

STUDIES ON THE FEEDING BIOLOGY OF
METAPENAEUS MONOCEROS (FABRICIUS) ALONG THE KAKINADA COAST

G. SUDHAKARA RAO*

Central Marine Fisheries Research Institute, Cochin-682 031

ABSTRACT

The stomach contents of 470 specimens from inshore catches at Kakinada and 475 specimens from the backwater catches at Boddu Venkataya Palem collected from January 1974 to December 1975 are analysed to study the food and feeding habits of *Metapenaeus monoceros*. The food of *M. monoceros* in the inshore waters comprised of 'other crustaceans' (30%), polychaetes (19.1%), prawns (17.5%), detritus (10.6%), fishes, (7.0%), algae (4.6%), molluscs (4.8%) and sand (2.6%) whereas it comprised of detritus (36.8%) 'other crustaceans' (15.5%), algae (11.6%), copepods (9.3%), polychaetes (8.6%), prawns (8.4%), molluscs (3.1%), angiosperm matter (2.9%), diatoms (2.7%) and fishes (1.2%) in the specimens obtained from backwaters. No seasonal variation either in the food items consumed or in the feeding intensity is apparent. In the inshore waters, adults eat more of 'other crustaceans' (38.9%), prawns (23%) and polychaetes (20.4%), whereas the juveniles preferred detritus (49.2%), algae (20.5%) and copepods (16%). In the inshore waters feeding intensity is found to be better in adults and at night than in juveniles and during the day. The juvenile *M. monoceros* is an omnivore but it becomes a carnivore on attaining adulthood.

INTRODUCTION

THE FOOD and feeding habits of penaeid prawns have been studied by Gopalakrishnan (1952), Menon (1951, 1953), Panikkar and Menon (1956), George (1959, 1974), Subrahmanyam (1973), Rao (1967), Kuttiyamma (1973), Thomas (1972, 1980) and Rao (1983) in India and Kishinouye (1900), Ikematsu (1955), Kubo (1956), Yasuda *et al.* (1957), Hall (1962) and Dall (1969) in the Indo-Pacific.

The food and feeding habits of *M. monoceros* were studied by George (1959, 1974) from the catches in the inshore and backwaters of Cochin, by Kuttiyamma (1973) from the inshore waters of Cochin and by Subrahmanyam (1973) from the Godavari estuarine system. The present account deals with the food and

feeding habits of *M. monoceros* obtained from the inshore waters and backwaters of Kakinada in respect of the relative abundance of the different categories of food items, seasonal variations and between day and night catches.

I wish to thank Dr. B. Krishnamoorthi, Emeritus Scientist, Central Marine Fisheries Research Institute and Prof. K. Hanumantha Rao, Department of Zoology, Andhra University for guidance, Dr. G. Luther, CMFRI for going through the manuscript and offering suggestions and to Dr. P.S.B.R. James, Director, Central Marine Fisheries Research Institute for his encouragement.

MATERIAL AND METHODS

For the present study, 470 stomachs of prawns ranging in total length from 57 mm to 172 mm from the inshore trawler catches at Kakinada and 475 stomachs of prawns ranging

* Present address: Central Marine Fisheries Research Institute, Visakhapatnam, Andhra Pradesh 530 003.

in total length from 23 mm to 110 mm from the backwater catches at Boddu Venkataya Palem (B. V. Palem) were analysed from January 1974 to December 1975. After noting the size, each individual was cut open to find out the feeding intensity and the contents of the anterior as well as posterior proventriculus.

The stomach contents were categorised into broad taxonomic groups. Decomposed plant and animal matter and their remains mixed with mud found in the stomach was treated as 'detritus'. Coarse sand present in stomachs of prawns from inshore catches, which could have been ingested was separated from 'detritus'. Such a separation was not possible in the case of prawns from backwater catches, due to the small size of the sand grains, and hence treated as part of the detritus.

The 'points (volumetric) method' (Pillay, 1952) was employed rather than the displacement method due to the small volume of gut contents. Since the 'occurrence method' or the 'volumetric method' alone is inadequate to give a correct picture of the importance of individual food items, both occurrence and volume have been taken into consideration for the present study. The values were arrived at by estimating the 'index of preponderance' as suggested by Natarajan and Jhingran (1961).

