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Food and feeding habits of commercially important demersal finfishes off Veraval coast

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ABSTRACT

Stomach contents of nine species of commercially important demersal finfishes off Veraval coast were examined. Fish samples were collected periodically from the commercial trawlers of Veraval from January 2009 to October 2010. The dietary components of each species was studied and expressed as percentage of numerical composition (C_N), percentage of gravimetric composition (C_W) and percentage of frequency of occurrence (F). The major food items in the stomachs of each species were determined using an Index of Relative Importance (*IRI*). The gut contents of the fish varied in number, weight, and their frequency of occurrence with species to species. The study showed that prey items that were smaller in size constituted the major bulk, while the large size prey items were in fewer numbers. Based on cluster analysis (Bray-Curtis similarity) of predator (fish) feeding similarities , six sub-groups and the following three major groups were identified: group I (detritus feeders) comprised *Pampus argenteus* and *Arius thalassinus;* group II, (pisces feeders), was the largest group identified and included *Saurida tumbil*, *Saurida undosquamis*, *Otolithes cuvieri* and *Johnius glaucus;* group III,(shrimp feeders), consisted of *Priacanthus hamrur*, *Nemipterus japonicus* and *Nemipterus mesoprion*. *Acetes* spp., prawns and juvenile finfishes were the most important food items consumed by majority of the species. The values of the feeding index did not show any significant variation in different months during the two years of observation. However, the feeding intensity was slightly higher during the period of September to December. The results of the present investigation could provide valuable information in formulating strategies for management of fishery resources in the region.

Keywords: Demersal finfishes, Food and feeding, Veraval coast

Introduction

The assessment of marine fish stock is an essential process to understand the changes in population of marine fishes. In the past decade, the management of marine resources has usually been defined on the basis of a single species model that has been used to develop multi-species models of exploited fish populations, which provide insight into the fluctuation of the marine resources (Gulland, 1991). The study of the feeding behaviour of marine fishes is necessary for fish stock assessment and ecosystem modeling. Stomach content analysis, even in its most casual and anecdotal form, can yield incidental but immediately valuable information, since predators are often better sampling devices than most commercial fishing gears (Caddy and Sharp, 1986). Information on the food habits of marine fishes, such as the predator-prey relationships, is useful in order to assess the role of marine fishes in the ecosystem. However, since the demersal group is important in relation to trawl fishery, its assessment as food of fishes is necessary to draw trophic relationship which may be useful in recognising the areas of their occurrence and abundance. Hence the present study was carried out to understand the food and feeding habit of commercially exploited demersal finfishes along the Veraval coast, Gujarat.

Materials and methods

Fish specimens (Table 1) were obtained from the commercial trawlers of Veraval, Gujarat, India (Fig. 1) from January 2009 to October 2010. Nine important demersal fish species (*Arius thalassinus, Johnius glaucus, Nemipterus japonicus, Nemipterus mesoprion, Otolithes cuvieri, Pampus argenteus, Priacanthus hamrur, Saurida tumbil* and *Saurida undosquamis*) were selected based on factors such as high demand of the species for downstream industries and the increase in annual landings in the last decade (CMFRI, 2000-2010, Fig. 2). During the study period, samples were collected every fortnight by multi-stage stratified random sampling method and then stored in boxes containing ice to slow any bacterial digestion process in the fish stomachs and make it easier to identify the prey. The fish samples were taken to the

Table 1. List of important demersal finfish species selected for dietary composition studies from waters off Veraval coast, Gujarat, India

Species	No. of samples	Length range (mm)	Mean length (mm)	Sex ratio (M/F)	Mature %
Arius thalassinus	515	310-562	397.7	3.5	30.4
Johnius glaucus	751	206-247	215.2	3.3	66.8
Nemipterus japonicus	1179	126-296	206.8	1.8	65.7
Nemipterus mesoprion	1112	104-260	176.3	1.6	44.2
Otolithes cuvieri	764	184-389	256.2	3.4	47.6
Pampus argenteus	661	154-535	233.0	1.6	54.7
Priacanthus hamrur	541	154-387	237.3	1.3	38.8
Saurida tumbil	770	132-412	279.4	3.2	25.4
Saurida undosquamis	713	178-387	247.1	2.4	35.5

