

## Food and Feeding Habits of the Deep-Water Mud Shrimp (*Solenocera melanthero*) of Visakhapatnam Coast, India

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### Abstract

The food and feeding habits of the shrimp *Solenocera melanthero* off Visakhapatnam coast were studied qualitatively and quantitatively. Feeding intensity differs in relation to gender, size, season and stage of maturity. Detritus was the major component of the food consumed, followed by crustaceans, molluscs, foraminiferans, fish remains, eggs; sand was also found as one of the gut contents. Diet preference in males and females was similar, but varied with size and season. The index of preponderance of detritus was 50.88% in males and 47.16% in females. Variation in feeding intensity was noticed in relation to size, months and season. The overall feeding intensity in males and females was categorized as actively fed (21.52% and 40.78% respectively), moderately fed (22.07%, 19.72%) and poorly fed (14.07%, 27.03%) respectively. *S. melanthero* may designate as an omnivorous detritivore with scavenging activity.

**Keywords:** crustaceans, detritus, feeding, food, *Solenocera melanthero*

### Introduction

Food is as diverse as the feeding habits of the organisms, whereas the feeding habit is determined by the habitat. Studies on food and feeding habits are helpful to assess the growth, abundance and ultimately the fishery of a particular species (Hill and Wassenberg, 1987; Cartes, 1993). The food and feeding habits of commercially important shrimps have been carried out by many investigators, but not much information is available on *Solenocera* species, except those of Kunju (1968) on *Solenocera indica* (*S. crassicornis*), Hall (1962) on *S. alticarinata* and *S. subnuda*, Froggia and Gramitto (1987) on *S. membranacea*, Aravindakshan and Karbhari (1994) and Dineshbabu and Manissery (2009) on *S. choprai*. Li *et al.* (2016) have studied the feeding ecology of the mud shrimp *S. melanthero* in the East China Sea. On *S. melanthero* there is no study in Indian waters.

*S. melanthero* is commonly known as the deep water mud shrimp; it can be seen buried on soft bottoms at depths between 50-152 m (Holthuis, 1980) and is widely distributed in Korea, Japan, Taiwan, The Phillipines, Indonesia (Crosnier, 1984) and also on East and West coasts of India (Muthu, 1971; George, 1979). It contributes with about 7.2% to the total shrimp landings at Visakhapatnam Fishing Harbour (Maheswarudu *et al.*,

2014, 2015) and is an important source of shrimp protein in the local markets. Hence an attempt was made to study the qualitative and quantitative analysis of food and feeding intensity in relation to season, gender, size and stage of maturity of *S. melanthero* (De Man, 1907) off Visakhapatnam coast.

### Materials and Methods

Shrimp samples were collected fortnightly for a period of two years except during fishing holidays (e.g. in May). After collection, the samples were brought to the laboratory. Males and females were separated and were made into different size groups with a 5 mm class interval in both males and females. Males were grouped into 10 size groups (55-60 mm to 101-105 mm), while females were grouped into 11 classes (51-55 mm to 111-115 mm). The maturity stages of both males and females were also recorded following the method of King (1948) as immature, maturing, mature and spent. Feed composition was analyzed every month; size groups and seasons whereas feeding intensity was analyzed monthly, considering also the maturity stages.

Stomach contents of 493 males and 541 females in the length range of 54-114 mm were examined. The intensity of feeding was noted and points were assigned on the basis of the distension of the stomach. The stomach of each

specimen was removed and dried on filter paper during the analysis. The contents of the cardiac stomach were teased into a petri-dish with sufficient amount of water and examined under the microscope. It was found difficult to identify the stomach contents to species as they lost their structure due to mastication in buccal cavity by the mandibles. Therefore, the food items were categorized into molluscs, crustaceans, fish and foraminiferan remains, unidentified eggs, detritus and also sand. Detritus consisted of decomposing organic matter with mud and sand particles.

The food and feeding habits of *S. melantho* was studied by the 'points (volumetric) method' of Pillay (1952). Since the 'occurrence' or 'volumetric' method alone is inadequate to determine the importance of individual food items, both the methods were taken into consideration.

