VOLUME 10 ISSUE 1 2024

ISSN 2454 – 3055

INTERNATIONAL JOURNAL OF ZOOLOGICAL INVESTIGATIONS

Forum for Biological and Environmental Sciences

Published by Saran Publications, India

International Journal of Zoological Investigations Vol. 10, No. 1, 656-667 (2024)

International Journal of Zoological Investigations
Contents available at Journals Home Page: www.ijzi.net
Editor-in-Chief: Prof. Ajai Kumar Srivastav
Published by: Saran Publications, Gorakhpur, India

ISSN: 2454-3055

Food and Feeding Habits of the Juvenile Mud Crab *Scylla serrata* (Forskal) from the Backwaters of Kalingapatnam Coast in Srikakulam Dist. of Andhra Pradesh, India

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Received: 14th November, 2023; **Accepted:** 22nd January, 2024; **Published online:** 2nd May, 2024

https://doi.org/10.33745/ijzi.2024.v10i01.070

Abstract: The present study was conducted to enquire the food and feeding habits of the juvenile mud crab, *Scylla serrata* (Forskal) which are caught by unbaited gears, from the back waters of Kalingapatnam coast, India. The mud crab, *S. serrata* is an economically important crustacean inhabiting the back waters of the Kalingapatnam coast in Srikakulam Dist. of Andhra Pradesh, India which lies on84.4^0 long. and 18.3^{0}latt. The stomach contents of crabs irrespective of size and sex were analyzed to identify the food contents. It was found that highest percentage of crustacean food item was found and it is followed by molluscs, polychaetes and fish flesh. Debris and sediments were also observed in a countable per cent, unidentified stomach contents and plant materials form very low per cent of the total food material. Juveniles were found as active feeders, while there was no variation in feeding habit among male and female. Although this species is omnivorous feeder but prefer to feed on single food item. Monthly samples were also studied to enquire that there is any seasonal variation in the food items. Irrespective of sex, intensity of feeding index was registered with high values in winter, as the water transparency and aggregation of prey increased. Reports on food and feeding behavior of mud crab *S. serrata* from coastal Andhra Pradesh are meager.

Keywords: *Scylla serrata*, Juvenile, Food and feeding habits, Crustacean

Citation: Pappu Kirankumar and Kumar Kalyan B.: Food and Feeding habits of the Juvenile mud crab *Scylla serrata* (Forskal) from the backwaters of Kalingapatnam Coast in Srikakulam dist. of Andhra Pradesh, India. Intern. J. Zool. Invest. 10(1): 656-667, 2024.

https://doi.org/10.33745/ijzi.2024.v10i01.070

Introduction

Andhra Pradesh State (India) is having a coastal area of nearly 720 kms, which includes estuaries, backwaters, mangroves, lagoons and rich resources of aquatic organisms among which the mud crabs are unique (Pappu, 2009). *S. serrata* is common in the mud flats of the littoral, parts of the supralittoral and the intertidal zones of the Bay of Bengal (Pappu, 2009). The species hardly

occurs in sandy and rocky areas. Though these crabs seem to prefer mangrove swamps, they exist in large numbers in shrimp ponds and in the burrows of the peripheral dykes. They are essentially euryhaline, but die beyond 70 ppt. *S. serrata* rarely tolerate turbid waters (Khan and Alam, 1991).Knowledge of the dietary habits of a species is essential for understanding its nutritional requirements and thus its interactions with other groups of animals (Jose, 2011).Crabs occupy different niches and inhabit many different habitats in a variety of geographical areas, this is reflected in the variety of food consumed by them (Chande *et al*., 1999; Dahdouh Guebas *et al*., 1999; Kyomo, 1999; Bryceson and Massinga, 2002). Viswanathan and Raffi (2015) reported on the natural diet of the mud crab *Scylla olivacea* in Pichavaram mangroves of India. Food and feeding habits of blue swimming crab *Portunus segnis* was studied by Safaie (2016) in the northern coastal waters of Iran. Sodamola *et al*. (2016) worked on Food and feeding habits of freshwater crabs.

