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Food and feeding habits of *Hemibagrus menoda* (Hamilton, 1822) (Siluriformes, Bagridae) in Kangsha River, Bangladesh

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Abstract. The menoda catfish, *Hemibagrus menoda*is is highly cherished due to its tasty flesh and market value but catches of this species from open water fisheries in Bangladesh are dwindling as a result of frequent overfishing and various anthropogenic and environmental causes. This research was conducted to identify the seasonal variation in food and feeding habits of the menoda catfish in its natural habitat which will assist in the design of an aquaculture program for the species. Freshly caught fishes were collected from the Kangsha River, located at Jaria-Janjhail (25^0 0′ 41.10″ N; 90^0 38′ 27.16″ E) Netrakona, Bangladesh, from March 2016 to February 2017. Stomach contents of the fish were analyzed by the frequency of occurrence, volumetric (points) methods and index of preponderance. The decapods, detritus, small fish and polychaetes constitute 1, 2, 3 and 4 ranks in the diet of *H. menoda*. Highest gastrosomatic index was recorded for male in September (6.90 ± 1.03) while for the female, the highest was in November (6.34 ± 0.41), indicating the period of highest feeding activity of both sexes. Feeding intensity based on size group showed that the rate of feeding decreases as fish increases in size. It is obvious that *H. menoda* is a carnivore and feeds mainly on crabs, prawns and small fishes.

Keywords: Feeding ecology, Gastrosomatic index, *Hemibagrus menoda*

Introduction

Feeding biology has been described as one of the least well studied and quantified components of vast majority of fish species (Talbot 1993). Food plays a vital role in fish life and to a large extent determines species abundance, growth rate and condition in a population but it varies remarkably according to the food preference of a species. The study of the food of a fish around the year is essential for a better understanding of the biology and fishery of the species (Kumar *et al.* 2015). Knowledge on food and feeding habits of fish has great importance in aquaculture practice as it helps to choose such species of fishes for aquaculture which will utilize all available potential food present in a water body without competition with each other but will live in association with other fishes (Hossain *et al.* 2016). Determination of food preference of fishes is essential in order to obtain correct picture of nutrition and feeding adaptations (Verma 2013). A food habits study might be conducted to determine the most frequently consumed prey or to determine whether a particular food category is present in the stomach of fishes (Chipps and Garvey 2007). Information on prey resources through quantitative assessment of food habits of fishes is vital to increasing fish production and fisheries management (De Vries and Stein 1990).

Food and feeding habit vary with the time of the day and season of the year therefore analysis of stomach contents is a method for determining the food and feeding habits of fishes by which we can easily find what the fish take as food (Ali *et al.* 2003). Extensive researches have been done on the food and feeding habits of several fishes (Hyslop 1980, Mamun *et al.* 2004, Yatuha *et al.* 2013, Verma 2013, Kaniz *et al.* 2013, Gupta and Banerjee 2014, Shinkafi and Ajoku 2015, Ouakka *et al.* 2017).

Hemibagrus menoda is a tropical, freshwater catfish found in the Ganges, Brahmaputra, Mahanadi and Godavari river drainages in Bangladesh, India and Nepal. The fish is one of the commercially important food fishes in Bangladesh but still only obtainable from the wild. Due to the large size (450 mm SL) and ornamental beauty of the menoda catfish (Ng and Ferraris 2000), it provides succour to the fishermen in the rural areas as source of protein and income. It commands a good market value ranging from BDT 600-700/kg for dead fish to BDT 2500/kg for live fish hence mostly purchased by the elites. However, due to frequent overfishing, siltation and excavation activities, the populations of this fish and other ichthyo fauna are fast declining and the fish is rarely found at the moment leading to the categorization of the fish as Near threatened (Bashar *et al.* 2009, IUCN 2015). Successful nursery rearing and culture of this fish in fish farms entails obtaining information on its food and feeding habits in the natural environment. Unfortunately, the ecology, diet and food items of *H. menoda* have not been studied and, thus, knowledge of the feeding habits of this fish remains rudimentary. The aim of the present study was to determine the composition of the diet of *H. menoda* and its relation to months and size in the Kangsha River, Bangladesh. The information garnered from this study might assist in the culture of this fish so as to curtail its imminent extinction.