Index of preponderance was estimated by taking into considerations the volume and occurrence of food items using the following formula, as suggested by Natarajan and Jhingran (1961).

$$I_i = V_i \cdot O_i / \sum V_i \cdot O_i \times 100$$

Where,

$I_i$  = Combined index or Preponderance Index of food item  $i$

$V_i$  = Volume index of food item  $i$  (as indicated by its percentage)

$O_i$  = Occurrence index of food item  $i$  (as indicated by its percentage)

The diet composition was studied in different months, on different size groups and seasons, adopting the method of Thomas (1980) in *Penaeus semisulcatus*, Rao (1988) in *Metapenaeus monoceros* and Murthy (1991) in *Metapenaeopsis*. The method was based on the degree of distension of the stomach and the amount of food inside the stomach as 'full', '3/4 full', '1/2 full', '1/4 full', 'traces' and 'empty', assigning 100, 75, 50, 25, 10 and 0 points respectively to each intensity of feeding. For finding out feeding condition, stomachs were grouped into actively fed (full and 3/4 full stomachs), moderately fed (1/2 full) and poorly fed (1/4 full and traces). Points were given to each food item on the basis of its relative volume to the other items in the stomach. For each month, the volume (expressed as points) of each food item and its percentage (volume index) was calculated from the points assigned to each food item. Similarly, the percentage of different food items (occurrence index) was determined from the total number of occurrences of all items in each month. The food preference of the shrimps was derived from the index of preponderance. The percentage occurrence of different intensities of feeding in a month was calculated from the total number of shrimps examined in a month. Food analysis was carried out in relation to months under study interval, gender, size-groups, seasons and maturity stages.

## Results

### Diet composition

The gut contents were detritus, crustacean remains, foraminiferans, molluscs (intact/broken), fish remains, sand, eggs etc. Detritus occupied the first position in both males and females, with the index of preponderance as 50.88% and 47.1% respectively. It was followed by

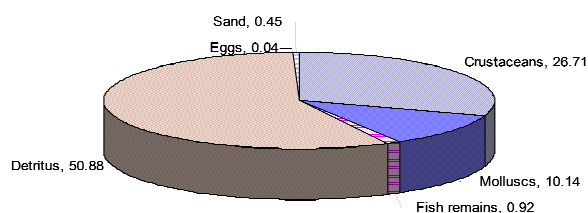


Fig. 1. Diet composition (Index of preponderance) of males of *S. melantho*

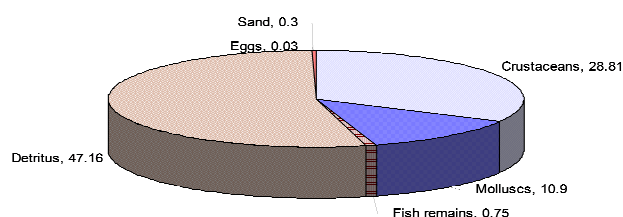


Fig. 2. Diet composition (Index of preponderance) of females of *S. melantho*

crustaceans (males with 26.71% and females with 28.81%), foraminiferans (males 10.87% and females 12.05%), molluscs (males 10.14% and females 10.90%), fish remains (males 0.92% and females 0.78%), eggs (males 0.04% and females 0.03%) and sand (males 0.45% and females 0.30%) (Figs. 1 and 2).

### Monthly variation

Detritus ranked first in all months in males and females except in August and October when it occupied the second position within males, whereas in females it was in August. In males, the crustaceans ranked first in August and October, second in December, January, March, April, July and September, third in the month of November, February and June. In females crustaceans were first ranked in August, second in December, January, March, April, June, July, September and October and on the third position in the remaining months. In males, foraminiferans occupied second position in June, third in March, July, August, September and October and fourth in the remaining months, whereas in females they were on the third position in December, March, April, June, July, August, September and October and fourth position in January, February and November. Molluscs were second dominant groups in the months of November and February, third in December, January and April and the remaining months showed the fourth position. Females ranked second in November and February months, third position in January and they occupied fourth position in the remaining months. Fish remains were represented as skeletal structures like vertebrae, spines, scales etc. Sand was also found in all the months under study in males and females although in lesser quantities. Eggs were the least encountered in the food contents, being not substantial in terms of volume (Figs. 3 and 4).