The knowledge of food and feeding habits are of fundamental importance in understanding its growth rate, gonad maturity and fecundity. Moreover, the nature of the food contents and its availability is also important as food plays an important role in the growth, sexual maturity, and several other factors by which we can easily determine the growth patterns of the organism and as a result can develop the methods for proper conservation. The magnitude of fish stocks in a region is a function of its food potentialities. The food is an important factor in the biology of an organism to estimate and evaluate their growth, fecundity, availability and migratory moments. Hence, the knowledge about the relationship between the organism and the food is essential for the prediction and exploitation of their stocks.

Aspects related to the food and feeding habits of the mud crabs were studied by several scientists. Du Plessis (1971) gave a preliminary investigation into the morphological characteristics, feeding, growth, reproduction and larval rearing of *S. serrata*. Anon (1975) gave notes on the food preferences of *S. serrata* (Forskal). Hill (1976) studied on the natural food, foregut clearance and activity of the crab *S. serrata.* Barker and Gibson (1978) described the mouthparts, histology of the alimentary tract and digestive physiology of the mud crab *S. serrata.* Hyslop (1980) made a review of methods and their application regarding stomach content analysis. The feeding habits of *S. serrata* were observed in the Cochin backwaters by Kathirvel (I981), Karwar waters was observed by Prasad and Neelakantan (1988) and Jayamanne (1992) on the Ennore estuary. Joel and Sanjeevaraj (1986) worked on the food and feeding of the two species of *Scylla* spp. Jayamanne and Jinadasa (1991) reported the food and feeding habits of the mud crab, *S. serrata* (Forskal) inhabiting the west coast of Sri Lanka. Micheli (1993) gave feeding ecology of mangrove crabs in Northern Eastern Australia. Millamena and Quinitio (2000) described the effects of diets on the reproductive performance in mud crabs. Pappu *et al*. (2008 a, b) made observations on the food and feeding habits of mud crab *S. tranquebarica*. Jose (2011) analyzed the food and feeding of the blue swimmer crab, *P. pelagicus*. Mamun *et al.* (2008) worked on the food and feeding habits of mud crab *S. serrata*. Ahmed *et al*. (2018) investigated the food and feeding habits of the blue crab, *Callinectes sapidus*.

Knowledge of feeding regimes of species is of great importance in understanding their ecological interaction (Safaie, 2016). The need of information on the food and feeding habits of *S. serrata* from the East coast of India has been greatly felt, since the available knowledge is limited and there are meager reports on the food and feeding habits. The aspects of food and feeding, of *S . serrata* has thus been chosen as the subject matter for the present study.

For years Kalingapatnam coast has been the potential fishing ground for *S. serrata* in India. Despite its importance in these fisheries, there is no information on the diet and preferred food items of the species from this area. Recently, this crab was identified to be the suitable species for

aquaculture. Hence, the present study has been undertaken to investigate the food and feeding habits of *S. serrata* from the back water region of Kalingapatnam. The results of this study may be useful for developing successful farming techniques for this species in the future.

Materials and Methods

The sampling for study on the Food and feeding habits took place from the back waters of Kalingapatnam coast during January 2022 - December 2022 (1 year) and the variations in food varieties from the stomach contents were analyzed, the data on the food and feeding habits was recorded to elevate the difference in food contents of juveniles. The seasonal variations in the food contents, intensity of feeding and monthly variations in the feeding habits were analyzed. The most occurring important item in the food, quality and quantity of food depending upon the season was also mentioned. Samples for the present study were collected from the local fisher men who caught this species by using unbaited gears which are collected by them in the night time and these samples were analyzed for the diet variation.

For analyzing the difference in the stomach contents of above collected samples, the sample specimens were collected from the fisher men twice a month during night time 3-4 h after placing the gear. Basing on all the above data collected, the seasonal variation in the diet and stomach contents was worked out. Soft-shelled or newly moulted, inactive crabs and also those that have lost cheliped and walking legs were not examined for the present analysis. Thus only normal/hard shelled crabs were selected. Nearly 36 specimens were analyzed from the selected study station for the food and feeding habits.

