



Food and feeding of the ridgeback shrimp, *Solenocera choprai* Nataraj, along Karnataka coast

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ABSTRACT

Though *Solenocera choprai* is an important shrimp resource from Karnataka coast, information on food and feeding of the species is lacking. 'Index of preponderance' method was used to study the food and feeding habit of the species. The food contents found were decapod crustaceans, unidentifiable mass, 'fish remains', molluscan shells, polychaete worms, sand, foraminiferans and small crustaceans (other than decapods) in the decreasing order of abundance. In adults, annual index of preponderance for decapod crustaceans, detritus and 'fish remains' were 43.82, 19.27 and 11.17 respectively. In females, the major component of the food was decapod crustaceans with indices above 40. Annual feeding intensity of adult *S. choprai* was 28.88% with the highest value of 54% observed in February and lowest value from June to December. The change in monthly feeding intensity of the species is found to be influenced by the disturbances in the sea bottom caused by upwelling. Feeding intensity was the highest in immature females (40.71%) followed by spent females.

Keywords : *Salenocera choprai*, Ridgeback shrimp, Food and feeding, Karnataka coast

Introduction

Solenocera choprai is widely distributed in the Indo-Pacific region, and is generally found buried on soft bottoms at depths between 50 and 175 m (Dall, 1999). In India, even though the species is caught from both east and west coasts, fishery for the species exists only in south Karnataka coast. Along Karnataka coast, the species is caught from a depth of 60 to 100 m, where the sea bottom is reported as sandy (Hashimi *et al.*, 1978; Harkantra *et al.*, 1980; Shankar and Karbassi, 1992) and the annual landing of the species was as high as 3,186 t in 2002. Even though extensive studies have been made on food and feeding habits of various shrimps from Indian waters, only few studies (Aravindakshan and Karbari, 1994; Dineshbabu, 2004) have attempted on the shrimps which are caught from fishing grounds beyond 50 m depth, especially those living in mid-shelf region of Indian waters.

Shrimps do not appear to be predators, but small sized, disabled or dying animals are readily attacked by starving shrimps (Dall, 1968). Apart from the preliminary studies on the diet of *S. choprai* from Bombay waters (Aravindakshan and Karbari, 1994), no other studies attempted on the food and feeding of the species from anywhere else in the world. However some studies were undertaken in other species belonging to *Solenocera* genus

i.e., food and feeding habits of *S. indica* (*S. crassicornis*) from Bombay waters (Kunju, 1968) as well as that of *S. alticarinata* and *S. subnuda* from Malaysian waters (Hall, 1962). During the present study, food composition and feeding intensity of adult males, adult females and juveniles of *S. choprai* during various months were analysed in detail.

Materials and methods

Samples of *S. choprai* collected during January to December, 2003 were analysed to study the food and feeding habits of the species. Stomach contents of 348 males, 351 females and 100 juveniles were analysed. Shrimps below 52 mm were considered as juveniles (Dineshbabu and Manissery, 2008). Adults of *S. choprai* were available throughout the trawling period in 2003 whereas the availability of juveniles were found restricted in November. So food and feeding studies on juveniles could be conducted only during November. Due to the nibbling action of mandibles on the food and mastication of food inside the stomach by the action of gastric mill, identification of the food organisms was based mainly on broken shell remains, spines, setae etc. The stomach contents were grouped as follows: decapod crustaceans (mostly shrimps), fishes, molluscs, polychaetes, crustaceans other than decapods, foraminiferans, sand and detritus

(decomposed plant and animal matter and their remains mixed with mud). Since the quantity of food in the stomach of shrimps were very little, 'points method' by Pillay (1952) was used. In order to get a clear picture of frequency of occurrence as well as volume of various items, 'Index of Preponderance' method (Natarajan and Jhingran, 1961) was used.

The index of preponderance was worked out using the following formula:

$$I = \frac{V_i O_i}{\sum V_i O_i} \times 100$$

Where V_i and O_i represent the percentage of volume and percentage of occurrence indices of each food item respectively and I , the index.