The intensity of feeding was determined by the degree of distention of the stomach and expressed as 'full', '3/4 full', '1/2 full', '1/4 full', 'trace' and 'empty' receiving 100, 75, 50, 25, 10 and 0 points respectively. From these points, volume for each food item and its percentage in the total volume of all stomach contents were calculated in each month. Similarly, the percentage occurrence of different food items was determined from the total number of occurrence of all items in each month. The index of preponderance indicated the food preferences of the prawns. The degree of fullness of the stomach in relation to the length of the prawn was also noted to

arrive at size-wise feeding intensity in various months. From the total number of prawns examined in a month, the percentage occurrence of stomachs with the different intensities of feeding was computed. Prawns with 'full', '3/4 full' and '1/2 full' stomachs were considered to have fed 'actively' while those with '1/4 full', 'trace' and 'empty' were considered as 'poorly' fed. Since the trends in both the years are more or less similar the data for both the years are pooled together.

FOOD AND FEEDING HABITS IN INSHORE WATERS

Composition of food

Index of preponderance of food items in the stomach contents of *M. monoceros* from the inshore catches in different months is given in Table 1. 'Prawns' represented by penaeids, carids and sergestids were invariably present in the stomach contents. They dominated the gut contents in January-April and July-August. Average contribution of prawns to the food was 17.7% and 19.1% in 1974 and 1975 respectively. Among penaeids, the remains of *Metapenaeus affinis*, *M. brevicornis*, *M. dobsoni*, *Metapenaeopsis stridulans*, *M. barbata*, *Parapenaeus longpisi* and *Trachypenaeus curvirostris* could be recognised. *Acetes* species were observed on a number of occasions. Carids could not be identified to species or generic level.

Copepods were invariably present although insignificantly. The proportion of copepods was better in January, April, September and December. The proportion of copepods was 2.1% in 1974 and 5.5% in 1975. Free living copepods of the family Calanoidea formed a major component.

Crustaceans other than prawns and copepods also formed an important dietary component of *M. monoceros* contributing 28.8% in 1974 and 30.3% in 1975. These 'other crustaceans'

were represented by fragments of shells of crabs, mysids, amphipods, tanaidaceans, isopods and decapod larvae. As this item is almost always present in the stomachs, it is certain that they form a regular diet throughout the year.

Polychaetes formed an important item of the food throughout the year. Due to their soft body these worms were crushed into a pulplike mass with setae and acicula embedded in it. Hence their identity could not be fixed. The proportion of polychaetes in the stomach contents was more in 1974 (19.0%) than in 1975 (18.1%).

Fishes contributing about 6.9% and 6.4% in 1974 and 1975 respectively formed a significant item of the food of *M. monoceros*. Fishes were represented in the form of skeletal structures like skull bones, vertebrae, scales, etc. In a few instances crystalline lenses of the eyes were found intact indicating that the entire animal was eaten. This item was better represented in January, March, June and October.

Detritus formed about 11.9% and 10.2% in 1974 and 1975 respectively and in good proportion during September-December. The presence of detritus in the stomach may be

TABLE 1. Index of preponderance of food items in the stomach contents of *M. monoceros* from the inshore catches at Kakinada (data for 1974 and 1975 are pooled)

Months	Prawns	Copepods	Other crustaceans	Polychaetes	Molluscs	Fishes	Algae	Sand	Detritus	No. of prawns observed
January	24.3	6.2	23.3	19.5	5.2	15.2	2.2	2.5	1.6	42
February	22.4	0.5	40.5	19.9	2.8	7.2	1.1	4.2	1.5	53
March	22.1	0.7	29.1	14.6	9.4	14.7	Nil	4.6	5.0	51
April	19.3	3.7	31.7	23.2	7.5	5.2	1.5	3.9	4.1	50
May	8.2	2.5	45.2	20.4	4.7	7.5	1.3	1.4	6.0	49
June	7.9	0.4	40.6	27.6	5.5	12.8	0.4	1.9	3.0	21
July	26.2	0.4	36.9	19.3	7.3	0.6	0.9	4.1	4.3	42
August	51.7	0.9	28.0	5.8	1.3	4.5	0.3	2.5	5.1	41
September	1.8	4.2	16.8	44.3	4.2	6.2	3.2	1.3	18.1	43
October	10.3	1.5	40.3	22.1	5.4	9.6	3.1	1.3	6.4	20
November	12.7	2.1	16.4	10.9	2.4	0.8	14.7	1.3	37.2	27
December	2.5	18.6	12.8	1.5	2.3	0.2	26.5	1.7	34.9	31
Average	17.5	3.5	30.1	19.1	4.8	7.0	4.6	2.6	10.6	39

Molluscs formed a regular food in all the months. They formed 7.1% and 1.8% in 1974 and 1975 respectively. They were represented by lamellibranchs followed by gastropods and cephalopods. Although only crushed shells were observed, their freshness indicated that they were ingested alive and the soft parts digested and absorbed subsequently.

due to the bottom feeding habit of these prawns coupled with the thorough mastication to which the food is subjected during feeding

Algae mostly represented by filamentous blue greens formed 3.9% and 6% of the food of *M. monoceros* in 1974 and 1975 respectively.

