostly comprises of plant matter represents 38.97%. On the other hand, higher quantity of miscellaneous food items i.e. muds, sand, detritus and debris, which represents overall 34.16%, was found in the gut of fish along with adequate quantity of food belongs to animal that represent 26.75% (Table 2, Figure 1). Overall, it was observed that algal matter formed an important component of food of *T. putitora* in all months of the year, besides the presence of insect's (larvae and adults), crustaceans and mollusks indicated that the fish is column feeder omnivorous. The qualitative and quantitative analysis of the gut contents was studied by using percent occurrence and percent volume methods. On the basis of the study, it was observed that food items present in the examined guts were grouped into 8 categories namely algal matter, unidentified plant matter, zooplanktons, macro invertebrates, fish remains, detritus, debris, mud and sand, which were broadly classified into three major groups such as plant matter, animal matter and miscellaneous. Overall, the plant matter constituted 38.79% by occurrence, 37.79% by volume with index of preponderance as 37.89%. While as, animal matter constituted 26.73% by occurrence, 22.65% by volume with index of preponderance as 9.95%. Miscellaneous food items represent a second highest group that contributed 34.16% percent by occurrence, 39.24% by volume with index of preponderance 51.92% (Table 3; Figures 2–4).

TABLE 2 Mean percentage values of annual diet composition of different food items found in the gut of *Tor putitora* from the Rajouri River of Pir Panjal Himalayan Range, India.

Food items	Percentage (%)
Plant matter (algae and unidentified plant matter)	38.97
Animal matter (zooplankton and macro-invertebrates)	26.75
Miscellaneous (sand Mud, debris and detritus)	34.16

3.2 Gastro somatic index (GaSI)

The gastro somatic index of both females and males of *T. putitora* in various months of the year are presented in Table 4; Figure 5 and 6. The gastro somatic index in case of females range from 3.78±1.03 to 7.93±2.98 with minimum GaSI was noted in the month of June and maximum in December, whereas the male fish showed GaSI values in the range of 3.12±1.16 to 6.84±2.02 with highest GaSI was noted in the month of December and lowest GaSI value was recorded in the month of July in male fish.

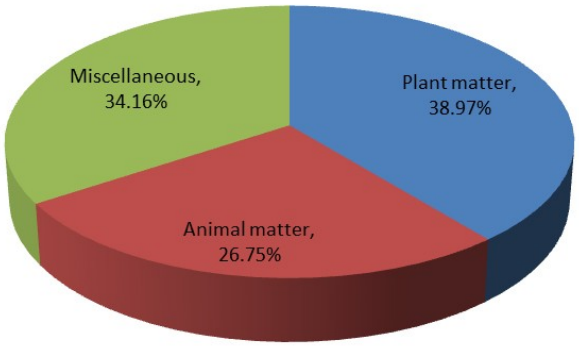

FIGURE 1 Showing mean percentage of total annual diet composition found in the gut of *Tor putitora* from the Rajouri River of Pir Panjal Himalayan Range, India.

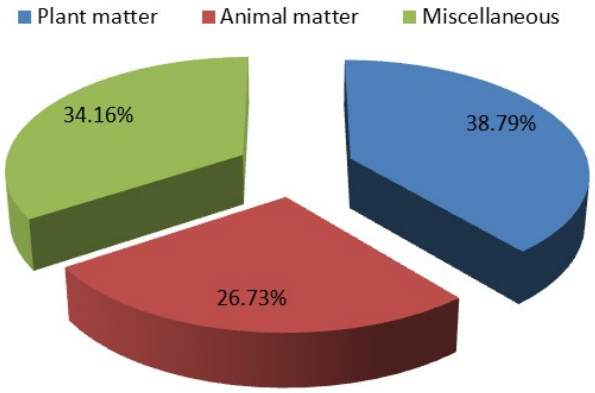

FIGURE 2 Showing mean percent occurrence of various food items found in the guts of *Tor putitora* from the Rajouri River of Pir Panjal Himalayan Range, India.

