Food and Feeding Biology of a Stream dwelling Ornamental Loach *Acanthocobitis botia* (Hamilton, 1822) from Upper Brahmaputra Basin, North East India

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ABSTRACT:

The food and feeding habit of a prominent freshwater ornamental loach species *Acanthocobitis botia* (Hamilton, 1822) was studied based on 462 individual specimens collected from upper Brahmaputra valley region in Assam, north-east India. The mean relative length of the gut (RLG) for the species was 0.94 ± 0.02 (range 0.85 - 1.15), indicating carni-omnivorous nature of its feeding. The gastrosomatic index (GaSI) value ranged between 2.15 and 2.71with variations between different length or size groups, sexes as well as seasons. Seasonal rise and fall in the feeding intensity was also observed where pre-monsoon being the active feeding period for the species in their natural habitat. Eight different categories of food items, viz., zooplankton, small fishes, insects, crustaceans, annelids, molluscs, plant matters as well as unidentified matters were identified during gut content analysis. Of these, decaying plant matters (27.65%), insects (13.25%), small fishes (12.8%) and zooplankton (9.75%), crustaceans (6.75%) were the most important food items encountered in the guts while occurrence of molluscs (3.5%) and annelids (3.15%) were relatively low in the gut. Considerable seasonal variation in occurrence and percent composition of food items in the diet was also observed. Calculation of index of pre-ponderance (I_i) reveals decayed plant matters, small fishes, insects, crustaceans and zooplankton are the major food items for this species. A considerable variation of feeding intensity was also observed for the individuals in different maturity stages where 40% of individuals in maturing stage exhibit highest active feeding while most individuals in ripe and spent stages were with empty gut thus showed poor feeding. Short and uncoiled alimentary canal and possession of a fleshy sub-terminal (inferior) mouth also suggests towards the carni-omnivorous feeding and bottom dwelling nature of the species.

Key words: Food and feeding biology, ornamental loach, *Acanthocobitis botia*, upper Brahmaputra basin.

1.0: INTRODUCTION:

Acanthocobitis botia (Hamilton, 1822) is a widely acclaimed and commercially important species of ornamental loach (Nemacheilidae: Osteichthyes) native to south-east Asian drainages including the Brahmaputra basin in Assam, north east India. This species is traded under various names such as 'mottled loach', 'sand loach' or 'zipper loach' in tropical aquarium fish industry. This species is usually a stream dweller; mostly inhabits the lower order streams in the plains of this region characterized with sandy-beds or soft bottom material and feeble water current (Das and Biswas, 2008). This species is also occasionally found in the commercial catch of rivers and floodplain wetlands (locally called as '*beels*') of this region.

Studies on feeding and reproductive biology and habitat ecology of fishes are indispensable for better understanding of their eco-biology, life history as well as sustainable resource management. Commercial exploitation of ornamental fish species involves successful domestication, rearing and their propagation in captivity which largely depends on having prior knowledge on type of food and feeding, reproductive strategies and preferred nature of habitat of the species concerned. Moreover, such information is also vital for species specific effective conservation and management plans.

Acanthocobitis botia is a commercially potential small indigenous fish species of this region and currently their exploitation is based on wild collection from their natural habitats. Further, natural population of this species has been dwindling over the years due to various reasons including alteration or modification of their natural habitat. This species is placed in data deficient (DD) category as per the conservation assessment and management plan (CAMP, 1998) in India. No previous reports are available on biological studies on *Acanthocobitis botia* including food and feeding habits from this region so far. Taking all these into consideration, the present study has been carried out on food and feeding habit of this species from upper Brahmaputra valley region.

2.0: MATERIALS AND METHODS:

2.1: Study area: The samples of *Acanthocobitis botia* for the present investigation was collected from Dibrugarh and Sivasagar districts of upper Assam located on the southern bank of the mighty Brahmaputra in north-eastern part of India (Fig-1) for two consecutive years between January, 2018 and December, 2019. This species is mostly found to inhabit the lower order streams and wetlands in the floodplain of the region (Fig-2).

2.2: Methodology

2.2.1: Collection of fish specimens: For the present study, fresh samples of *Acanthocobitis botia* were collected by randomly visiting different fishing grounds (mainly streams in the floodplain) and commercial fish landing centres of the study area (i.e., Dibrugarh and Sivasagar district of upper Assam). The majority of the local fishermen employed cast net to capture smaller sized fishes including this species (Fig-3). The collected fish specimens were transported to the laboratory in ice box for study.