Sand was found in all the months forming 2.6% and 2.7% of the gut contents in 1974 and 1975 respectively.

In a few instances tunicates, hydroids and brittle stars were also found in the stomachs.

The two year study shows that the food of *M. monoceros* comprised of 'other crustaceans' (30%), polychaetes (19.1%), prawns (17.5%), detritus (10.6%), fishes (7%), algae (4.6%) and molluscs (4.8%).

during 1974 and from 23.8% in August to 75% in January during 1975 (Fig. 1). Feeding activity was more in 1974 (49.6%) than in 1975 (43%).

Food of prawns in relation to size

In order to study size-wise variations in the food habits, samples of *M. monoceros* obtained from trawler catches were classified into two groups viz., juveniles and adults. As males and females attain maturity around 100 mm

TABLE 2. Feeding intensity in *M. monoceros* from inshore catches at Kakinada (data for 1974 and 1975 are pooled)

Months	Empty	Trace	$\frac{1}{4}$ full	$\frac{1}{2}$ full	$\frac{3}{4}$ full	full	No. of prawns observed	
January	..	6.8	6.8	23.9	21.1	19.5	21.8	42
February	..	Nil	8.8	20.5	35.6	16.5	18.6	53
March	..	4.8	18.6	35.5	21.4	9.0	10.7	51
April	..	Nil	10.1	32.9	31.9	14.3	10.7	50
May	..	1.8	14.9	41.7	22.6	11.3	7.7	49
June	..	Nil	28.6	47.6	9.5	4.8	9.5	21
July	..	9.5	14.3	33.3	35.7	2.4	4.8	42
August	..	7.4	21.7	24.1	14.8	12.4	19.6	41
September	..	7.1	28.0	32.4	25.4	4.6	2.4	43
October	..	Nil	10.0	20.0	35.0	15.0	20.0	20
November	..	10.0	24.3	26.8	19.6	12.1	7.1	27
December	..	7.1	27.1	24.5	19.5	19.2	2.4	31
Average	..	4.5	17.8	30.3	24.3	11.8	11.3	—

Feeding intensity

Different grades of feeding intensity in terms of percentage are given in Table 2. The occurrence of stomachs of different feeding intensities varied randomly in different months. In most of the month '1/4 full' stomachs were more and the other types showed gradual reduction from '1/4 full' to 'full' and in the other direction from '1/4 full' to 'empty'.

The percentage of actively fed prawns ranged from 23.8% in May to 91.3% in February

in total length (Rao, 1985), those measuring upto 100 mm were considered as juveniles and those beyond 100 mm as adults. The relative importance of food items and feeding intensity in juveniles and adults is presented in Fig. 2.

It is evident from Fig. 2 that the food of juveniles was mainly comprised of detritus (49.2%), algae (20.5%), copepods (16%) and 'other crustaceans' (8.2%) while that of adults contained more of 'other crustaceans'

