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FOOD AND FEEDING HABITS OF *TOR TOR (HAMILTON,* 1822*)* AND *SCHIZOTHOROX RICHARDSONII* (GRAY, 1832) INHIBITING BHAGIRATHI RIVER, TEHRI GARHWAL, INDIA

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ABSTRACT
Scientific knowledge about food and feeding habits of fish species is an important condition factor for increasing fish production. Food and feeding habits of the fish vary from with the time of day, with the season of the year, with the environmental condition and with different food matter present in the water body. In the present study, an attempt has been made to investigate the food and feeding habits of the *Tor tor* and *Schizothorox richardsonii* from Bhagirathi river, Tehri Garhwal. On the basis of qualitative and quantitative analysis of gut contents, mahseer is omnivorous in nature and generally changes its food habit from carnivorous to omnivorous with growing size adult depends more on plant matter while *Schizothorox richardsonii* has been categorized as herbivorous. *Schizothorox richardsonii* inhabiting Bhagirathi River (a cold water hillstream river) is a periphytonic feeder, feeding on Bacillariophyceae, Chlorophyceae, Cyanophyceae, detritus, and sand in this very preferential order. Enterosomatic index (ESI) of selected fish species indicates low feeding during spawning, while during pre- and post-spawning periods feeding increases. The mean value of Gastrosomatic index (GaSI) and active feeding in *Schizothorax richardsonii* were found to be maximum 4.03 in January 2017 and minimum 1.24 in November 2016 respectively. Mahseer feeds voraciously from November to June (Gastrosomatic 4.23) and feeding decreases from July to October (Gastrosomatic 1.78). Highest Gastrosomatic Index and active feeding occurred during winter (January) prior to the breeding season started and a lowest Gastrosomatic Index value, as well as poorer active feeding, occurred during the breeding season.

KEYWORDS: *Tor tor*, *Schizothorox richardsonii*, Bhagirathi River, food and feeding.

INTRODUCTION

Fish species are the most nutritional, attractive, and remarkable variety of aquatic life. Food is an important factor in the ecology of fishes and required growth, reproduction and far-reaching migration. Food and feeding habits of fish are helpful for fishery biology and culture purposes. *Tor tor (*Hamilton, 1822*)* and *Schizothorax richardsonii* (Gray, 1832) belongs to family Cyprinidae under an order Cypriniformes of series Pisces. These are one of the important food and game fish. These fishes are also called 'Indian Trouts' because of its semblance with family Salmonidae. They inhabit both lentic as well as lotic water bodies of Bhagirathi River. *Tor* and *Schizothoracinae* are the specialized groups of fishes which inhabit snow-fed torrential streams of the Himalayas in India. *Tor* fish species have head slightly shorter than depth; dorsal profile more sharply arched than ventral profile, lips thick fleshy with continuous labial fold across the lower jaw, mouth is small and its gape does not extend below the eyes, snout pointed, jaws of about the same length, two pairs of barbels, maxillary ones slightly longer than rostral ones but shorter than eye, interorbital space flat. *Schizothorax richardsonii* have very small scales on their body. The reduction or degeneration of scales in *Schizothoracinae* is a character shared by high altitude fishes of the family Cobitidae and Salmonidae. The reduction in size or absence of scales on the body is the distinguishing character of *Schizothorax richardsonii* from other species. *Schizothorax* species are characterized by inferior mouth; horny covering on the lower jaw; hard papillated band on the chin; two pairs of barbels; three rows of pharyngeal teeth; last undivided ray of dorsal fin bony and posteriorly serrated. Smooth and soft skin is requisite for hill stream fishes since 'it is helpful in cutaneous respiration. The genus Tor, called ‘mahseer’ in India, Pakistan, Nepal, and Bhutan, is widespread in southern Asia, from Afghanistan in the west, to Thailand and Malaysia in the east, and also present in China. The genus includes Tor tor (Hamilton, 1822) and nine other species. Mahseers are well known as game and food fish, and they are favored particularly by the people of the Himalayan foothills of northern and eastern India. Thomas (1897) and McDonald (1948) narrated in detail their sporting and fighting nature and how to fish them. *Schizothorox richardsonii* was reported to be distributed in the eastern Himalayas, through Garhwal (Mishra M 1982), Kumaon to Jammu and Kashmir Himalayas in West. In Himalayan hill streams, this genus predominates in catches in Alakananda (Badola B.S. and Singh H.R. 1981), Bhagirathi (Sharma R.C. 1988) in Jhelum river of Kashmir and in rivers Yamuna and Ganga. This paper details the food and feeding habits of *Schizothorax richardsonii* and *Tor tor*, inhabiting the Bhagirathi River. Das and Moitra (1963) have categorized fishes into herbivores which feed