Materials and Methods

Sample collection and preservation

Freshly caught samples of *H. menoda* were collected monthly (March 2016 – February 2017) from the Kangsha River located in Jaria–Jhanjail, Netrakona district, Bangladesh (Fig. 1). A total of 84 fish- 42 females and 42 males were collected for the study. Their total length ranged from 27.80–52.00 cm and body weight ranged from 230–1038 g. The fishes collected were preserved immediately by freezing to cease further digestion of food materials and to prevent loss of resolution. The fish were cut open by the ventral side and the sex recorded accordingly. The stomach was then removed, preserved in 10% formalin and labeled for further analysis.

Methods of gut content analysis

Frequency of occurrence method

The number of guts in which each food item occurred was recorded and the number expressed as a percentage of total number of food containing guts that were examined using the formula (Ikusemiju and Olaniyan 1977):

$$\%Fi = \frac{ni}{n} \text{ x } 100$$

Where, $\%Fi$ = percentage frequency of occurrence of a given food item $\boldsymbol{i}$ in the sample,

ni = number of guts in which a given food item $\boldsymbol{i}$ occurred
n = total number of guts with food items examined

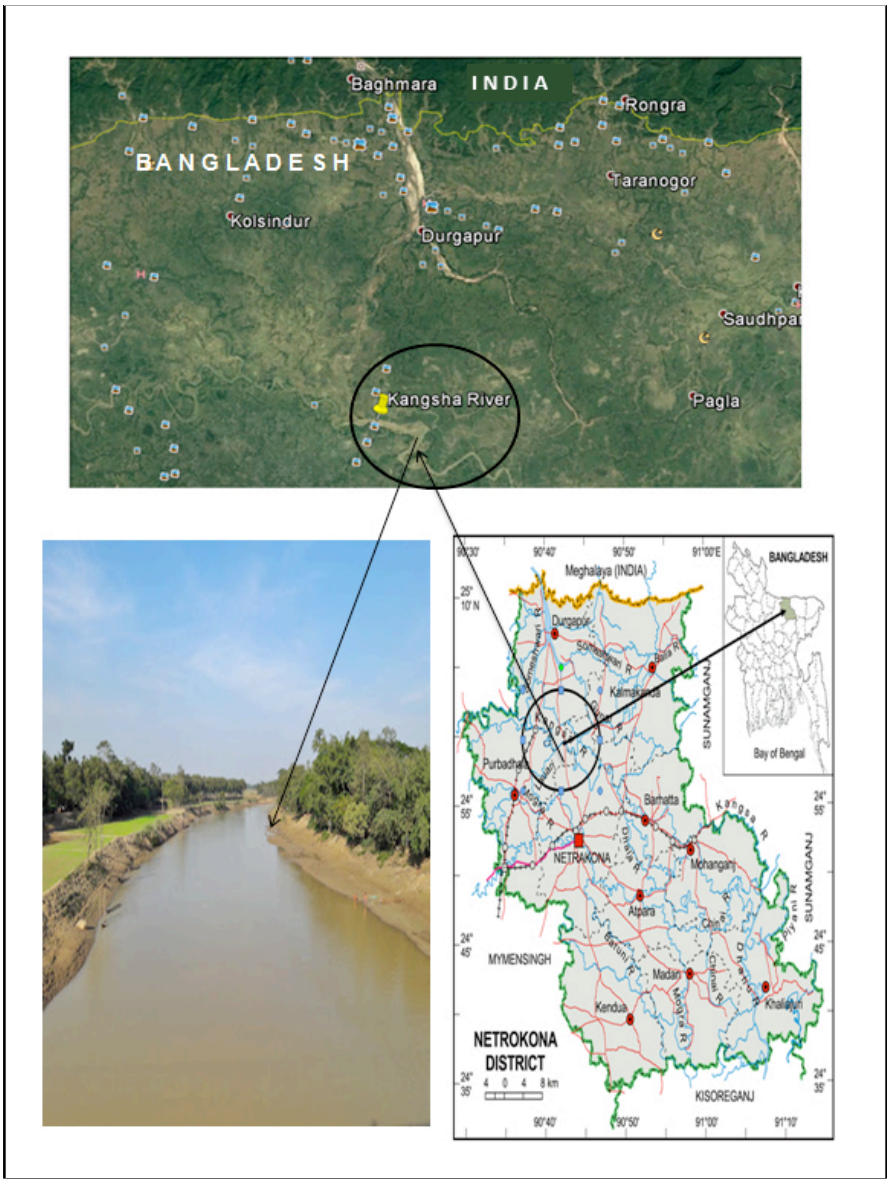

Fig. 1. Map of the study area showing the sampling site in the Netrakona District, Bangladesh.

Points (volumetric) method

Each food item in the stomach was allocated points in proportion to its visually estimated contribution to gut volume (Hyslop 1980). In this way, one large organism counts as much as several small ones. Points were first allocated to the stomach content based on the size of the fish and fullness of the stomach and recorded as P_t. The points allotted to the stomach were subdivided to each food item according to the volume of it present in the stomach and recorded as P_i. The relative abundance of particular food items investigated in the gut was calculated. All the points gained by each food item were summed up and scaled down to percentages to give percentage composition of the food of all the fish examined as follows:

$$\%\,P\boldsymbol{i} = \frac{P\boldsymbol{i}}{P\boldsymbol{t}} \times 100$$

Where,

$\%P\boldsymbol{i} =$ the percent contribution of the item i,

$P\boldsymbol{i} =$ the value of points allotted to the item i

$P_t =$ the number of points allotted to the stomach

Gastro somatic index (GaSI)

$$\text{GaSI} = \frac{\text{Weight of the gut}}{\text{Total weight of the fish}} \times 100 \qquad \text{(Desai 1970)}$$

Results

Seasonal variation of dietary composition of H. menoda by frequency of occurrence and points (volume) method

