J. mar. biol. Ass. India, 2000, **42** (1&2) : 124 - 134

Food and Feeding habits of Malabar sole *Cynoglossus macrostomus* Norman

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Abstract

The food and feeding habits of Malabar sole *Cynoglossus macrostomus* Norman occurring along the coastal seas off Kerala were studied both qualitatively and quantitatively during 1994-96. The samples for the study were collected from three widely located centres like Cochin, Ambalapuzha and Neendakara. The fish mainly adapted to a bottom habitat feeds on polychaetes and detritus, amphipods, copepods, small molluscs and foraminifera. Active feeding was found immediately after spawining during October - November and February March. There was not much difference in the forage items noticed at different centres. Since the detritus is an important food component followed by other macrobenthos the fish can safely be placed between trophic level I and II.

Introduction

Investigations on the food and feeding habits of fishes have traditionally been important in fishery biological studies since food is one of the key factors that profoundly influence the shoaling, behaviour, migration, condition and even the fishery. The Pleuronectids, comprising the flatfishes by virtue of their body form and bottom habitat have attracted the attention of many workers. In India, the flatfishes support a commercial fishery especially along the southwest coast. The annual production of the resource during 1999 was 45,000t. Our knowledge on the food and feeding habits of flatfishes is confined to the works of Seshappa and Bhimachar (1955) on Malabar sole, *Cynoglossus semifasciatus;* Pradhan (1959) on *Pseudorhombus elevatus;* Pradhan (1969), Abraham and Nair (1976) on *Psettodes erumei;* Kuthalingam (1957) on *Cynoglossus lingua;* Devadoss and Pillai (1973), Devadoss *et al* (1977), Ramanathan and Natarajan (1980) and Ramanathan *et al* (1977) on other flatfish species. Among the flatfishes, only few species like the Malabar sole support a fishery of commercial importance. The species contributed nearly 95% of the total 25,000 t of flatfishes landed in Kerala. Apart from the studies on the food and feeding habits of the Malabar sole by Seshappa and Bhimachar (1955) carried out at Calicut in the immediate post independence period not much information is available on this aspect especially at a time when the exploitation pattern of many a fishes has undergone dramatic changes due to mechanisation of the craft, technological innovations in gear and extended area of operation. The present study, therefore, attempts to give a detailed account on the food and feeding habits of Malabar sole

Cynoglossus macrostomus off Kerala coast based on sample coverage from three distantly placed centres such as Cochin, Neendakara (Quilon) and Ambalapuzha (Alleppey).

The author is grateful to Dr. Mohan Joseph Modayil, Director, C.M.F.R. Institute, Cochin and to Dr. N. G. K. Pillai, HOD, Pelagic Fisheries Division for their kind encouragement in publishing this account.

Material and methods

Samples of Malabar sole *Cynoglossus macrostomus* were collected from the trawl landings at Cochin and Neendakara (Quilon) Fisheries Harbours and from the *mini* trawl landings at Ambalapuzha (Alleppey). Weekly sampling was carried out at Cochin and fortnightly at the other two centres during August 1994 to July 1996. The study is based on a total of 6778 fishes of the size range 45-165 mm. Fish samples were preserved in 5% formalin. Both qualitative and quantitative analyses of the food items were carried out. The food items were sorted out using a binocular microscope and the volume and occurrence of each item were recorded. The Index of Preponderance, a method suggested by Natarajan and Jhingran (1961) was followed in the analyses. The extent of feeding was based on the degree of fullness of the stomach and the amount of food contained in it was expressed as full, $^3/_4$ full, $^1/_2$ full, $^1/_4$ full, trace and empty with points 100, 80, 60, 40, 20, 10 and 0 assigned respectively.

Results

Qualitative analysis

The dietary components of Malabar sole can be grouped under major categories like polychaetes, amphipods, copepods, mysids, small molluscs and detritus. The occurrence of these items indicated that the fish is a carnivorous detritus feeder. Among polychaetes *Prionospia pinnata* was found to be the favourite food as this item was noticed in all the months. Other species like *Phyllochaetopterus* sp.; *Pectinaria* sp., and *Clymene* sp. occurred occasionally. Amphipods like *Cheiriphotis megachelis* and *Grandidierella bonnieri* occurred during certain seasons. Among copepods *Temora, Centropagus and Fabidocera* were encountered. Apart from these the diet included young ones of bivalves like *Tellina, Pholas, Cardium, Arca, Barnea* and gastropods. Settled detritus occurring throughout the year constituted a major component in the diet. Among foraminifera *Ammonia beccarii* occurred during most of the period. These observations indicated that the Malabar sole is a typical bottom feeder moslty feeding on detritus and macrobenthos. Occasionally they have been found to gravitate for feeding on small organisms like mysids and copepods.