laboratory for further analysis. The total length of the specimens was measured from the tip of the snout to the longest caudal fin ray and fresh weight of the individual specimens was also measured. The ventral side of the belly region of the fishes was split open to expose the internal organs in order to determine the sex, maturity stage and then the fish guts were removed. The intensity of feeding was determined based on the degree of distension of the stomach wall and the amount of food contained in it and classified as 'gorged' (G), 'full' (F), '3/4 full' (3/4F), '1/2 full' (1/2F), '1/4 full' (1/4F), 'trace' (T) and 'empty' (E) according to the methods of Pillay (1952). The wet weight of the stomach contents was taken using an electronic balance to the nearest mg. All food items in the stomachs were identified to the most precise taxonomic level, *i. e*., genera, whenever possible. The digested portion of the food when mixed with high amounts of mucus of the stomach was excluded while assessing the percentage composition of the gut contents. The total number, wet weight, and frequency of occurrence of each prey item in the stomach of the fishes were recorded. The dietary components for each species studied were expressed as a percentage of

Fig. 1. Map showing the location of Veraval and Veraval fish landing complex in Gujarat, India

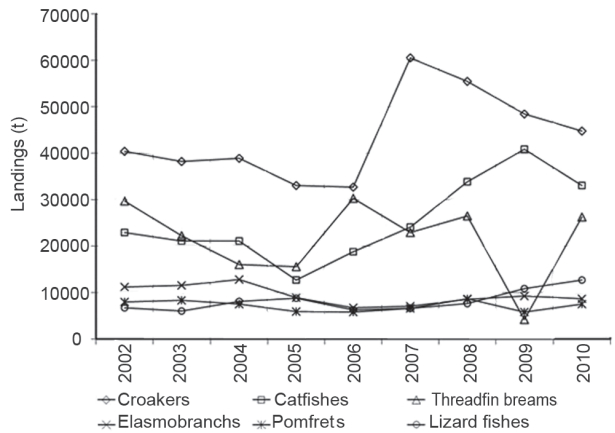

Fig. 2. Trend of dominant demersal finfishes landing in Veraval coast, Gujarat, India from 2002 to 2010

numerical composition (C_N), percentage of gravimetric composition (C_W) and percentage of frequency of occurrence (F) (Hyslop, 1980). The most important food item was determined by using the Index of Relative Importance (*IRI*) of Pinkas *et al.* (1971): IRI = $(C_N + C_W) \times F$. Bray-Curtis similarity coefficient (Bray and Curtis, 1957) cluster analysis was done using a software package Primer-6, for classification of fishes (Predator) based on %IRI to determine the most preferred prey group. Non-metric Multi Dimensional Scaling (MDS) was applied for graphical representation of predator grouping.

Results and discussion

Arius thalassinus

Arius thalassinus forms a major part of the cat-fish catches landed by trawlers in Veraval, and available throughout the year. A total number of 515 specimens in the size range 310-562 mm with a mean length of 397.7 mm were examined. Variation in percentage of feeding intensity for size classes with regard to the degree of stomach fullness is given in Fig. 3. The highest percentage of empty and gorged stomachs was recorded in the size classes of 550-