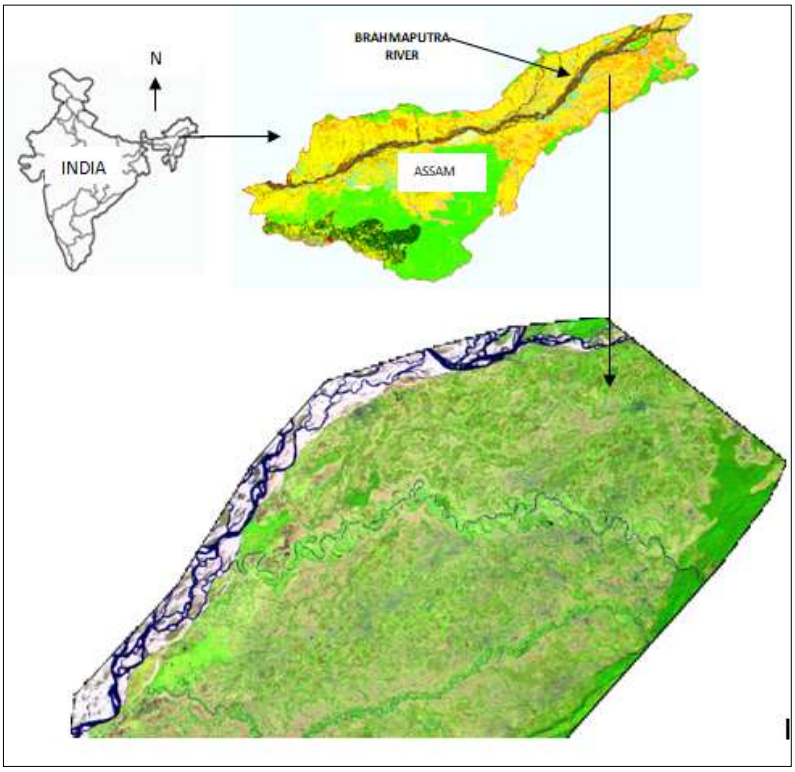

Fig-1: Map of the study area showing drainages in Dibrugarh and Sivasagar district of upper Assam

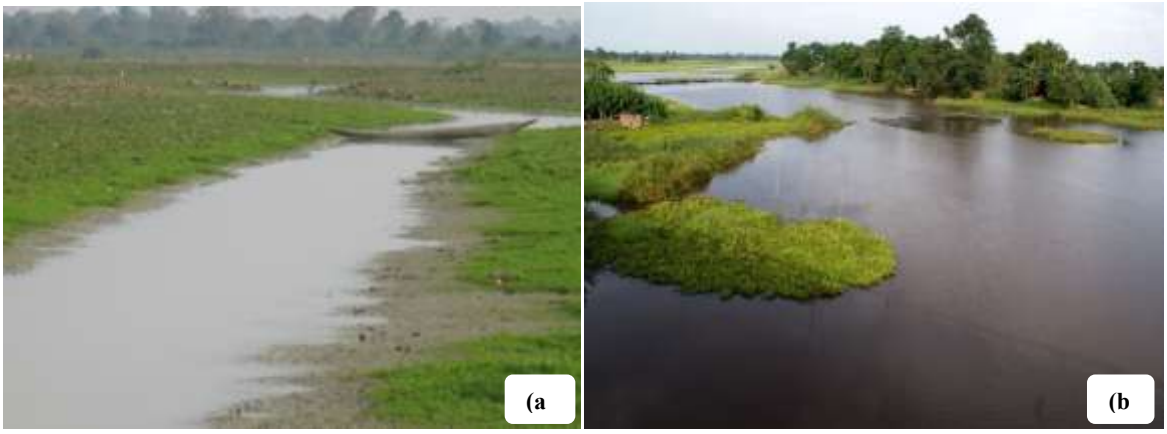

Fig-2: Photograph of typical habiats of *Acanthocobitis botia* (a) Stream and (b) Wetland ('*beel*')