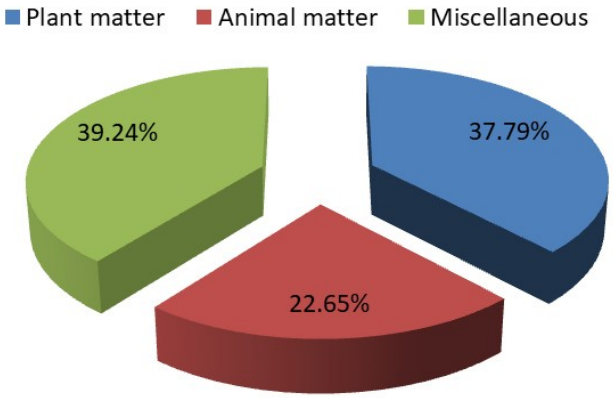

FIGURE 3 Showing mean percent volume of various food items found in the guts of *Tor putitora* from the Rajouri River of Pir Panjal Himalayan Range, India.

3.3 Feeding intensity (FI)

Feeding intensity of females fish was reported within the range from 1.67±1.08 to 4.86±1.52 with minimum feeding intensity was noted August and maximum in December, while in case of male it ranged from 1.57±1.07 to

4.52±1.55 with minimum feeding intensity also recorded in the month of August and maximum in December Table 4; Figure 5 and 6. Both male and female fish showed no differences in their feeding intensity with respect to their sex. Feeding intensity is a measure of stomach fullness and it was also calculated at different stages of maturity simply by gross examination. The feeding intensity (stomach fullness) of both males and females of *T. putitora* at various stages of development is presented in Table 5. During the maturation and ripening stages (stages III and IV), feeding intensity was increased, however in the ripe stage-V, feeding intensity decreased significantly. The maximum empty stomach was found in ripe and spent male fish (stages V and VI), whereas, it was only identified in females during the ripe stage.

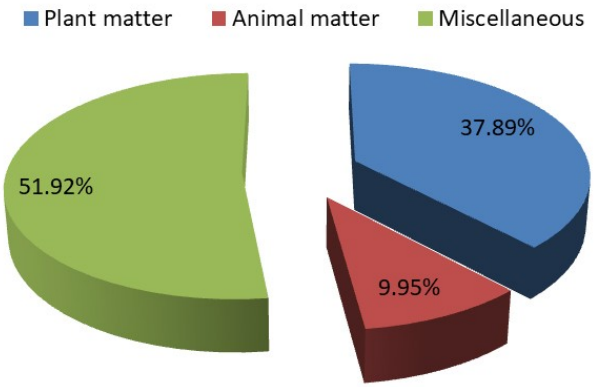

FIGURE 4 Showing mean index of preponderance of various food items found in the guts of *Tor putitora*.

TABLE 3 Index of volume, index of occurrence and index of preponderance of different food items of *Tor putitora* from the Rajouri River of Pir Panjal Himalayan Range, India.

Food items	Type	Index of occurrence (Oi)	Index of volume (Vi)	OiVi	Index of preponderance (Ii)
Plant matter	Cyanophyceae	5.92	5.97	35.3424	2.85
	Bacillariophyceae	3.66	3.76	13.7616	1.12
	Chlorophyceae	0.83	0.87	0.7221	0.05
	Filamentous algae	17.7	18.8	332.76	26.9
	Other algae	0.18	0.18	0.0324	-
	Unidentified plant matter	10.5	8.21	86.205	6.97
	Total	38.79	37.79	-	37.89
Animal matter	Rotifers	6.27	4.63	29.0301	2.34
	Copepoda	1.98	0.58	1.1484	0.09
	Cladocera	1.11	0.92	1.0212	0.08
	Protozoa	0.41	-	-	-
	Crustacea	3.05	2.27	6.9235	0.55
	Insect larvae	8.68	8.32	72.2176	5.84
	Insect adults	2.98	3.24	9.6552	0.78
	Molluscs	1.56	1.87	2.9172	0.23
	Fish remains	0.69	0.82	0.5658	0.04
	Total	26.73	22.65	-	9.95
Miscellaneous	Detritus	17.3	18.2	314.86	25.4
	Mud and sand	15.8	20.8	328.64	26.5
	Debris	1.06	0.24	0.2544	0.02
	Total	34.16	39.24	1236.05	51.92