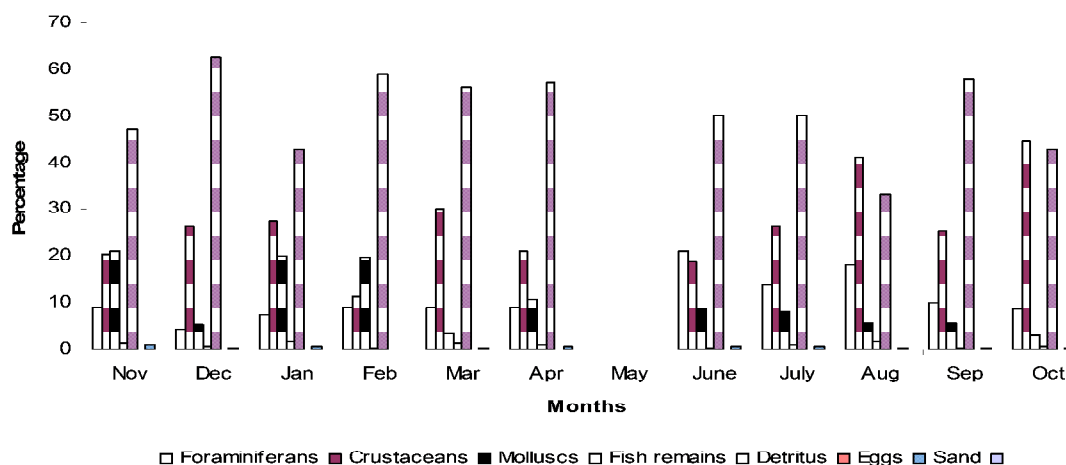


Fig. 3. Month-wise variations of diet composition in males of *S. melantho*

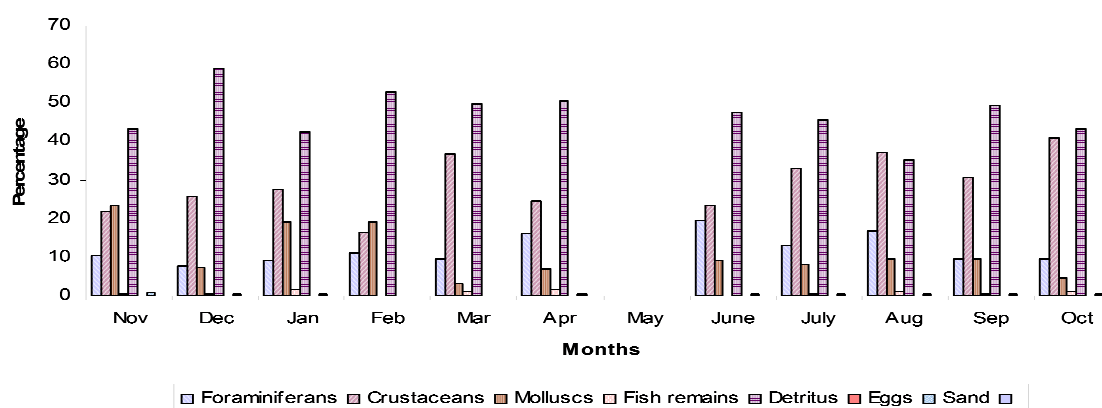


Fig. 4. Month-wise variations of diet composition in females of *S. melantho*

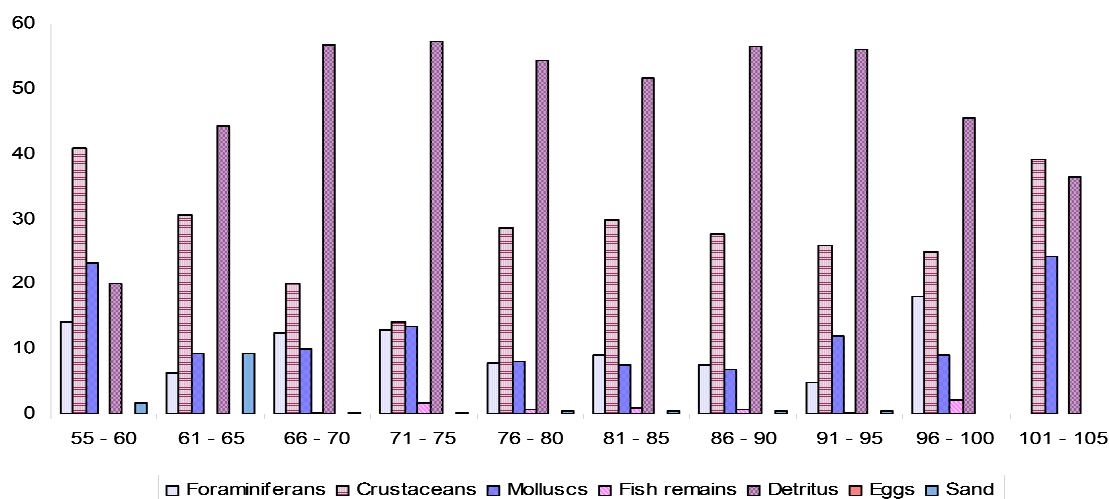


Fig. 5. Diet composition in different size-groups of males of *S. melantho*

#### Variation in different size groups

Detritus was the major component in all the size-groups of males, with an index of about 44 except in 55-60 mm and 101-105 mm size-groups, in which crustaceans were dominant with indices of 40.85 and 39.25 respectively. Crustaceans were found in large quantities in the remaining size-groups. Foraminiferans were on the third position in

the size-groups of 66-70 mm, 81-85 mm, 86-90 mm and 96-100 mm and in the remaining size-groups it occupied the fourth position. Molluscs were in the second position in the size-group of 55-60 mm, on the third position in the size-groups of 61-65 mm, 71-75 mm, 76-80 mm, 91-95 mm and 101-105 mm. They occupied the fourth position in the size-groups of 66-70 mm, 81-85 mm, 86-90 mm and 96-100

mm. Fish remains were followed by sand and eggs (Fig. 5).