After recording the morphometric data, the captured specimens were killed immediately by keeping them in 70% alcohol (Stefano *et al*., 1996). It is because usually, in the decapod crustaceans the food will be digested with in 3 h of ingestion. Stomach is fully emptied after approximately 12 h (Joll, 1982; Sarda and Valladares, 1990). Dissection was done from the dorsolateral margin through the 'front' carapace which was then lifted anteriorly to expose the inner organs. By cutting the epithelium of the foregut the stomach contents were exposed. The stomach contents were removed carefully with the help of a fine forceps (Joel, 1992). A visual estimation of the fullness of the stomach was made immediately after the removal of stomach and the scoring was from 1-5 according to the degree of fullness, i.e. about full, 3/4 full, 1/2 full, 1/4 full, 0% empty and the points were allotted as 100, 75, 50, 25, and 0, respectively (Shanti and Manjulatha, 2008). The categories used in classifying the stomach contents were Molluscans, Crustaceans, Polychaete, Fish remnants, Leaf litter, Mud/Debris and the remaining was considered as digested or unidentified food particles. All the stomachs were subsequently opened and their contents were washed with alcohol into Petri dish and examined under a binocular microscope. The percentage occurrence of different food items was determined from the total number of occurrence of all items in each month. To evaluate the importance of each food item, the AIndex of preponderance@ proposed by Natarajan and Jhingran (1961) was followed. The monthly averages obtained by Volumetric and Occurrence methods were substituted in the following formula and the AIndex of preponderance@ values were calculated as:

$$I = (100^{*} V^{*} O) / \text{Sum of } (V^{*} O).$$

Where I is the Index of Preponderance of food items, V and O are its percentage of volume and occurrence, respectively. The specimens present in the present investigation with stomachs classified as full, 3/4full, were considered as actively fed, crabs with 1/2 full stomachs were considered as average feeding and those under the category of 1/4 full and empty were considered to be poorly fed.

Results

Crabs include omnivores, filter feeders, detritus

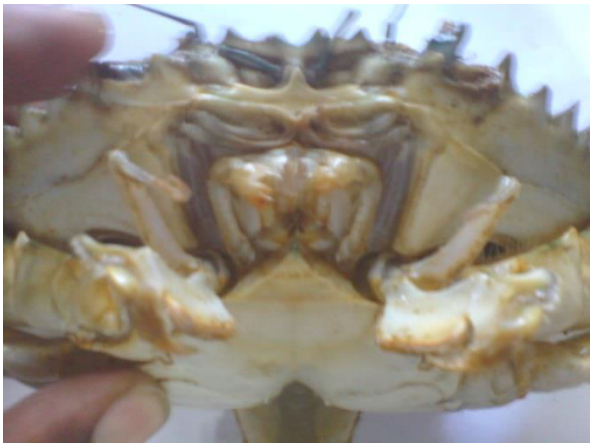

Fig. 1: *Scylla serrata* mouth parts.

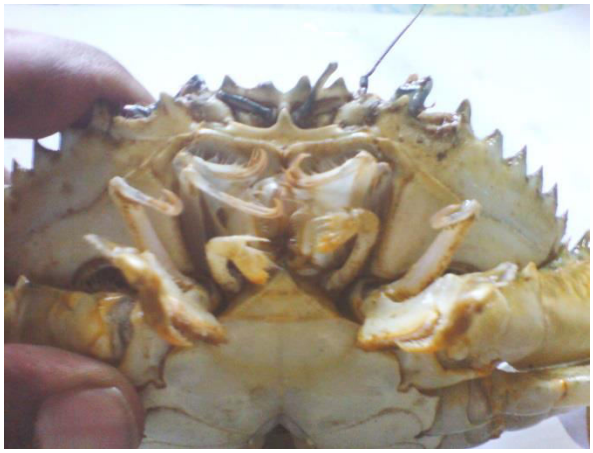

Fig. 2: *Scylla serrata* mouth parts.

feeders, plants and carrion feeders, scavengers and predators and many of them use more than one method of feeding and various sources of food (Sastry, 1983).

