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Natural food and feeding habits of a locally available freshwater prawn *Macrobrachium dayanum* (Henderson) from Jammu waters, North India

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Abstract
The aim of the present study was to work out the natural food and feeding habits of *Macrobrachium dayanum* in Gho-Manhasa Stream Jammu. Samples were collected monthly between January 2004 and December 2004. A total of 480 specimens of *Macrobrachium dayanum* (*M. dayanum*) were analysed by categorizing them into four categories based on size and sex. Out of total 480 analysed specimens 214 (44.58%) guts were found to be empty while about 266 (55.41%) contained food. The frequency of empty stomachs decreased with increasing size. Index of preponderance revealed that detritus was the dominant food item of *M. dayanum*. Algae, the second most dominant food item was found to decrease with increase in size. After detritus and algae other important food items were found to be insecta, sand, annelids, macrophytes, mollusca, unidentified matter, crustacean and Rotifers. Based on overall analysis of different size groups the *M. dayanum has* been categorized as detriti-omnivore feeding on both animal and plant matter with detritus as dominant food item.

Keywords: *Macrobrachium dayanum*, natural food, gut content analysis, index of preponderance, Jammu.

1. Introduction
Besides edible fishes, the edible crustaceans are also considered as delicious food throughout the world and thus, command a market in both domestic and international circuits. In India there are 18 species of shrimps and three species of crabs, which are commercially important [1]. In the very recent past, a freshwater prawn viz. *Macrobrachium* has emerged as an accepted candidate for aquaculture. Out of 125 species of *Macrobrachium*, only a small number (*Macrobrachium rosenbergii*, *Macrobrachium malcolmsonii*, *Macrobrachium birmanicum*, *Macrobrachium choprai* etc.) have been exploited from the culture point of view. In addition to the above mentioned species, *M. dayanum* has been rendered to as a notable crustacean withstanding good economic potential [2]. The species is recorded to attain a maximum size ranging from 84 mm (female) to 92mm (male) [3] and in Jammu (Jammu and Kashmir) a maximum size up to 65mm and 60 mm has been reported [4, 5]. The palatable size of the prawn though small when compared to other cultivable species of prawn, the absolute uniqueness of *M. dayanum* lies in the fact that it completes whole of its life cycle in freshwater as compared to its counterparts who have to spend a part of their life cycle in brackish or sea water thus, making the culture of *M. dayanum* practically convenient and economically notable. Knowledge about the diet of animals based on the analysis of gut contents is fundamental to the understanding of nutritional requirements and their interactions with other organisms [6]. It is substantial to know the diet of an animal in its habitat in order to be aware of its nutritional requirements and its interaction with other organisms. The knowledge of the feeding biology and ecology helps to evaluate, identify and quantify the resources that specie uses (with the help of gut content analysis) provides information on those selected from the choices available from the environment [7, 8]. Studies on the feeding biology of *Macrobrachium* spp. is scarce limited to some reports on *Macrobrachium Borelli* [9]; *M. acanthurus*) [10, 11]; *M. vollenhovenii* [12] and *M. carcinus* [13]. The knowledge about the feeding habits of *M. dayanum* is very limited. Therefore, the aim of this study was to work out food and feeding habits of *Macrobrachium dayanum* from Jammu.

2. Materials and method

2.1 Collection of samples

To identify the food of various developmental stages of prawn *Macrobrachium dayanum*, the animals of different size, including plankton and benthic groups were sampled in Gho-Manahasa stream between January 2004 and December 2004.

Prawns were sampled using rectangular haul/sweep net with 1620 cm^2 mouth area (1mm mesh size) and 80cm long during the morning (0800 - 1000 hrs). During the catch operations, net was manually dragged up to a distance of 10 to 15 feet along the limnetic-littoral transitional zone (mid-vegetated and open water zone) and the entrapped individuals were categorized into different size groups and gently placed in vials having 5% formalin. The categorization on the basis of sex was made to reveal the feeding stratagem of animals under investigation right from larval stage to adult stage and between males and females. The prawns were divided into four size groups: MdfI (Size 6.0 mm – 20.0 mm); MdfII (Size 20.1 mm – 40.0 mm); MdfIII (Size 41.0 mm – 60.0 mm Male); MdfIV (Size 41.0 mm – 60.0 mm Female).