on plant material, carnivores which feed on animal material and omnivores which feed on one or more groups of organisms, *i.e.*, plankton, benthos. The composition of the diet of the mahseer clearly indicated that it is a marginal bottom feeder and is mainly herbivorous (macro-vegetation and algae =63%) and carnivorous to a lesser degree (molluscs and insects =18.8%) in feeding habitat. *Schizothorax richardsonii* is a bottom feeder, mainly herbivorous and their horny jaws are helpful in scraping off algae from stones and rocks in the fast running water. According to Das and Moitra (1956) the RLG values of herbivorous fishes such as *Labeo rohita* and *Labeo gonius* were about 12.0 and 9.5 respectively. In the *Schizothorax richardsonii* true stomach is absent; the esophagus is followed by an intestinal bulb. The intestinal bulb compensates for the absence of the stomach in herbivorous fishes. The juveniles feed upon aquatic insects, their larvae, and nymph, as the relative length of the gut is less than the adults. The more length of the gut in adults indicates that the fish is totally herbivorous in the adult stage. Further, the scraping mechanism in the jaws is absent in the young stage and thus fish feed upon insect larvae. Its food mainly consists of diatoms (Bacillariophyceae) *i.e. Navicula sp., Synedra sp., Cymbella sp., Fragillaria sp., Diatoma sp., Gyrosigma sp., Nitzschia sp., Amphora sp., Tabellaria sp. Algae* (Chlorophyceae) found in the gut contents are *Ulothrix sp., Spirogyra sp., Chara sp., Claadophora sp., Hydrodictyon sp.* and *Zygnema sp.* The average of the gut content annually constitutes 61.5% plankton (51% diatoms and 10.50% algae), 19.5% digestive material and 19% sand in the *Schizothorax* fishes. The bottom-feeding habit of the fish is correlated with the ventral position of the mouth as the significant amount of sand was also recorded in the gut contents. This ventral position of the mouth with hard papillae plate is helpful for the scraping of algae and diatoms from the surface of rocks in torrential streams.

MATERIAL AND METHODS

Study area

The study area was confined to the long stretch of Bhagirathi riverine system in Garhwal Himalaya. In Present study, four sampling zones have been selected for analysis of the physic-chemical parameters and phytoplankton determination. Sampling zone Z1 (Upper Bhagirathi river Basin) was selected from Bandra koti ($30^0$30'16.99 N longitude, $78^0$23'04.08 E latitude) to Jhinwali ($30^0$27'01.96 N longitude, $78^0$25'51.41 E latitude), Sampling zone Z2 (Pre impoundment of Tehri reservoir) is from Jhinwali to Tehri ($30^0$24'29.03 N longitude, $78^0$27'30.08 E latitude), Sampling zone Z3 (Post impoundment of Tehri reservoir) from Tehri to Koteshwar ($30^0$15'12.90 N longitude, $78^0$31'27.11 E latitude), Sampling zone Z4 (Lower Bhagirathi river Basin) from Koteshwar to Devprayag ($30^0$14'63.15 N longitude, $78^0$59'82.51 E latitude).