3.4 Relationship between total length and gut length

In case of female the maximum value of mean total length was measured as 29.8 cm and the corresponding mean gut length was 44.86 cm. The ratio of total length and gut length was calculated as 1:1.50. In female, the relative length of gut (RLG) value was noted in the range from 1.16±0.82 to 2.15±0.57 (Table 6). Similarly, in case of male the maximum value of mean total length measured as 28.63 cm and the mean gut length was 47.38 cm. The ratio of total length and gut length of male fish was calculated as 1:1.65. Also, the relative length of gut (RLG) value ranged from 1.14±0.13 to 2.14±0.62 was reported in male fish (Table 6). Total length (TL) and gut length (GL) of *T. putitora* were positively correlated. Mathematical relationship between TL and gut GL was also established. The regression equation in case of females between TL and GL is represented as GL= 1.4393 TL + 4.6052 and correlation coefficient R^2 = 0.6871. Whereas in case of males GL= 1.3753 TL + 6.0808 and correlation coefficient R^2 = 0.5572 and shows positive linear relationship with each other (Figure 7 and 8). The gut length was found to be longer than the total length. In female, the ratio of body length

to gut length was calculated to be 1:1.50, while in case of male, it was 1:1.65.

TABLE 4 Average gastrosomatic index and feeding intensity of males and females *Tor putitora* during various months of the year (mean±SD).

Months	Female			Male		
	No. of stomach examined	Average gastro somatic index	Feeding intensity	No. of stomach examined	Average gastro somatic index	Feeding intensity
Jan	10	7.28±2.17	4.37±1.87	12	6.60±2.29	4.27±1.82
Feb	10	5.13±2.12	3.17±1.52	12	5.86±2.27	3.72±1.54
Mar	12	5.12±2.10	3.63±1.32	15	5.51±2.12	3.63±1.27
Apr	12	4.96±1.97	3.52±1.30	15	5.09±1.76	3.52±1.32
May	15	4.63±1.92	2.82±1.23	17	4.84±1.63	2.82±1.32
Jun	15	3.78±1.03	2.44±1.18	17	4.42±1.38	2.54±1.17
Jul	13	4.27±2.04	1.98±1.16	15	3.12±1.16	1.92±0.88
Aug	14	4.34±2.12	1.67±1.08	15	4.16±1.22	1.57±1.07
Sep	12	4.14±2.22	2.42±1.12	12	5.07±1.07	2.44±1.12
Oct	12	5.58±2.47	3.87±1.11	12	5.11±2.22	3.40±1.12
Nov	10	6.79±2.87	3.21±1.13	12	6.12±2.17	4.28±1.17
Dec	10	7.93±2.98	4.86±1.52	10	6.84±2.02	4.52±1.55

*monthly observations for GaSI and FI analysis = 309; derived from the same collection of 375 specimens (female = 145; male = 164)

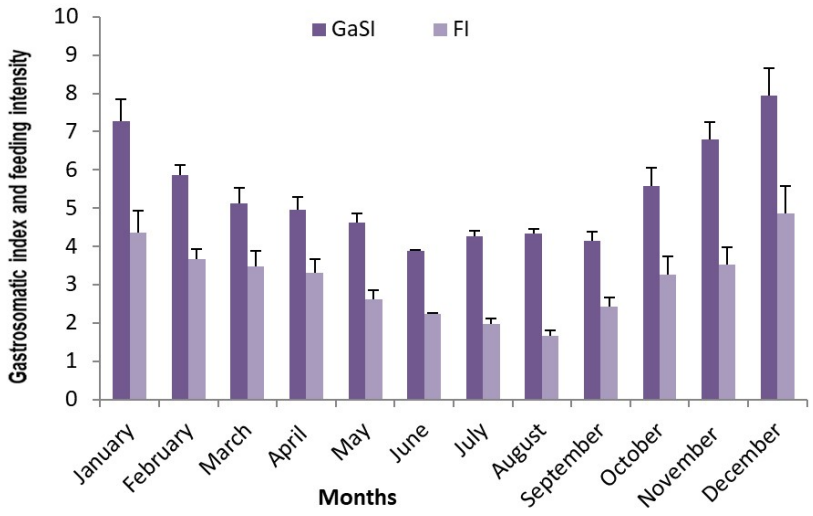

FIGURE 5 Showing monthly representation of gastro somatic index (GaSI) and feeding intensity (FI) of female *Tor putitora*.