The intensity of feeding was determined by the degree of distension of the stomach due to the presence of food inside the anterior and posterior chambers of the proventriculus. This is expressed as full, $\frac{3}{4}$ full, $\frac{1}{2}$ full, $\frac{1}{4}$ full, trace and empty and each one was assigned, 100, 75, 50, 25, 10 and 0 points respectively. For finding out feeding condition, stomachs were grouped into actively fed (full and $\frac{3}{4}$ full stomachs), moderately fed ($\frac{1}{2}$ full and $\frac{1}{4}$ full) and poorly fed (less than $\frac{1}{4}$ full). The stomachs were cut open and the contents were examined under a microscope. The indices of preponderance were then computed to indicate the food preference of the species. The index of preponderance for the year was also calculated taking the total number of samples examined during the year. The degree of fullness of stomach in relation to size of the animal was noted to study the intensity of feeding in juveniles and adults. From the total number of specimens examined in the month, the percentage occurrence of stomachs with different intensities of feeding was computed. Food analysis was done in relation to months, sex, maturity stages and

size-groups. The samples were classified into groups with a class interval of 5 mm total length. The stages were classified (Dall *et al.*, 1990) as 'immature', 'early maturing', 'late maturing', 'mature' and 'spent'.

Test of analysis of variance (ANOVA) of food components and feeding conditions between males and females, between juveniles and adults, between months and between maturity stages of females were carried out with the help of SPSS statistical software (version 7.0).

Results

General diet composition

The food contents found in adult *S. choprai*, in the order of abundance were, decapod crustaceans, unidentifiable mass, 'fish remains', molluscan shells, polychaete worms, sand, foraminiferans and small crustaceans (other than decapods). Decapod crustaceans, dominated by shrimps formed the major component in the stomach content of *S. choprai* (Table 1). During February and September, juvenile crabs dominated the food items and in other months, shrimps were dominant.

Unidentifiable mass consisting of decomposed plant and animal matter and their remains mixed with mud ranked second among the food items with an annual index of 19.27. Maximum concentration of unidentifiable mass was during the monsoon months and also immediately after monsoon. 'Fish remains' constituted the third important component with an index of 11.17. This component ranked first in June and from August to September, ranked second with an index of more than 20. Fish bones, spines, scales and fish eggs were identified from the stomach. Molluscan shells were present throughout the year and ranked fourth with an index value of 8.15. Polychaete worms were recorded in the stomach only in January and April. This component ranked fifth among the food components (index of 7.16). Sand was found invariably in all stomachs and ranked sixth with an

Table 1. Month-wise 'index of preponderance' of food items of *S. choprai* (adults)

Month	Small crustaceans	Decapod crustaceans	Polychaetes	Fish remains	Molluscan shells	Foraminifer-an shells	Sand	Unidenti-fiable mass	No. of shrimps
Jan	1.72	34.41	11.20	7.47	12.42	3.60	5.63	23.55	65
Feb	2.22	39.10	4.57	17.59	11.27	4.76	4.86	15.62	38
Mar	2.03	59.13	3.54	9.51	4.95	2.05	2.96	15.84	40
Apr	1.07	46.10	10.78	7.65	6.71	2.88	4.81	20.01	80
May	2.22	51.57	0.00	22.69	1.91	1.09	2.93	17.59	40
Jun	0.27	9.19	6.31	35.95	2.04	1.59	9.28	35.39	40
Aug	1.20	32.10	0.00	26.95	3.70	1.35	4.55	30.15	36
Sep	1.53	44.48	5.81	11.10	4.86	1.77	3.19	27.26	70
Oct	1.17	50.68	0.00	16.82	8.31	2.48	5.48	15.06	60
Nov	2.57	47.31	7.70	11.53	7.07	3.75	5.56	14.51	129
Dec	2.82	48.17	4.05	7.70	8.96	3.88	6.71	17.71	101
Annual	1.92	43.82	7.16	11.17	8.15	3.27	5.24	19.27	699

index of 5.24. This item was probably an accidental inclusion while the shrimp was feeding at the bottom. Along with sand, foraminiferan shells were also found in good quantity throughout the year, with an index of 3.27. Important foraminiferan genera identified were *Spiroplecta*, *Rotalia*, *Elphidium* and *Globigerina*. Small crustaceans other than decapods constituting amphipods, *Cypris* and *Lepas* larvae formed a minor component in the food content with an overall index of 1.92.