The mud crab *S. serrata* is an omnivore, scavenger, bottom feeder and cannibalism is also observed. It mostly feeds on slow moving and sessile invertebrates, crustaceans, polychaete, decayed fish and other aquatic organisms. Small aquatic weeds, leaves, mud, debris, which form very small per cent of the diet and algae is also consumed. As the food items are cut into very minute pieces by the gastric mills (Figs. 1, 2), they are difficult to be identified up to the lower taxonomic level, and due to mutilation and advanced stage of digestion most amount of food is not possible to be identified, so the present identification of the stomach contents, as far as possible, were made up to the Phylum level. Mud and debris was also considered as food item because this form some percentage of food content, as these consume the mud in the burrows, and this item is also seen in stomachs of all forming, nearly 1-3% of the food content.

The classification of the identified food matter is done up to the level of the Phylum and they are indicated as follows:

- M - Molluscans
- C - Crustaceans
- P - Polycheate
- F - Fish remnants
- L - Leaf litter
- M/D - Mud/ Debris

- U - Unidentified matter

The fullness of the stomach is represented as follows:

- ST - Stomach fullness
- 100 - Full
- 75 - 3/4 Full
- 50 - 1/2 Full
- 25 - 1/4 Full
- 0 - Empty

There is as yet no established methodology for the quantitative description of gut contents in crustaceans that feed on macroscopic food items. Several studies of foregut contents have used the percentage occurrence of food types as the only measure of relative intake of different food items (Donaldson, 1975; Hill, 1976; Williams, 1982; Dahdouh-Guebas *et al*., 1999). Other studies have used the point's method (Hynes, 1950; Hyslop, 1980), in which each food category is awarded points proportional to its estimated contribution to stomach volume, taking into account the size and abundance of the food item. All these methods lead to some sort of confusion relating to the food taken and the fullness of the stomach. The important food item mostly occurring, intensity of feeding based on the original fullness of the stomach is quiet difficult and confusing to estimate. So the present method of the AIndex of preponderance@ proposed by Natarajan and Jhingran (1961) was followed which gives the idea of volume and the occurrences of the food items, respectively, by which the intensity of the feeding of the organism can be given. The crabs observed during the present study are reported mainly omnivores, scavengers, opportunistic feeders, and bottom feeders, filter feeders, preying on slow-moving invertebrates such as molluscs, crustaceans and polychaete. The analysis of the stomach contents revealed that the food item of juvenile mud crabs mainly includes crustaceans as the major and important food item.

But crabs prefer moving items than sessile organisms and plants. The mud and debris particles are due to the bottom feeding habit taking bottom mud and sand particles along with decaying organic matter and shoots. Mud particles are observed more during winter season. The unidentified food material is in more proportion due to advanced digestion. The molluscans are identified by their shell; the crustaceans are identified by the presence of the shell and some appendages of crabs; juvenile and newly molted inactive crabs remnants are observed more in this group of food item; the fish remnants are identified by the presence of the bones, scales and small pieces of fins; the polychaete were identified by the presence of the segments of their body, the leaf particles are identified for the green color plant tissue matter; the mud and debris is identified by the presences of its smooth texture and the granular/sand crystals in the food. The entire remaining food item is considered as the unidentified food item or semi digested and digested food particles.

The analysis and comparison revealed that the food contents were molluscans, crustaceans, fish remnants, polychaete, leaf litter, mud/debris and the remaining unidentified food matter. The monthly variations in the feeding habits are recorded. Intensity of feeding is analyzed by as fullness of the stomach contents.

Percentage frequency of food items is calculated by the per cent of that particular food item in the overall food content and on basis of percentage gained by that food item its importance is reflected. It is the stage of digestion that renders a food-item as identifiable or unidentifiable.

Analysis of stomach contents of juveniles from the estuarine area of Kalingapatnam on annual basis revealed that the food mainly include, crustaceans, forming about 26.64% of the intake, the next most occurring item is the fish remnant forming 12.35%, molluscans by 3.33% and polychaete by 1.85%, leaf litter is 3.20%, mud/debris particles are 2.42% and the remaining food item is unidentified by 50.18% on an average.