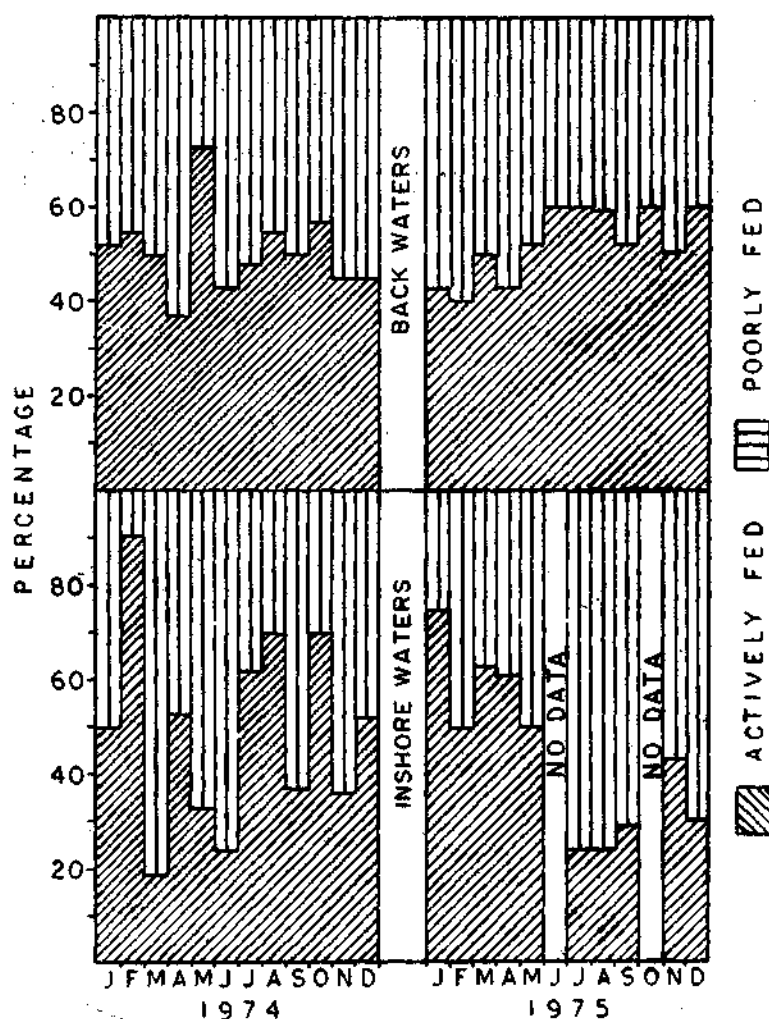


FIG. 1. Feeding intensity of *M. monoceros* in inshore waters and backwaters during the years 1974 and 1975.

(38.9%), prawns (23%), polychaetes (20.4%) and fishes (8.5%). Analysis of stomachs of different feeding intensities indicate that '1/4 full', '1/2 full' and 'full' stomachs were more in adults than in juveniles. The proportion of actively fed adults was more (51.6%) than that of juveniles (37.7%) indicating that adults are more active feeders than juveniles.

Food and feeding habits in relation to day and night catches

Stomach contents from samples obtained from day catches and night catches were studied during February-May 1975 to find out variations in the food and feeding habits of *M. monoceros*. Indices of preponderance for different food

items in day catches and night catches are shown in Fig. 3. 'Other crustaceans', prawns and polychaetes formed the major items of food in both day catches and night catches. Fishes were better represented in the stomachs of day catches than those at night. Algae formed a significant proportion of the food

with 'trace' food were rarely encountered in prawns of night catches, whereas they formed a good proportion in prawns of day catches (Fig. 3). In the prawns caught during night '1/2 full', '3/4 full' and 'full' stomachs were more, whereas those caught in the day had more stomachs with 'trace' and '1/4 full'

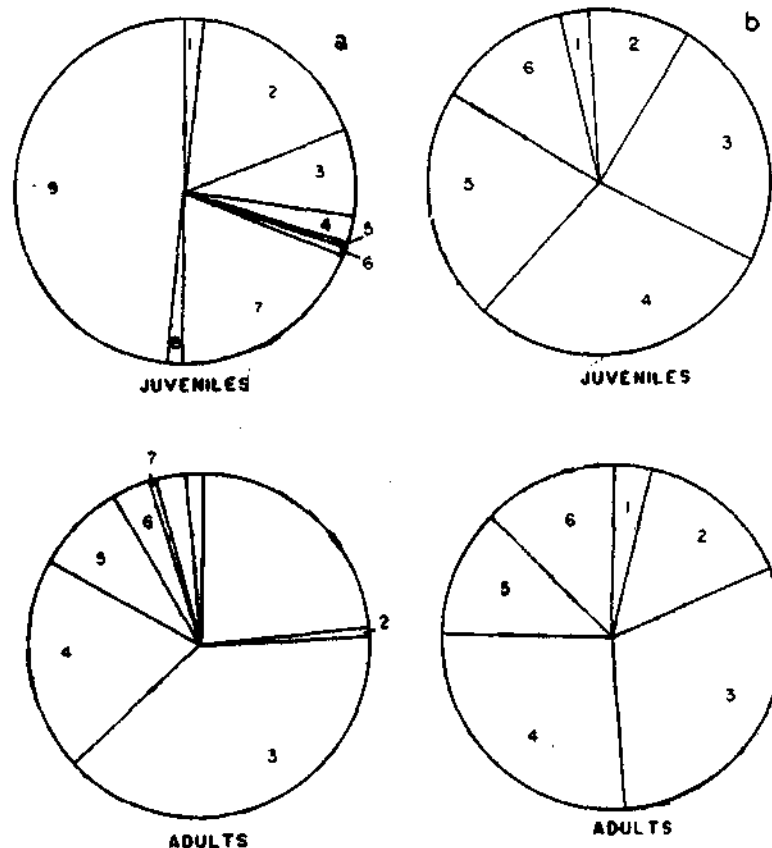


FIG. 2. Relative importance of food items (a) and feeding intensity (b) of *M. monoceros* juveniles and adults from inshore waters : (a) 1. Prawns, 2. Copepods, 3. Other crustaceans, 4. Polychaetes, 5. Fishes, 6. Molluscs, 7. Algae, 8. Sand and 9. Detritus (b) 1. Empty, 2. Trace, 3. $\frac{1}{2}$ full 4. $\frac{1}{4}$ full 5. $\frac{3}{4}$ full, 6. full.

in the day catches while it was insignificant in those at night. Similarly detritus formed a considerable quantity of the stomach contents in prawns of day catches while it is negligible in those at night.