The plankton samples were collected from pond by filtering 100 litres of surface water through silk bolting round mouth conical plankton net (50-100 µm mesh size), preserved in 5% formalin and examined under stereomicroscope (100-400X) with Reyne's mount (Chloral hydrate, 50 gm; water, 50 ml; Glycerine, 12.7 ml; Gum Arabic, 30 g) and identified to lowest possible taxonomic level with the help of many books [14, 15, 16].

The benthic samples were collected from both stream and pond with the help Ekmen' dredge. Samples collected were then sieved through sieve no. 40 having 256 meshes/cm^2. Macrobenthic organisms were picked up from the sieved material with the help of foreceps/brush and preserved in 5% formalin and examined under stereomicroscope (100-400X) for further identification. The identification was carried out by following of many books [14, 15, 16].

To study food preferences and feeding ecology a total number of 120 guts/group of *M. dayanum* was analysed. For every group 10 guts/month were analysed to study. Most of the items found in the foregut though damaged were identifiable while contents of the hind gut were practically unidentifiable. The categorization of the dietary items was made on basis of hard parts (carapace, shell and exoskeleton) and soft bodied organisms with quick digestion and without hard parts were categorized as detritus. The total length (TL) of prawns ranged from 6.0-60.0 mm in case of *M. dayanum*.

The preserved specimens were then brought to the wet lab of the Department of Zoology, University of Jammu for further analysis. The preserved specimens were measured for their total length (TL) (nearest to 0.1mm using a divider under stereomicroscope). The alimentary tracts were removed, weighed (nearest to 0.1grams) and measured (nearest to 1.0 grams). The gut contents were emptied in petridishes containing freshwater. All the food items were examined using a stereomicroscope (100-400X) and identified to the lowest possible taxonomic level with the help of many books [14, 15, 16].

The results so obtained were used to compute percentage volume of food items in the gut (%V), percentage of occurrence of guts having particular food item (%O) and Index of preponderance (IOP) of the food items in the gut of *M. dayanum*.

Individual stomach fullness scale was estimated to a subjective scale, ranging from 0 (empty) to 5 (full) [17]. Through the estimates of percentage volume and frequency of occurrence of prey organisms, the Index of Preponderance (IOP) [18] was calculated as follows:

$$\mathbf{IOP = V_iO_i\ (\sum V_iO_i)^{-1}X100}$$

Where:

V_i = volume (percentage) of "i" item

O_i = frequency of occurrence (percentage) of "i" item

3. Results and Discussion

A total of 480 specimens of *Macrobrachium dayanum* were analysed by categorizing them into four categories based on size and sex. Out of total 480 specimens analysed 214 (44.58%) guts were found to be empty while 266 (55.41%) contained food. Food items identified in the gut of *Macrobrachium dayanum* were categorized into 10 main groups: viz., algae, rotifers, cladocerans, molluscs, annelids, insects, macrophytes, unidentified matter (UM), sand/mud and detritus (Table-1). Perusal of the said table divulge that while zooplankton comprised of Cladocera (*Moina sp*., *Daphnia sp*., *Simocephalus sp*., *Alona sp*., *Chydorus sp*. etc.), Copepoda (*Cyclops sp*. and *Mesocyclops sp*.) and Rotifera (*Brachionus sp*., *Keratella sp*., *Filina sp*., *Lecane sps*., *Polyarthra sps*., *Hexarthra sps*. etc), phytoplankton were represented by algal assemblages which were predominantly filamentous. In fact Cladocera and Copepoda were present all through the year with Copepoda showing dominance in winter when Cladocera recorded a decline in their population. The littoral benthic communities were dominated by Oligochaeta, Rotifera, Cladocera, Copepoda, Decapoda (*M. dayanum*, *M. kistensis*), Mollusca (*Lymnea*, *Gyralus*, *Uniomerus sps*.), Annelida (*Tubifex*, *Lumbriculus*, *Chaetogaster*) and Insecta (*Anax*, *Tabanus*, *Chironomus*, *Forcipomyia*, *Tipula sps*.) respectively. However, most of the algae registered abundance in post monsoon than in summer and early spring [5, 16].

