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Feeding Biology of *Barilius bendelisis* (Hamilton 1807) from the Hill Streams of Manas River, Assam, India

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ABSTRACT

The present paper is concerned with the study of food and feeding habits including feeding intensity, the nature of food consumed, and the index of preponderance of food items. The gut contents of 158 specimens of *Barilius bendelisis* caught from the hill streams of Manas River, Assam, India revealed that the main food consists of insect larvae (48.78%) occupying the first rank in grading among all the other food items, followed by phytoplankton (22.55%), sand and mud (14.49%), others (10.45%) and debris (1.42%). The mean value of relative length of the gut (RLG) was calculated 1.271 indicates the omnivorous nature of *Barilius bendelisis*. Average seasonal Gastro-somatic index (GSI) ranged from 5.089 ± 1.94 to 9.344 ± 2.48 for males and that of female from 5.095 ±1.98 to 11.166 ±2.89. Moreover, instances of poor feeding and empty stomachs were rarely observed in all the four seasons. These findings suggest that the feeding intensity of *Barilius bendelisis* is high and it is an active feeder.

Keywords Index of preponderance, Manas River, Gastro somatic index, Relative length of gut, Feeding intensity.

INTRODUCTION

Barilius bendelisis, also known as Hamilton's barila, is an indigenous cyprinid that is distributed along the hilly streams as well as temperate rivers (25°C) of the Himalayan region in north eastern India (Mir *et al.* 2014). It is an excellent fish for ornamental trade in addition to being a food fish.

Fishes, like any other organisms, require energy to fuel their body machinery and processes, including growth, metabolism and reproduction. Polling (1993) stated that feeding habits of fish help to determine the ecological condition of fish, niche in the ecosystem and preferred food items. Although substantial amount of literature is available on feeding biology of different fish species, very less information on the food and feeding habits of *B. bendelisis* is available till date. Although, food and feeding habits of *B. bendelisis* have been studied by few workers (Badola and Singh 1980, Rawat and Nautiyal 1995, Sahoo *et al.* 2009, Koundal *et al.* 2016), one of the important aspects of feeding biology, i.e., index of preponder-

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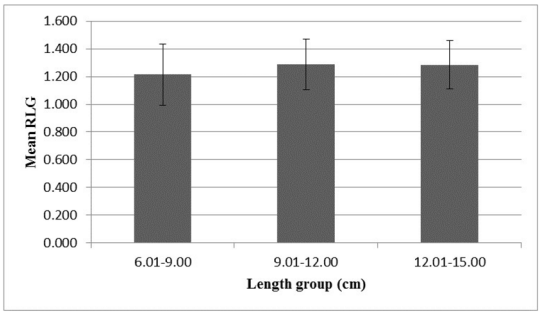

Fig. 1. Mean variations of RLG in different size groups of *B. bendelisis.*

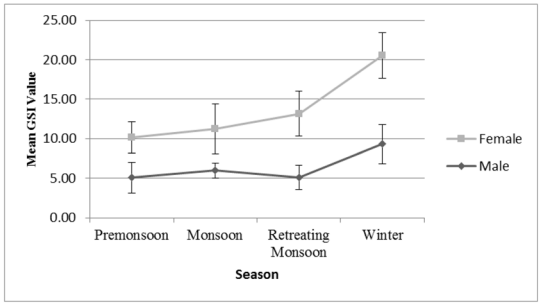

Fig. 2. Mean variation of GSI of *Barilius bendelisis* in different seasons.

ance has not been discussed in any of their studies. Moreover, not a single report on food and feeding habits of *B. bendelisis* is available from Manas River, Assam. Therefore, the present investigation is undertaken to study the feeding habits of *B. bendelisis* from this river.

MATERIALS AND METHODS

The present study was carried out for a period of three years i.e. from January 2014 to December 2016. Altogether, 158 specimens of *B. bendelisis* were collected randomly from the three sampling sites of Manas river– Mothanguri (26°46′9″ N 90°57′42″ E, 87.5 m MSL), Narayanguri (26°39′6″ N 90°59′43″ E, 56.7 m MSL) and Bekipar (26°29′71″ N, 90°55′16″ E, 40.8 m MSL) for the study. Fishes were identified following the taxonomic keys (Nath and Dey 2000). The guts were removed from the specimens after the specimens were measured up to centimeter (cm) and weighted up to three decimal points. The guts were then cut lengthwise and the contents of each gut were scraped out carefully with a soft brush and examined under a binocular microscope. The weights of emptied guts were also recorded to figure out the weight of ingested food. Identification of food organisms was carried up to generic level following Needham and Needham (1997), APHA (2005), Battish (1992) and Edmonson (1992). Both qualitative and quantitative methods of gut content analysis were done as recommended by Hynes (1950) and Pillay (1952). RLG has been estimated following Al-Hussainy (1949), GSI (Desai 1970) and degree of fullness of gut as per methodology of Bhuiyan *et al.* (2006).

Table 1. Seasonal variations of fullness of gut in *B. bendelisis*.