A detailed analysis of intensity of feeding indicates that 'empty' stomachs and stomachs

condition. Clearly the feeding intensity in *M. monoceros* is higher during night than in day. Even the food contents observed in the day catches could be the remnants of earlier night's feeding. It was further observed that several of those day catches with 'trace' and '1/4 full' contained good quantities of a

yellowish brown fluid. Obviously this fluid is nothing but a mixture of digestive juices and digested food which is in the process of absorption (Dall, 1969).

(36.8%), 'other crustaceans' (15.5%), algae (11.6%), copepods (9.3%), polychaetes (8.5%), prawns (8.4%), molluscs (3.1%), angiosperm matter (2.9%), diatoms (2.7%) and fishes

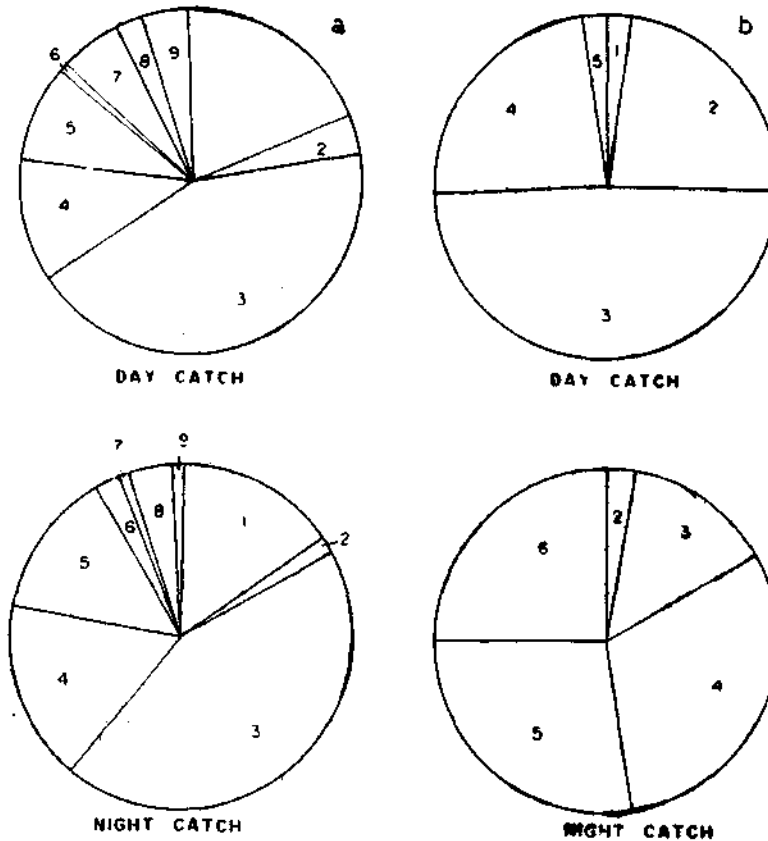


FIG. 3. Relative importance of food items (a) and feeding intensity (b) of *M. monoceros* from day catches and night catches : (a) 1. Prawns, 2. Copepods, 3. Other crustaceans 4. Polychaetes, 5. Fishes, 6. Molluscs, 7. Algae, 8. Sand, 9. Detritus and (b) 1. Empty, 2. Trace, 3. $\frac{1}{2}$ full 4. $\frac{1}{3}$ full, 4. $\frac{2}{3}$ full, 6. full.

FOOD AND FEEDING HABITS IN BACKWATER PRAWNS

Quantitative and qualitative analysis of 228 prawns in 1974 and 247 prawns in 1975 from the backwater catches at B. V. Palem were carried out to study the food and feeding habits of juveniles of *M. monoceros*. Month-wise analysis did not indicate any seasonal trend in the food composition (Table 3). Detritus

(1.2%) contributed to the food of *M. monoceros* in the juvenile backwater phase.

The feeding intensity in different months is presented in Table 4. In most of the months '1/2 full' stomachs dominated forming about 27.7%. The percentage of actively fed prawns ranged from 36.9% to 72.7% in 1974 and from 40% to 60% in 1975 (Fig. 1).