Decapods: This constitutes the bulk of the fish diet. Frequency of occurrence method indicated that the decapods form the most frequently ingested food item with 61.9% (Table I). Similarly, the yearly average composition by volume showed this group of food items to be the largest (33.95%) consumed by *H. menoda* (Table II). The decapods found in the stomach of this fish constitute mainly the crabs and prawns. The crabs were represented by the Freshwater species (*Acanthopotamon martensi*) while the main species of prawn identified was the Giant river prawn (*Macrobrachium rosenbergii*). The highest consumption of this preferred prey was in May (19.23%) while the lowest was recorded in July (2.94%) (Table I).

Algae: This constitutes the second most commonly ingested food items by frequency of occurrence (Table I) which comprises of Diatoms (52.8%), Cyanophyceae (48.81%), Chlorophyceae (44.05%), Desmids (26.19%) and Euglenephyceae (16.07%). However, though this group of organisms is highly represented, their composition by volume (Table II) showed they occupy very small portion of the food composition. The Diatoms with 5.19% by points were represented by the genus *Navicula, Nitzschia, Cycotella, Fragilaria and Surirella*; Chlorophyceae (1.97%) represented by *Tetraedron* and *Chlorella*; Cyanophyceae (2.39%) represented by *Aphanizomenon* and *Oscillatoria*; Desmids (1.37%) represented by *Cosmarium* and *Closterium*; Euglenephyceae (0.84%) represented by *Euglena*.

Detritus: Detritus was found in 51.19% of the guts examined (Table I). It contributes 10.93% by volume of the annual average composition of the fish diet (Table II). It was found in the gut of the fish throughout the year with the highest occurrence by volume recorded in April 2017 (16.51%) and the lowest in July 2016 (0.00%) (Table II).

Unidentified: These refer to the animal and plant parts which as a result of the stage of digestion could not be identified. The unidentified food items were found in 35.71% of the total guts examined (Table I). They constitute 7.03% (Table II) by volume of the yearly average intake of food by *H. menoda*. The highest occurrence was in April 2017 while the lowest was in October, December and January (0.00%) (Table I).

Polychaetes: The polychaete worms formed 34.52% (Table I) of the food items found in the 84 stomachs examined and accounted for 8.93% by volume (Table II) of the food consumed annually. The maximum occurrence of polychaetes in the guts was observed in June (10.71%) while the minimum was recorded in September, March and May (0.00%).