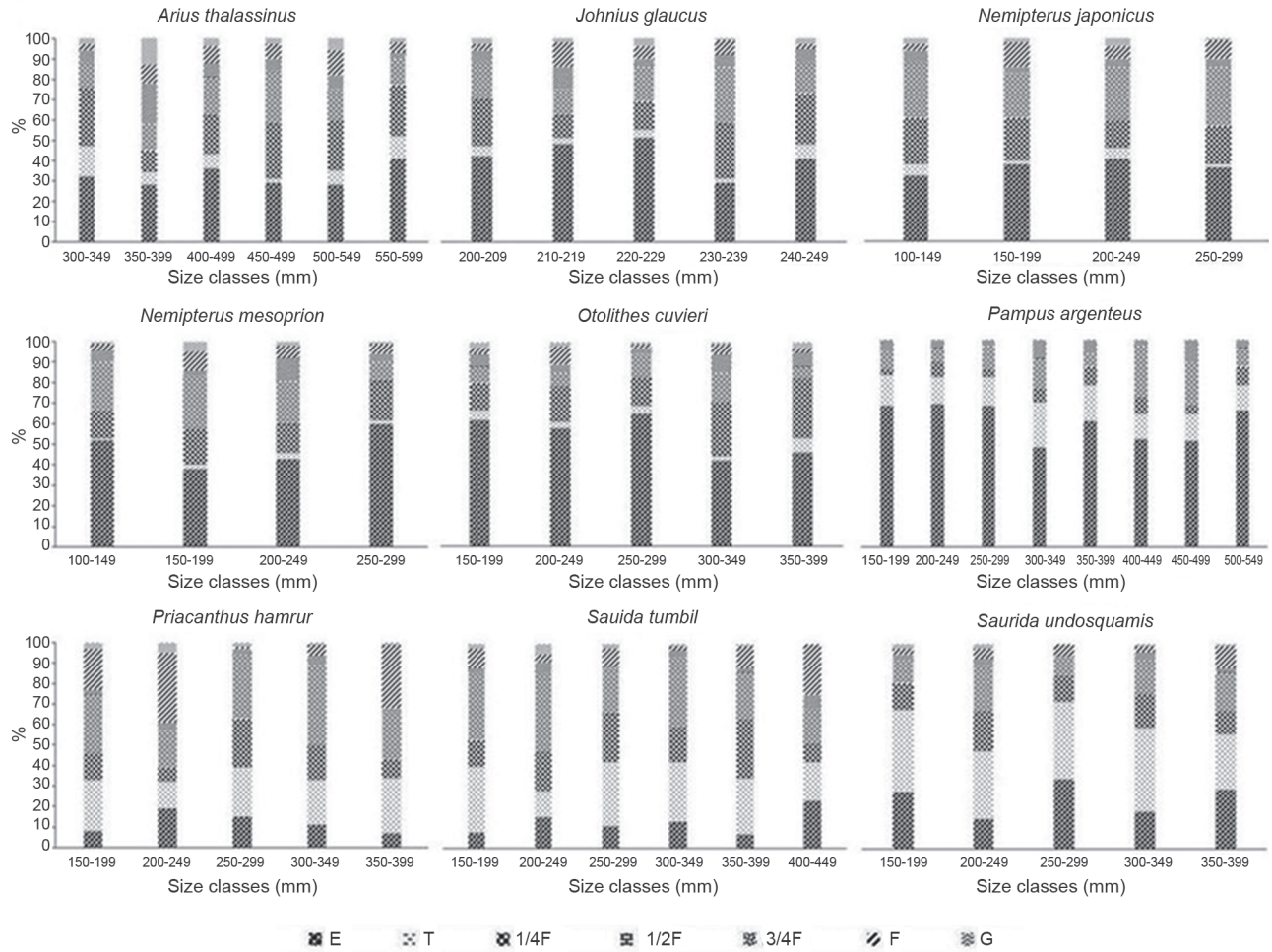

Fig. 3. Variation in percentage of feeding intensity for demersal finfishes of Veraval coast as function of body size

599 mm and 350-399 mm total length (TL) respectively. The feeding intensity was found to decrease with the increase in body size. This may be due to the dietary shift in the individual fish as a body requirement and also the active feeding nature of the individual with regards to age. Diet composition for size classes with respect to the cumulative percentage IRI of main prey groups is shown in Fig. 4. Detritus and mostly organisms of the benthic epifauna along with the fish are the main prey groups present in the diet of all size classes. Higher percentage of detritus was recorded from the size classes of 450-499 mm to 550-599 mm TL. Pisces and crustaceans were noticed in higher percent in the size classes of 400-449 mm TL and 350-399 mm TL respectively. Other prey groups *viz*., decapods, cephalopods and polychaetes, occurred in stomachs of specimens belonging to medium and large size classes. According to Chacko (1949), this fish is omnivorous, feeding at the surface and also browsing at the bottom. In the present observation, the stomach content analysed included a higher percentage of detritus followed by crabs and teleosts (*Cynoglossus* sp., *Saurida* sp., *Otolithes* sp. and young eels) and a lesser but significant quantity of prawns *(Parapenaeopsis stylifera* and *Metapenaeus affinis), Acetes* sp. Gastropods and fish & prawn digest (Table 2). From the results it is clear that *A. thalassinus* is carnivorous and the food comprises higher percentage of detritus and mostly organisms of the benthic epifauna along with fishes.