Monthly variation in the percentage composition of diet

Decapod crustaceans were the major constituent of the food throughout the year except in June. In June, ‘fish remains’ were the major component. In monsoon months, from June to August, the quantity of unidentifiable mass was found in the stomach was more compared to other months. Analysis of variance (ANOVA) showed significant monthly variation ($p < 0.01$) in food content.

Diet composition of juveniles

Unlike adults, ‘fish remains’ were the major component of food item in juveniles during November (only period in which both adult and juveniles were observed in the catch in tandem) with an index of 38.1 (Fig.1). In adults, the dominant food component during this period was decapod crustaceans with an index of 47.31. Unidentifiable mass was found in comparatively less percentage in juveniles than in adults. Foraminiferans, sand and molluscan shells showed higher index. Polychaete worms were not

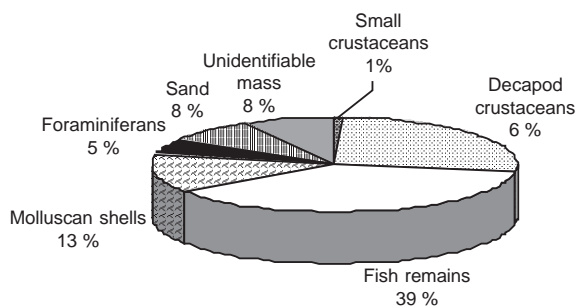


Fig. 1. Diet composition (Index of preponderance) of juveniles of *S. choprai* in November

seen in the stomach content of juveniles. The analysis of variance in food component between adults and juveniles showed significant variation in the case of ‘fish remains’, foraminiferans, molluscan shells and polychaetes ($p < 0.01$) and also small crustaceans ($p < 0.05$).

Diet composition in males and females

There was no marked difference between the diet composition of males and females (Fig. 2 and 3). In both cases, decapod crustaceans were the major component with

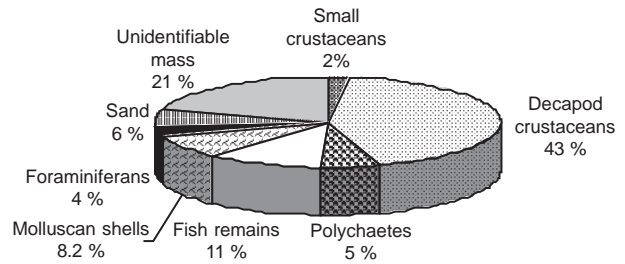


Fig. 2. Annual diet composition (Index of preponderance) of males of *S. choprai*.

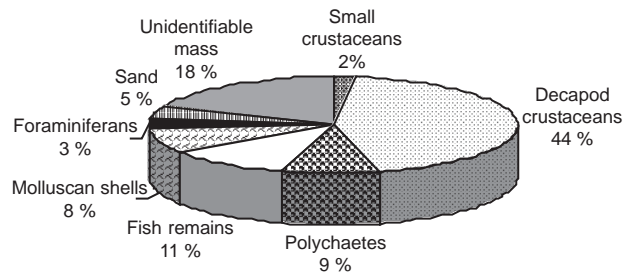


Fig. 3. Annual diet composition (Index of preponderance) of females of *S. choprai*.

indices of 43.49 and 44.04 in males and females respectively. Polychaete worms recorded higher index in females than in males particularly during January and April. There was no significant variation in food component between males and females.