Small fish: Small fish, mostly comprising *Mystus tengara* and *Amblypharyngodon mola,* were found in 30.95% of the guts examined (Table I). They were also found in the stomach throughout the year except in January and February and constitute 13.47% by volume of the food ingested by the fish. The highest composition of fishes by volume was recorded in September (26.00%) while the lowest (0.00%) was recorded in January and February (Table II).

Zooplankton: The zooplankton were the least encountered food items and were represented by three groups *viz*. Rotifera (*Brachionus*), Copepoda (*Calanoids)* and Cladocera (*Daphnia*) with yearly percentage occurrence of 3.57, 7.14 and 27.38, respectively (Table I). Despite their occurrence in considerable number of guts, their composition by volume in all the 84 stomachs examined was 0.91%, 0.99% and 3.03% respectively (Table II).

Mud: Mud was encountered in 64.29% of the examined stomachs which was the highest occurrence (Table I). The yearly average percentage composition of mud in the diet of *H. menoda* was 9.65% with the highest recorded in January (14.29%) and lowest in February (Table II). Though mud recorded the highest occurrence but it is hereby regarded as incidental prey and not a food item. It merely shows the bottom-dwelling nature of *H. menoda* which might have ingested the mud in an attempt to capture prey.

Ontogenic relationship between size class and food habit of *H.menoda*

The percentage composition by volume (points) of the different food items in relation to Index of fullness and size class (Total length) of *H. menoda* are presented in Table III.

Size class 1 (25 -34 cm): Fishes belonging to this size class recorded highest index of fullness (3.8) and total points (287). Among food items, this size class ingested the highest percentage of decapods (120), polychaetes worms (32), small fish (30) and detritus (30).

Table I. Seasonal variation of dietary composition of *Hemibagrus menoda* in the Kangsha River Bangladesh by frequency of occurrence

		Algae					Zooplankton								
Date	No. of fish examined	Diatoms	Chlorop-hyceae	Cyanophyceae	Desmids	Euglenephyceae	Rotifera	Copepoda	Cladocera	Decapoda	Polychaetes	Detritus	Small fish	Mud	Unidentified
		Percentage number of guts food item occurred													
Jul-16	7	2.94	0.00	8.82	2.94	5.88	0	0	11.76	2.94	5.88	14.71	5.88	20.59	5.88
Aug-16	7	12.50	6.25	6.25	6.25	3.13	0	0	15.63	6.25	3.13	12.50	9.38	6.25	12.50
Sep-16	7	12.50	12.50	6.25	6.25	3.13	0	3.13	0.00	12.50	0.00	12.50	9.38	12.50	9.38
Oct-16	7	9.76	12.20	7.32	4.88	4.88	2.44	0	0.00	17.07	9.76	7.32	9.76	14.63	0.00
Nov-16	7	10.00	10.00	6.00	6.00	4.00	2	2	8.00	14.00	10.00	10.00	8.00	6.00	4.00
Dec-16	7	9.76	7.32	9.76	7.32	4.88	0	2.44	7.32	17.07	9.76	9.76	7.32	7.32	0.00
Jan-17	7	18.75	0.00	18.75	0.00	0.00	0	0	0.00	12.50	6.25	21.88	0.00	21.88	0.00
Feb-17	7	14.29	8.57	20.00	2.86	2.86	0	0	5.71	8.57	8.57	2.86	0.00	20.00	5.71
Mar-17	7	12.50	9.38	15.63	9.38	0.00	0	0	9.38	15.63	0.00	12.50	3.13	6.25	6.25
Apr-17	7	8.33	8.33	2.78	5.56	2.78	2.78	2.78	0.00	16.67	8.33	2.78	8.33	19.44	19.44
May-17	7	7.69	7.69	3.85	3.85	3.85	0	3.85	3.85	19.23	0.00	7.69	7.69	15.38	15.38
Jun-17	7	7.14	14.29	0.00	7.14	3.57	0	3.57	3.57	7.14	10.71	10.71	10.71	7.14	14.29
% occurrence for the year		52.38	44.05	48.81	26.19	16.67	3.57	7.14	27.38	61.90	34.52	51.19	30.95	64.29	35.71
Yearly average % occurrence		10.51	8.04	8.78	5.20	3.25	0.60	1.48	5.43	12.46	6.03	10.43	6.63	13.12	7.74