Johnius glaucus

A total of 751 specimens of size range 206-247 mm were examined during the study. The proportion of fishes with active and moderate feeding reduced with increasing length. The proportion of empty stomachs was higher (44.4%) in the largest length group (220-249 mm TL) (Fig. 3). However, there was not much difference noticed in the number of fishes with respect to feeding intensity. Generally, there was a gradual decrease in the occurrence of crustacean in the diet of various size groups of *J. glaucus*. The percentage composition ranged from 53.4% in the size group 200-209 mm TL to 42% in the size group 240-249 mm TL (Fig. 4). The percentage occurrence of

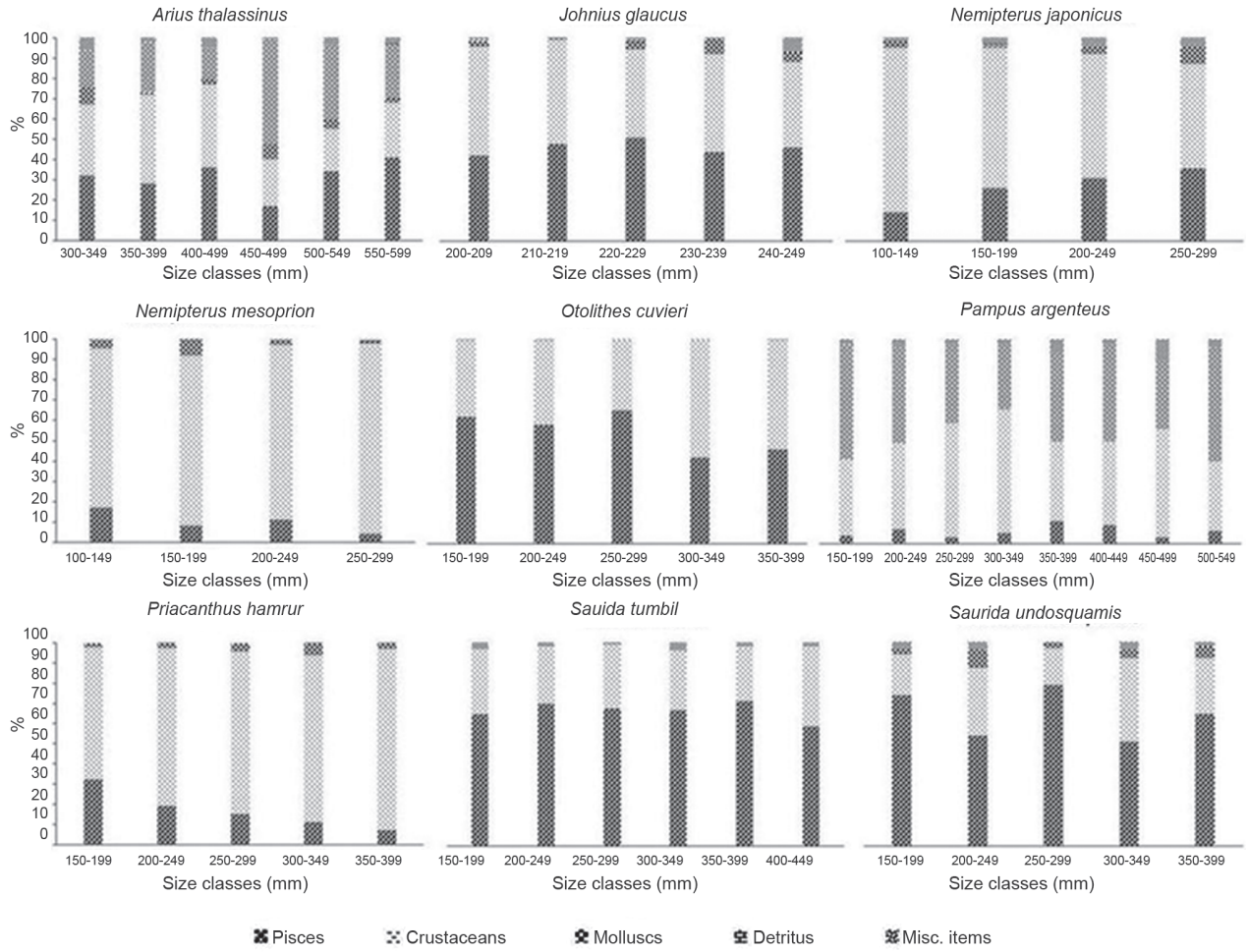

Fig. 4. Diet composition of demersal finfishes of Veraval coast as a function of body size, based on the % IRI values of the major prey groups

fishes was 51% in the size group 220–229 mm TL. From the results it is clearly understood that this is a carnivore preferring a benthic habitat. The food of *J. glaucus* is mainly composed of fishes and crustaceans. *Acetes* spp., prawns, *Metapenaeus* spp. and squilla were representatives of the crustacean group. Fishes comprised *Bregmaceros* sp., *Coilia* sp., *Cynoglossus* sp. and ribbonfish . The other organisms that formed part of the diet were crabs, copepods, *Loligo* sp., *Sepia* sp. and squilla (Table 2). The feeding intensity was generally low except during the post-spawning periods (September to October and March to May) (Fig. 5). Raje (2000) reported that