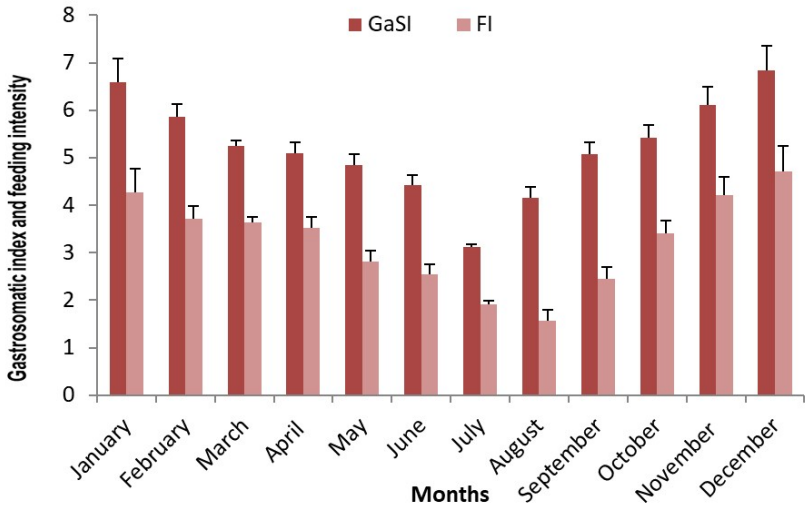

FIGURE 6 Showing monthly representation of gastro somatic index (GaSI) and feeding intensity (FI) of male *Tor putitora*.

TABLE 5 Feeding Intensity of *Tor putitora* during different maturity stages.

Maturity stages	Females (%)			Males (%)		
	Empty guts	Medium fullness guts	Full guts	Empty guts	Medium fullness guts	Full guts
I	12	10	10	10	12	10
II	12	10	10	10	12	10
III	12	12	8	12	10	8
IV	10	12	8	12	10	8
V	10	10	10	15	10	10
VI	10	8	12	10	10	10

TABLE 6 Showing mean total length (TL), gut length (GL) and relative length of gut (RLG) of female and male *Tor putitora*.

Months	Female (mean ± SD, cm)			Male (mean ± SD, cm)		
	TL	GL	RLG	TL	GL	RLG
Jan	33.5	72	2.15±0.57	30	60	2.01±0.34
Feb	32	68	2.12±0.23	31.5	62	1.96±0.17
Mar	42	80	1.90±0.13	42	76	1.80±0.15
Apr	26.5	40	1.50±0.10	23	38.6	1.67±0.12
May	25	38.6	1.54±0.05	25.2	37	1.46±0.10
Jun	30	48	1.60±0.08	18.2	26.3	1.44±0.08
Jul	18.9	28.8	1.52±0.12	34	40	1.17±0.04
Aug	27	32	1.18±0.65	28	32	1.14±0.13
Sep	18.2	30.4	1.67±0.74	32	52	1.62±0.23
Oct	36	42	1.16±0.82	18.2	30.4	1.67±0.52
Nov	38	68	1.78±0.72	38	64	1.68±0.57
Dec	23.5	50.3	2.14±0.87	23.5	50.3	2.14±0.62

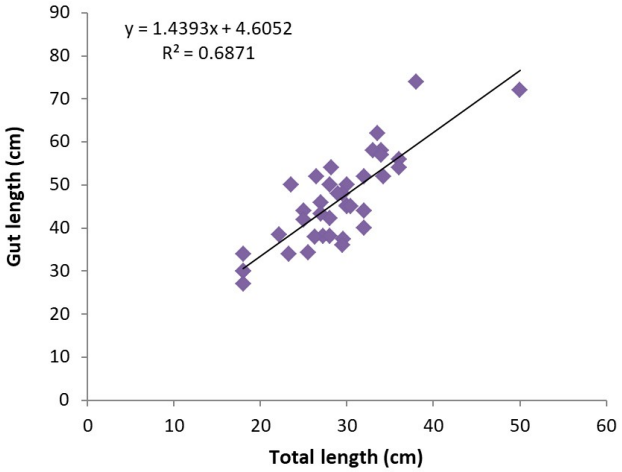

FIGURE 7 Showing relationship between total length (TL) and gut length (GL) of female *Tor putitora*.