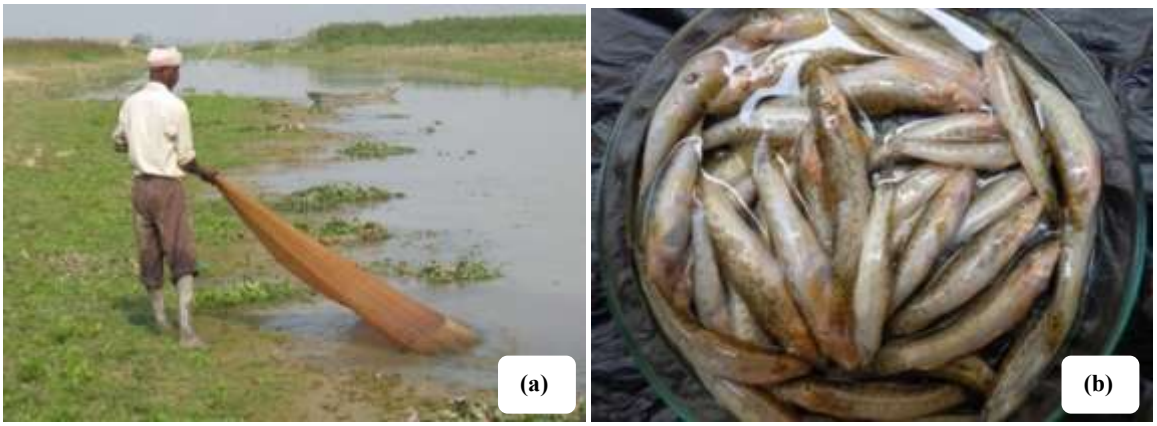

Fig-3: Photograph showing
(a) local fishermen employing cast net for capturing fishes incluidng *Acanthocobitis botia* and
(b) sample specimens of *Acanthocobitis botia* collected for study

d) Gut content analysis: Both qualitative and quantitative analysis of the gut content was done seasonally to examine the components of diet or food ingested by the fish. The samples were analyzed qualitatively and quantitatively by eye estimation method by examining the content of gut under compound microscope; both volumetrically following Pillay (1952) and occurrence method as suggested by Hynes (1950) using the formula-

$$\text{Percentage of occurrence of a food type} = \frac{\text{Number of guts where the food occurred}}{\text{Total number of guts analyzed}} \times 100$$

$$\text{Percentage of numerical count} = \frac{\text{Number of individual food items}}{\text{Total number of food items}} \times 100$$

For evaluating the relative importance of all the food items the index of preponderance for all food items was evaluated following standard method of Natarajan & Jhingran, 1961. The formula used for the calculation of index of preponderance was-

$$I_i = \frac{\text{ViOi x 100}}{\sum \text{ViOi}} \times 100$$

(Where I_i is the index of preponderance, V_i and O_i represents the percentage volume and occurrence of particular food item respectively.

e) All the relevant data thus collected were analyzed using Microsoft Excel (2010 version).

3.0: RESULTS:

Different aspects food and feeding biology of the ornamental loach *Acanthocobitis botia* from upper Brahmaputra basin was studied based on 462 (252 male and 210 female) individuals collected during the period of study. The total length of the specimens ranged between 6.2 and 9.2 cm with a mean length of 7.7 $\pm$1.12 (cm) while the body weight ranged between 1.2 and 9.6g with a mean weight of 4.7 ($\pm$ 1.94) g. Morphological examinations of the dissected gut of the species reveals that it has a short and uncoiled alimentary canal and possess a fleshy sub-terminal (inferior) mouth (Fig-4).

RLG value: The calculated mean RLG value for the species was ranged from 0.85 to 1.15 which suggests carni-omnivorous nature of feeding of the species. Moreover, variation of RLG value in different length or size groups of the species was also observed during the study indicating a decrease of RLG value with increase in the total length of the fish (Table-1).