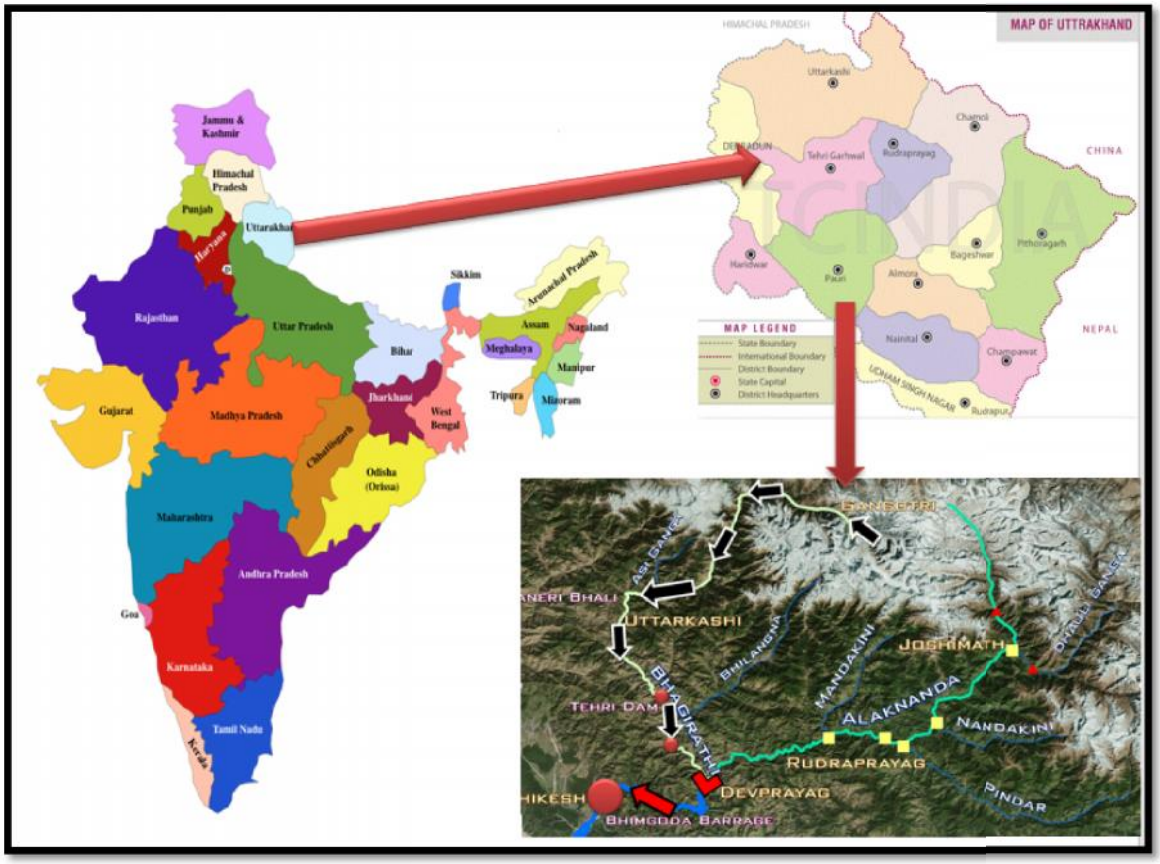

FIGURE 1: Geographical location of the study area.

Sample collection

Fish samples were collected with the help of cast net (mesh size, 4.5 to 5.5 cm) along the 50-km stretch of river Bhagirathi from September 2016 to September 2017. Fishes were preserved in 10% formaldehyde. In the laboratory, the length and weight of each specimen were recorded in a conventional manner. The total length of the alimentary canal was also recorded. Its weight, with and without contents, was recorded to determine the quantity of food consumed. Quantitative feeding expressed as an Enterosomatic index (ESI) has been calculated according to the formula.

$$\text{Enterosomatic index} = \frac{\text{Weight of food}}{\text{weight of fish (g)}} \times 100$$

While feeding intensity was determined by Gastro-somatic index (GaSI).

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

This being a stomachless fish, by microscopic examination of the anterior part of the alimentary canal, the percentage composition of different food components was determined by visual (point estimation) method. Gut contents were analyzed both qualitatively and quantitatively (Hynes, 1950). The volume of food in the gut of fish was measured by Pillay, (1952) and various food items are identified (Needham and Needham 1962). The intensity of feeding was recorded on the basis of the state of distention of the gut and by determining the gastro somatic index (gut weight expressed as a percentage of body weight). For quantitative gut content analysis, the methods like the frequency of occurrence, numerical count and gravimetric method as suggested by (Lagler, 1956) were applied.