The dominant food items found in each group of *M. dayanum* are as follows:

MdfI (Table 2 & 3): A total number of 120 guts (10 guts per month) were analysed to study stomach contents of MdfI. Out of the 120 guts, 75 (62.5%) were found empty while 45 (37.5%) contained food items. Moreover, stomach fullness scale to deduce the feeding index of *M. dayanum* revealed higher values on scale 3 (12.5%) followed by scale 2 (11.66%) and scale 1 (10.83%).

On the basis of IOP (Index of preponderance), stomach contents of MdfI indicated predominance of detritus (55.0%) followed by Algae (30.02%), Sand (4.72%), Insects (3.78%), Macrophytes (2.52%), Molluscs (1.51%), Annelids (1.32%), Unidentified matter (0.64%), Rotifers (0.35%) and Cladocerans (0.08%).

MdfII (Table 2 & 3): Of the total 120 guts analysed, 61 (50.83%) were found empty and 59 (49.11%) contained food. Moreover, stomach fullness scale revealed higher values on scale 3 (15.83%) followed by scale 4 (11.66%), scale 2 (8.33%) in the present study.

Stomach contents of MdfII indicated detritus (70.03%) as predominant food on the basis of IOP followed by algae (13.52%), Insects (8.54%), Annelids (2.26%), Sand (2.1%), Macrophytes (1.11%), Molluscs (0.96%), Cladocerans (0.57%), Rotifers (0.49%) and Unidentified matter (0.37%) respectively.

MdfIII (Table 2 & 3): Out of the total 120 guts analysed, 36 (30.0%) were found empty while 84 (70.0%) were found filled with different food items. Stomach fullness scale reveals higher values on scale 5 (24.16%) and scale 4 (15.83%) in this group.

Stomach contents of MdfIII showed higher prevalence of detritus (73.82%) on basis of IOP. This was followed by Insects (9.5%), Algae (5.89%), Sand/mud (5.68%), Annelids (1.94%), Molluscs (1.38), Cladocerans (0.78%), Macrophytes (0.55%), Unidentified matter (0.4%). No rotifers were noticed in the guts of MdfIII during the study period.

MdfIV (Table 2 & 3): Of the 120 guts analysed, 42 (35%) were found to be empty and only 78 (65%) contained food. Stomach fullness scale revealed higher values on scale 4 (15.83%) followed by scale 5 (15.0%) and scale 2 (13.33%).

Stomach contents of MdfIV showed pre-eminence of detritus (75.45%) on basis of IOP, which was subsequently followed by Insects (12.30%), Algae (6.48%), sand/mud (5.23%), Unidentifiable matter (0.5%), Annelids (0.21%), Molluscs (0.09%), Crustaceans (0.07%), Macrophytes (0.05%) and Rotifers which comprised negligible proportion of the food (0.004%) during the study period.