Table-1: Mean value of RLG and GaSI observed in different size or length groups of *Acanthocobitis botia*

Size group (cm)	**RLG Value** (Mean ±SD)	**GaSI value** (Mean ±SD)
6.2 -7.2	1.15 (± 0.01)	2.15 $\pm$ 0.02
7.3 - 8.2	0.96 (± 0.02)	2.50 $\pm$ 0.06
8.3 - 9.2	0.85 ($\pm$ 0.07)	2.71$\pm$ 0.02

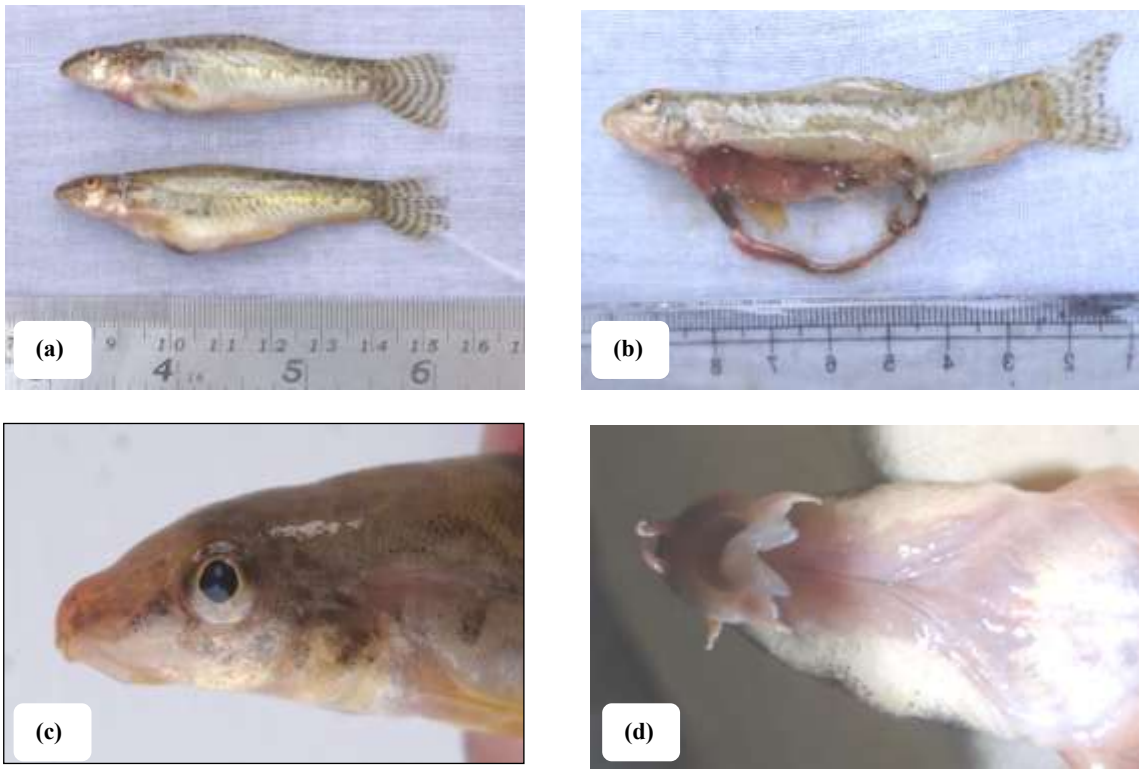

Fig-4 (a-d): Photograph showing the (a) adult specimen, (b) morphological feature of the alimentary canal and (c and d) the mouth of *A. botia*

Gastrosomatic index (GaSI): The GaSI value for *A. botia* was observed in the range between 2.15 and 2.7 for various size or length groups (Table-1). GasI value of the species also shows seasonal variation in both male and female individuals that reflects seasonal rise and fall in the feeding intensity in the species (Table-2). For males the maximum value of GaSI was observed in post-monsoon (2.8± 0.35) while the minimum value was recorded in winter (2.0 ± 0.25). Likewise, for females of this species too, the GaSI value was maximum during post-monsoon (2.5 ± 0. 32) while the minimum was recorded during monsoon (1.9 ± 0.45). Thus, the GaSI value showed an increase in pre-monsoon indicating active feeding period for the species in their natural habitat.