Quantitative analysis

A comparison of the Index of Preponderance of the dietary components of the Malabar sole observed at Cochin and Neendakara was made. The components were grouped as mentioned under qualitative analysis. Among polychaetes

Prionospia pinnata was one of the most common item that occurred throughout the year at Cochin with a percentage index varying from 0.1 to 97. Other polychaetes like *Phyllochaetopterus* sp.; *Pectinaria sp.* and *Clymene* sp. were noticed occasionally during February to May.

The crustacean diet showed similarity in the occurrence and the component's seasonal pattern of availability in the environment off Cochin and Neendakara. The index of mysids varied from 0.2 to 98 and that of copepods 0.2 to 79. Crustaceans like young ones of *Neptunus* sp.; hermit crabs and penaeid prawns such as *Parapenaeopsis stylifera* were also encountered in minor quantities at Cochin. Among molluscs, the gastropods noticed in the diet of Malabar sole at Neendakara were similar to that observed at Cochin. The index varied from 0.01 to 10. Bivalves like *Tellina, Nucula, Arca* and *Cardium* were noticed in the diet of the fish at Neendakara. Detritus as a food item was observed throughout the period as at Cochin. This constituted a major portion of the diet with high index value. The index was highest in May followed by March. The ranking of food items with respect to both males and females is indicated in Tables 1 and 2. The study indicated that there is no difference in the food items consumed between male and female Malabar sole.

There are only some minor variations in the ranks obtained by the forage organisms. The food items in the order of dominance were polychaetes, detritus, mysids, copepods amphipods, foraminifera and bivalves. Polychaetes and detritus occurred in the diet througout the year. The monthly relative index of these two were low during December and then during March to May. The mysids and copepods were found to occur during December to March. The large foraminifera like *Ammonia beccari* also followed a same pattern in the occurrence. The monthly variations in the occurrence of these items were simply a reflection of the availability of these food items in the environment. The flatfishes, like other demersal finfishes migrate to inshore areas during upwelling. During such times there is reduction in the quanity of detritus consumed. Since the bottom conditions are disturbed during such times they resort to off bottom feeding on items like copepods and amphipods.

Further, the monthly food items of males and females were pooled and the ranks (as per Index of preponderance) obtained for various food items at Cochin were compared with the rankings obtained at Neendakara. The annual pooled data indicating the rankings of important forage items based on the index of preponderance separately for males and females at Cochin and combined for both sexes at Neendakara during 1994-95 and 95-96 are shown in Table 3.

There is good correspondence in the rankings of food items between the two centres. The important food items at both centres showed striking similarity. The minor differences observed could be

Table 1 *Ranking of the dietary components of C. macrostomus (male & female) at Cochin during 1994-95*

Contents	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
POLYCHAETES											
P. pinnata	1	1	1	2	4	3	1	3	1	6	
Phyllochaetopterus spp.	5	-	5	-	-	-	-	-	4	7	-
Pectinaria spp.	-	-	-	-	-	-	-	-	-	9	-
Clymene spp.	-	-	-	-	-	-	-	-	-	9	-
Gastropods											
Oliva spp.	-	-	-	-	8	6	7	-	-	-	-
Tibia spp.	-	-	-	4	-	7	7	-	-	-	-
Architectonia spp.	-	-	-	8	15	9	-	8	-	-	-
Turretella spp.	-	-	-	-	13	10	-	-	-	-	-
Dentalium	-	-	-	-	-	12	-	-	-	-	-
Gastropod remains	-	-	-	-	10	-	-	-	-	8	-
Arca/Cardium	-	-	-	-	14	12	-	-	-	8	-
Nucula spp.	-	3	6	8	9	8	6	-	-	5	-
Pholas spp.	4	4	-	-	-	-	-	-	-	-	-
Bivalve remains	-	-	-	8	6	-	-	-	5	6	-
Planaria	-	-	-	8	12	-	-	-	-	-	-
CRUSTACEANS											
Amphipods	-	-	-	-	-	-	-	-	3	-	-
Mysids	-	-	2	-	2	2	2	2	6	2	1
Copepods	-	-	4	-	5	1	4	1	-	1	3
Squilla	-	-	-	-	-	-	-	7	-	-	-
Alima larva	-	-	-	-	-	12	-	-	-	-	-
Hermit crabs	-	-	-	-	7	11	-	-	-	-	-
Prawns	-	-	-	3	-	-	-	-	-	-	-
Mites -	-	-	-	-	-	11	-	-	-	-	-
OTHER ITEMS											
A. beccarii	-	-	-	6	3	4	5	4	7	4	-
Foraminifera	-	5	8	5	11	-	8	6	8	9	-
Coscinodiscus	3	-	-	7	-	11	-	-	9	-	-
Chaetoceros	-	-	-	-	15	12	-	-	-	-	
Algae	-	-	7	-	-	-	-	8	-	-	-
Fish eggs	-	-	-	-	-	-	-	-	-	-	4
DETRITUS	2	2	3	1	1	5	3	5	2	3	2

