

**FOOD AND FEEDING BEHAVIOUR OF *NEMIPTERUS JAPONICUS* (BLOCH)
POPULATIONS OFF VISAKHAPATNAM, SOUTH INDIA***

D. MANIKYALA RAO** AND K. SRINIVASA RAO

Department of Zoology, Andhra University, Waltair

ABSTRACT

Qualitative and quantitative analyses (volumetric and frequency of occurrence methods) of stomach contents of *Nemipterus japonicus*, caught off Visakhapatnam, are made. *Squilla*, crabs, prawns, teleosts, cephalopods, amphipods, polychaetes and other miscellaneous items in that order of preponderance constituted the food spectrum of the species. Degrees of fullness, on the basis of stomach wall distensions are assessed and average amount of feeding calculated. Feeding intensity is high during March-November and low during December-February. Nature of food is size-dependent and fishes in higher length-groups preferred large-sized prey like crabs, teleosts and cephalopods. The composition and preference of food items are not sex-dependent.

INTRODUCTION

THREADFIN BREAMS belonging to the genus *Nemipterus* constituted about 13% of the total bottom-trawl catches at Visakhapatnam during July, 1977—June, 1980 (Rao, 1981). Of the eight species of the genus, recorded from Indian waters, the Japanese threadfin bream *Nemipterus japonicus* is the most common one and forms a commercially important fishery along the Indian Coast. Although the abundance of *N. japonicus* catches varies seasonally, the species forms fishery almost throughout the year, ranging from 50% (late December-mid March) to 90% (late March-early December) of the total nemipterid catches at Visakhapatnam Fishing Harbour.

Earlier studies were either of a preliminary nature (Chacko, 1949; Rao, 1964; Kuthalingam, 1965; George *et al.*, 1968; Eggleston,

1972) or covering a very wide area (Krishnamoorthi, 1971) to draw any meaningful relationship between changes in food and feeding habits and variations in catches. The present study is confined to the waters off Visakhapatnam where commercial exploitation of the species is done.

In the present study, qualitative and quantitative analyses of stomach contents of *N. japonicus* were carried out according to seasons, size and sex. Variations in the average amount of feeding were also studied.

We thank the University Grants Commission and the Council of Scientific and Industrial Research, New Delhi for financial assistance.

MATERIAL AND METHODS

Samples of fish, each not exceeding 25 in number were collected over a 30 month period (May 1977 - October 1979) from the trawl catches landed at Visakhapatnam Fishing Harbour, which was visited twice a week. They were examined after fixation in 5%

* Formed a part of Ph.D. Thesis, Andhra University, Waltair.

** Present address : Department of Zoology, Akkineni Nageswara Rao College, Gudivada 521 301.

formaldehyde solution for about a fortnight (Windell and Bowen, 1978). The period from May to April is considered as the statistical year to follow the seasonal pattern in the feeding habits of the species. A total number of 1,443 specimens during May 1977-April 1978 period, 1,061 specimens during May 1978-April 1979 period and 287 specimens during May 1979-October 1979 period (half year) were examined in the present study.

The stomachs were separated after recording the date of capture, sex, standard length and stage of maturity of each fish. The degree of stomach fullness was assessed on the basis of distension of stomach folds (Rao, 1964). Average amount of feeding was calculated taking into account the number of fish with empty stomachs. Six categories of stomach fullness, namely 'empty', ' $\frac{1}{4}$ full', ' $\frac{1}{2}$ full', ' $\frac{3}{4}$ full', 'full' and 'gorged' could be recognised. Numerical values of 0.0, 0.25, 0.50, 0.75, 1.00 and 1.50 were assigned respectively to the above categories. The values gained by all the stomachs examined in a given sample were averaged to obtain the average amount of feeding according to season, size, sex and stage of maturity. The fish in a given sample were considered to be intensely fed when the average amount of feeding reached 0.75 or above.

Each stomach was considered as a unit and the stomach contents were separated qualitatively first, to the nearest taxon possible and their quantity was determined volumetrically. Frequency of occurrence of each item was also taken into account to find out the relative preference of different items. Details of the analyses are according to Hynes (1950) and Windell and Bowen (1978).