Detritus was the major diet in all size-groups of females with highest index value of 57.47 in 106-110 mm and the lowest of 35.34 in 71-75 mm group. In the size-group of 66-70 mm crustaceans were dominant with an index of 39.15. Foraminiferans were on the second position in 51-55 mm size-group with an index of 23.16. Foraminiferans were also dominant with third position in the size-groups of 66-70 mm, 86-90 mm, 91-95 mm, 96-100 mm with indices of 17.00, 11.91, 8.88 and 12.88 respectively, fourth in the size-groups of 71-75 mm, 76-80 mm, 81-85 mm, 101-105 mm, 106-110 mm and 111-115 mm size-groups with indices of 10.02, 11.47, 12.22, 5.17, 6.88 and 8.74. In the size groups of 71-75 mm, 76-80 mm, 81-85 mm, 101-105 mm, 106-110 mm and 111-115 mm, molluscs occupied the third position and the fourth in the remaining size-groups. They were followed by fish remains, sand and eggs in all of the size-groups (Fig. 6).

#### Seasonal variation

Detritus was dominant in males in all seasons with indices of 48.91, 57.49 and 47.88 in winter, summer and rainy season respectively. Crustaceans were on the second position with an index of 29.76 in winter, 20.92 in summer and 28.00 in rainy season. Molluscs occupied the third position in winter (12.36) and summer (11.23) except in rainy season (7.11) when that position was occupied by foraminiferans (15.67). Foraminiferans, fish remains, sand

and eggs were in the order of abundance in all the seasons. Also among females, the same order of index of preponderance of diet was observed. Detritus was the major diet in all seasons. Crustaceans stood second with indices of 46.93 in winter, 51.13 in summer and 44.38 in rainy seasons. Foraminiferans were on the third position in summer with an index of 12.22 and in rainy season with 14.73. Molluscs ranked third in winter with an index of 13.58. Fish remains, sand and eggs were next in the order of abundance in the diet (Fig. 7).

#### Feeding intensity - Monthly variation

Different intensity of feeding in different months was noticed. Within males, the actively fed were found in the months of January (45.09%) and the lowest was noted in June (3.85%). Moderately fed were found in October with 28.78% and lowest in February (13.04%). Poorly fed stomachs were recorded in June (69.23%) and lowest in January (25.49%). Empty stomachs were present throughout the year with high occurrence in August (22.22%) and low in July (6.66%) (Fig. 8). In case of females, the actively fed were found in January (52.62%) and low in June (22.86%). Moderately fed were more in February (28.57%) and had low values in March (11.90%). Poorly fed were more in March (40.47%) and low in January (15.79%). Empty stomachs were found in all the months with higher values in April (17.24%) and lower in January (3.51%) (Fig. 9).