Table 2 *Ranking of the dietary components of C. macrostomus (male & female) at Cochin during 1995-96*

Contents	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
POLYCHAETES											
P. pinnata	3	-	1	2	4	3	1	5	3	3	-
Phyllochaetopterus spp.	-	-	-	-	-	-	-	2	1	2	-
Clymene spp.	-	-	-	7	-	-	-	-	4	-	-
Pectinaria spp.	-	-	-	-	-	-	-	9	-	-	-
MOLLUSCS											
Oliva spp.	-	-	-	10	3	7	6	-	9	-	-
Architectonia spp.	-	-	-	-	-	11	-	-	-	-	-
Turretella spp.	-	-	-	-	8	10	7	-	-	-	-
Gastropod remains	-	-	-	-	-	-	-	10	-	-	-
Arca/Cardium	-	-	-	-	9	9	-	-	-	-	-
Nucula spp.	-	-	4	5	7	-	7	6	-	-	-
Bivalve remains	-	3	4	3	6	5	-	-	6	6	-
CRUSTACEANS											
Amphipods	-	1	-	-	-	-	-	-	3	5	-
Mysids	2	-	-	-	1	1	4	3	-	-	-
Copepods	1	-	-	4	3	2	3	4	8	-	-
Daphnia	-	-	-	10	-	-	-	-	-	-	-
OTHERS											
Large foraminifera	-	-	-	9	5	6	5	7	5	4	-
A. beccarii	-	-	-	10	-	8	7	8	7	7	-
Coscinodiscus	-	5	-	6	-	11	7	11	9	-	-
Chaetoceros	-	6	-	-	-	-	—	-	-		
Algae -	-	4	2	-	-	-	-	-	-	-	-
Fragilaria sp	-	-	-	8	-	-	-	-	-	-	-
DETRITUS	-	2	3	1	2	4	2	1	2	1	-

attributed to the variability in the abundance of the forage organisms in the environs of these two centres

Food in relation to size of the fish

The fishes were grouped into 5-mm size groups and the occurrences of forage items were worked out. In both sexes, the fishes less than 90 mm in size the occurrences of polychaetes were higher. This trend was noticed with respect to items like amphipods, copepods and foraminifera. However, the presence of gastropods were higher in larger fishes of 100-155 mm. Further, the young ones of males included algae in their diet compared to the females. The percentage occurrence of amphipods was less in the middle size

Table 2 *Ranking of the dietary components of C. macrostomus (male & female) at Cochin during 1995-96*