Studies on the role of feeding in the functional aspects of species prove viable tool for the evaluation of structure and functioning of ecosystems. Appraisal of table 3 suggests omnivore nature of *M. dayanum* in general and detritivore in particular since detritus comprised chiefly about 68.59% of food followed by algae (13.97%) and insects (8.53%). Many workers [7, 19] reported that the decapod crustaceans are usually opportunistic omnivores, obtaining their food from the bottom of their habitats or from the fauna associated with submerged and shore vegetation in water bodies, they eat just about anything that comes in their way. Freshwater prawns in general are observed to be omnivores. Similar observations have been made for other related species viz. *M. malcolmsonii* [20] and *M. affinis* [21]. Some workers [8, 9, 10, 11, 22, 23, 24] have propounded that decapods diet comprise different food items, wherein detritus forms an important and quite common component. *M. dayanum* (MdfIII and MdfIV) seems to be energy maximizers selecting the food on the basis of energy contents. A similar dietary shift has been reported for *Palaemonetes argentines* [17] and Crabs [25, 26]. In general, it was observed that small but abundant micro-crustaceans, such as rotifers, cladocerans and copepods constitute a minor part of prawn food. Zooplankton however, may play an important nutritional role in some stages of crustacean life cycle [27].

Observation of table 2 indicates that out of total 480 specimens analysed, 214 (44.58%) stomachs were empty and only 266 (55.41%) stomachs contained food items. Comprehensive review of tables 2 & 3 reveals that empty stomachs decrease in number with an increase in size being greater (62.5%) for MdfI followed by MdfII (50.83%), MdfIII (30.0%) and for MdfIV (35.0%). Although detritus was the main food component, its bulk increased with an increase in the size of the prawn. Smaller food components such as algae and rotifers were observed to show a declining trend as age/size of the animal increased and consequently size of prey increased with an increase in the size of prawn. Collins (1999) [17] also recorded similar observation and attributed the same to be due to the size and rigidity of the mouth parts. Cladocerans and insect larvae (mainly chironomids) however, showed a marked increase in the composition of food vis-à-vis increase in age, the increment of insect component being significantly higher than cladoceran component. Macrophytes constituted a large proportion of stomach content (Table-3), which is apparently due to their ready availability in the habitat since small larvae were mostly attached to the macrophytes of littoral benthic community. It was further observed that as the size and age of prawn increased, the animal's stomach revealed a decline in macrophytes element mainly because of the reason that with advancing age the animal tends to occupy the benthic region. Algae and detritus formed the major food component throughout the year in all size groups where as other food items recorded irregular pattern of fluctuations with respect to the seasons and size groups of *Macrobrachium dayanum*. Comparison of MdfIII (adult males) with MdfIV (adult females) shows that number of empty stomachs were less in male than female thus revealing higher feeding activity of males as compared to females. This feature may be attributed to the fact that during the breeding seasons of prawns which extends from February to May and August to September more number of females were found with empty stomachs than male (Table 2). Further, empty stomachs were commonly found in summer (May-July) and winter (December-February). Similar results were placed on record [28] for *Acetes intermedius* wherein 65.0% empty stomachs were recorded in summer and 58.8% empty stomachs in fall. The present studies do not comply with certain findings where all filled stomachs were in *P. argentines* [17] and in some cases only 3 empty stomachs out of 102 analysed stomachs in case of *M. acanthurus* [10, 11]. Stomach fullness scale (Table 2) also varied among sexes and diverse size groups. While as in MdfI maximum numbers of stomachs were found to occur on scale 3 followed by 2 and 1, in MdfII it followed 3, 4 and 2, in MdfIII scale 5, 4 and 1 and in MdfIV scale 4, 5 and 2. In general it was observed that the stomach fullness scale for the 480 specimens analysed, 3, 4 and 5 scale dominated. High categories of stomach fullness (3, 4 and 5) as recorded during the present investigation are in accordance with some workers [17, 29].

Present studies revealed *M. dayanum* to be an omnivore feeding on both plant and animal matter. If detritus part is kept aside, the animal and plant matter seems to be almost equal. Table 4 indicates that in all the size groups the value of RLG (Relative length of the gut) was less than 1, thus suggesting its tendency towards carnivory. Similar results have been reported by several authors [30, 31] who opined that the gut length of animal depends upon the nature of food they consume, and the length progressively increases with increasing proportions of vegetable/plant matter in the diet. Laboratory observations (wherein a variety of plant and animal origin food were offered) during the present study period also revealed that *M. dayanum* showed strong preference for soft bodied prey items such as annelids and chironomids which being soft bodied were easily digestible and also provide better nutrition with very less effort on the part of predator.