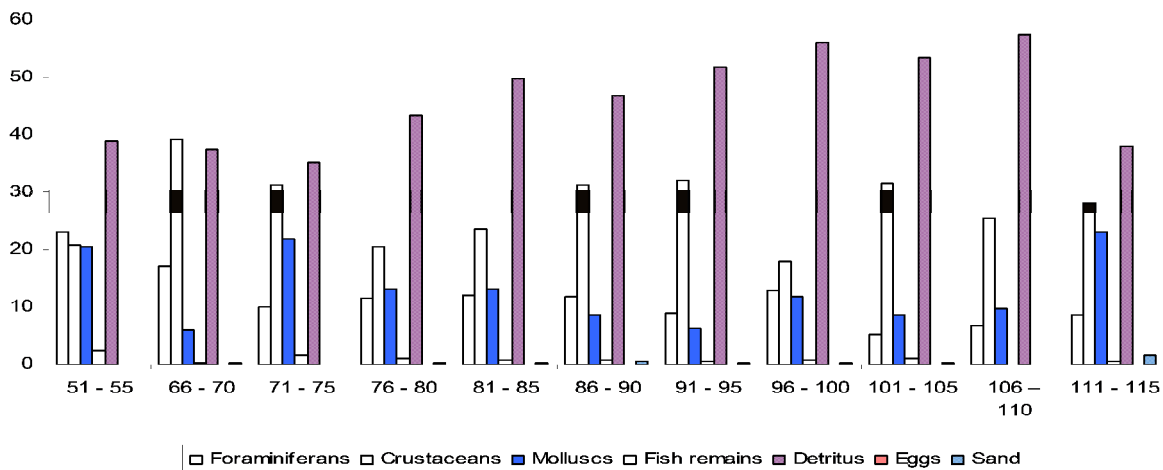


Fig. 6. Diet composition in different size-groups of females of *S. melantho*

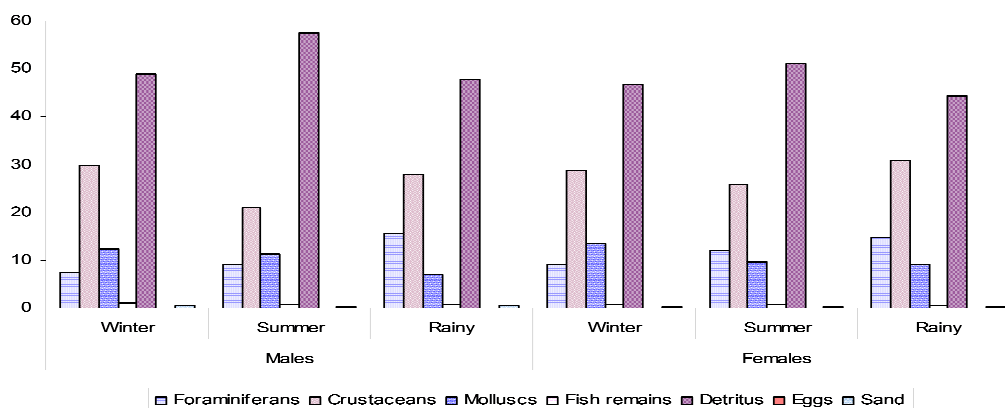


Fig. 7. Diet composition of males and females of *S. melantho* in different seasons