Table-2: Seasonal variation of GaSI for male, female and combined sexes of *A. botia*

Season	Sex		
	Male	Female	Combined
1. **Pre-monsoon**(March-May) (n=120)	2.5 ± 0.42	2.4 ± 0.33	2.42 ± 0.11
2. **Monsoon**(June-August) (n=96)	2.1 ± 0.21	1.9 ± 0.45	1.92 ± 0.16
3. **Post-monsoon**(September-November) (n=110)	2.8 ± 0.35	2.5 ± 0. 32	2.6 ± 0.23
4. **Winter**(December-February) (n=136)	2.0 ± 0.25	2.1 ± 0.24	1.99 ± 0.21

Gut content analysis: Both qualitative and quantitative analysis of content of the gut of *A. botia* has been carried out randomly in order to examine the different food items they consumed in their natural habitat. Out of the 462 adult fish samples collected during the study period, 390 (i.e., 84%) were non-empty (having different food items) while the remaining 72 (16%) were found to be empty. Qualitative analysis of gut content of the species showed plant and animal matters as its food items; which can be broadly differentiated into 8 categories viz., zooplankton, small fishes, insects, crustaceans, annelids, molluscs, plant matters as well as unidentified matters (Fig-5). Analysis of percent composition of food items in *A. botia* showed plant matters and unidentified matters contributed about half of the gut content while the other half of the gut content was contributed by food items of animal origin that include insects (13.25%), small fishes (12.8%) and zooplankton (9.75%), crustaceans (6.75%), molluscs (3.5%) and annelid (3.15%).

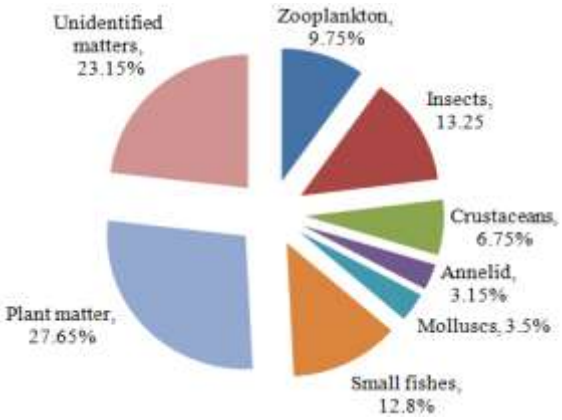

Fig- 5: Relative proportion (% composition) of food items in adult *Acanthocobitis botia*

Again, seasonal variation in the percentage composition of food items in the gut of *Acanthocobitis botia* was also observed during the study period (Table-3). Food items like zooplankton (5.9% to 9.2%), crustaceans (8.75% to 13.5%), annelids (2.4% to 2.95%) and molluscs (4.2% to 7.5%) showed little seasonal variation in their occurrence as food. However, highest and lowest percentage of insects as food item was recorded during post-monsoon (22.5%) and winter (16.8%), respectively. Both small fishes and decaying plant matters were recorded as major food items in this species. Maximum occurrence of small fishes (25.75%) in the gut content was found during post-monsoon whereas maximum plant matter (21.5%) was found during pre-monsoon. A considerable seasonal variation was also observed for unidentified matters (from 8.5% in post-monsoon to 20.5% in pre-monsoon) as food item in *A. botia*.

Table-3: Seasonal variation of different food items (%) in *Acanthocobitis botia*

Sl. No.	Food Items	Season			
		Pre-monsoon	Monsoon	Post-monsoon	Winter
1	Zooplankton	8.75	5.85	5.9	9.2
2	Insects	17.85	20.35	22.5	16.8
3	Crustaceans	8.75	10.55	13.5	11.8
4	Annelid	2.85	2.5	2.95	2.4
5	Molluscs	4.2	6.6	7.5	6.1
6	Small fishes	15.6	21.15	25.75	23.4
7	Plant matter	21.5	19.6	13.4	16.1
8	Unidentified matters	20.5	13.4	8.5	14.2

Index of Pre-ponderance: Calculation of index of pre-ponderance (I_i) for this species is also carried out and is presented in Table-4 where decayed plant matters found to be the most dominant food item for this species followed by small fishes, unidentified items, insects, crustaceans and zooplankton. Other food items such as molluscs and annelids were encountered occasionally, that too in small quantity and thus may be considered as least preferred food for them.