the gut content of *J. glaucus* from the same region comprised crustaceans and fishes. According to him, *Acetes* spp., *Solenocera* spp. and other penaeid prawns constituted the crustacean diet, whicle *Coilia dussumieri* and fish larvae formed the fish component. But during the present observation, apart from crustaceans and fishes, *Loligo* sp. and *Sepia* sp. were also recorded.

Nemipterus japonicus

N. japonicus constitutes 69% of the threadfin bream landing in the Veraval region. They are landed throughout the year, except during June to August due to ban on monsoon trawling. The percentage occurrence of various levels of stomach distensions to the total number of stomachs was compared with the monthly average volume to arrive at the intensity of feeding. The body size-wise variation in the feeding intensity is shown in Fig. 3. Empty stomach was recorded in all the size classes with high percentage of 41% in the size class 200-249 mm TL. The percentage of month-wise fluctuation in occurrence of empty stomach is given in Fig. 5. Fishes with empty stomachs formed 37.05% (Fig. 5). Poorly fed fishes occurred throughout the year except in April and December. The diet composition of *N. japonicus* with respect to size classes showed higher percentage of crustacean prey in all the size classes (Fig. 4). The diet of *N. japonicus* is

Table 2. Annual average % Index of Relative Importance (*IRI*) of different prey items identified in the diet of demersal finfishes from Veraval coast of Gujarat, India during 2009-10