Table 1: Percentage occurrence of stomachs in various degrees of fullness of *S. serrata* juveniles from Kalingapatnam

Month	Full	¾ Full	½ Full	¼ Full	Empty
January	5	5	10	30	50
February	0	5	10	35	50
March	0	15	20	30	35
April	15	10	35	20	20
May	10	0	40	15	35
June	15	10	55	15	5
July	20	15	40	20	5
August	40	25	0	20	15
September	45	30	15	5	5
October	50	35	10	5	0
November	30	35	25	0	10
December	20	20	15	25	20

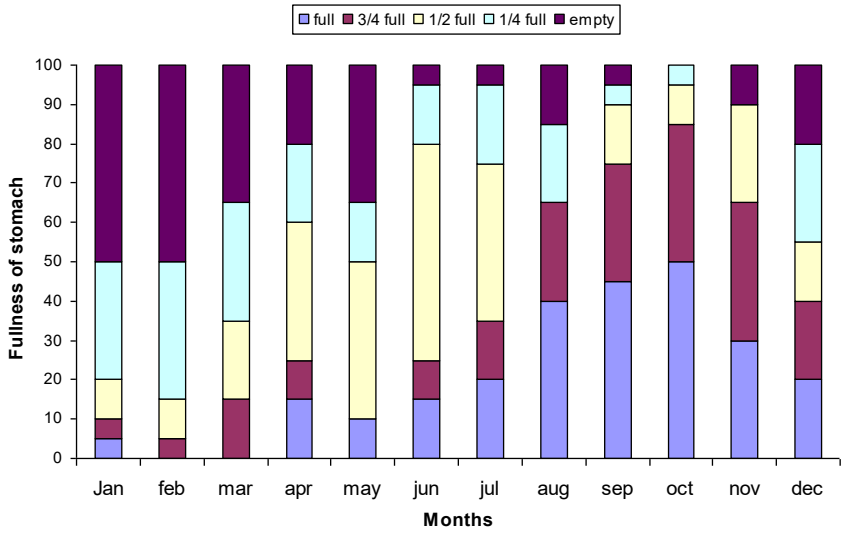

Fig. 3: Percentage occurrence of stomachs in various degrees of fullness of *S. serrata* juveniles from Kalingapatnam.

Monthly variations in feeding habits:

Crustaceans formed the main and important food item throughout the year in which small shrimps and juvenile crabs of same and different genus are dominant during December. Fish remnants are dominant during March. The occurrence of molluscans in the food item is noticed more during December. Polychaete are found more during August, leaf litter is more during February, mud particles are observed more during the months of December.

Intensity of Feeding:

Crabs with high intensity of feeding, by having more number of Full stomachs during October,

Table 2: Percentage frequency of dominant food components in *S.serrata* juveniles from Kalingapatnam

Month	Molluscans	Crustaceans	Polychaetes	Fish remnants	Leaf litter	Mud/ debris	Unidentified matter
January	4.9	29.8	0	9.2	3.7	3.9	48.5
February	4.2	25.3	1.9	16.5	4.2	4.2	43.7
March	3.9	20.2	1.5	19.8	3.3	0.5	50.8
April	3.4	19.1	0	18.3	4	1.1	54.1
May	2.5	18.5	0	14.1	3.9	1.9	59.1
June	1.9	20.5	0	15.4	3.3	2.1	56.8
July	1.7	25.1	1.7	12.3	2.8	2	54.4
August	1.5	29.9	4.1	9.9	2.4	2.8	49.4
September	2.1	34.2	3.8	10.4	3.1	1.9	44.5
October	3.9	32.3	4	7.8	3.1	1.5	47.4
November	4.8	31.9	3.1	8.3	2.1	3.2	46.6
December	5.2	32.9	2.1	6.3	2.6	4	46.9

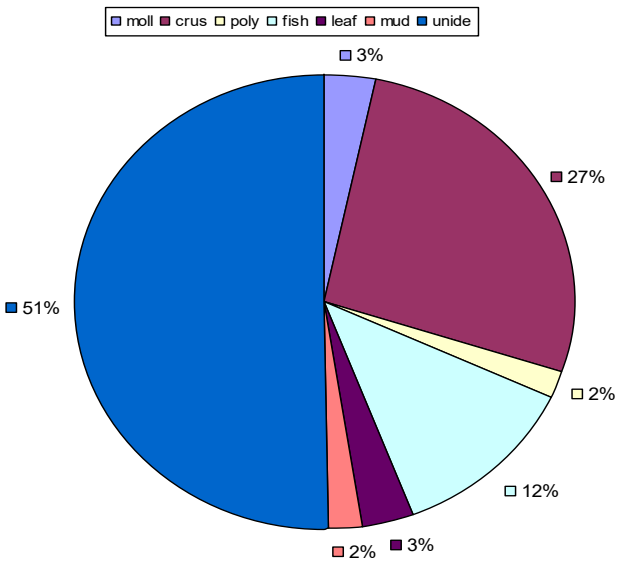

Fig. 4: Percentage frequency of dominant food components in *S. serrata* juveniles from Kalingapatnam.