The index, designated as 'Index of Preponderance' proposed by Natarajan and Jhingran (1961) was calculated to grade the relative importance of the food items.

RESULTS

Regular food items in the order of importance (overall % composition from May 1977 to October 1979) were *Squilla* spp. (18.32%), crabs (13.95%), prawns (11.71%), juveniles of eels (0.86%) and other teleosts (7.26%), cephalopods (3.90%), amphipods (2.17%) and polychaetes (1.54%). Occasional items were small brittle stars, holothurians, mole-crabs, isopods, small bivalves gastropods and fish scales, which were grouped under the category of 'miscellaneous items'. Crabs were mainly represented by *Charybdis* sp. and *Neptunus* sp. The prawns encountered in the stomachs were mainly penaeid prawns. Juveniles of eels were the most preferred item of the teleost food component. The other teleosts met within the stomachs were flatfish, anchovy, *Bregmaceros* sp., apogonids, silverbellies and small *Trichiurus* sp. Cephalopods were represented by *Sepia* sp. and *Loligo* sp. of small size and occasionally octopods. Amphipods could not be identified since they were found mostly in broken condition. Among the polychaetes, *Polydora* sp., eunicids, aphroditids and glycerids were common.

Seasonal variations in food and feeding habits

The study reveals a general pattern of high feeding intensity (according to average amount of feeding) during the May-October/November period and low feeding intensity during the December-February/March period (Table 1).

Index of preponderance : According to the index, *Squilla* was the most preferred food item in all the periods (26.40 in 1977-1978, 29.63 in 1978-1979 and 29.24 in May-October 1979 period and 28.38 during the whole period of investigations, May 1977-October 1979) (Table 2). Crabs and prawns were the next in importance. Teleosts, other than eel juveniles and cephalopods maintained the fourth and fifth ranks respectively. Amphipods, polychaetes, eel juveniles and other miscellaneous items occupied sixth to ninth places (Table 2).

TABLE 1. *Specimens examined and values of average amount of feeding in different months (from May 1977 to October 1979)*

		May	June	July	August	Septem- ber	October	Novem- ber	Decem- ber	January	February	March	April
Total number of specimens examined	(a)	44	152	65	59	192	98	130	128	164	143	174	94
	(b)	49	—	77	75	130	107	120	101	111	93	132	66
	(c)	69	24	71	38	45	40	—	—	—	—	—	—
Number of empty stomachs	(a)	4	19	Nil	10	28	18	36	48	78	26	53	22
	(b)	5	—	9	9	10	13	25	40	50	66	20	8
	(c)	8	Nil	Nil	Nil	2	Nil	—	—	—	—	—	—
Average amount of feeding	(a)	0.79	1.08	1.10	0.82	1.01	0.78	0.63	0.43	0.46	0.66	0.50	0.71
	(b)	0.56	—	0.81	0.88	0.86	0.79	0.76	0.46	0.53	0.27	0.79	0.82
	(c)	0.96	0.99	1.04	0.99	0.86	1.05	—	—	—	—	—	—

(a) May 1977 to April 1978. (b) May 1978 to April 1979. (c) May 1979 to October 1979.

Seasonal variations in the indices of preponderance (Fig. 1) of different food items are detailed below. (Digested matter is excluded in describing the ranks of the food items.)

Squilla

Squilla was the most preferred food item throughout the period of investigation (particularly during July-November period) according to index of preponderance (Fig. 1).

almost throughout except in May 1978 (fourth) and January 1979 (sixth). In the half year study, prawns occupied higher positions in all the six months (Fig. 1).

Juveniles of eels

The item was the most preferred among the teleosts ingested by the species. However, the item showed no seasonal trend in its abundance (Fig. 1).