	Fish species								
Food items	*A. thalassinus*	*J. glaucus*	*N. japonicus*	*N. mesoprion*	*O. cuvieri*	*P. argenteus*[#]	*P. hamrur*	*S. tumbil*	*S. undosquamis*
Pisces									
Apogon sp.	8.7	-	4.2	2.8	5.4	-	-	7.6	-
Bombayduck	-	-	-	-	-	-	-	11.7	-
Bregmaceros sp.	-	11.2	1.8	-	1.4	-	3.2	-	-
Coilia sp.	-	20.9	-	-	31.8	-	-	-	-
Cynoglossus sp.	9.3	9.6	-	2.8	2.3	0.6	-	9.2	13.2
Decapterus sp.	-	-	-	-	-	-	8.6	5.9	16.7
Fish larvae	-	-	-	-	4.9	2.8	1.6	-	-
Juvenile eel	1.8	-	-	-	-	-	-	-	-
Leiognathus spp.	-	-	3.1	-	-	-	1.7	2.9	-
Nemipterus spp.	-	-	1.2	0.2	-	-	7.9	6.8	12.7
Otolithes sp.	1.6	-	-	-	-	-	-	-	-
Platycephalus sp.	-	-	-	1.4	-	-	-	7.3	-
Polynemus spp.	-	-	-	-	0.7	-	-	-	-
Sardinella spp.	-	-	-	-	-	-	-	3.7	-
Saurida spp.	0.3	-	-	-	-	-	2.5	5.3	17.4
Stolephorus spp.	-	-	-	-	0.9	-	-	-	-
Thrissocles spp.	-	-	-	-	-	-	-	1.4	13.9
Trichiurus sp.	8.3	8.9	-	1.7	4.3	-	-	-	-
White bait	-	-	-	-	-	-	-	0.6	-
Crustaceans									
Acetes sp.	3.9	22.8	52.4	61.3	38.6	4.4	35.3	18.6	-
Copepods	-	-	-	-	-	30.2	-	-	-
Crabs	14.1	1.6	5.3	8.6	-	-	-	-	-
Metapenaeus affinis	7.6	-	-	-	0.8	-	-	-	-
Other penaeid prawns	-	16.2	22.6	16.4	2.6	12.3	37.4	7.8	21.4
Parapenaeopsis stylifera	5.3	-	-	-	2.3	-	-	-	-
Fenneropenaeus indicus	-	-	-	-	1.7	-	-	-	-
Squilla	-	4.1	4.4	1.8	2.1	-	-	10.6	-
Molluscs									-
Gastropods	0.9	-	-	-	-	-	-	-	-
Loligo sp.	-	1.8	1.7	1.7	-	-	1.4	-	2.6
Sepia sp.	-	2.3	2.1	0.5	-	-	-	-	1.3
Octopus	-	-	-	0.3	-	-	-	-	-
Detritus	36.3	-	-	-	-	47.4	-	-	-
Miscellaneus items[*]	1.9	0.6	1.2	0.5	0.2	2.3	0.4	0.6	0.8

[*]Unidentified biological materials observed in the fish stomach.
[#]Most of the time all of the fishes were having empty stomach or fully digested material

constituted mainly by crustaceans *i. e.*, *Acetes* spp., penaeid prawns, crabs, *squilla*, juveniles of fishes such as flatheads, lizardfishes and fish larvae (Table 2). *Acetes* spp. ranked highest among the food organisms (52.4%) of the total volume of stomach contents. Highest consumption of *Acetes* spp. occurred during March-April and September-October. *Acetes* spp. is the dominant group of crustaceans available along the north-west coast of India and its rich stock enable *N. japonicus* to feed on it voraciously (Manojkumar, 2004). *Acetes* spp. was the main species found in the stomach

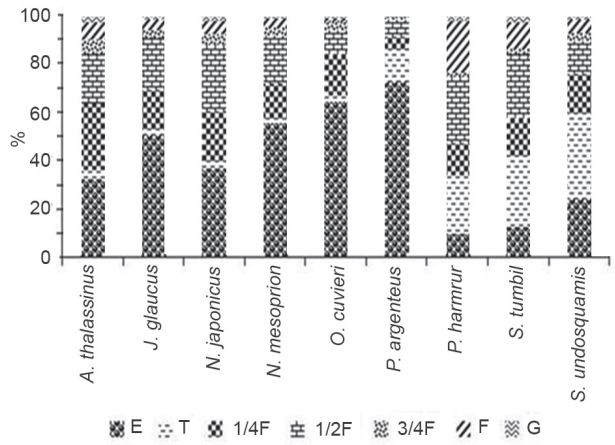

Fig. 5. Percentage feeding intensity of important demersal finfish species at Veraval coast of Gujarat, India observed during the period 2009-2010