Table-4: Index of Preponderance of various food items found in the gut content of *Acanthocobitis botia*

Sl. No.	Food Items	% of Volume	% of Occurrence	V_iO_i	Index of Preponderance (I_i)
1	Zooplankton	6.75	9.75	65.8	4.01
2	Insects	12.1	13.25	160.3	9.95
3	Crustaceans	8.55	6.75	57.7	3.58
4	Annelids	3.1	3.15	9.77	0.61
5	Molluscs	4.8	3.5	16.8	1.04
6	Small fishes	28.2	12.8	360.9	22.3
7	Plant matter	21.2	27.65	586.2	36.3
8	Unidentified Components	15.3	23.15	354.2	21.9
	Total	100	100	1611.67	-

Fullness of gut: During the present investigation, percentage occurrence of different degree of fullness of stomach (i.e., feeding intensity) in different seasons of the year was also observed for *Acanthocobitis botia* and is given in Table-5. Highest active feeding (53.8% individuals with full gut and 19.2% individuals with ¾ full gut) were observed during pre-monsoon and monsoon (40.4% full and 21.1% ¾ full) whereas poor feeding was observed during pre-monsoon and winter for this species. About 60% of individuals studied during pre-monsoon and winter were found to be either nearly empty or empty.

Table-5: Seasonal variation of feeding intensity (fullness of gut) in *Acanthocobitis botia*

Season	No. of Specimens (n)	Active Feeding		Moderate feeding ½ full	Poor Feeding		Empty
		Full	¾ Full		¼ full	Nearly Empty	
Pre-monsoon	120	53.8	19.2	10.2	7.6	4.1	5.1
Monsoon	96	40.4	21.1	17.1	6.3	8.1	7.0
Post-monsoon	110	3.4	4.2	12.1	24.1	19.1	37.1
Winter	136	1.1	3.2	14.1	19.1	22.2	40.3
Overall	462	24.6	11.9	13.4	14.3	13.4	22.4

Again, during the present study, a considerable variation of feeding intensity was also observed in individuals in different maturity stages (Fig-6). A maximum of 40% of individuals in maturing stage showed highest active feeding (53.8% individuals with full gut and 19.2% individuals with ¾ full gut) while individuals in ripe stage observed maximum poor feeding. Besides, 62.1% in ripe stage and 73.3% individuals in spent stage were recorded with empty stomach.

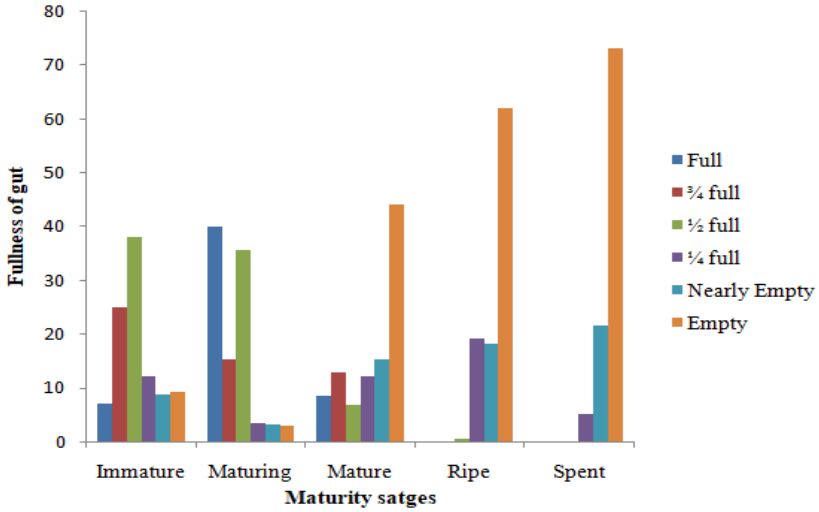

Fig-6: Percentage of fullness of gut of *Acanthocobitis botia* in different maturity stages

4.0: DISCUSSION:

Studies on food and feeding habits constitute a critical aspect of fish biology. Each and every aspect of the life of a fish species including survival, growth and reproduction is affected by quality and quantity of the available natural food in their habitat. Such investigations are also essential for evaluating the ecological role and position of a fish species in the trophic structure or trophic relationships of the ecosystem (Allan and Castillo, 2007; Baijot and Moreau, 1997). This also facilitates fisheries resource management in the context of both capture as well as culture fisheries.