Contents	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
POLYCHAETES											
P. pinnata	3	-	1	2	4	3	1	5	3	3	-
Phyllochaetopterus spp.	-	-	-	-	-	-	-	2	1	2	-
Clymene spp.	-	-	-	7	-	-	-	-	4	-	-
Pectinaria spp.	-	-	-	-	-	-	-	9	-	-	-
MOLLUSCS											
Oliva spp.	-	-	-	10	3	7	6	-	9	-	-
Architectonia spp.	-	-	-	-	-	11	-	-	-	-	-
Turretella spp.	-	-	-	-	8	10	7	-	-	-	-
Gastropod remains	-	-	-	-	-	-	-	10	-	-	-
Arca/Cardium	-	-	-	-	9	9	-	-	-	-	-
Nucula spp.	-	-	4	5	7	-	7	6	-	-	-
Bivalve remains	-	3	4	3	6	5	-	-	6	6	-
CRUSTACEANS											
Amphipods	-	1	-	-	-	-	-	-	3	5	-
Mysids	2	-	-	-	1	1	4	3	-	-	-
Copepods	1	-	-	4	3	2	3	4	8	-	-
Daphnia	-	-	-	10	-	-	-	-	-	-	-
OTHERS											
Large foraminifera	-	-	-	9	5	6	5	7	5	4	-
A. beccarii	-	-	-	10	-	8	7	8	7	7	-
Coscinodiscus	-	5	-	6	-	11	7	11	9	-	-
Chaetoceros	-	6	-	-	-	-	—	-	-		
Algae -	-	4	2	-	-	-	-	-	-	-	-
Fragilaria sp	-	-	-	8	-	-	-	-	-	-	-
DETRITUS	-	2	3	1	2	4	2	1	2	1	-

attributed to the variability in the abundance of the forage organisms in the environs of these two centres

Food in relation to size of the fish

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Table 3. Ranking of food items in males and females of Malabar sole at Cochin and Neendakara

	Cochin				Neendakara (Quilon)	
	1994-95		1995-96		1994-95	1995-96
	M	F	M	F	M & F	M & F
Polychaetes	1	1	2	1	1	3
Detritus	3	3	1	2	2	1
Mysids	2	2	4	3	4	2
Copepods	4	4	3	4	3	6
Foraminifera	5	5	7	7	5	5
Amphipods	6	6	5	5	6	4
Bivalves	7	7	6	6	7	7

groups. In 55-mm males the mysids formed 100% in 1994-95 which gradually got reduced in the larger fishes. This trend was observed in females also. But during 1995-96 fluctuations in the occurrence of mysids were noticed. The occurrence of copepods was comparatively higher in the smaller fishes, lower in the medium sized and again higher in the larger sized fishes. This pattern was visible in the occurrence of bivalves also. Foraminifera were noticed in 65-145 mm size fishes with a higher percentage in fishes 95 mm and above. Detritus was a dominant item found in all the size groups (Figs. 1 and 2)

Food preference in immature and mature fish

Since the size at first maturity of Malabar sole was 97 mm (Jayaprakash, 1999), fishes below this size were treated as immature and those above as mature. The results of the analyses by pooling the data for 1994-95 and 1995-96 are given in Table 3. The study indicated that the percentage composition of the food items in both immature and mature fishes in both sexes in the order or dominance were detritus, polychaetes, amphipods mysids, copepods and molluscs.

Condition of feed

To study the condition of feed the data from the three centres were considered. Fishes with full, $^{3}/_{4}$ full and $^{1}/_{2}$ full were treated as actively fed and the remaining like $^{1}/_{4}$, trace and empty stomachs as poorly fed. A comparison of the feeding condition of the Malabar sole at Cochin, Ambalapuzha and Neendakara indicated striking similarity (Fig. 3). But data from Ambalapuzha showed active feeding (96%) during August compared to very poor feeding observed at other two centres during the period. Ambalapuzha area is known for the Mud banks (*Chakara*) that occurs during the southwest monsoon in Kerala. The food of Malabar sole from this area during the *Chakara* season indicated that bivalves like *Barnea* sp.; *Tellina* sp. and *Nucula* sp. dominated the diet followed by copepods, detritus, polychaetes and gastropods. Upto 38 bivalves