Diet composition in relation to size

The specimens were classified into six size classes, 60- 65 mm, 66-70 mm, 71-75 mm, 76-80 mm, 81-85 mm and 85-90 mm. Decapods were the major component in the diet of shrimps of all length ranges. From 66 to 85 mm, the index of decapod crustaceans was above 40, whereas in the lower and upper size ranges, the index was comparatively low. In shrimps of 71 to 85 mm, ‘fish remains’ had an index value of >12 whereas in lower and higher size-classes, the index was below 10. In males of size >85mm, the index for polychaete worms was the highest and the indices for molluscan shells, foraminiferans and sand were the lowest. Analysis of variance did not show any significant difference in the food content in different size groups of males.

In females, eight size classes were differentiated viz., 65- 70 mm, 71-75 mm, 76-80 mm, 81-85 mm, 86-90 mm, 91-95 mm, and 96-100 mm and 100-115 mm. In females also, decapod crustaceans were the major diet component in all size groups. The index was highest (61.11) in lower sized shrimps i.e., below 70 mm. Sand and foraminiferans showed highest index in the lowest size-class shrimps and lowest index in the highest size-class shrimps. In the case

of 'fish remains' the trend was opposite with smallest index seen in smallest size class and highest index in the highest size class. Analysis of variance of food content with different size groups of females showed significant difference ($p < 0.01$), except for 'fish remains' and sand.

Diet composition in relation to maturity stages of females

In all the maturity stages, the major component of the food was decapod crustaceans with indices above 40. Highest index of decapod crustaceans was observed in mature females (65.36). 'Fish remains' showed lowest index in immature females (4.74), whereas in all other stages, the index was above 10. There was significant variation in the occurrence of small crustaceans and unidentifiable mass with maturity stages of females ($p < 0.01$), and that of decapod crustaceans ($p < 0.05$).

Feeding intensity

Feeding intensity of the adult *S. choprai* during the period of study was 28.88% (Table 2). During November and December, shrimps showed increased feeding intensity (Fig. 4). In February, actively fed (37%) and moderately fed (47%) females were more than those in other months

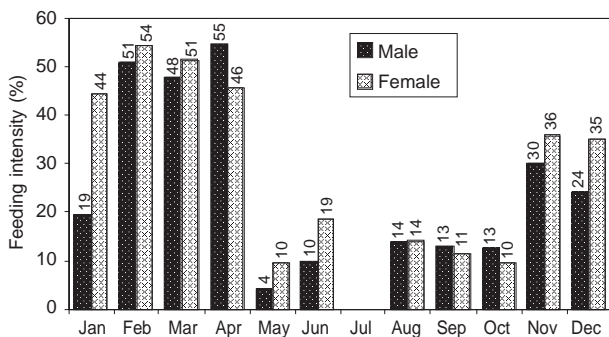


Fig. 4. Month-wise feeding intensity in males and females of *S. choprai*.

(Table 2). Actively fed shrimps were not seen in October. Stomach fullness indicated significant variation ($p < 0.05$) with sex.

Feeding intensity of the juveniles was 42%. Twenty six percentage of the juveniles were actively fed and 41% were moderately fed (Fig. 5). Fullness of stomach between juveniles and adults showed significant difference ($p < 0.05$).

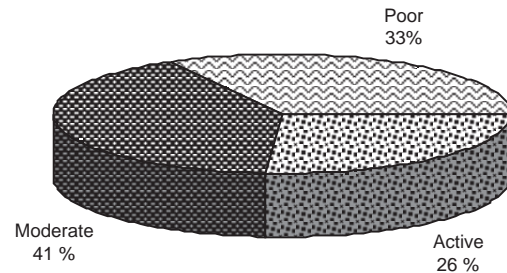


Fig. 5. Feeding condition in juveniles of *S. choprai* in November

In males, the annual feeding intensity for the year was 26% with the highest during February-April (Fig. 4). The feeding condition in males of *S. choprai* is given in Fig. 6. Actively fed males were more in April (40%). Moderately fed males were more in February (60%). From May to October, majority of the males were poorly fed (69-90%).