TABLE 2. Indices of preponderances of different food items of *N. japonicus* during different periods

	May '77-April '78	May '78-April '79	May-October '79	May '77-October '79
<i>Squilla</i>	.. 26.40 (2)*	29.63 (2)	29.24 (1)	28.38 (2)
Crabs	.. 14.59 (3)	9.21 (4)	21.91 (2)	13.64 (3)
Prawns	.. 9.32 (4)	16.85 (3)	20.65 (3)	13.39 (4)
Eel juveniles	.. 0.22 (10)	0.14 (9)	0.01 (10)	0.15 (10)
Other teleosts	.. 5.59 (5)	6.38 (5)	10.40 (5)	6.61 (5)
Cephalopods	.. 1.42 (6)	6.05 (6)	1.88 (6)	2.84 (6)
Amphipods	.. 0.28 (9)	0.26 (7)	1.55 (7)	0.40 (7)
Polychaetes	.. 0.68 (7)	0.14 (10)	0.12 (8)	0.37 (8)
Miscellaneous items	.. 0.47 (8)	0.22 (8)	0.06 (9)	0.32 (9)
Digested matter	.. 41.03 (1)	31.12 (1)	14.19 (4)	33.90 (1)

* Figures in parentheses indicate the ranks of individual food items in their respective periods.

Crabs

In general, crabs occupied second to fourth positions from June 1977 to January 1978 according to index of preponderance and later they were elevated to first position during February-April 1978. The indices in 1978-79 are too erratic to discern any definite trend in the occurrence of crabs. The item gained high index values during July-October 1979 period (Fig. 1).

Prawns

Prawns occupied first to third positions during May-September 1977 after which they were relegated to lower positions. In 1978-1979, the item gained higher ranks (first to third)

Other teleosts

The item ranked first to fourth positions during August 1977-March 1978. In 1978-1979, teleosts were relegated to lower positions, namely second to fifth positions throughout the year (Fig. 1).

Cephalopods

In 1977-1978, the item's rank varied from second (January 1978) to eighth (June 1977). But in 1978-79, the item occupied third to fifth positions during September 1978-March 1979 period. In the succeeding half year period, however, the item was relegated to fifth or sixth position (Fig. 1).

The other recognisable food items, namely amphipods and polychaetes are of minor importance in the diet of *N. japonicus*, as observed from their low indices (Fig. 1).

different length groups. Number of specimens examined and values of average amount of feeding in different length groups are represented in Fig. 2.