RESULTS

Seasonal qualitative fluctuation in fish food

Seasonal or monthly fluctuations in the food of fishes are well known. This does not only vary in different fish species but also in the same species due to availability of food organism in a particular water body, which the fish inhabits. Therefore in the present study, the fluctuation of different food items has been studied. The food items identified are given in the table (Table 1 & 2) showing the monthly fluctuation of food items for *Tor* and *Schizothorax* fish species. Diatoms were present in food in all the season in both fish species. In animals, food, a different type of crustacean and insects were always dominant showing there to be preferred in the animals food item. Nematodes, Rotifers, Protozoan's and some fish parts were also present in food items. The quantities of there were recorded low then crustacean and insects. Some hairs, threads, sand particles, and decaying organic matter, *etc*. were also found in the gut of the fish, which show that Tor feeds at the bottom and side water of the river.

Qualitative and Qualitative variation in food composition:

During 2016-2017, qualitative gut analysis of *Schizothorax richardsonii* has indicated the presence of Bacillariophyceae (*Gomphonema sp., Cymbella sp., Nitzschia sp., Rhopalodia sp., Achnmthes sp., Fragillaria sp., Navicula sp., Synedra sp., Amphora sp., Pinnularia sp., Melosira sp., Chlorophyceae (Ulothrix sp., Hormdium sp., Pediashum sp*.), Cyanophyceae (*Oscillatoria sp., Lyngbya sp., Phormedium sp., Cylindrospemum sp., Stigeoclonium sp*.), respectively. Annual mean percentage compositions were 62-63% of Diatoms, 11-12% of Blue-green algae, 13-14% of Green filamentous algae, 7-8% of detritus and 5-6% of sand. In Bhagirathi river the plant food component of *Schizothorax richardsonii* is reported to be 70-80%, the rest being detritus and sand. Qualitative gut analysis of *Tor tor* has indicated the presence of Macrophytes (*Hydrilla sp., Vallisneria sp., Cerataphyllum sp., Polygonium sp.,*

TABLE 1: Monthly qualitative and quantitative feeding variations in *Schizothorax richardsonii* inhabiting Bhagirathi River

Month	Diatoms (%)	Blue-green algae (%)	Green filamentous algae (%)	Detritus (%)	Sand (%)
September	66.3	9.4	8.9	6.9	8.5
October	65.9	14.1	8.2	7.9	3.9
November	67.3	6.8	11	7.6	7.3
December	70.5	7.9	12.8	5.5	3.3
January	71.9	8.5	12.5	3.9	3.2
February	66.5	15.9	11.4	3.3	2.9
March	61.9	12.2	15.2	6.1	4.6
April	62.3	11.3	10.8	8.9	6.7
May	53.7	11.6	14.6	12.1	8
June	51.3	8.7	21.8	11.6	6.6
July	54.1	14	15.8	12.2	3.9
August	54.0	17.3	14.1	8.5	6.1

TABLE 2: Monthly qualitative and quantitative feeding variations *Tor tor* inhabiting Bhagirathi river

Season	Enterosomatic Index (ESI) *Schizothorax richardsonii*		Enterosomatic Index (ESI) *Tor tor*	
	Female	Male	Female	Male
	4.02	2.98	3.40	2.82
	4.01	3.12	2.23	2.10
Winter	3.8	3.02	1.74	1.54
	4.15	2.86	0.97	0.92
	5.59	4.61	1.63	1.47
	3.76	2.97	1.89	1.29
Summer	4.11	4.97	3.85	2.95
	5.92	5.93	7.56	5.90
Monsoon	11.05	10.5	4.10	3.50
	8.79	6.68	3.80	3.14

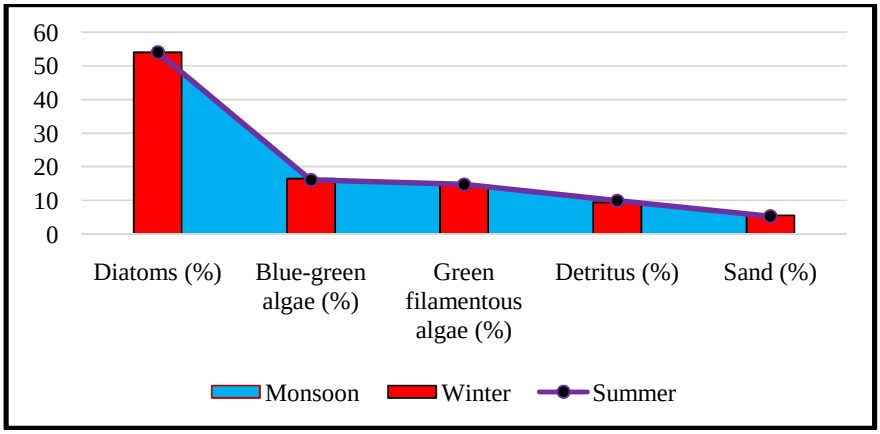

FIGURE 2: Seasonal variations in the qualitative and quantitative feeding of *Schizothorax richardsonii*