The above analysis clearly shows that *M.*

TABLE 3. *Index of preponderance of food items in the stomach contents of M. monoceros from the backwater catches of B.V. Palem (data for 1975 and are pooled)*

Months	Prawns	Copepods	Other crustaceans	Polychaetes	Molluscs	Fishes	Diatoms	Algae	Angiosperm matter	Detritus	No. of prawns observed
January ..	1.6	27.6	19.0	6.6	0.6	0.7	2.2	21.3	1.9	18.6	42
February ..	2.9	10.5	8.8	7.3	3.5	0.2	2.2	33.5	3.5	27.7	40
March ..	20.4	5.8	10.1	4.4	4.1	2.3	0.6	5.8	2.1	44.5	44
April ..	1.9	2.8	8.2	10.5	2.6	0.6	11.1	12.3	2.5	47.5	40
May ..	35.2	3.7	20.8	3.6	1.1	0.1	1.2	3.3	1.1	29.9	43
June ..	19.3	12.3	9.4	1.6	0.5	1.8	1.1	20.7	2.3	31.0	41
July ..	6.7	11.8	23.9	5.7	1.1	1.1	0.2	7.4	1.8	40.4	42
August ..	1.5	4.9	6.8	7.5	3.4	0.8	1.0	1.7	7.5	65.1	42
September ..	1.3	6.1	31.8	3.6	4.7	Nil	3.6	6.0	5.9	37.0	41
October ..	1.5	8.0	3.9	25.7	3.2	1.8	1.1	2.9	2.1	49.8	40
November ..	5.7	5.4	25.5	16.0	6.9	3.8	3.8	15.9	2.2	14.9	40
December ..	3.3	12.3	18.2	10.2	5.7	0.7	4.8	8.6	1.6	34.7	40
Average ..	8.4	9.3	15.5	8.6	3.1	1.2	2.7	11.6	2.9	36.8	21

TABLE 4. *Feeding intensity in M. monoceros from backwater catches at B. V. Palem (data for 1974 and 1975 are pooled)*

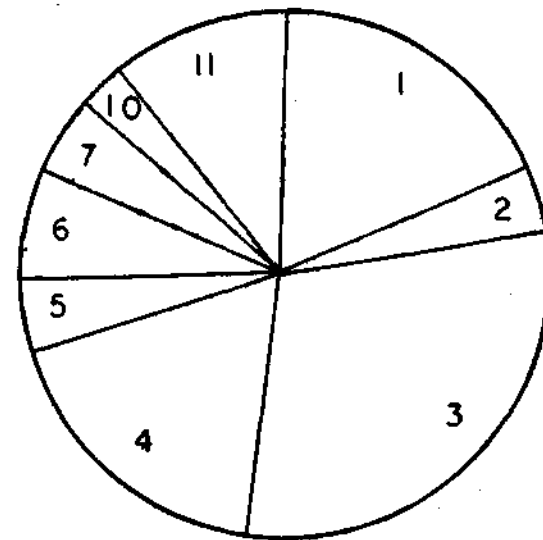
Months	Empty	Trace	$\frac{1}{2}$ full	$\frac{1}{2}$ full	$\frac{3}{4}$ full	Full	No. of prawns observed
January ..	21.4	4.8	26.2	33.3	7.1	7.1	42
February ..	22.5	10.0	20.0	25.0	15.0	17.5	40
March ..	18.2	6.8	25.0	31.8	9.1	9.1	44
April ..	20.0	17.7	22.4	22.2	10.0	7.6	40
May ..	18.6	Nil	18.8	27.9	18.6	16.0	43
June ..	5.0	16.8	26.8	29.3	14.8	7.4	41
July ..	4.8	11.9	28.6	23.8	26.2	4.8	42
August ..	15.0	5.0	22.5	35.0	17.5	5.0	40
September ..	22.0	9.8	17.0	21.8	14.6	14.8	41
October ..	14.6	7.3	19.5	31.7	19.6	7.3	41
November ..	17.5	5.0	30.0	22.5	15.0	10.0	40
December ..	17.5	5.0	25.0	27.5	15.0	10.0	40
Average ..	16.4	8.3	23.5	27.7	15.2	9.7	—

monoceros occurring in the backwaters feeds actively throughout the year. The peaks in the incidence varied randomly with no seasonal trend.

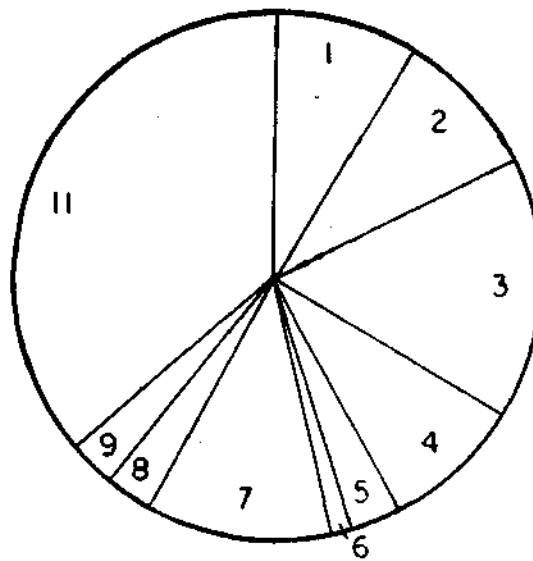
It is evident from Fig. 4 that detritus which was the major constituent of the stomach contents in the juvenile backwater phase is replaced by 'other crustaceans' in the adult inshore phase. Similarly, diatoms and angiosperm matter, mostly represented by mangrove plants like *Avicennia* and *Rhizophora* which were observed in considerable proportion in the juveniles were absent in the stomachs of the adults. The 'fish' component was much higher in the prawns from inshore water catches than in the prawns from backwater catches.