Although food preferences deliberated so far reveal detriti-omnivorous nature of *M. dayanum* which is in stark contrast to the RLG values (Table 4) that suggest detriti-carnivory nature of the said prawn. A number of other workers have also reported that prawns prefer animal food as compared to algae and other plant material [32, 33]. Preference for animal food could be related to taste preference and to the relative ease of food that can be triturated by the gastric armature, processed by the 'filter-press' and digested by the hepatopancreas [23]. Owing to differential values of RLG and food preferences recorded during the current study, it is felt that till more elaborate studies are made on this aspect of prawn it would be

apt to place *M. dayanum* in detriti-omnivore category.

As is evident from the table 3, organic detritus (as unidentified debris) appeared quite regularly in the diet of prawn throughout the year and in different size groups although its utilization as food source seems to be important to maturing prawn when it leads a benthic existence. Besides detritus component recorded an increase with the size of prawn. Particulate detritus is known to serve as a substrate for microorganisms like bacteria, fungi and protozoa. These microorganisms are probably more important as food than the substrate [34, 35]. Organic detritus was readily consumed when other preferred food items were less available. Some workers [36, 37] mentioned that decapod crustaceans are omnivorous and detritivorous. *Acetes paraguayensis* was reported as omnivorous feeding mainly on members of littoral benthic and lotic communities [29]. We also get support from the studies on the feeding habits and food of in case of *M. acanthurus* [10]; *M. lamarrei* [38]; *M. vollenhovenii* [39] and *M. carcinus* [13] which were found to be omnivorous in their feeding habits.

Table 1: List of the food items recorded during study period (A) Gho-Manhasa Stream (B) Gut of *M. dayanum.*

Food items	A	B	Food items	A	B	Food items	A	B
ALGAE			*Polyarthra* sp.	+	+	**ARTHROPODA**		
Cyanophyceae			*Lecane* sp.	+	-	**Odonata**		
Oscillatoria sp.	+	+	*Filinia* sp.	+	+	*Anax* sp.	-	-
Spirulina sp.	+	+	*Monostyla* sp.	-	-			
						Diptera		
Euchlorophyceae			**ANNELIDA**			*Tabanus* sp.	-	-
Volvox sp.	+	+	*Tubifex* sp.	+	+	*Chironomus* sp.	+	+
			Lumbriculus sp.	+	+	*Forcipomyia* sp.	+	-
Zygophyceae						*Tipula* sp.	-	-
Zygnema sp.	+	+	**CRUSTACEA**					
Cosmarium sp.	-	-	**Cladocera**			**MOLLUSCA**		
Spirogyra sp.	+	+	*Daphnia* sp.	+	-	**Gastropoda**		
			Moina sp.	+	-	*Lymnea* sp.	+	-
Bacillariophyceae			*Ceriodaphnia* sp.	+	-	*Gyralus* sp.	+	-
Navicula sp.	+	+	*Simocephalus* sp.	+	-	*Pelecypoda* sp.	+	-
Cymbella sp.	+	+	*Bosmina* sp.	+	+	*Uniomerus* sp.	-	-
Fragillaria sp.	+	-	*Alona* sp.	+	+			
Diatoma sp.	+	+	*Chydorus* sp.	-	+	**VEGETAL REMAINS**	+	+
			Leydigia sp.	-	-			
Ulithricophyceae			*Macrothrix* sp.	-	-	**SAND**	+	+
Ulothrix sp.	+	+						
Microsporas sp.	+	-	**Copepoda**			**UNIDENTIFIED MATTER**	+	+
			Mesocyclops sp.	+	+			
Euglenophyceae			*Cyclops* sp.	+	-			
Euglena sp.	+	-	*Diaptomus* sp.	+	-			
Phacus sp.	+	+						
			Ostracoda					
ROTIFERA			*Cypris* sp.	+	+			
Brachionus sp.	+	+	*Stenocypris* sp.	+	-			
Keratella sp.	+	+						

Table 2: Number of empty guts and stomach fullness scale of *M. dayanum* observed during the study period.