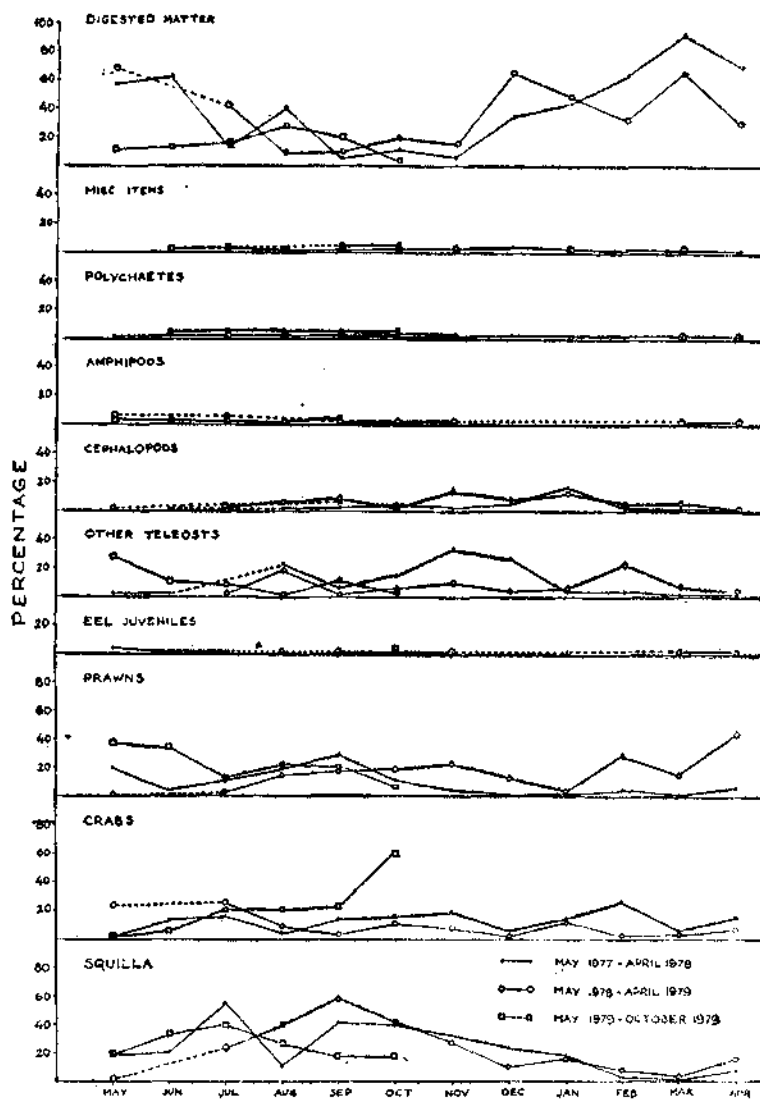


Fig. 1. Monthly variations in the indices of preponderance of different food items.

Size-related variations in food and feeding habits Squilla

Values of indices of preponderance are taken as the basis of studying the variations in food composition (barring digested matter) in

The item ranked first in most of the length groups in 1977-1978, excepting 9.1-10.0 cm, 15.1-17.0 cm and 18.1-19.0 cm length groups in

which it ranked second. In 1978-1979, the trend was slightly different. *Squilla* was of secondary importance in the lower length groups (8.1-11.0 cm) and again in the 17.1-19.0 cm

or third position in the size range of 9.1-16.0 cm in 1977-1978. In the next year, the food item generally occupied second or third position throughout the size range (Fig. 3).

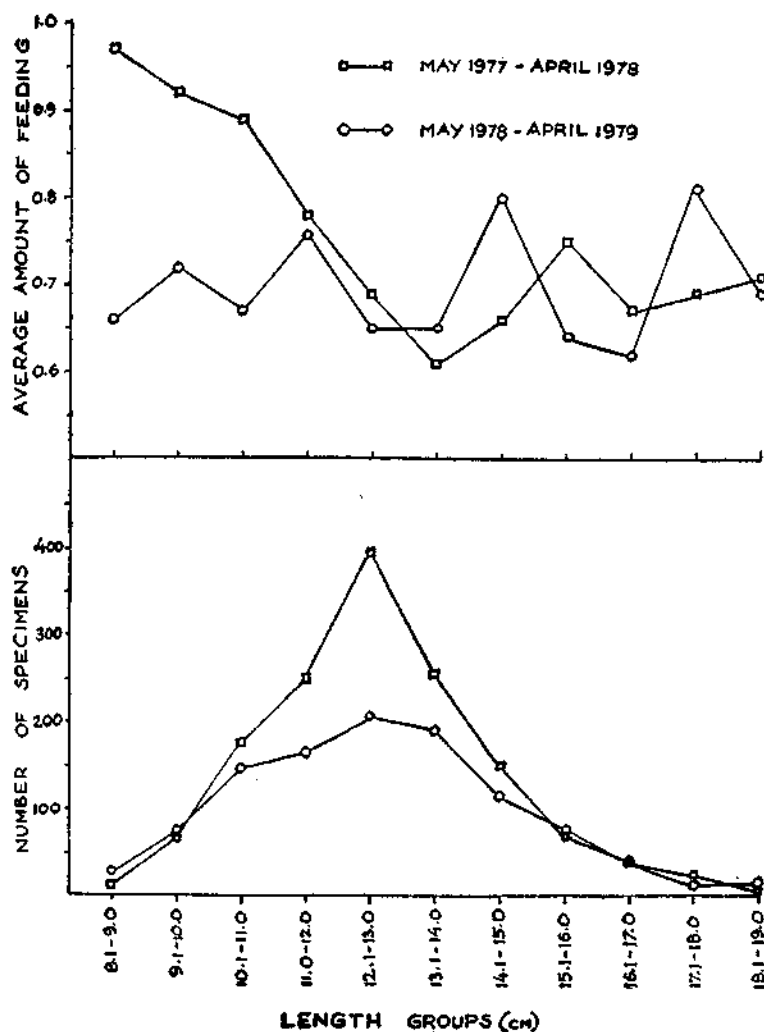


Fig. 2. Number of specimens examined and values of average amount of feeding in the different length groups.

length groups. In all the length groups between 11.1 cm and 17.0 cm, the item ranked first (Fig. 3).