TABLE 3: Monthly variations in Enterosomatic Index (ESI) of *Schizothorax richardsonii* and *Tor tor* inhabiting Bhagirathi river

Month	Macrophytes (%)	Blue-green algae (%)	Mullusca (%)	Insect (%)	Miscellaneous (%)
September	50	16.2	9.9	5.2	18.7
October	53.5	15	7.5	4.1	19.9
November	68.5	5.2	10.3	5.4	10.6
December	74.5	8.3	7.7	3.7	5.8
January	76.7	9.6	5.2	3.9	4.6
February	77.8	8.4	3.2	7.2	3.4
March	68.6	13.7	11.1	3.4	3.2
April	64.8	12.5	11.5	4.2	7
May	58.9	7.9	10.2	14.6	8.4
June	55.8	9.6	18.7	10.2	5.7
July	50.5	10.2	18.1	7.2	14
August	48.2	15.8	10.2	9.6	16.2

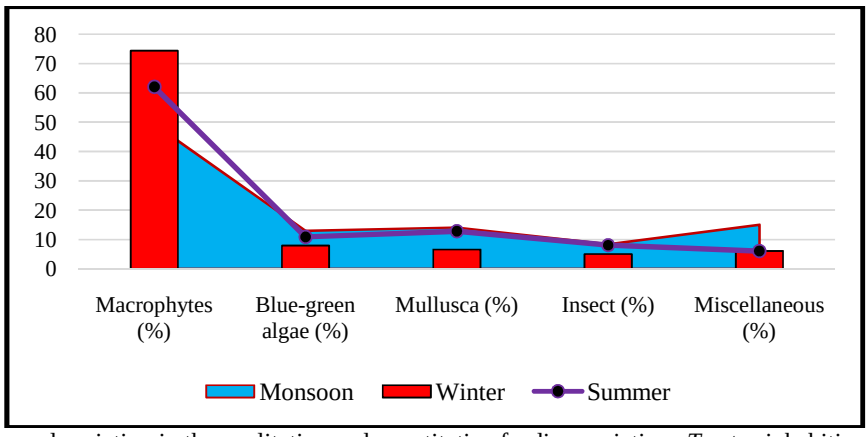

FIGURE 3: Seasonal variation in the qualitative and quantitative feeding variations *Tor tor* inhabiting Bhagirathi river

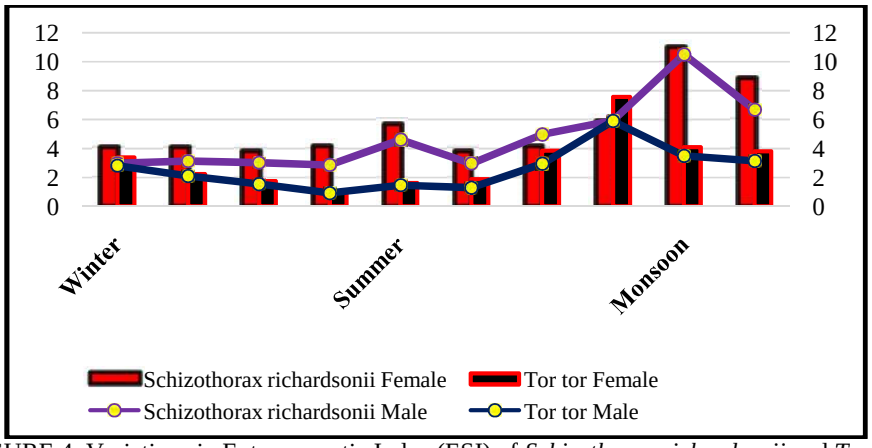

FIGURE 4: Variations in Enterosomatic Index (ESI) of *Schizothorax richardsonii* and *Tor tor*