Note: Percentage occurrence for the year not equal to 100 due to multiple scores

Table II. Composition by points (%volume) of different prey items in the diet of *H. menoda* in the Kangsha River, Netrakona from March 2016 – February, 2017

	Algae					Zooplankton								
Date	Diatoms	Chlorophyceae	Cyanophyceae	Desmids	Euglenephyceae	Rotifera	Copepoda	Cladocera	Decapoda	Polychaetes	Fishes	Detritus	Mud	Unidentified
July	4.28	0.00	2.14	2.14	2.14	0.00	0.00	1.79	37.50	12.06	18.00	0.00	8.93	1.79
August	2.90	1.94	1.94	1.94	0.97	0.00	0.00	2.15	44.09	10.75	17.20	2.15	8.60	5.38
September	2.424	2.42	0.606	0	0.606	0.00	3.03	0.00	39.39	16.67	16.00	7.58	7.58	3.03
October	2.142	2.14	1.428	0.714	0.714	1.43	0.00	0.00	46.50	10.00	11.43	10.00	8.57	0.00
November	1.32	0.99	0.33	0.33	0.33	0.910	0.910	3.66	44.04	12.89	11.00	8.79	6.59	7.20
December	5.924	2.96	2.962	1.481	1.481	0.00	1.23	2.46	37.04	11.11	7.41	14.81	11.11	0.80
January	15	0	6.429	0	0	0.00	0.00	0.00	21.29	14.29	7.14	14.29	14.29	7.14
February	7.5	0.75	1.75	1.75	0.75	0.00	0.00	7.14	18.00	11.50	25.00	12.50	0.00	12.50
March	10	5	5	5	0	0.00	0.00	12.50	12.50	0.00	12.50	12.50	12.50	12.50
April	1.468	0.73	0.734	0.367	0.367	0.00	0.00	0.00	52.32	0.00	14.68	16.51	11.01	10.09
May	5.404	2.7	2.702	1.351	1.351	0.00	4.06	4.06	29.73	0.00	10.81	16.22	13.51	8.11
June	3.948	3.95	2.62	1.316	1.316	0.00	2.63	2.63	25.00	7.89	10.53	15.79	13.16	7.89
Yearly av. points (%)	5.19	1.97	2.39	1.37	0.84	0.19	0.99	3.03	33.95	8.93	13.47	10.93	9.65	7.03

Table III. Feeding intensity (Index of fullness) based on size group and points method

Size group (cm)	No. of fish examined	Index of fullness	Algae	Zooplankton	Decapoda	Polychaetes	Fishes	Detritus	Mud	Unidentified	Total
25-34	52	3.8	26	11	120	32	30	30	28	10	287
35-44	23	3.6	18	7	89	33	21	28	19	13	228
45-54	9	3	14	2	78	34	8	32	22	12	202

Size class 2 (35–44 cm): The fishes of this size class showed increased consumption of polychate worms (32%) and reduction in the intake of decapods. The index of fullness reduced to 3.6 and the percentage of total points of food items reduced to 228 as the fish size increased.

Size class 3 (45–54 cm): The index of fullness was 3.0 while the percentage of total points of ingested food items of this size class was the lowest (202). The composition of various food items in the stomach of this size class further reduced except those of polychaetes (34%) and detritus (32%).

Gastrosomatic index (GaSI)

The results for variation in GaSI for both female and male *H. menoda* are presented in Table IV. Significant difference ($p < 0.05$) was recorded between the mean GaSi for female (3.78 ± 1.31) and male (4.43 ± 2.35) *H. menoda* (Fig. 2). Analysis of monthly variation showed the lowest GaSI for both female (2.11 ± 0.96) and male (2.18 ± 0.34) in July. Highest GaSI was recorded for male in September (6.90 ± 1.03) while for the female the highest GaSI was in November (6.34 ± 0.41). No significant difference ($p > 0.05$) was observed between the monthly GaSI for both sexes. However, the mean difference was found to be significant ($p < 0.05$) when ANOVA was conducted on the effect of seasons on the GaSI during the study period. The highest GaSI was recorded in early winter while the lowest occurred in late winter (Fig. 3).