Crabs

Crabs occupied first or second position in the higher length groups (16.1-19.0 cm) and second

Prawns

In 1977-1978, prawn component was graded as second or third in all the groups of 8.1-15.0 cm size range, showing a decline thereafter (fourth or fifth in the 15.1-19.0 cm size range). In 1978-1979, prawns ranked first in the lower

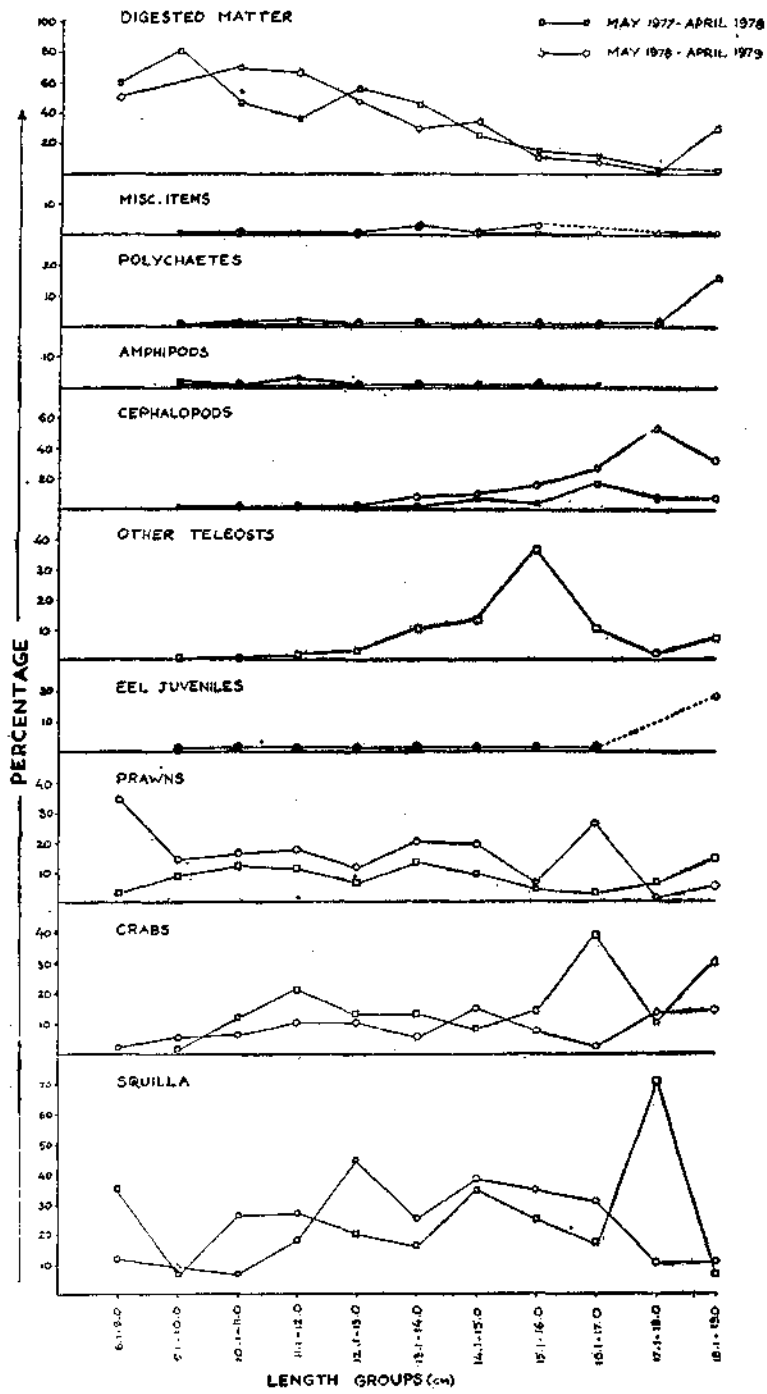


Fig. 3. Variations in the indices of preponderance of food items in the different length groups.

length groups of 8.1-11.0 cm, second in the size range of 11.1-15.0 cm and declined further in the higher length groups. Prawn component was a preferential food item in the length range of 8.1-15.0 cm (Fig. 3).

Juveniles of eels

The item ranked fifth to ninth in the grading indices of different length groups in the two years. The juveniles occupied second position in the 18.1-19.0 cm length group in 1977-1978 (Fig. 3).