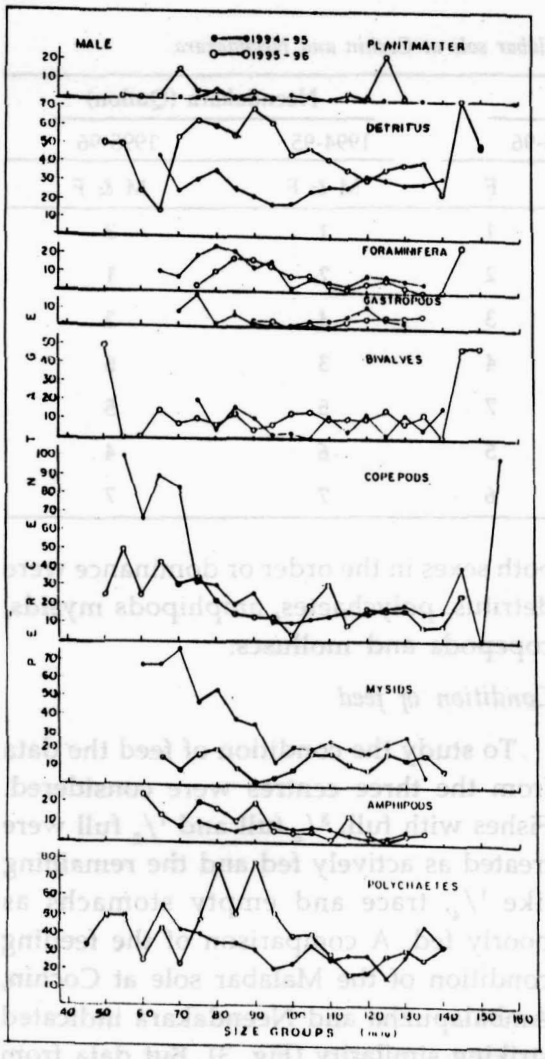

Fig. 1. *Percentage occurrence of various food items in the stomachs of males of C. macrostomus in different size groups during 1994-95 & 1995-96*

have been recorded in a single stomach during July. The occurrence of bivalves, copepods and polychaetes in the diet of the fish points out the existence of rich faunistic assemblage in the area immediately after the cessation of *Chakara* (Regunathan *et al.*, 1984). The general picture that evolved based on the samplings at Cochin, Ambalapuzha and Neendakara was that the period December to May appeared to be the time of active feeding.

Feeding in relation to maturity

The average volume of the stomach contents in each size groups for both sexes in each month were calculated by dividing the total volume points gained by all

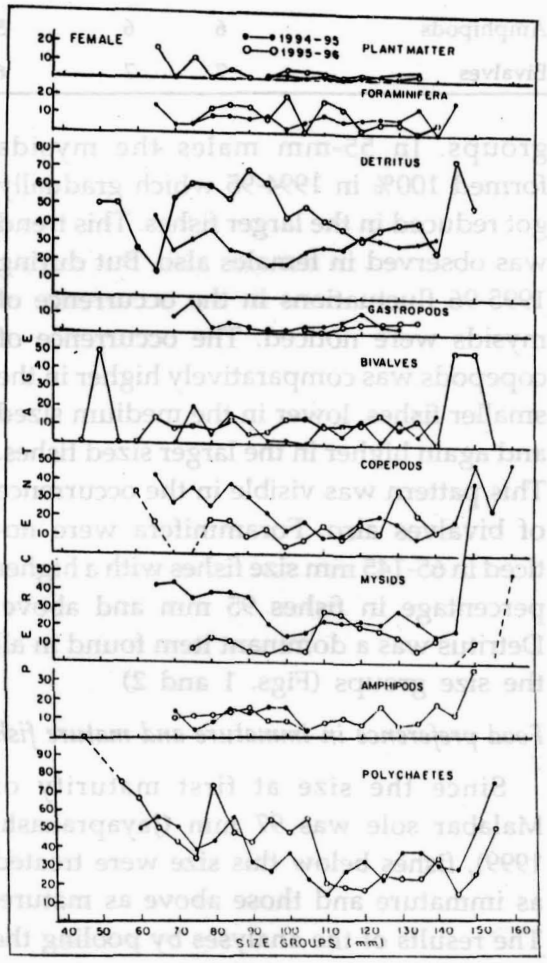

Fig. 2. *Percentage occurrence of various food items in the stomachs of females of C. macrostomus in different size groups during 1994-95 and 1995-96*

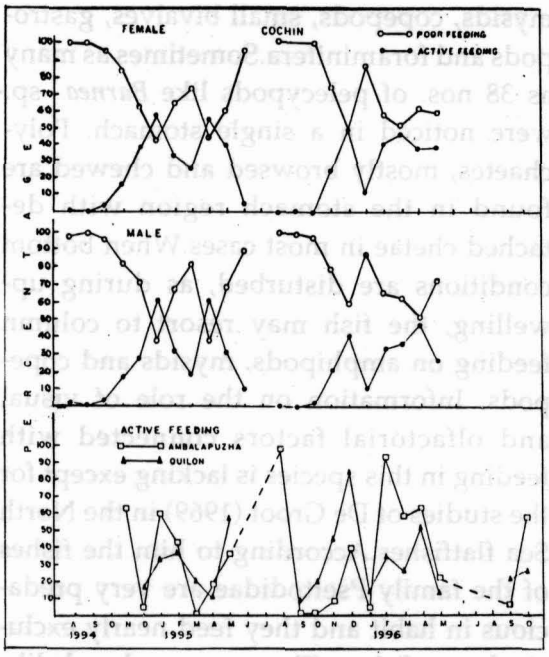

Fig. 3. *Percentage occurrence of active and poor feeding in females (upper panel) and males(middle panel) of C. macrostomus at Cochin; and at Ambalapuzha and Neendakara (lower panel) during 1994, 1995 and 1996.*