Parameters	MdfI N = 120; Empty = 75		MdfII N = 120; Empty = 61		MdfIII N = 120; Empty = 36		MdfIV N = 120; Empty = 42		Mean N = 480; Empty = 214	
	N	%O	N	%O	N	%O	N	%O	N	%O
No. of empty guts	75	62.5	61	50.83	36	30.0	42	35.0	214	44.58
Total no. of guts with food	45	37.5	59	49.11	84	70.0	78	65.0	266	55.41
Stomach fullness scale										
1	13	10.83	8	6.6	16	13.33	10	8.33	47	9.79
2	14	11.66	10	8.33	8	6.66	16	13.33	48	10.0
3	15	12.5	19	15.83	12	10.0	15	12.5	61	12.70
4	3	2.5	14	11.66	19	15.83	19	15.83	55	1.45
5	0	0	8	6.6	29	24.16	18	15.0	55	11.45

Table 3: Percentage volume (%V), Frequency of occurrence (%) and Index of preponderance of the food items in the guts of *M. dayanum* analysed during the study period.

Items	MdfI N = 120; Empty = 75			MdfII N = 120; Empty = 61			MdfIII N = 120; Empty = 36			MdfIV N = 120; Empty = 42			Mean N = 480; Empty = 214		
	Vol.%	%O	IOP	Vol.%	%O	IOP	Vol.%	%O	IOP	Vol.%	%O	IOP	Vol.%	%O	IOP
Algae	24.54	75.50	**30.02**	16.83	45.57	**13.52**	9.33	39.28	**5.89**	10.58	38.46	**6.48**	15.32	49.70	**13.97**
Rotifera	2.0	11.11	**0.35**	3.33	8.47	**0.49**	0.00	0.00	**0**	0.58	0.51	**0.004**	1.47	5.02	**0.21**
Cladocera	0.75	6.66	**0.08**	2.41	13.55	**0.57**	3.75	13.09	**0.78**	3.75	1.28	**0.07**	2.66	8.64	**0.37**
Mollusca	1.91	48.8	**1.51**	3.58	15.25	**0.96**	5.16	16.66	**1.38**	3.75	1.53	**0.09**	3.60	20.56	**0.98**
Annelida	3.91	20.8	**1.32**	6.33	20.3	**2.26**	7.83	15.47	**1.94**	5.83	2.3	**0.21**	5.97	14.71	**1.43**
Insecta	8.79	26.6	**3.78**	11.0	44.06	**8.54**	12.41	47.61	**9.5**	13.41	57.6	**12.3**	11.40	43.96	**8.53**
Macrophytes	7.5	20.8	**2.52**	3.75	16.94	**1.11**	2.91	11.90	**0.55**	2.25	1.41	**0.05**	4.10	12.34	**1.03**
Unidentified Matter	2.0	20.0	**0.64**	1.25	16.94	**0.37**	1.75	14.28	**0.4**	2.25	1.53	**0.5**	1.81	13.18	**0.48**
Sand	7.29	40.0	**4.72**	6.41	18.64	**2.1**	6.75	52.38	**5.68**	6.25	52.56	**5.23**	6.67	40.89	**4.43**
Detritus	41.29	82.2	**55**	45.08	88.13	**70.03**	50.08	91.66	**73.82**	51.33	92.3	**75.45**	46.94	88.57	**68.59**

Table 4: Relative Length of the Gut of *M. dayanum*.

S. No.	Size Group	Average RLG
1.	MdfI	0.66±0.02
2.	MdfII	0.78±0.03
3.	MdfIII	0.87±0.03
4.	MdfIV	0.89±0.05

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