Other teleosts

Teleosts were graded first in the 15.1-16.0 cm and second in the 14.1-15.0 cm length groups in 1977-1978. In the remaining length groups, the item's rank varied from fourth to sixth. In 1978-1979, teleosts maintained fourth or fifth rank in all the length groups except in 15.1-16.0 cm and 17.1-18.0 cm length groups, in which the item was positioned second (Fig. 3).

Cephalopods

While the item was graded fifth to eighth in the size range of 9.1-16.0 cm, they occupied higher positions in higher length groups (16.1-19.0 cm) in 1977-1978. In the next year, cephalopods ranked first in the 17.1-19.0 cm length range and second in the 16.1-17.0 cm length group. In both years, the preponderance of cephalopods was high in higher length groups (16.1-19.0 cm) (Fig. 3).

Amphipods and polychaetes occupied relatively higher positions in lower length groups than in higher length groups (Fig. 3).

Food and feeding habits in relation to sex

A total number of 725 males and 718 females during May 1977-April 1978 and 498 males and 563 females during May 1978-April 1979 were examined for the study.

Tables 3 a and 3 b show indices of preponderance of various food items in males and

females respectively during May 1977-April 1979.

In the food of both males and females, *Squilla* ranked first (barring digested matter), Crabs, prawns, teleosts and cephalopods, in that order, showed their importance in the food of males (Table 3 a). In the food of females, prawns occupied a higher position than crabs (Table 3 b). Indices of food items of minor importance like amphipods and polychaetes varied from males to females.

These analyses show that there are no marked differences in the food composition between males and females.

DISCUSSION

The Japanese threadfin bream *Nemipterus japonicus* is essentially a carnivore feeding on crustaceans (*Squilla*, crabs and prawns) teleosts, cephalopods, amphipods and polychaetes in that order and miscellaneous items like brittle stars, holothurians, small bivalves, gastropods, mole crabs, isopods and megalopa larvae.

The various components of the food spectrum indicate that the species is mainly a bottom feeder. Food items such as *Squilla*, crabs, prawns, teleosts, cephalopods are actively mobile and are hunted before they are ingested by the predator, namely *N. japonicus*. The bream shaped body with forked caudal fin is designed for moderately fast swimming. Large eyes indicate that the fish feeds by sight, which is further highlighted by the absence of tactile organs. Feeding activity appears to be much reduced in the night (Rao, 1964) which is further supported by the fact that remains of digested matter constituted the bulk of the stomach contents in the samples landed ashore in the morning after night-fishing during the December-February/March period.

Preliminary examination of stomach contents of other species, i.e. *N. tolu*, *N. mesoprion*

TABLE 3 a. *Indices of preponderance of different food items in males of N. japonicus during May 1977-April 1979*

Food items	Vol. (ml)	Occ.	V _i	O _i	V _i O _i	$\frac{V_i O_i}{\sum V_i O_i} \times 100$
<i>Squilla</i>	.. 90.00	290	22.42	17.92	401.77	29.28 (2)*
Crabs	.. 44.85	284	11.17	17.55	196.03	14.29 (3)
Prawns	.. 58.40	209	14.54	12.92	187.86	13.69 (4)
Eel juveniles	.. 12.45	25	3.10	1.55	4.81	0.35 (9)
Other teleosts	.. 63.90	103	15.92	6.37	101.41	7.39 (5)
Cephalopods	.. 56.00	67	13.95	4.14	57.75	4.21 (6)
Amphipods	.. 1.80	88	0.45	5.44	2.45	0.18 (10)
Polychaetes	.. 6.90	54	1.71	3.34	5.71	0.42 (8)
Miscellaneous items	.. 6.95	58	1.73	3.58	6.19	0.45 (7)
Digested matter	.. 60.25	440	15.01	27.19	408.12	29.74 (1)
					$\sum V_i O_i$	
Total	.. 401.50	1618	100.00	100.00	1372.10	100.00

* Figures in parentheses indicate the ranks of individual food items.

Number of specimens examined : 1,223.

Average amount of feeding : 0.73.