Seasons	No. of specimens examined	Active feeding Full	¾ full	Moderate feeding ½ full	Poor feeding ¼ full	Empty
Pre monsoon	31	29.03	16.13	16.13	12.90	25.81
Monsoon	17	29.41	29.41	23.53	17.65	0
Retreating monsoon	46	41.30	28.26	13.04	17.39	0
Winter	64	51.56	21.88	9.38	14.06	3.13
Overall	158	41.8	23.4	13.29	15.19	6.33

RESULTS

Relative length of gut (RLG) values in *B. bendelisis* showed little variation among different size groups (Fig. 1). The lowest value was found as 0.745 (±0.22) in 6.01-9 cm group whereas the highest values as 1.712 (±0.18) in 9.01-12 cm group and the overall mean RLG was recorded as 1.271 (±0.19).

Fullness of the gut and feeding intensity

In *B. bendelisis*, out of 158 guts examined, 66 (41.8%) were found full, 37 (23.4%) were 3/4th full, 21 (13.29%) were ½ full, 24 (15.19%) were nearly empty and 10 (6.33%) were absolutely empty. Seasonal feeding intensity indicated active feeding (full and 3/4 full) during the winter season (73.44%), moderate feeding (23.53%) and poor feeding (17.65 %) were observed in monsoon season. Empty stomachs were recorded only during the pre-monsoon (25.81%) and

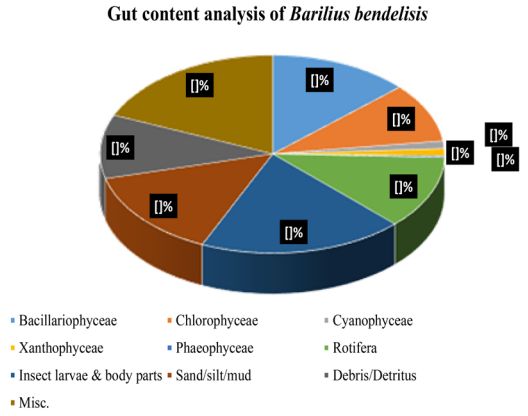

Fig. 3. Diagrammatic representation of gut contents of *Barilius bendelisis*.

winter seasons (3.13%). As a whole, active feeding was observed in all the four seasons, highest being in the winter season (Table 1).

Average seasonal GSI of *B. bendelisis* revealed lowest value in pre monsoon and highest in winter for both the sexes (Fig. 2). GSI values ranged from 5.089 ± 1.94 (pre monsoon) to 9.344 ± 2.48 (winter) for males and that of female from 5.095 ± 1.98 (pre-monsoon) to 8.032 ± 2.84 (winter). As a whole, the feeding intensity was found to be high and more or less similar in all the seasons.

Gut content analysis

The percentage composition of food items in the guts examined in different seasons has been summarized in the Table 2. The food items encountered in the examined stomachs were grouped into six broad categories–(i) phytoplankton, (ii) zooplankton, (iii) insect larvae, (iv) sand and mud, (v) debris and (vi) miscellaneous group.

Gut content analysis of *B. bendelisis* revealed that the fish feeds on a variety of food items the most preferred among which were insect larvae and phytoplankton. A diagrammatic representation of gut contents of *Barilius bendelisis* is shown in Fig. 3. The most prevalent phytoplankton group in the gut of the fish was Bacillariophyceae. Altogether 16 genera of Bacillariophyceae, 25 genera of Chlorophyceae, 3 genera of Cyanophyceae, 1 genera each from Xanthophyceae and Phaeophyceae were observed. Among zooplanktons, 2 genera from the group Rotifera were observed. Some sand particles, detritus organic matter and undigested materials have also been observed in the gut suggesting omnivorous feeding habit of *B. bendelisis*.

Index of preponderance

The index of preponderance, in which a amalgamation of volume and occurrence of food contents is taken into account to accurately grade the different food items in the order of preference, revealed that insect larvae (48.75%) were the ideal food item, occupying the first rank in grading while, the last rank was occupied by debris (1.42%) suggesting it to be the least preferred food item (Table 3).

Table 2. Percentage of food combination of *Barilius bendelisis* in different seasons.

Seasons	No. of fish examined	Phytoplankton					Zooplankton	Insect larvae	Sand and mud	Debris	Misc. group
		Bacillariophyceae	Chlorophyceae	Cyanophyceae	Xanthophyceae	Phaeophyceae	Rotifera				
Pre-monsoon	35	15.45	9.55	0	0	0	9.38	21.88	9.38	12.5	21.88
Monsoon	29	11.97	8.25	1.79	1.12	1.11	12.12	21.21	9.09	12.12	21.21
Retreating monsoon	45	12.01	9.78	0	3.63	0	13.56	16.95	22.03	10.17	11.86
Winter	51	13.28	11.31	3.19	0	0	12.5	16.67	16.67	6.94	19.44