DISCUSSION

Panikkar and Menon (1956) summing up the different opinions about the diet of prawns, remarked that 'it is well-known that the food of prawns consists of detritus, both animal and plant, that accumulates at the bottom of their habitat, and they prefer areas with a muddy bottom. Along with the detritus they naturally take in large quantities of sand and mud'. Gopalakrishnan (1952) after analysing the stomach contents of *P. indicus* concluded that the species is omnivorous. But Hall (1962) is of the opinion that penaeidae in general cannot be considered as detritus feeders. He agreed with the findings of Kishinouye (1900) Ikematsu (1955), Kubo (1956) and Yasuda *et al.* (1957) that certain species are carnivorous; he grouped several Malaysian species according to their food preferences, as those feeding mainly on larger crustacea, smaller crustacea, vegetable matter, etc. George (1974) observed that sand grains, mud and detritus formed less in importance and small crustaceans dominated the food of *M. monoceros* in the backwater phase of its life history supporting the view expressed by Hall (1962). However, George (1959) and Kuttiyamma (1973) observed



INSHORE CATCHES



ESTUARINE CATCHES

FIG. 4. Relative importance of food items of *M. monoceros* from inshore waters and backwaters.

- | | |
|-----------------------|-----------------|
| 1. Prawns, | 2. Copepods, |
| 3. Other crustaceans, | 4. Polychaetes, |
| 5. Molluscs | 6. Fishes, |
| 7. Algae, | 8. Diatoms, |
| 9. Angiosperm matter, | 10. Sand and |
| 11. Detritus. | |

M. monoceros in the inshore waters to be omnivorous. Rao (1983) studying the food of *M. kutchensis* found that it is omnivorous with possible preference to crustaceans and algae although considerable amount of detritus was found in the stomachs. Thus the present study supports the views expressed by earlier workers that *M. monoceros* is an omnivore in the estuarine phase and turns as a carnivore in the inshore adult phase.

Although there is evidence to suggest that prawns 'brouse' on the epiflora of the mud substrate (Dall, 1969), the present study indicates that *M. monoceros* to some extent feeds in the water column also. The fact that most of the crustaceans found in large quantities were those recorded from the water column supports the above deduction. Apart from crustaceans, the presence of fishes and errant polychaetes in the stomach contents gives ample evidence that *M. monoceros* actively feeds in the water column. On a number of occasions purely pelagic forms like sergestids and cephalopods were observed in the stomach contents indicating that *M. monoceros* often resorts to feeding pelagic animals. George (1959) also found Pelagic crustaceans in the stomachs of *M. monoceros* and suggested vertical diurnal migrations for feeding.

Menon (1951) observed that in smaller prawns detritus was more which was replaced by vegetable matter in larger size groups. Gopalakrishnan (1952) did not notice any difference in the diet of small and large specimens of *P. indicus*. Thomas (1980) did not find any change in the feeding habits of *P. semisulcatus*

in different size groups. George (1974) noticed that the gut contents of smaller specimens of *M. monoceros* contained more unrecognisable matter including mud and detritus than those of larger specimens and that they exhibited selective feeding in different size groups. In the present study on *M. monoceros* it is observed that there is clear change in the food and feeding habits from juveniles to adults. It was also observed that the feeding intensity was more in adults than in juveniles in the sea. In this context it is pertinent to note that juveniles survive for a longer time after capture than adults. Thus the time lapse between final feeding and death in juveniles is longer resulting in the possibility of digestion during this period. Hence, the observed lower feeding intensity could be an artifact.

Williams (1955) reported that the feeding activity was minimum in winter by recording most of the stomachs as empty and good feeding in the other seasons of the year. Such seasonal differences were not observed by Thomas (1980) on *P. semisulcatus* and the present study on *M. monoceros*.

Eldred *et al.* (1963) found *P. duorarum*, which is also a burrowing species like *M. monoceros* to be nocturnal feeder. But under very turbid water conditions, juveniles and preadults feed during day time. Thomas (1980) observed that the intensity of feeding in *P. semisulcatus* was better during the darker hours of the day. In the present study also it is observed that the feeding intensity was more in the night as indicated by the analysis of the stomachs of night catches and day catches.