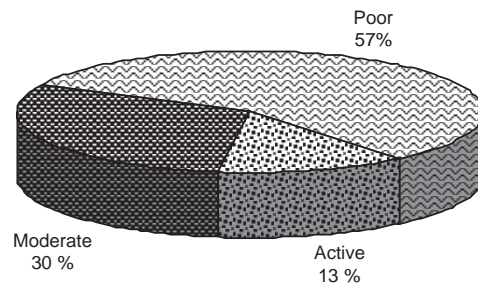


Fig. 6. Annual feeding condition of males of *S. choprai*.

Table 2. Month-wise feeding intensity and feeding condition in adults of *S. choprai*

Fullness/ Month	Full	3/4 full	1/2 full	1/4 full	Trace	Empty	Actively fed (No.)	(%)	Moderately fed (No.)	(%)	Poorly fed (No.)	(%)	Feeding intensity	No. of shrimps
Jan	11	1	7	18	18	10	12	18.46	25	38.46	28	43.08	33.15	65
Feb	11	3	8	10	6	0	14	36.84	18	47.37	6	15.79	53.55	38
Mar	11	2	9	7	10	1	13	32.50	16	40.00	11	27.50	49.38	40
Apr	24	2	19	13	18	4	26	32.50	32	40.00	22	27.50	50.06	80
May	0	1	0	5	7	27	1	2.50	5	12.50	34	85.00	06.75	40
Jun	2	0	3	3	14	18	2	5.00	6	15.00	32	80.00	14.13	40
Aug	0	1	4	5	10	16	1	2.78	9	25.00	26	72.22	13.89	36
Sep	1	2	2	5	38	22	3	4.29	7	10.00	60	85.71	12.21	70
Oct	0	0	4	6	31	19	0	0.00	10	16.67	50	83.33	11.00	60
Nov	18	7	15	32	31	26	25	19.38	47	36.43	57	44.19	32.44	129
Dec	10	3	18	24	26	20	13	12.87	42	41.58	46	45.54	29.55	101
Annual	88	22	89	128	209	163	110	15.74	217	31.04	372	53.22	28.88	699

In females, the annual feeding intensity for the year 2003 was 31.57%. Highest feeding intensity was observed during February (54.46%) (Fig. 4). During this month, 39.29% shrimps were actively fed and 42.86% were moderately fed. In May and October, the feeding intensity was below 10% and poorly fed females were more than 80%. In October, actively fed shrimp was not recorded. The feeding condition of females of *S. Choprai* is given in Fig. 7.

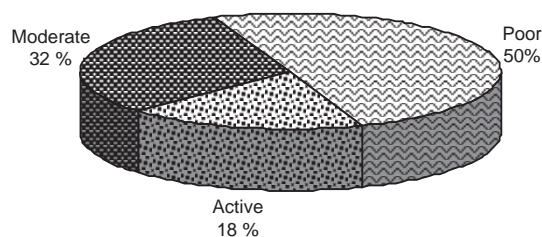


Fig. 7. Annual feeding condition of females of *S. choprai*.

Feeding intensity was highest in immature females (40.71%). Spent females showed higher feeding intensity than the maturing ones. Among immature shrimps, 21.43% were actively fed and 57.14% were moderately fed. More than 50% of early maturing, late maturing and mature females were poorly fed. Analysis of variance of fullness of stomach with different maturity stages of females showed significant variation ($p < 0.05$).

Discussion

Studies conducted by Aravindakshan and Karbari (1994) on the diet composition of *S. choprai* collected from 40-70 m depth during 1977-1986 off Bombay showed that crustaceans formed 50% of the food component, followed by polychaetes (15%), foraminiferans and molluscs (together 10%). Sand grains and debris formed 25% of the gut content. During the present study also crustaceans were found to be the major component and molluscan shells and foraminiferans were found throughout the year. Polychaete worms were less in concentration compared to the results of the previous study. However 'fish remains' formed one of the major constituent of the gut content. Sand and unidentifiable mass formed one fourth of the stomach content as reported by Aravindakshan and Karbari (1994). Due to intensive fishing activity at depths beyond 50 m, this area received a lot of discarded fishes from trawlers. The presence of 'fish remains' in the stomach of *S. choprai* in the present observation can be attributed to this. Similar observations were reported by Saint-Marie and Chabot (2002) in American lobster, *Homarus americanus*, in which those caught from the areas of trawl discards were found to have more 'fish remains' in the stomach content than