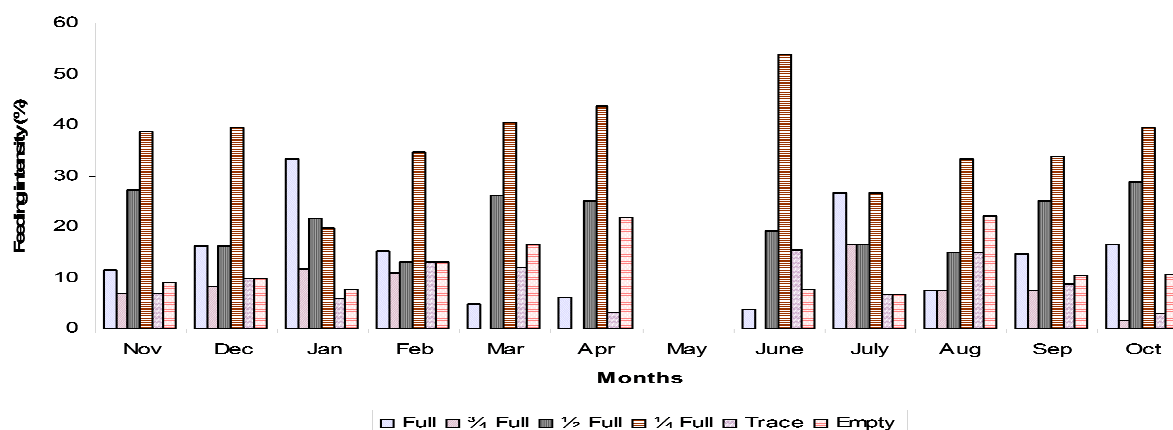


Fig. 8. Month-wise feeding intensity in males of *S. melantho*

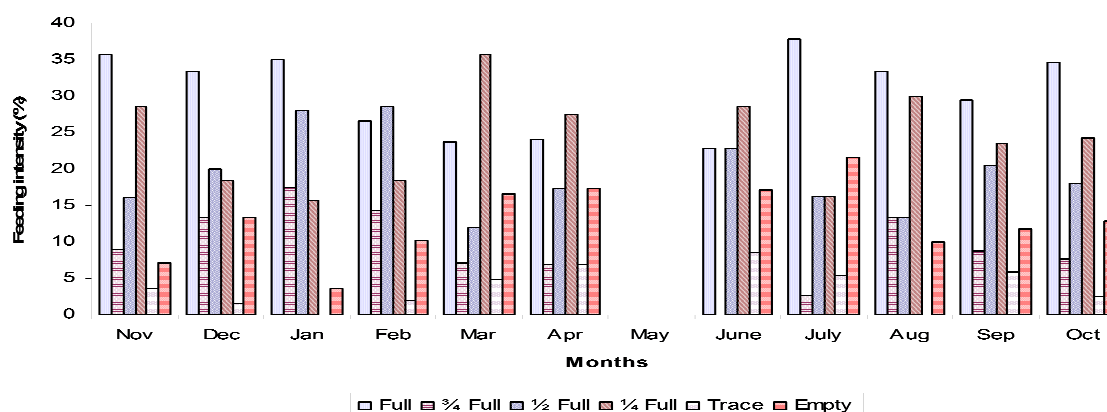


Fig. 9. Month-wise feeding intensity in females of *S. melantho*

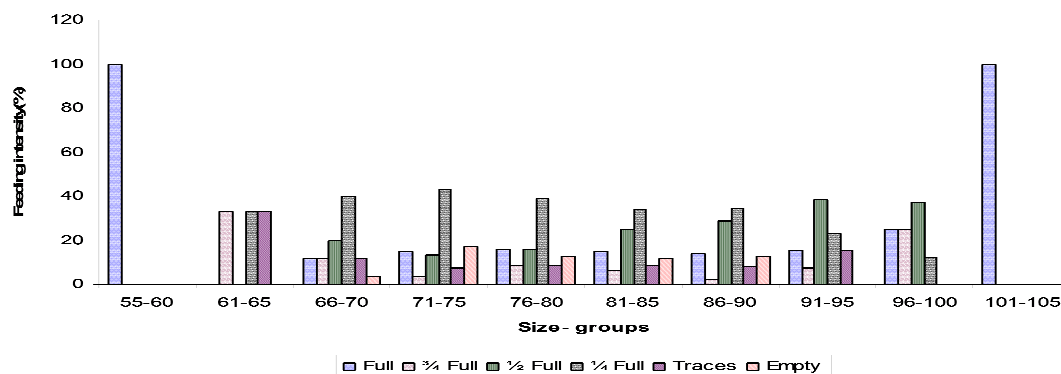


Fig. 10. Feeding intensity in different size-groups of males of *S. melantho*

#### Variation in different size-groups

In males the more actively fed shrimps were recorded in 55-60 mm and 101-105 mm, followed by 96-100 mm, 61-65 mm size-groups, while the others showed normal levels. Moderately fed groups increased with increase in the size of the shrimps. Poorly fed shrimps were found in 61-65 mm size group. Feeding intensity was low in the remaining size-groups. Empty stomachs were found in 66-70 mm and were high in 71-75 mm (Fig. 10). In females, the actively fed groups were found to be more in 71-75 mm size-groups and low in 106-110 mm. Moderately fed were more in 106-110 mm (28.21%) and less in 101-105 mm (13.09%) size-groups. Poorly fed were more in 51-55 mm and 66-70 mm

size-groups and lower values in 111-115 mm size-groups. Empty stomachs were more in 61-65 mm size-groups and less in 106-110 mm (Fig. 11).

#### Variation in different maturity stages

In males, the actively fed condition was more in immature (27.63%) than the maturing (21.93%) and mature (9.47%) stages. More moderately fed condition was recorded in the maturing males with 22.58%, followed by immature (22.37%) and mature (21.76%). The poorly fed condition was more in immature males (47.37%) than the mature (44.65%) and maturing (43.87%). The empty stomachs were observed more in mature (14.12%) than