stomachs examined. The volume points of food items were worked out based on the total volume. The study revealed that both in the males and in females the seasonal pattern was similar in immature and mature fishes. (Figs. 4 and 5). October-November and February-March are the peak spawning periods of Malabar sole (Jayaprakash, 1999). The period immediately following the spawning coincided with active feeding. What piques interest is that the immature fishes also showed active feeding during the same period. The active feeding, therefore, in both mature and immature fishes coincides with abundance of forage organisms in the environment.

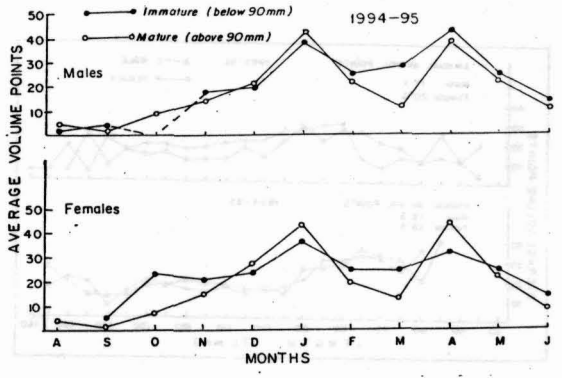

Fig. 4. *Average volume points of stomachs in immature & mature males and females of C. macrostomus during 1994-1995*

Feeding intensity in relation to size groups

The condition of feed was further studied by finding out the average volume points in different size groups at Cochin. In the size groups 55-90 mm in both sexes, the average volume points were higher. Slight reduction in the volume points was noticed from 95 mm to 140-mm fishes and further upwards it showed an increase (Fig. 6). The pattern of the average volume points in different size groups fol-

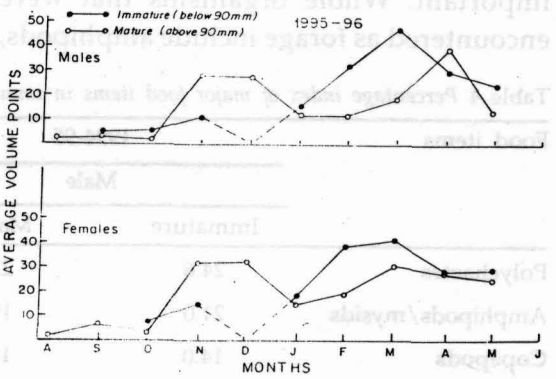

Fig. 5. *Average points of stomachs in immature and mature males and females of C. macrostomus during 1995-1996*

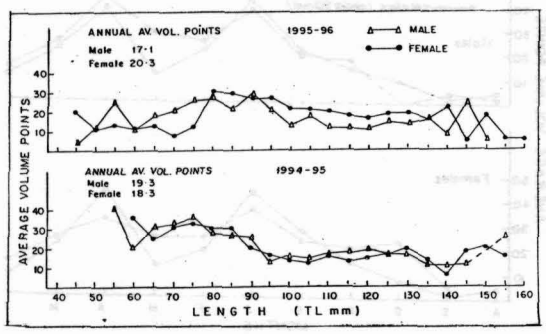

Fig. 6. *Average volume points of stomachs in males and females of C. macrostomus in various size groups Lower panel - 1994-95 & Upper panel - 1995-96*

lowed a similar trend in both sexes with some minor variations.