Table IV. Monthly GaSI (Mean± SD) for female and male *H. menoda*

Month	Female	Male
July	2.11±0.96	2.18±0.34
August	3.51 ± 1.41	4.60±2.45
September	3.71± 1.03	6.90 ± 0.33
October	5.27 ± 1.53	5.87 ± 0.41
November	6.34 ± 0.41	5.79 ± 0.31
December	4.36 ± 0.05	3.92 ± 0.22
January	2.91 ± 0.28	2.65 ± 0.69
February	3.21 ± 0.63	3.12 ± 0.15
March	2.52 ± 0.54	2.67 ± 0.02
April	4.63 ± 2.00	3.22 ± 4.37
May	3.10 ± 0.88	2.46 ± 0.04
June	3.95 ± 0.04	5.34 ± 0.47
Yearly average	3.78 ± 1.31	4.43 ± 2.35

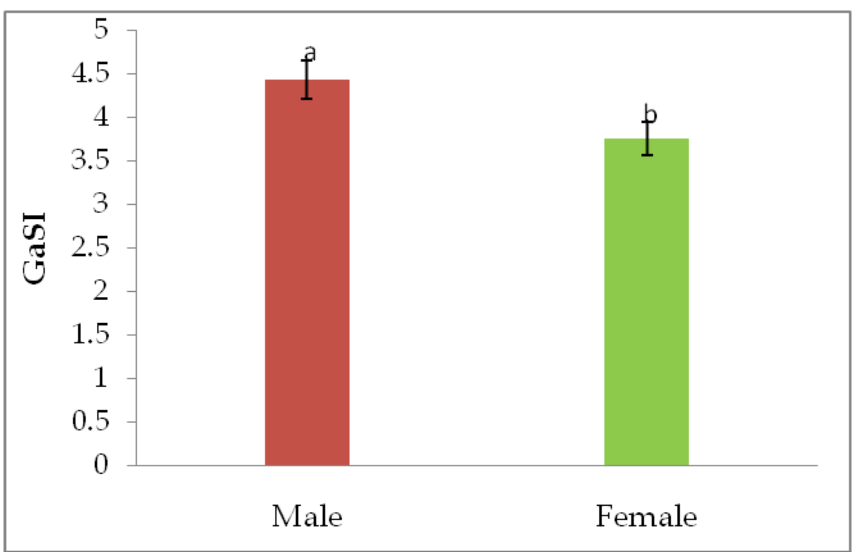

Fig. 2. Yearly average Gastrosomatic index for Male and Female *H. menoda*.

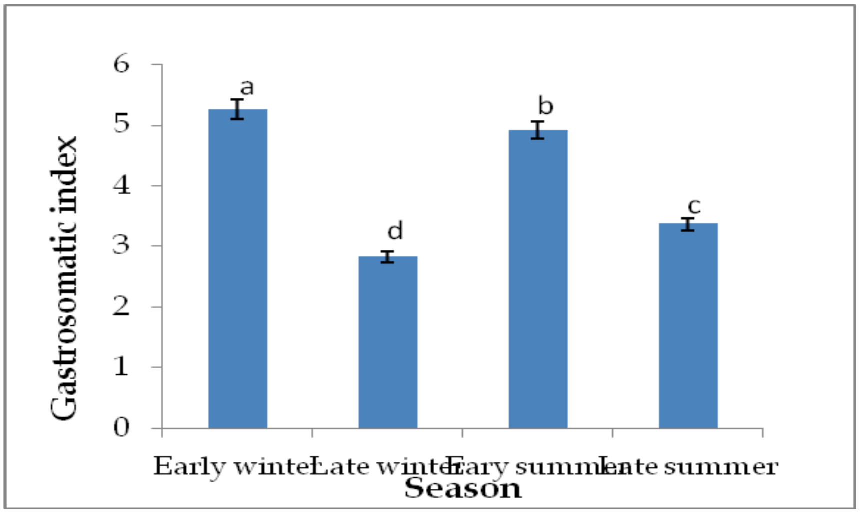

Fig. 3. Gastrosomatic index of *H. menoda* according to season.