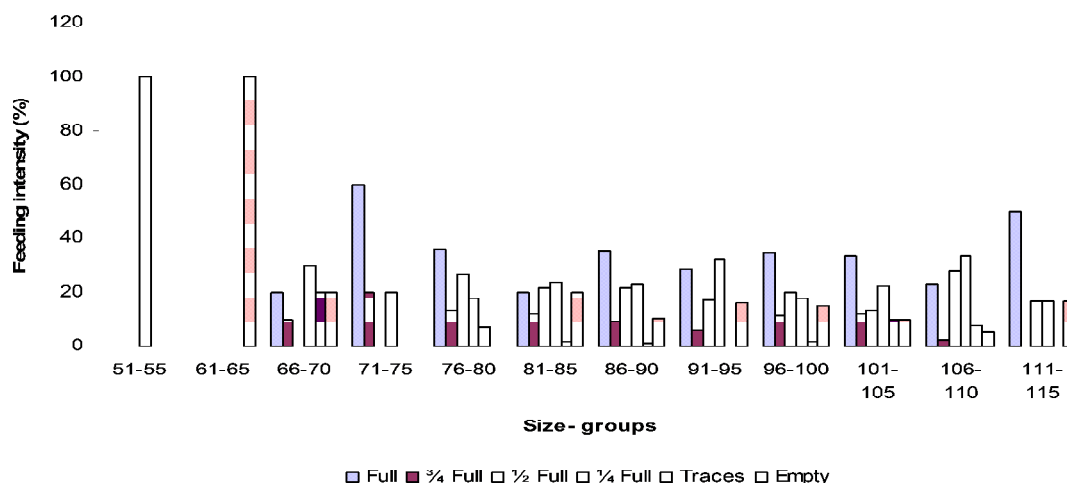


Fig. 11. Feeding intensity in different size-groups of females of *S. melantho*

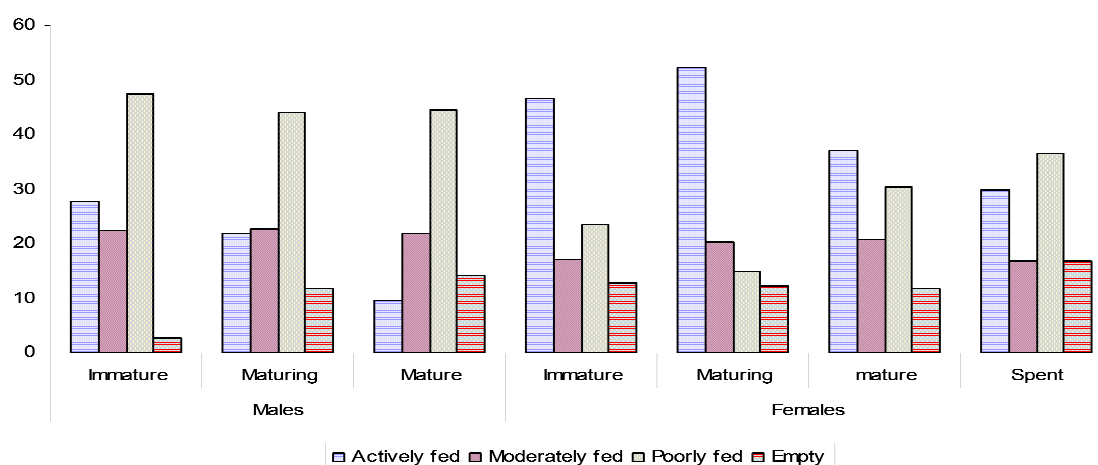


Fig. 12. Feeding intensity with reference to maturity stages in males and females of *S. melantho*

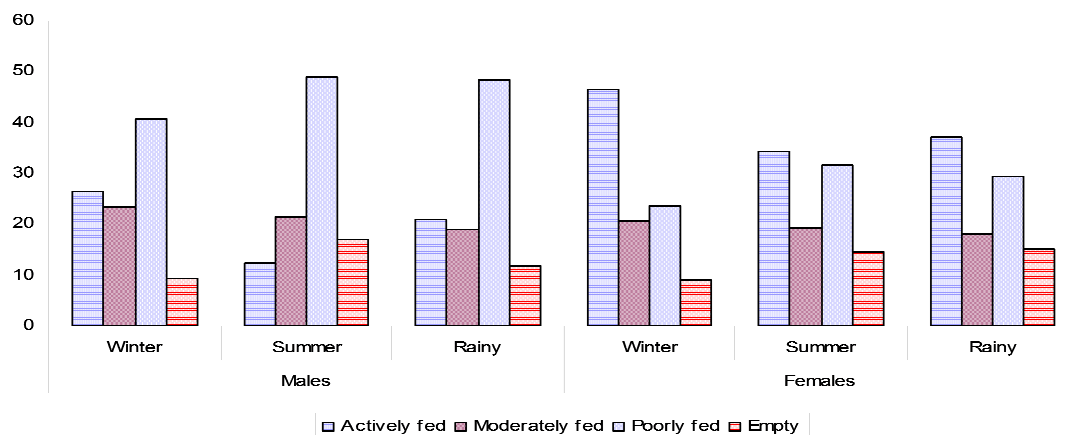


Fig. 13. Feeding intensity with reference to seasons in males and females of *S. melantho*

maturing (11.62%) and immature (2.63%). Maturing females dominated in actively fed condition (52.21%), followed by the immature (46.80%), mature (37.04%) and spent (30%). In moderately fed category, mature female showed higher percentage (20.80%) than the maturing (20.35%), immature (17.02%) and spent (16.67%). The poorly fed stomach condition was observed more among spent females (36.66%) than the mature female (30.48%),

immature (23.41%) and maturing females (15.05%). Spent females were found with high percentage of empty stomachs (16.67%) followed by immature (12.71%), maturing (12.39%) and mature females (11.68%) (Fig. 12).