TABLE 4: Seasonal variations in the Gastro-somatic index (GaSI) of *Schizothorax richardsonii* inhabiting Bhagirathi river

Seasons	The average weight of gut (g)	The average weight of fish (g)	Average GaSI
	1.83	60.1	2.02
Summer	1.56	38.65	4.03
	0.85	51.47	3.03
	0.74	40.96	1.65
Monsoon	2.59	71.23	1.8
	1.7	51.6	3.29
	2.6	74.2	3.5
Winter	1.37	55.6	2.46
	1.36	50.22	2.7

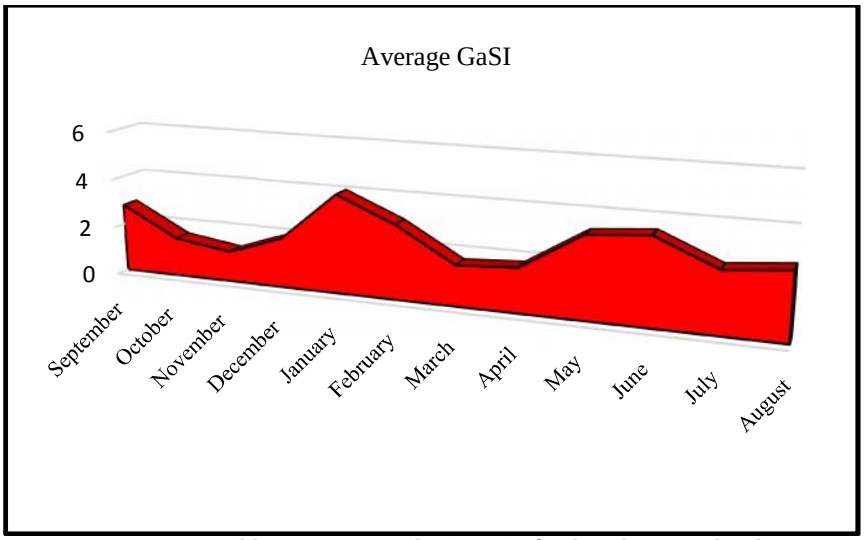

FIGURE 5: Monthly variations in the (GaSI) of *Schizothorax richardsonii*

TABLE 5: Seasonal variations in the Gastro-somatic index (GaSI) of *Tor tor* inhabiting Bhagirathi river

Seasons	The average weight of gut (g)	The average weight of fish (g)	Average GaSI
	9.8	315	3.11
Summer	9.9	390	2.54
	4.8	330	1.45
	4.8	478	1.00
Monsoon	9.5	658	1.44
	3.3	280	1.18
	12.6	320	3.94
Winter	11.2	302	3.71
	13.1	300	4.37