those caught from the fishing grounds which is having no trawl discards. The study conducted on the food and feeding habits of shrimps, *P. semisulcatus*, *P. canaliculatus*, *P. merguensis* and *M. monoceros* in two different ecosystems in Philippine waters (Tiews *et al.*, 1968) showed that diet composition of shrimp was related to the availability of food items than their selective feeding. Considerable amount of foraminiferans in the gut content of shrimps caught offshore than in the near shore waters was also reported in this study. There is a patch of sandy region off South Karnataka extending from a depth of 50 to 200 m which is not seen anywhere in the west coast of India (Hashimi *et al.*, 1978; Harkantra *et al.*, 1980 and Shankar and Karbassi, 1992). The fishing ground of *S. choprai* also falls within this region (60 to 100 m). Hashimi *et al.* (1978), during their studies on benthic population of this area, found that 70% of the coarse fraction is formed by foraminiferan shells. High concentration of foraminiferans in the substratum may be the reason for consistent presence of good quantity of foraminiferan shells in the gut content of *S. choprai*.

Feeding intensity of the adults showed wide fluctuations during the period of study. Feeding intensity was highest during January-April and was very low during May-October. From November onwards, feeding intensity again increased (from 30 to 32%). Decapod crustaceans were having indices of 59.3 and 51.57 during March and May respectively, whereas 'fish remains' showed high index of preponderance during May to August. Sharma (1978) reported that the upwelling in south-west coast of India starts in deeper waters from May onwards leading to a total churning of the sea bottom and this disturbance will cease by September. The low feeding intensity during May-October can be attributed to the disturbance and instability of the bottom waters due to upwelling resulting in the scarcity of preferred food items. During the monsoon months, gut contents showed more percentage of unidentifiable mass. Tiews *et al.* (1968) also described similar changes in food preference of shrimps according to food availability during various seasons in Philippine waters.

There was significant variation in food preference between adult and juvenile of *S. choprai* with reference to polychaetes, 'fish remains' and smaller crustaceans. Differences in the composition of food content of juveniles and adults were reported by Subramanyam (1973) in *Metapenaeus monoceros* and Cartes and Sardah (1989) in *Aristeus antennatus*. Cartes and Sardah (1989) stated that in species having extended breeding season it is a natural mechanism to reduce intra-specific competition of food between them, so as to ensure better survival of the species.

In the present study, food preference of females of *S. choprai* in different maturity stages showed significant variation, especially in the case of crustaceans as food, with mature females preferring more than other stages. Similar findings were reported by Scarrat (1980) in lobsters who observed that they have consumed more crabs, mussels and fish but fewer echinoderms as they approach maturity. By habit, *S. choprai* is a burrowing species with antennules acting as a respiratory tube for breathing while burrowing (Chan, 1998). Analysis of the catch data recorded during day and night trawl operations revealed that the fishery was successful only during night time, which suggests that the activities of *S. choprai* including feeding are more during night than day. Eldred *et al.* (1961) while studying the habits of *P. duorarum* inferred that most of the shrimps which are having a burrowing habit have a nocturnal feeding habit.