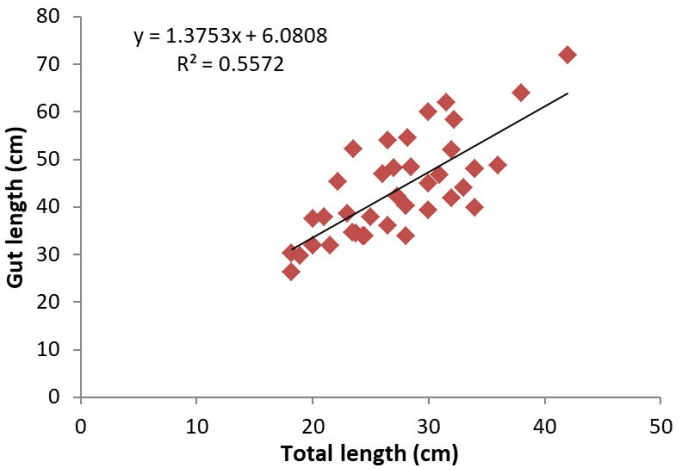

FIGURE 8 Showing relationship between total length (TL) and gut length (GL) of male *Tor putitora*.

4 | DISCUSSION

In the present study, the gut content analysis revealed that the *T. putitora* is opportunist omnivores. On an average plant matter, predominantly diatoms, and animal matter, primarily rotifers and insects make up the majority of their food. Besides these miscellaneous food items such as sand, mud and detritus or debris represents a sizeable composition of food items were found in the gut of this fish. These findings are in conformity with some other studies reported in the past by different workers (Basudha and Vishwanath 1999; Kariman *et al*. 2009; Khaing and Khaing 2019), who reported that the average percentage of food items of *T. putitora* consists of 12 categories, chlorophyceae (28.58%), cyanophyceae (11.55%),

bacillariophyceae (20.92%), xanthophyceae (0.84%), protozoa (2.67%), rotifera (8.01%), crustacea (5.24%), fish parts (0.55%), insects (1.27%), unidentified plant matter (6.41%), unidentified animal matter (5.72%) and sand and debris (26.50%).Similar results were also reported by Kumar *et al*. (2009), while studying on food and feeding habits of *T. putitora* under pond conditions. Das Gupta (1991), while studying on food and feeding habits of *T. putitora*, reported that gut content analysis and the relative length of gut (RLG) value showed that the fish is an omnivore.

During the present study, it is reported that diatoms were shown to be an important constituent of food of *T. putitora* in all months of the year. The observations on gut content analysis are significant for providing taxonomic information on fish diets, behaviors of fish in their habitat, stock assessment models and knowledge of sustaining (replenishment) more exploited species in a mono or poly culture system (Vander *et al*. 1997; Sivadas and Bhaskarn 2009). The food of the *T. putitora* was found to contain the highest amount of plant matter as well as a good amount of animal matter, mud and sand. Occurrence and volumetric methods revealed that plant matter contributes (38.79%) by its occurrence and (37.79%) by volume. Whereas animal matter contributes (26.73%) by occurrence and (22.65%) by volume, besides good quantity of sand and mud was found throughout the year, which contributes about (34.16%) by occurrence and (39.24%) by volume in the gut of fish, which suggests that *T. putitora* is benthic feeder with scraping and suction behavior. Junger *et al*. (1989) attributed the change in Cyprinid diet to an increase in gut transit time, which resulted in better plant digestion by the fish. It has also been found that the ontogeny differences in feeding behavior demonstrated in an efficient way to reduce intra-specific competition, when two or more groups depends on same food source (Helfman 1978).