#### Seasonal variation

Actively fed condition was more intense within males and females during winter (26.50%) than in rainy (21.02%)

and summer (12.37%) season. The moderately fed males were dominant in winter (23.50%), followed by summer (21.41%) and rainy season (18.92%). The poorly fed condition was more often noticed in summer (49.02%), followed by rainy season (48.34%) and winter (40.64%). The empty stomachs were observed more in summer (17.20%) than in rainy season (11.72%) and winter (9.36%). In females, the actively fed condition was high in winter (46.55%), followed by rainy season (37.07%) and summer (37.07%). Moderately fed females were more in winter (20.52%), followed by summer (19.25%) and rainy season (18.25%). The poorly fed stomach condition was observed more in summer (31.77%) than in rainy season (29.55%) and winter (23.71%). The empty stomachs were more in rainy season (15.13%) than in summer (14.71%) and winter (9.22%) (Fig. 13).

## Discussion

The study of food and feeding is of fundamental importance in proper understanding of the growth rate, population concentration, gonadal maturation and other metabolic activities (Nandakumar and Damodaran, 1998). *S. melantho* is commonly known as deep water mud shrimp living at 50-152 m depth, where the sediment is generally particulate and decomposing organic matter (Holthuis, 1980). It is detritus feeder and the mandibular palp has been modified into shovel-like structure to push the mud into the mouth. Moreover, the presence of broken parts of other crustaceans, molluscs etc., in the maxillipeds, mandibular teeth and in the gut contents confirm that it is a scavenger.

Kunju (1968) has reported that the *S. indica* feeds mostly on crustaceans (44.69%) and fish (22.12%), followed by polychaetes (2.96%), mollusks (1.90%), sand (1.95%), debris (25.54%) and miscellaneous items like foraminiferans and algal filaments. The diet composition of *S. choprai* of Bombay consisted of crustaceans (50%), followed by polychaetes (15%), foraminiferans and molluscs (10%), sand grains and debris (25%) (Aravindakshan and Karbhari, 1994). According to them, there was no significant difference in the diet composition between males and females. Dineshbabu and Maniserry (2009) have observed decapod crustaceans, unidentifiable mass, fish remains, molluscan shells, polychaete worms, sand, foraminiferans and small crustaceans, in the order of preference, in the diet of *S. choprai* along Karnataka coast. Li *et al.* (2016) have recorded 42 different prey categories in the diet of *S. melantho* at East China Sea, including small crustaceans, foraminifera, polychaetes (75% of the prey abundance), molluscs and fish larvae and eggs.

Kunju (1968) has reported that females of 51 to 70 mm and 91 to 110 mm groups and the males of 47 to 70 mm size-group of *S. indica* consume more crustaceans than the other size-groups. Dineshbabu and Maniserry (2009) have found no significant differences in the food content in different size groups of males of *S. choprai*, whereas in females the variation in food content was significant in different size groups except in 'fish remains' and 'sand'. Li *et al.* (2016) have observed that small shrimps preferred relatively small food items such as foraminifera and algae, whereas larger shrimps preferred polychaetes and crustaceans. Trophic diversity has varied within the size classes.

In *S. melantho* of the present study, detritus occupied the first position in males in all size groups except in 55-60 mm in which crustaceans have dominated and the rest of the diet was in the order of detritus, crustaceans, foraminiferans, molluscs, fish remains, eggs and sand. Females have also showed detritus as the major component in all size groups except in 66-70 mm size group in which crustaceans were dominant.

Dineshbabu and Maniserry (2009) have found wide fluctuations in the feeding intensity of the adults in *S. choprai* with highest during January-April and the lowest in May-October and increase in feeding intensity from November (30-32%). They have also reported that the feeding intensity was the highest among immature females (40-71%) followed by spent and maturing females.

In the present study both the males and females of *S. melantho* showed the highest level of actively fed in January and the lowest in June, whereas poorly fed condition has been seen in all the months in case of males.

As far as the feeding intensity concerned it was high in immature and low in mature males, whereas it was high in maturing females and low in spent ones. The percentage of empty stomachs was more in mature condition in males and in spent females. Dineshbabu and Maniserry (2009) have observed in *S. choprai* along Karnataka coast the highest feeding intensity in immature females (40.71%) followed by spent females. Li *et al.* (2016) have found low feeding activity in females of *S. melantho* with advanced stage of maturity of ovary in the East China Sea. Li *et al.* (2016) have observed varied trophic diversity among the seasons and between the sexes in *S. melantho* in East China Sea. According to them, highest values have been found in fall and high feed overlapping in both sexes and size classes in different seasons.

## Conclusions

In the present study the feeding intensity of *S. melantho* differed among seasons and between genders. In males, poorly fed condition was higher in all the seasons than the actively fed whereas actively fed condition was high in all seasons in females followed by poorly fed and moderately fed condition. The shrimp *S. melantho* may be designated as an omnivorous detritivore with scavenging activity. In the present study on *S. melantho* it has been found that detritus constitutes the major proportion of the diet in males and females with an index of preponderance of 50.88% and 47.16% respectively.

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