TABLE 3 b. *Indices of preponderance of different food items in females of N. japonicus during May 1977-April 1979*

Food items	Vol. (ml)	Occ.	V _i	O _i	V _i O _i	$\frac{V_i O_i}{\sum V_i O_i} \times 100$
<i>Squilla</i>	.. 63.60	285	22.86	18.15	414.91	25.59 (2)*
Crabs	.. 31.00	231	11.14	14.71	163.87	10.11 (4)
Prawns	.. 39.90	186	14.34	11.85	169.93	10.48 (3)
Eel juveniles	.. 4.00	11	1.44	0.70	1.01	0.06 (10)
'Other' teleosts	.. 39.15	82	14.07	5.22	73.44	4.53 (5)
Cephalopods	.. 24.20	50	8.70	3.18	27.67	1.71 (6)
Amphipods	.. 2.55	117	0.92	7.45	6.85	0.42 (7)
Polychaetes	.. 5.10	54	1.83	3.44	6.30	0.39 (8)
Miscellaneous items	.. 4.10	45	1.47	2.88	4.23	0.26 (9)
Digested matter	.. 64.65	509	23.23	32.42	753.17	46.45 (1)
					$\sum V_i O_i =$	
Total	.. 278.25	1570	100.00	100.00	1621.38	100.00

* Figures in parentheses indicate the ranks of individual food items.

Number of specimens examined : 1,281.

Average amount of feeding : 0.70.

and *N. delagoae* available at Visakhapatnam indicated that nemipterids, as a whole, are sight-feeders.

Chacko (1949) observed high quantities of both phytoplankton and zooplankton in the guts of *N. japonicus* obtained from the Gulf of Mannar and remarked that the species occasionally fed at the bottom. Rao (1964), who worked out the daily rhythmicity in feeding of several fishes from Visakhapatnam and its northern regions, observed teleosts, anemones, amphipods, prawns, *Squilla* and cephalopods and several other organisms in smaller quantities in the guts of *N. japonicus*.

study in respect of food spectrum, food preference, seasonal variations in food habits, feeding activity and feeding behaviour agree with each other. Eggleston (1972) observed that *N. japonicus* fed on crustaceans, fish, cephalopods, polychaetes and lamellibranchs in the northern China Sea (Hong Kong).

The above account obviously reveals some geographical differences in the food composition of *N. japonicus*. At one extreme are the planktonic organisms reported from the Gulf of Mannar (Chacko, 1949) where the bottom, is sandy and rocky (Luther, 1975). At the other extreme are the immobile benthic fauna

TABLE 4. Specimens examined and values of average amount of feeding in the different length groups (cm) during May 1977-April 1979

		8.1- 9.0	9.1- 10.0	10.1- 11.0	11.1- 12.0	12.1- 13.0	13.1- 14.0	14.1- 15.0	15.1- 16.0	16.1- 17.0	17.1- 18.0	18.1- 19.0
Number of specimens examined ..	(a)	9	66	175	252	394	253	152	70	42	24	6
	(b)	23	71	145	164	204	189	117	73	39	20	13
Average amount of feeding ..	(a)	0.97	0.92	0.89	0.78	0.69	0.61	0.66	0.75	0.67	0.69	0.7
	(b)	0.66	0.72	0.67	0.76	0.65	0.65	0.80	0.64	0.62	0.81	0.61

(a) May 1977-April 1978. (b) May 1978-April 1979

Kuthalingam (1965) from Mangalore found that penaeid prawns constituted the main food of the species up to a depth range of 30 m and the fish that were obtained from 30-50 m depth range contained large quantities of fish remains in their stomachs. *Squilla* also made its appearance in these samples. George *et al.* (1968) from Cochin noticed that the important food organisms were echinuroids, amphipods and polychaetes which formed the bulk of the diet. *Squilla*, crabs and prawns which are considered the most important food organisms in the present study, occupied much lower positions in the grading index given by them. Krishnamoorthi's (1971) findings (based on samples from Andhra-Orissa Coast) and results of the present

like anemones and isopods reported by Rao (1964) from samples collected off Barua and Puri where the feeding grounds are mostly muddy or slimy in nature (FAO, 1961). Although regional differences in the food of the fish might arise because of the nature of the substratum, which may vary with depth in the same locality, the fact that the fish feeds by sight is undeniable. In the light of such overwhelming support upholding the strict bottom feeding behaviour of the fish, feeding on plankton as reported by Chacko (1949) is rather untenable. The gill rakers of *N. japonicus* are not suitable for plankton feeding.