The present study on different aspects of food and feeding habit of *Acanthocobitis botia* suggests the species is carni-omnivorous in feeding, polyphagous in nature, being subsists on a wide variety of food items. Morphological features of the alimentary canal of a fish species provide an idea about the feeding habit and nature of food it consumed. Each species of fish has a constant ratio between the gut length with that of the total length (i.e., the RLG value) and this value of a given fish species has a close relationship with its nature of food (Das and Moitra, 1956). Thus, RLG value is often used to determine the feed preferences and also used as a predictor of the general dietary types in a number of fish species (Berumen *et al.,* 2011; Rahman *et al*., 2012; Koundal *et al*., 2013). Presence of a short and uncoiled alimentary canal and a mean RLG value of 0.94 ±0.02 (range 0.85-1.15) for *Acanthocobitis botia* indicate towards a carni-omnivorous nature of its feeding. Moreover, the fleshy sub-terminal (i.e., inferior) mouth also suggests bottom dwelling scavenging nature of the species.

Seasonal rise and fall in mean GaSI values (from 2.15 to 2.7) or feeding intensity was also observed in different length groups or size groups as well as between the sexes (i.e., male and female) of *Acanthocobitis botia*. In case of *Acanthocobitis botia,* the record of maximum GaSI value for both the sexes suggests post-monsoon season is the active feeding period for the species, though minimum GaSI value for the male and female of the species being recorded in winter and monsoon, respectively. In certain fish species, low feeding intensity during monsoon for females may be due to more intensive sexual stress for them in comparison to their male counterparts (Khumar and Siddiqui, 1989). Likewise, low temperature coupled with non-availability of preferred food in the habitat could be the reason for decline in feeding intensity in winter as observed in *Acanthocobitis botia.* Moreover, poor feeding intensity by the gravid individuals during breeding season (monsoon happens to be the breeding season for the species) has also been reported in other species (Saikia *et.al*, 2013).

Food and feeding habits of fishes vary from species to species, even within the species in different stages of its life cycle. Based on qualitative analysis of the ingested food present in the gut, eight major types of food items, viz., zooplankton, small fishes, insects, crustaceans, annelids, molluscs, plant matters and unidentified matters have been recognized for this species. Of these, both decaying plant matters and unidentified matters are the most common food items and constitute the major share of the stomach content while other food items like insects, crustaceans, small fishes and zooplanktons collectively contributes substantially to the natural food base consumed by the species. Further, occurrence of such food items suggest also suggests that the species has been feeding close to the bottom. The higher occurrence and volumetric contribution of decaying plant matters in guts of *A. botia* showed the importance of this food item in their nutrition. However, detritus is considered to be low in nutritional value (Bagenal and Braum, 1978; Bowen, 1979) and increased consumption of detritus by a fish species could be a response to a decline of higher value primary food resources (Bowen, 1979; King *et al*., 2003).

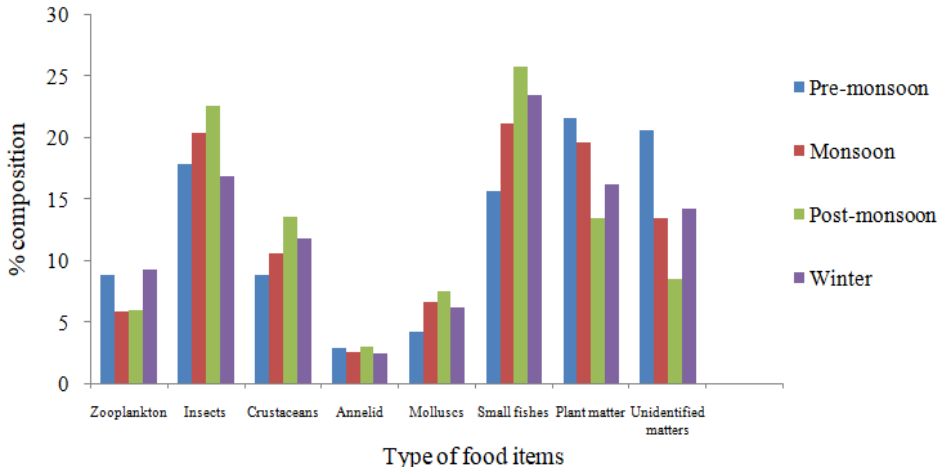

Fig-6: Seasonal variation in percent composition of food items in the gut of *Acanthocobitis botia*