3/4 full stomachs, are recorded during October and November,in these months the crabs are considered to be actively feeding. The feeding is seen average during June with more number of 1/2 full stomachs. The crabs with more 1/4 full stomachs were observed during February and empty stomachs were recorded more during the months of January and February. This period is considered as poor intensity of feeding (Tables 1, 2; Figs. 3, 4).

Percentage Frequency of Food Items (*Tables 1, 2; Figs. 3, 4*):

Crustaceans: Highest with 34.2% in September and lowest with 18.5% in May.

Molluscans: Highest with 5.2% in December and lowest with 1.5% in August.

Fish Remnants: Highest with 19.8% in March and lowest with 6.3% in December.

Polychaete: Highest with 4.1% in August and lowest with 1.5% in March.

Leaf Litter: Highest with 4.2% in February and lowest with 2.1% in November.

Mud/Debris: Highest with 4.2% in February and lowest with 0.5% in March.

Discussion

According to the present study even though mud crabs are omnivores, they are mostly carnivorous. The main food of these crabs were molluscans, fish remnants, crustaceans, polychaetes, leaf litter and mud particles. Similar findings were reported by McDermott (1960) and Meyer (1994) also they reported that crab is primarily carnivorous, consuming molluscs, crustaceans, and annelids. In the present observations it is proved that *S. serrata* is a predator, omnivore, bottom and filter feeder. The feeding behavior of *Scylla serrata* (Hill, 1976), and *S. tranquebarica (*Pappu *et al*., 2008 a, b), have shown that they are scavengers and predators, mostly on slow moving and sessile invertebrates. Hill (1976) using infrared light, studied the feeding habits and revealed that *S. serrata* waits for the sun set inside its burrow and then spends the night out with feeding. *C. arcuatus* (Paul, 1981) has shown a greater feeding activity at night, especially just after dusk. The results of the present study are also in agreement with this finding.

As a result of the present study there is an assumption that cannibalism in the mud crabs may be due to scarcity of the shelter due to the encroachment of the natural habitats and urbanization of the backwaters which results in the scarcity of the shelter for the mud crabs living near by. This is supported by Luppi *et al*. (2001). The intensity of cannibalism in crustaceans might occur for several factors including availability of refuge/shelter. substrate/ shelter preference (Pottle and Elner, 1982: Day and Lawton 1988). However, the availability of shelter has been considered the most crucial factor ejecting cannibalism in crabs (Luppi *et al*., 2001; Catacutan, 2002).

Mud crabs are nocturnal feeders, which remain buried during the day and emerging at sunset. Hill (1976) concluded that mud crab are not well adapted to capturing mobile prey. The crab feed on benthic invertebrates, which are either sessile or slow moving, and this was observed by Patel *et al*. (1979) in India. The result of the present work is similar to these findings. Their natural food consists of 50 per cent of molluscs and 21 per cent crustacean, mainly grapsid crab. Fish remains were rarely found in the foregut of mud crab. Gut clearance of organic tissues was almost completed after 12 h. Fish bones and shells are retained in the gut for 3 and 6 days, respectively. Almost similar observations are made in the present study.

From the stomach contents of crabs directly taken from the field, it was evident that animal material was the main food item in the diet of *S. serrata*, which is primarily regarded as omnivore. This species possesses strong chelae and frequently attack other crabs, fish, crustacean etc. A low percentage of algal material was also found in their stomachs. Various authors have reported that crabs accidentally ingest algae (Elner, 1981; Laughlin, 1982). At low temperatures crabs do not come outside of their burrows and may consume clay and probably opportunistic food items (Mia *et al*., 2001). The results of the present study are in agreement with this finding. The stomach contents were higher in summer than during low temperatures persisting in winter, and similar conclusions were given by Mia *et al*. (2001). Portunid crabs are reported as being mainly carnivorous, preying on slow-moving invertebrates such as mollusks and crustaceans.