Important food items, namely *Squilla*, crabs, prawns, teleosts and cephalopods are abun-

dant—with some minor variations—during the June / July - November / December period of the study. In the samples landed during December - March period, majority of the stomachs contained only remains of digested matter.

The present investigation suggests that the nature of food of the species is size-dependent. Fish in higher length groups, more often ingested cephalopods, crabs and teleosts in large quantities than those in lower length groups. The occurrence of such actively mobile benthic organisms like crabs, cephalopods, *Apogon* spp. and *Trichiurus* sp. in the higher length groups indicates that larger fish feed very close to or near the bottom, feeding on actively moving organisms. Although amphipods and polychaetes are not highly preferred food items, their higher grading in

lower length groups, according to the index of preponderance, indicates the tendency of *N. japonicus* to feed at deeper levels (predating on actively moving organisms) as they grow larger. These observations also suggest that as the fish grow to larger sizes, the feeding spectrum of the species narrows down to a very few number of organisms of larger size. These observations are in conformity with the views expressed by Eggleston (1972) who studied the feeding habits of three species of *Nemipterus* in the waters of Hong Kong (South China Sea).

From the present study it is obvious that composition and preference of food is the same in both sexes. But observations on average amount of feeding in both sexes, show that males exhibit a little higher feeding intensity than females.

REFERENCES

- CHACKO, P. I. 1949. Food and feeding habits of the fishes of Gulf of Mannar. *Proc. Indian Acad. Sci.*, 29B : 83-97.
- EGGLESTON, D. 1972. Patterns of biology in the Nemipteridae. *J. mar. biol. Ass. India*, 14 : 357-364.
- FAO, 1961. Report to the Government of India on a survey of Fishery resources of the Bay of Bengal. Project FAO/ETAP 158 ; based on the work of V.M. Naumov, FAO/TA Marine Fisheries Biologist, FAO Report 1393, 60 pp.
- GEORGE K. C., M. G. DAYANANDAN AND P. KARUNAKARAN NAIR 1968. Food of some demersal fishes from the trawl grounds off Cochin. *Indian J. Fish.*, 15 : 81-87.
- HYNES, H. B. N. 1950. The food of sticklebacks (*Gasterosteus aculeatus* and *Pygosteus pungitius*) with a review of methods used in studies of the food of fishes. *J. anim. Ecol.*, 19 : 36-58.
- KRISHNAMOORTHY, B. 1971. Biology of the threadfin bream *Nemipterus japonicus* (Bloch). *Indian J. Fish.*, 18 : 1-21.
- KUTHALINGAM M. D. K. 1965. Notes on some aspects of the fishery and biology of *Nemipterus japonicus* (Bloch) with special reference to feeding behaviour *Ibid*, 12 : 500-506.
- LUTHER, G. 1975. Studies on the biology and fishery of some marine fishes of India. *Ph.D. thesis, Andhra University, Waltair*, 326 pp.
- NATARAJAN, A. V. AND A. G. JHINGRAN 1961. Index of preponderance—a method of grading the food elements in the stomach analyses of fishes. *Indian J. Fish.*, 8 : 54-59.
- RAO, D. MANIKYALA 1981. Studies on the biology and biometry of the threadfin bream *Nemipterus japonicus* (Bloch), with observations on the nemipterid fishery off Visakhapatnam (Bay of Bengal). *Ph.D. Thesis, Andhra University, Waltair*, 224 pp.
- RAO K. SRINIVASA 1964. Food and feeding habits of fishes from trawl catches in the Bay of Bengal with observations on diurnal variations in the nature of feed. *Indian J. Fish.*, 11 : 277-314.
- WINDELL, J. T. AND S. H. BOWEN 1978. Methods for study of fish diets based on analysis of stomach contents. In : T. B. Bagenal (Ed.) *Methods for assessment of fish production in freshwaters*. IBP Handbook No. 3, Blackwell Scientific Publications, Oxford and Edinburgh. pp. 219-226.