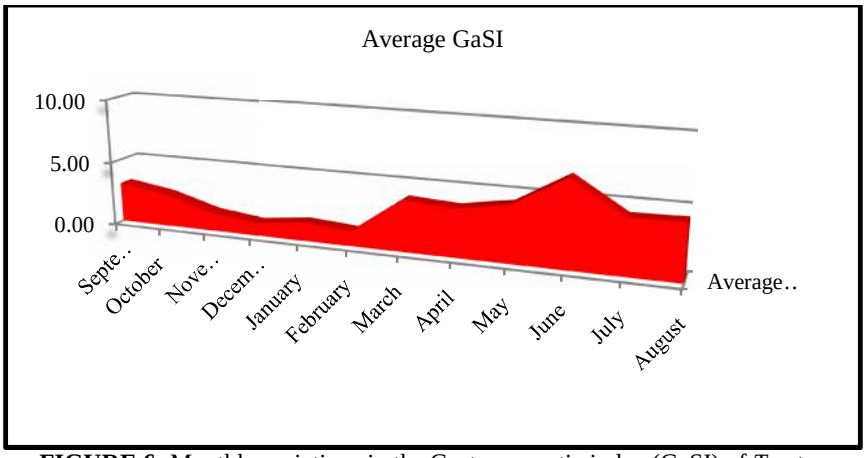

FIGURE 6: Monthly variations in the Gastro-somatic index (GaSI) of *Tor tor*

Potamogeton sp., Algae: - *Spirogyra sp., Ulothrix sp., Zygnema sp., Chara sp., Chloroccum sp., Diatoms sp., Ulothrix sp., Nitzchia sp., Synedra sp.*), *Navicula sp.*, respectively. During 2016-2017, annual mean percentage compositions were 62-63% of Macrophytes, 11-12% of Blue-green algae, 10-11% of Mollusca, 6-7 % of Insect and 59-10 % of Miscellaneous Diatoms, forming a major percentage of food throughout the year (Table 1), decreases quantitatively during Monsoon. Sand particles were rare and therefore, considered as incidental food (which is found rarely in the stomach contents). Similar observations have also been made by Dasgupta (1988, 1990 & 1991). In this study, a change in the diet with an increase in size was also observed. The smaller specimens consumed more of animal matter whereas large specimens consumed more of vegetable matter. The percentage of feeding was higher among the younger fishes as compared to the bigger fishes. Similar reports have also been made by Dasgupta (1988, 1990&1991). Generally, during the spawning season, feeding rate would be relatively lower and it increases immediately after spawning. Low production of diatoms in response to increased velocity and water level due to snowmelt in the catchment, may explain the low percentage of this food in *Schizothorax richardsonii* in monsoon. As compared to this, during September- January there is an increase in the production of diatoms due to low velocity and fall in water level which may result in their greater occurrence in the food of fish. Chlorophyceans formed the second major component of fish food which was recorded in low percentage during breeding. In May-August, following a rise in water temperature and isolation, augmented by the allogenic overflow of algae, there is a rise in algal production Malik *et al.*, 2018. The allogenic flow of detritus and sand from the catchment, during spring rains and increased snowmelt during spring and summer, may contribute to increased percentage occurrence of detritus and sand in the alimentary canal of this snow trout.

Gastro-somatic index (GaSI)

During the present study, the gastro-somatic index of *Schizothorax richardsonii* ranged from 2.02-4.03 in summer to 2.46-3.50 in winter. After the rainy season the GaSI was observed higher. In the rainy season the GaSI was in 1.64, 1.8, and 3.29 (Table 4). Similarly, in *Tor tor* the gastro-somatic index ranged from 1.45-3.11 in summer to 3.71-4.37 in winter. After the rainy season, the GaSI was observed higher. In the rainy season, the GaSI was in 1.00, 1.18, and 1.44 (Table 5). The seasonal GaSI or feeding intensity during the period of study has been presented in Figure 5 & Figure 6. It is clear from the figure that there is a rise and in the feeding intensity of the fish. It was found out that GSI was lowest during the breeding period of both the fish species and highest during the pre-breeding period. Dasgupta (1991) reported that the species breeds during the April/May October/November indicating that the period of low feeding intensity coincides with the spawning period. The low feeding activity during the peak breeding season may be attributed to the completely developed gonads, permitting limited space in the abdominal cavity for the intake of food. Further, the intensity in food intake increased following spawning and the fact that the fishes need more food for their growth. Dasgupta (1988), Sharma et al., (2018) reported that the species is a voracious feeder in natural condition. The present study revealed that to be a voracious feeder not only in Riverine water but also in culture condition in ponds as indicated by the high values of its gastro-somatic indices (GaSI).

Enterosomatic index (ESI)

It has been observed in the present study that ESI values increase with an increasing total length of the fishes (Figure 4). The ESI values show slightly higher in case of female fish species than male in both the fishes throughout the year. It is also evident that ESI and RLG value has a close relationship with the nature of the food of the fish (Dasgupta, 1988). In omnivorous fishes, the ESI values were lower than herbivorous fishes since the vegetable matter requires more time for digestion. In the present study, the average ESI value of *Schizothorax* fish species ranged from 3.8-11.05 in female, 3.02-10.05 in male. A similar observation was made by Sharma *et al.*, 2018 while studying food and feeding habit of *Schizothorax* fishes. Similarly in *Tor tor* the average ESI value of ranged from 0.97-7.56 in female, 0.92-5.90 in male (Table 3). Hence the species was found to be omnivorous which is further supported by the gut content analysis. This is further supported by the result obtained on the food and feeding habits as well as the morphology of the alimentary

canal. Morphology of the gut suggests that the gut is in a transitional stage between herbivorous and omnivorous condition (Das and Pathani; 1978).

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