Typical studies are those on *S. serrata* (Hill, 1976).

Leaf litter/Plant materials are found in the fore gut contents of *S. serrata* and it formed about 4% of the total food in an average. This might be when the crab is feeding on the macroscopic organisms attached on the shoots and roots of the plants the crabs might have ingested the plant material when there is a scarcity of food or may be just as contamination. Here too, similar case is with the observations of Chande and Mgaya, (2004).

According to the present work there was no diet difference between the male and female. Williams (1982) also reported similarity in diet between sexes and among crabs of different sizes.It was not always possible to identify all of the items in the foreguts of the crabs because of their fragmented and particularly digested nature and so broad taxonomic groups were categorized.

The frequency of crabs with empty foreguts changed throughout the year with more crabs having empty foreguts during winter and less during summer (Satish, 1986). Similar results were observed in the present findings of the foreguts of mud crab *S. serrata*.

Mud crab *S. serrata* include filter feeders, detritus feeders, plant and carrion feeders, scavengers and predators and many of them use more than one method of feeding and various sources of food similar reports were given by Sastry (1983). According to the present observations *S. serrata* have proved that they are scavengers and predators, mostly on slow-moving invertebrates, these prefer moving organisms than sessile items. Hill (1976) found that about 65% of *S. serrata* had identifiable materials, mostly gastropod remains, in their foreguts. The present findings support this study.

One would expect males with larger chelae, to have higher feeding rates and therefore higher stomach content indices than females. There has been report that there is no functional adaptation of the enlarged chelae, other than for digging larger burrows (Kyomo, 1986). Feeding rates are higher in females than in males. Males spend much time during the active period on mating behavior (e.g. digging larger burrows), and therefore less on feeding. The hypertrophied chelae are probably used also for clasping females larger than themselves during mating (Kyomo, 1986). These results are similar to the present work.

In spite of the circadian and seasonal variations found in the diets of various species of crustaceans there seems to be no differences between the sexes. Our results for female and male *S. serrata* agreeing with those observed for *Callinectes ornatus* (Haefner, 1990), *Callinectes danae* (Branco and Verani, 1997).

The ingestion of sand could have been accidental or because it was in association with organic matter where algae, bacteria and other microorganisms grow, as has been recorded for the estuarine crab.

Seasonal variations in the animal diet of *S. serrata* as reported in the present study are due to the changes in the availability of food items in different seasons throughout the year. These findings are similar to the observations made by Satish (1986).

The presence of the plant material and the mud/debris in the foregut content of the mud crab *S.serrata* is seen more during the months of December – February which is a low temperature winter season. This may be due to the scarcity of the food item during this season as the crabs might have been feeding on the mud particles and plant matters.

Finally, the results of this and other studies cited above strongly suggest that despite the diversity in their food and feeding habits, portunid crabs are opportunistic omnivores with a preference for animal food and having the behavior of active predation of sessile and slow-moving macro-invertebrates.

Conclusion

S. serrata is an opportunistic feeder, bottom feeder, filter feeder and omnivore. Juveniles feed

mostly the crustacean food. Crabs are seen actively feeding during the months of September, October and November. Average feeding in March, April, June and July, poor feeding intensity during January and February when the temperatures are low. According to the entire analysis it was proved that crabs prefer animal food than plant food. They predate moving animals than sessile organisms. Ability of catching fast moving organisms is lacking. Scavenging behavior is observed by the presence of more different varieties of animal food in the stomach contents. The variations in the food item in stomach content may be related to the presence of different types of food available in that particular environment, order of preference and requirement of food by the organism. Mud/debris and plant matter is found in food as a small percentage during all the months and this may be due to scarcity of food and a character of opportunistic feeding.

The local fauna made the important part of crab food and it is area and availability dependent. Feeding intensity is seen high the months of September and October. The diversity of the food is subjected to the preference of the animal.

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