Table 3. Index of preponderance of different food items of *B. bendelisis.*

Food items	% of volume	% of occurrence	V_1O_1	$V_1O_1 \times 100/\sum V_1O_1$	Grading
Phytoplankton	16.17	26.02	420.63	22.55	II
Zooplankton	3.58	12.24	43.83	2.35	V
Insect larvae	49.52	18.37	909.50	48.75	I
Sand and mud	17.09	15.82	270.29	14.49	III
Debris	2.73	9.69	26.47	1.42	VI
Miscellaneous group	10.92	17.86	194.97	10.45	IV

DISCUSSION

Das and Moitra (1963) mentioned that RLG value is lowest in carnivorous fish, higher in omnivorous fish and highest in herbivorous fish. In *B. bendelisis*, the values of RLG have been observed to vary from 0.745 to 1.712 with a mean value of 1.271 (±0.19). Since, in the present study, RLG was measured more than '1' but less than '3' thus depicting the omnivorous nature of *Barilius bendelisis* (Al Hussainy 1949). However, since RLG value was found to be less than '1' in the smaller size groups of the fish species, it can be concluded that the juveniles are carni-omnivorous. This is supported by the findings of Badola and Singh (1980) and Rawat and Nautiyal (1995). The values of RLG not only vary from species to species, but also in the same individual at different stages of its life. Sinha and Moitra (1976) also said that as fishes grow in length, there occurs a change in their food habits from carnivorous to herbivorous through the omnivorous type. Girgis (1952) also stated that RLG values are highest in the older fishes and lowest in the fry stage.

Increase in GSI values during monsoon and winter seasons depicting high feeding intensity and decrease in pre monsoon and retreating monsoon depicting poor feeding intensity in both the sexes indicate their pre spawning period followed by their spawning period. This suggests that during these two seasons, i.e. monsoon and winter, the fish feed more voraciously due to a higher energy demand associated with gonadal development. Consequently, decline in GSI and therefore, feeding intensity during pre-monsoon and retreating monsoon can be attributed to the recovering stages of gonads. Scarcity of preferred food may also be another reason. Gupta and Banerjee (2013) opined that GSI increases gradually after spawning season with increased feeding activity and during pre-spawning season feeding activity increases maximally represented by high GSI values. Similar observations on low GSI value during the breeding season have been reported in many fish species (Gandotra *et al.* 2007, Begum *et al.* 2008, Sarkar and Deepak 2009, Mondal and Kaviraj 2010).

Presence of full and 3/4th full guts was there in all the four seasons. Empty guts and instances of poor feeding were very few and found only in pre monsoon and winter which may be attributed to reduced feeding activity during the spawning season (Geetha *et al.* 1990). However, presence of full guts all throughout the year suggests that active feeding was continuous even in the spawning seasons and that feeding intensity of *B. bendelisis* is high and it is a voracious feeder. Similar findings have been reported by Rawat and Nautiyal (1995).

From the above observation, it was evident that the fish feeds on a variety of food items, most preferred among which, were insect larvae and phytoplankton. Bacillariophyceae was observed to be the most common phytoplankton present in the gut of *B. bendelisis*. Highest density of bacillariophyceae is harboured by substrates like rocks and stones in lotic systems like hill streams (Nautiyal *et al.* 2000). Presence of higher proportion of bacillariophyceae in the gut of *B. bendelisis* indicates that this fish browses on stony and rocky substrates and is a surface feeder. Similar conclusion was made by Sahoo *et al*. (2009) and Koundal *et al.* (2016).

According to Das and Moitra (1955), a fish is considered a herbivore, if more than 80% of the average annual food is formed by algae and higher aquatic plants; an omnivore, if it feeds approximately on 50% of both plant or animal food, the plant food ranging from 11.9 to 79.1% and the animal food from 14.6 to 78.1% in the average annual food, if, however, the fish feeds more than 80% animal food

in their annual diet, it is considered a carnivore. In the present study, gut content of *B. bendelisis* contained 25.6% phytoplankton and 31.07% of food constituted of zooplankton and insects. Therefore, the fish could be classified as an omnivore.

Index of preponderance values also revealed that insect larvae were the most preferred food item occupying the first rank in grading followed by phytoplankton, sand and mud, miscellaneous groups and zooplankton. Debris occupied the last rank in grading. These findings suggest that the basic food of *B. bendelisis* is insect larvae as it has been recorded in all the four seasons in the gut during the study period. Secondary food is phytoplankton. Sand, mud and other miscellaneous group can be considered as incidental food whereas zooplankton and debris, since scarcely observed in the gut might be the obligatory food consumed when preferred food is not available or might be accidentally consumed. The classification of food of fishes into the above four categories has been done by Nikolsky (1963).

CONCLUSION

Study on food and feeding habits of *Barilius bendelisis* revealed their basic, secondary, incidental and obligatory foods. On the basis of food selection, the fish species was classified as omnivorous and on the basis of ecological niche, surface feeder. However, RLG study concluded that there was a slight change in food habit as it grows, since the juveniles are carni-omnivorous whereas the adults omnivorous in nature. GSI analysis revealed that feeding intensity was high in pre spawning season and low in the spawning season. However, since that active feeding was observed continuous even in the spawning seasons, it can be concluded that feeding intensity of *B. bendelisis* is high and it is a voracious feeder.

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