Discussion

The Malabar sole that is specialised to a bottom habitat mostly lies in the loose mud and its food and feeding is strongly influenced by the structure of the benthic fauna. Except during times when the bottom conditions are disturbed, the fish resorts to feeding on the detritus and macrobenthos.The size of forage items is important. Whole organisms that were encountered as forage include amphipods, mysids, copepods, small bivalves, gastropods and foraminifera.Sometimes as many as 38 nos. of pelecypods like *Barnea* sp. were noticed in a single stomach. Polychaetes, mostly browsed and chewed are found in the stomach region with detached chetae in most cases.When bottom conditions are disturbed, as during upwelling, the fish may resort to column feeding on amphipods, mysids and copepods. Information on the role of visual and olfactorial factors connected with feeding in this species is lacking except for the studies of De Groot (1969) in the North Sea flatfishes.According to him the fishes of the family Psettodidae are very predacious in habit and they feed nearly exclusively on fishes. They possess brush like groups of teeth on the gill arches, which prevent the prey from struggling out. This indicates that they are visual feeders, and hence feeding takes place mostly during day time. *Cynoglossus* species on the other hand feed mainly on polychaetes with crustaceans as a close second. Seshappa and Bhimachar (1955) observed that polychaetes formed the main constituent of the food of Malabar sole *C. semifasciatus*

Table 4 *Percentage index of major food items in immature and mature Malabar sole*

Food items	1994-95		1995-96	
	Male		Female	
	Immature	Mature	Immature	Mature
Polychaetes	24.6	22.8	28.7	22.6
Amphipods/mysids	21.0	19.4	22.9	20.1
Copepods	14.0	12.8	14.7	12.6
Molluscs	7.1	10.8	6.0	10.2
Detritus	33.3	34.2	27.7	34.5

(=C. *macrostomus*). De Groot (1971) in his studies on the food of 12 species of *Cynoglossus* observed that the crustaceans formed the main constituents and concluded that the species of the genus are crustacean feeders. Studies on the food of *Cynoglossus lingua* and *Solea elongata* by Kuthalingam (1957, 1960), *Pseudorhombus elevatus* by Pradhan (1959), *Psettodes erumei* by Pradhan (1969), Devadoss *et al* (1977) and Ramanathan and Natarajan (1979) indicated that the large growing flatfishes are voracious carnivores feeding on crustaceans and fishes. In Malabar sole the visual factor is not involved when feeding detritus, but this is an important factor while feeding on polychaetes, copepods and amphipods.

The bottom fauna studies by *Seshappa* (1953) at Calicut have shown that during the monsoon (June-August) the inshore bottom is very poor in organisms that form the food of Malabar sole. The return of the adult fishes to the inshore areas coincides with the settlement of polychaetes and other benthic fauna. Large shoals of Malabar sole appear during August/September and are popularly known as *Manthayilakam*. These fishes feed on the abundant polychaetes. The seasonal change in the forage items of the Malabar sole is a reflection of the availability of the forage in the environment. The present study has confirmed the earlier observations of Seshappa and Bhimachar (1955). Mathew *et al* (1989) has indicated the seasonal abundance of mysids; Pillai (1989), and Rosama and Iyer (1979) have showed the pattern of abundance of copepods in the Eastern Arabian Sea. The pattern of occurrence of these two items as forage items of the Malabar sole in different months clearly reflected the *in situ* abundance of these organisms in the environment. Ortega-Salas (1980), Lande (1976) and Arntz (1971) while studying the seasonal changes in the food of the North Sea dab *Limanda limanda* pointed out that the food composition is strongly influenced by the structure of macrobenthic fauna available as food resource. Further, the fish includes in the diet a lot of detritus that contain a variety of benthic organisms as well as decaying phyto-zooplankton. Detritus occurs at the bottom in coarsely particulate form and is perhaps the most readily available, universally abundant and nutritive food material in the shallow areas of the sea. In many environments the importance of settled detritus as food of fish is much greater than all other food groups combined. The productivity of the bottom macrobenthos depends on the dead phyto-zooplankton that fall to the bottom continuously from the upper layers. However, there occur inter annual variations in the quantity of this shower of dead organisms which would be much more at times when primary and secondary productivity are higher. Fishes like Malabar sole effectively utilizes this energy source trapped in the detritus. The abundance of this fish in the environment has a clear cyclic pattern correlated to such cyclic pattern of productivity in the sea and intensity of deposition of detritus.

The food association in fishes is gener-

ally ecological and seldom taxonomical. Those that feed on phytoplankton and attached or floating algae come under trophic level I; zooplankton and other filter feeding animals (pelagic and benthic) under trophic level II; fishes like Malabar sole with a major portion of the diet like detritus (both suspended and settled is a heterogeneous mixture) comes almost midway between these two trophic levels.

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