Discussion

Examination and evaluation of feeding by occurrence and points method indicated that *H. menoda* feed on a variety of prey including crabs, prawns, small fish and the polychaete worms, algae, smaller zooplankton, detritus and mud. This suggests that *H. menoda* is primarily a carnivorous europhagus feeder. Hajisamae *et al.* (2006) studied the feeding ecology of *Silago sihama* and *Silago ingenuua* and reported polychaete and other benthic organisms in the gut content and categorized the fishes as carnivores, as observed in the present study. This is in line with Smith (2001) who reported that copepods and cladocerans comprised most of the diet of paddlefish. Our findings agree with Ramana and Rao (2014) who reported that *Nibea maculate* was a carnivore whose main food being fish and fish larvae, followed by crustaceans (occasional/secondary), molluscans (incidental) and the polychaetes (obligatory). In contrast, catfishes may have different feeding habits as suggested by Yatuha *et al.* (2013) that *Clarias liocephalus* was a generalist feeder whose diet was dominated by aquatic larvae and plant material.

Organisms in the algae group constitute the second most common prey found in the fish stomach based on occurrence method but occupied very small portion by volume. The presence of algae in the stomach might have been from the smaller fish stomach. Randall (2004) pointed out that not everything found in the stomach of a fish represent what is specifically sought as food. The author further added that sand, stones or pieces of algae might be encountered in the stomach of carnivores and that these items were probably taken in accidentally with the prey or in attempt to capture prey. The presence of detritus indicated that *H. menoda* are bottom feeders and fed on decomposed organic matter that constitutes organic debris, pieces of dead and decomposed animals. This agrees with Yatuha *et al.* (2013) who stated that the dominance of detritus in the *Clarias liocephalus* stomach further confirms the species' primarily benthophagic feeding habit. The consumption of detritus might be due to the scarcity of its regular food items in certain periods of the year. This extends the view of Tadesse (1999) that detritus are less nutritious than phytoplankton to support growth and maintenance of the fish but still a compartment of their diets probably due to low productivity of lake Chamo, Ethiopia.

Feeding intensity in *H. menoda* decreased with increase in length of the fish. This corroborates with reports in other fish species including *Clarias batrachus* (Thakur 1978, Yatuha *et al.* 2013) and supports the idea that the catfish feed less intensively as it grows. This is further supported by the reduced composition of food items in the stomach of fishes in the larger size group observed in this study, except those of the polychaetes and detritus. The present findings are in agreement with Wassef and Eisawy (1985) that there is a gradual decrease in the volume of ingested food as fish size exceeded 25 cm. In addition Verma (2013) mentioned that feeding intensity of *Labeo dyocheilus* decreases as the fish increases in length and age. However the lack of clear-cut ontogenic shift in food intake in our study might be because fishes at very young stages were not captured during the sampling. The lowest feeding intensity for both male and female *H. menoda* in July might suggest a relationship with the reproductive activity of the fish.

Evaluation of gastrosomatic index of *H. menoda* enabled us to characterize the seasonal variation in feeding intensity of the fish. The higher feeding intensity in early winter and early summer could be attributed to the favourable temperature that might have enhanced the productivity of the water body as well as metabolic process in the fish. The low feeding intensity observed in late winter could be due to the low temperature in the water body which could have decreased the metabolic rate and thus feed intake (Sharma *et al.* 2013). Feeding intensity was unexpectedly low in late summer, a period when the standard metabolic rate for the fish would be expected to increase with increasing water temperature, hence demand greater food consumption (Brill 1987). Our data was not consistent with the general trend that female feeding intensity is higher than the males. This could be due to presence of more fishes in the smaller size group of the sample. It could also be due to the male fish being in better condition (Jega *et al.* 2017). The composition of stomach of *H. menoda* revealed that this species is primarily a carnivorous species, which is the case for most catfishes. In this regard, feeds of animal source such as trash fish, chicken viscera, worms and small prawns may be used during the culture of *H. menoda*.

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