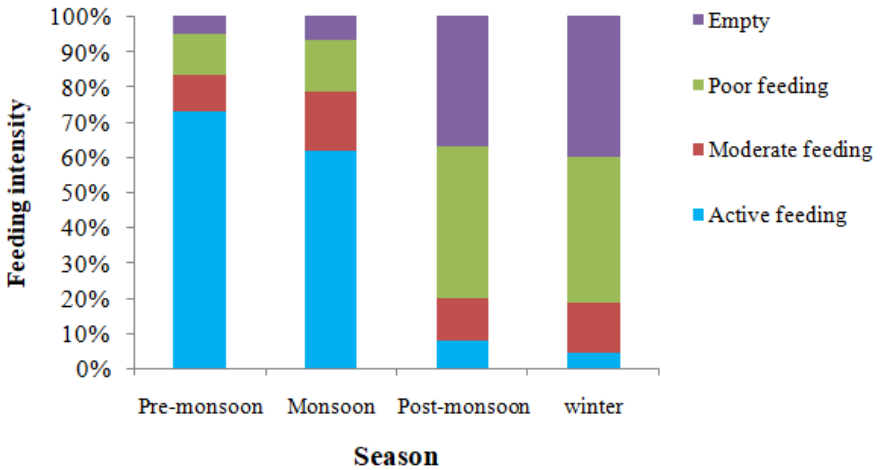

Fig- 7: Seasonal variation of feeding intensity (fullness of gut) in *Acanthocobitis botia*

Seasonal variation was observed on the type of food and their proportion (i.e., % composition of food items) in the gut of *Acanthocobitis botia* during the study period (Fig-6). Food items like zooplankton (5.9% to 9.2%), crustaceans (8.75% to 13.5%), annelids (2.4% to 2.95%) and molluscs (4.2% to 7.5%) showed little seasonal variation in their occurrence as food in *Acanthocobitis botia*. However, highest percentage of both small fishes (25.75%) and insects (22.5%) as food item was recorded during post-monsoon while maximum plant matter (21.5%) was found in the gut during pre-monsoon. A considerable seasonal variation was also observed for unidentified matters (from 8.5% in post-monsoon to 20.5% in pre-monsoon).

Moreover, calculation of index of pre-ponderance (I_i) for this species reveals that decaying plant matters found to be the most common food item while small fishes and unidentified matters also have a major share in the gut content of *Acanthocobitis botia.* Food items like insects, crustaceans and zooplankton contributed towards a major portion of food for this species in their natural habitat whereas other food items such as molluscs and annelids are occasionally encountered in the gut content. Again, seasonal variation in feeding intensity (as percentage occurrence of different degree of fullness of stomach) for *Acanthocobitis botia* also observed during the present study. Maximum percentage of active feeding (full and $3/4^{th}$ full gut) occurs during pre-monsoon while maximum percentage of poor feeding (1/4 full and nearly empty gut) occurs during winter for this species (Fig-7).Moreover, individuals with empty gut dominated the catch during winter. In tropical region, the availability of food items changes throughout the year due to seasonal changes, which also reflects in seasonal variation of feeding habits of fish species (Desta *et al*., 2006). A considerable variation of feeding intensity has also been observed in individuals in different maturity stages. A maximum of 40% of individuals in maturing stage showed highest active feeding while individuals in ripe stage showed maximum poor feeding. The type of food items consumed by a fish depends on prey availability, season and habitat differences and size of the fish (Admassu and Dadebo, 1997; Sibbing and Nagelkerke, 2001). It is also noted that the diet composition of fish may vary with in wide ranges on temporal and spatial conditions and environmental factors, particularly in aquatic systems where the water levels have been known to fluctuate, the quality and abundance of food items for fish vary significantly through time (Cabana *et al.,* 1994). The major factors that influence the diet of a fish include fish size, maturity, condition, season, depth of water-body and habitat types (Persson and Crowder, 1998).

5.0: CONCLUSION:

The present study on food and feeding biology of the stream dwelling loach *Acanthocobitis botia* confined to studying the food items available in the guts at the time of laboratory analysis. Mean RLG value, presence of a short and uncoiled alimentary canal, fleshy sub-terminal (i.e., inferior) mouth as well as availability of different food items of both plant and animal origin is indicative of carni-omnivorous, polyphagous and bottom dwelling scavenging nature of feeding of the species. There are also seasonal variations in diet composition and feeding intensity while stages of sexual maturity of individuals are also influencing their feeding patterns. Further elaborate research in this aspect of the species is suggested, especially considering the formulation of artificial diet for captive rearing and propagation of the species for commercial exploitation.

6.0: Acknowledgement:

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