The gastro somatic index (GaSI) is a measure of fish feeding intensity (Desai 1970). The feeding intensity is referred to as fullness of stomach. It differs from seasons, availability of favored food, maturity stages, and breeding season of the species. In the present study, the gastro somatic index of *T. putitora* was found to vary throughout the year. The GaSI was generally low during the months of March, April, July, August and September, when the guts were found with insufficient food content and even some guts found empty as well. Low feeding activity during peak breeding season could be attributed to fully mature or developed gonads that occupy the most space in the abdomen, there by compressing the gut that results in decreasing the capacity of holding more food as storage items. Food intake varies more in females than in males due to the fact that the ovaries in case of female fish are larger and spacious than the testes. It was also found that GaSI values changed slightly with different months of the year, indicating that the fish does not feed at the same rate throughout the year. The maximum feeding intensity of *T. putitora* was observed during the months of January to March and November to December. During these months the fish maintains high rate of feeding (non-spawning period and pre-spawning) and low in mid-March to April and June to October (spawning-period) in both sexes. The high rate of feeding intensity during non-spawning seasons could be due to the extra energy required for gonads development, beside this many empty stomachs was observed from July to September, which corresponds to the spawning season of fish (Kulkarni and Ogale 1991). Sometimes intense feeding was observed in these months, which could be related to other factors than breeding. Similar findings on the GaSI were reported in *Catla catla* (Raj Kumar *et al*. 2006), which demonstrated that feeding intensity was highest during the winter months (non-spawning phase) and lowest during the summer months (spawning period). There is a positive correlation between the GaSI and gut fullness. Both the indices (GaSI and fullness) were observed low during gonadal maturation and remained so until the end of the spawning season (Balendra *et al*. 2011). Gupta and Banerjee (2014), while studying on the food and feeding habits of freshwater catfish, *Mystus tengara*, suggested that feeding activity changes according to the breeding season. However, lowest feeding activity reported during intense breeding season, while highest feeding activity has been observed during pre-spawning months. Similar type of feeding intensity in connection to maturity stage has also been reported by Khan (1988) and Serajuddin *et al*. (1998) in *Cyprinion macrostomus* and *Mastacembelus armatus*, respectively. Arthi *et al*. (2011) studied the feeding intensity or gastro somatic index of the fish *Ompok bimaculatus* and *Ompok malabaricuss*, they revealed that feeding intensity was low in August and June, suggesting that this was not due to a lack of food, but related to the breeding season of the fish. Their findings are consistent with the current study, which found that *T. putitora* feeding intensity was high during non-spawning periods and low during spawning periods, that is correlated with the availability of space in the abdominal cavity which was occupied by developed gonads during the spawning period. While as the decreased feeding intensity observed from April-July could be attributed to gonadal maturity. Many workers also have found similar declines in feeding during the breeding season in other fish species (Kurup 1993; Arthi *et al*. 2011; Chaturvedi and Saksena 2013; Mushahida-Al-Noor *et al*. 2013; Khongngain *et al*. 2016). It has also been recorded that feeding intensity mostly been increased in herbivorous fish species from April to June, but decreases from July to August when the fish reproduces; feeding activities also becomes lower during the winter months in Indian freshwater fishes (Das and Moitra 1963; Khongngain *et al*.

2017).

In the present study it was noted that the relative length of the gut was in the range from 1.14 to 2.14 showing that the fish under study is omnivores. These findings are conformity with those of Das Gupta (2004), who reported an average RLG value of 0.70 in carnivorous, 1.37 in omnivorous, 3.70 in planktivorous and 4.77 in herbivorous fishes. In general, relative length of gut increases as plant matter increases and decreases as animal matter increases. Similar findings were observed in the present investigation, which showed that relative length of gut increases as total length of fish increases. It is well established that herbivorous fishes usually have long digestive tubes, and the relative length of gut in these species generally ranged from 1.14–2.14. In carnivorous fishes, it was observed that relative length of gut (RLG) values ranged from 0.58 to 0.945 (Bahuguna and Singh 1981). Das and Srivastava (1979), reported that increase in relative gut length from fingerling to adult stages in *Cirrhinus mrigala*, *C. reba* and *C. calbasu* is attributed to a shift from animal to plant feeding habits.

5 | CONCLUSIONS

In conclusion, our study showed that on the basis of food items examined from the gut of *T. putitora* have mainly been grouped into 8 categories i.e. macro invertebrates, zooplanktons, algal matter, unidentified plant matter, fish remains, detritus, unidentified-debris, mud and sand, which were broadly classified into three major groups such as plant matter, animal matter and miscellaneous materials. On the basis of percentage of index of preponderance, the food items comprise of plant matter representing 38.97%, miscellaneous food items 34.16% and animal matter representing about 26.75%, respectively. However, on the basis of quantitative and qualitative analysis of food items, relative length of gut (RLG), index of preponderance revealed that the *T. putitora* is considered as column feeding omnivore. The knowledge generated during the current study could be used for management and conservation programs for this endangered cold-water fish from its natural habitat.

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ETHICAL APPROVAL

All applicable international, national and/or institutional guidelines for the care and use of animals were followed in this study.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

AUTHORS' CONTRIBUTION

Shahid Mehmood contributed to the drafting of manuscript, collection of sample, experimental work and statistical analysis. Imtiaz Ahmed conceived, designed, reviewed the manuscript and supervised the study. Md. Niamat Ali, help in drafting of the manuscript, supervision & correction.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on a reasonable request from the corresponding author.

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