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References

- Aravindakshan, M. and Karbari, J. P. 1994. Studies on the fishery and biology of ridgeback shrimps, *Solenocera choprai*, Nataraj, occurring off Maharashtra coast. *J. Mar. Biol. Ass. India*, 36: 96-99
- Cartes, J. E and Sardah, F. 1989. Feeding ecology of the deepwater aristeid crustacean, *Aristeus antennatus*. *Mar. Ecol. Prog. Ser.*, 54: 229-238
- Chan, T. Y. 1998. Shrimps and Prawns. In: Carpenter, K. E. and Niem V. H. (Eds.) *FAO identification guide for fishery purposes – The Living Marine Resources of the Western Central Pacific, Vol.2, Cephalopods, Crustaceans, Holothurians and Sharks*, p. 827-1155.
- Dall, W. 1968. Food and feeding of Australian penaeid shrimps. *FAO Fisheries Report*; 57: 251-258.
- Dall, W. 1999. Australian species of Solenoceridae (Penaeoidea: Decapoda) *Mem. Qld. Mus.*, 43: 553-587.
- Dall, W., Hill, B. J., Rothlisberg, P. C. and Staples, D. J. 1990. The biology of penaeidae. *Adv. Mar. Biol.*, 27: 1-488.
- Dineshbabu, A. P. 2004. An account on the fishery and biology of the penaeid shrimp, *Parapenaeus fissuroides indicus* Crosnier, 1985 recorded for the first time from Indian waters. *J. Mar. Biol. Ass. India*, 46: 90- 94.
- Dineshbabu, A. P. and Manissery, J. K. 2008. Reproductive biology of ridgeback shrimp, *Solenocera choprai* Nataraj, (Decapoda, Penaeoidea, Solenoceridae) off Mangalore coast, south India. *Fish. Sci.*, 74: 798- 803.
- Eldred, B., Ingle, R. M., Woodburn, K. D., Hutton, R. F. and Jones, H. 1961. Biological information on the commercial shrimp, *Penaeus duorarum* Burkenroad, in Florida waters. *Fla. State. Bd. Conserv. Prof. Ser.*, 3: 1-139
- Hall, D. N. F. 1962. Observation on the taxonomy and biology of some Indo-West Pacific penaeidae (Crustacea, Decapoda). *Fish. Pubs. Colon. Off.*, 17: 229 pp.
- Harkantra, S. N., Nair, A., Ansari, Z. A. and Parulekar, A. H. 1980. Benthos of the shelf region along the west coast of India. *Indian J. Mar. Sci.*, 9: 106-110.
- Hashimi, N. H., Kidwai, R. M. and Nair, R. R. 1978. Mean-size and coarse-fraction studies of sediments between Vengurla and Mangalore on the west coast of India. *Indian J. Mar. Sci.*, 7: 231-238.
- Kunju, M. M. 1968. Some aspects of biology of *Solenocera indica*, Nataraj. *FAO Fish. Rep.*, 57: 467-485.
- Marte, C. L. 1980. The food and feeding habits of *Penaeus monodon* collected from Makty river, Aklan. *Crustaceana*, 38: 225-236.
- Natarajan, A. V. and Jhingran, V. G. 1961. Index of preponderance – a method of grading the food elements in the stomach analysis of fishes. *Indian J. Fish.*, 8: 54-59.
- Pillay, T. V. R. 1952. A critique of the methods of study of food of fishes. *J. Zool. Soc. India*, 4: 185-200.
- Saint-Marie, B. and Chabot, D. 2002. Ontogenic shifts in natural diet during benthic stages of American lobster (*Homarus americanus*), off the Magdalen Islands. *Fish. Bull.*, 100: 106-116
- Scarrat, D. J. 1980. The food of lobster. In: Pringle, J. D. Sharp, G. J. and Caddy J. F. (Eds.), *Proceedings of the workshop on the relationship between sea urchin grazing and commercial plant/animal harvesting, Canada Tech. Rep. Fish. Aquat. Sci.*, 954: 66-91.
- Shankar, R. and Karbassi, A. R. 1992. Sedimental evidence for paleobeach off Mangalore, west coast of India. *J. Geol. Soc. India*, 40: 241-252.
- Sharma, G. S. 1978. Upwelling off south-west coast of India. *Indian J. Mar. Sci.*, 7: 209- 218.
- Subramanyam, C. B. 1973. Fishery and biology of *Metapenaeus monoceros* (Fabricius) from Godavary estuarine system. *Fish. Technol.*, 2: 26-41.
- Tiews, K., Bravo, S. A. and Ronquillo, I. A. 1968. On the food and feeding habits of some Philippine shrimps in Manila Bay and San Miquel Bay. *Proc. Indo-Pacif. Fish. Conc.*, 13: 88-92.

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