REFERENCES

- DALL, W. 1969. Food and feeding of some Australian penaeid shrimp. *FAO. Fish. Rep.*, 57: 2: 252-259.
- ELDERD, B., R. M. INGLE, K. D. WOODBURN, R. F. HUTTON AND H. JONES 1961. Biological observations on the commercial shrimp *Panaeus duorarum* Burkenroad in Florida waters. *Proc. Pap. Ser. Mar. Lab. Fla.*, 3: 1-139.
- GEORGE, M. J. 1959. Notes on the bionomics of the prawn *Metapenaeus monoceros* Fabricius. *Indian J. Fish.*, 6 (2): 269-279.
- . 1974. The food of the shrimp *Metapenaeus monoceros* (Fabricius) caught from the backwaters. *Ibid.*, 21 (2): 495-500.
- GOPALAKRISHNAN, V. 1952. Food and feeding

- habits of *Penaeus indicus* M. Edwards. *J. Madras univ.*, **22 B** (1) : 69-75.
- HALL, D. N. F. 1962. Observations on the taxonomy and biology of some Indo-West Pacific Penaeidae (Crustacea, Decapods). *Fish. Publ. Colon. Office Lond.*, **17** : 1-229.
- IKEMATSU, W. 1955. On the life history of *Metapenaeus jayneri* (Miers) in the Ariake Sea. *Bull. Japan. Soc. Sci. Fish.*, **20** (11) : 969-978.
- KISHINOUE, K. 1900. Japanese species of the genus *Penaeus*. *J. Fish Bureau Tokyo*, **8** (1) : 1-29.
- KUBO, I. 1956. A review of the biology and systematics of shrimps and prawns of Japan. *Proc. Indo-Pacific Fish. Coun.*, **6** (3) : 397-398.
- KUTTIYAMMA, V. J. 1973. Observations on the food and feeding of some penaeid prawns of Cochin area. *J. mar. biol. Ass. India*, **15** (1) : 189-194.
- MENON, M. K. 1951. The life history and bionomics of an Indian penaeid prawn *Metapenaeus dobsoni* (Miers). *Proc. Indo-Pacific Fish. Coun.*, **3** (2) : 80-93.
- , 1953. Notes on the bionomics and fishery of the prawn *Parapenaeopsis stylifera* (M. Edw.) on the Malabar Coast. *J. Zool. Soc. India*, **5** (1) : 153-162.
- NATARAJAN, A. V. AND V. G. JHINGRAN 1961. Index of preponderance a method for grading the food elements in stomach analysis of fishes. *Indian J. Fish.*, **8** (1) : 54-59.
- PANIKKAR, N. K. AND M. K. MENON 1956. Prawn fisheries of India. *Proc. Indo-Pacific Fish. Coun.*, **6** (3) : 328-344.
- PILLAY, T. V. R. 1952. A critique of methods of study of food of fishes. *J. Zool. Soc. India*, **4** : 185-200.
- RAO, A. PRABHAKARA 1967. Some observations on the biology of *Penaeus indicus* H. Milne Edwards and *Penaeus monodon* Fabricius from the Chilka Lake. *Indian J. Fish.*, **14** : 251-270.
- RAO, G. SUDHAKARA 1983. Observations on the seasonal prawn fishery of the little Rann of Kutch during 1980. *Indian J. Fish.*, **30** (1) : 124-134.
- 1985. Studies on the biology and fishery of the brown prawn *Metapenaeus monoceros* (Fabricius, 1798) along the Kakinada Coast. *Ph. D. Thesis, Andhra University, Waltair*.
- SUBRAHMANYAM, M. 1973. Fishery and biology of *Metapenaeus monoceros* (Fabricius) from the Godavari estuarine system. *Indian J. Fish.*, **20** (1) : 95-107.
- THOMAS, M. M. 1972. Food and feeding habits of *Penaeus monodon* Fabricius from Korapuzha Estuary. *Ibid.*, **19** (1 & 2) : 202-204.
- 1980. Food and feeding habits of *Penaeus semisulcatus* DeHaan at Mandapam. *Ibid.*, **27** (1 & 2) : 130-139.
- WILLIAMS, A. B. 1955. A contribution to the life histories of commercial shrimps (Penaeidae) in North Carolina. *Bull. mar. Sci. Gulf Caribb.*, **5** (2) : 116-146.
- YASUDA, J., T. YATSUYANGI AND K. MEEKWN 1957. The study of species of prawn which live on the beach, with special reference to Kuruma-ebi, *Penaeus japonicus* Bate. *Res. Rep. Inland Sea Mar. Proc. Res. Inst.*, **10** (57) : 20-27.