throughout the year. Penaeid prawns ranked second among the food items in the stomach and formed 22.6% of the total volume (Table 2) and the percentage occurrence was high when the volume of *Acetes* spp. was low and *vice versa*. Squilla contributed 5.6% and crabs formed 5.3% of the total volume of food and were present during January-February, April-May and December respectively. Juvenile squids formed 1.7% of total volume of stomach contents. According to Kuthalingam (1965), *N. japonicus* is cannibalistic and feeds mainly on *Metapenaeus dobsoni* and *Parapenaeopsis stylifera* followed by fishes, along the Mangalore coast. According to Krishnamoorthy (1971), this species is highly predaceous and possibly a sight feeder of crustaceans, molluscs, annelids and echinoderms. More or less similar type of feeding was reported in *N. japonicus* by Vinci (1982) and Rao *et al.* (1991) from the sea off Vizhinjam and Vishakapatnam respectively. The present study reveals that *N. japonicus* is a carnivore feeding mainly on *Acetes* spp., penaeid prawns, crabs, squids, juvenile fishes, squilla and fish larvae.

Nemipterus mesoprion

According to the index of preponderance (Table 2) of various food items in stomachs of *N. mesoprion, Acetes* spp. formed the most dominant food item followed by penaeid prawns, other crustaceans, fishes and molluscs. *Acetes* were present in the diet in almost all the months with the highest consumption in September and the lowest in April. Penaeid prawns were the second important item; represented by *Solenocera* spp. *Parapenaeopis* spp., and *Metapenaeus* spp. The maximum value of preponderance for these species was recorded in January and the lowest in November. The other crustacean food comprised mainly of crabs and squilla. It was maximum during April and minimum in November. Molluscs comprised *Loligo* spp., *Sepia* spp. and *Octopus* were found to be more during November and less in January. Digested matter was composed of fish scales and bones, crustacean appendages and mucus. Food in relation to size classes clearly indicates that crustaceans were the most preferred food by the juveniles and as the size of fish increased, it showed preference to fish (Fig. 4). The presence of penaeid prawns, deep-sea prawns, crabs and stomatopods was observed in the fish samples of size beyond 150 mm TL. Molluscs, represented by young ones of squids, cuttlefishes and octopus were occasionally present in the stomach of fish above 220 mm TL. Very less amount of miscellaneous food items were observed in the stomach of all the size classes. The results show ontogenetic variations in the trophic spectrum of *N. mesoprion*. The young ones feed mainly on crustaceans, whereas the adults consume predominantly teleosts (Manojkumar, 2008). The results of present investigation reveal that *N. mesoprion* is a demersal carnivore, whose diet is mainly composed of crustaceans, fishes, and molluscs. More or less similar type of feeding habits was also observed in *N. japonicus* (Krishnamoorthi, 1971; Vinci, 1982), *N. mesoprion* (Rao, 1989) from the sea off Andhra-Orissa, Kerala (Vizhinjam) and Waltair respectively.

Rao (1989) reported that *N. mesoprion* off Visakhapatnam is carnivorous, feeding on crustaceans and teleosts. Among crustaceans, the main food items were *Penaeus* spp., *Metapenaeus* spp., *Acetes* spp. and squilla and the percentage of abundance of crustaceans was more during January –May. Raje (1996) noticed that *N. mesoprion* off Veraval was a carnivore, and the diet was composed of crustaceans, fishes, molluscs and annelids. *Acetes indicus* and *Acetes johni* formed the most dominant food items followed by fishes, prawns, other crustaceans, molluscs and annelids. According to Joshi (2005), the major fishes observed in the diet of *N. mesoprion* off Cochin were *Stolephorus* spp. and *Leiognathus* spp. and crustaceans such as prawns, mysids, crabs, squilla, *Acetes* spp. and deep-sea prawns. Similar observations were made by Zacharia and Nataraja (2003) and Manojkumar (2007; 2008) from Karnataka and Malabar coast respectively. The results of the present study showed close similarities with earlier observations on the food of *N. mesoprion* from the Indian waters.

Otolithes cuvieri

In the present study, it was observed that *O. cuvieri* is a carnivore feeding on a mixed diet consisting of teleost fishes and crustaceans. The importance of different feeding intensity and prey items in relation to length classes was studied (Fig. 3 and 4). *Acetes indicus* was preferred by all the size groups. Teleost fishes were present in the stomach

of fish of 150 mm TL and above. Manojkumar (2003) reported that the presence of fishes in the stomach increased with size of the fish. But in the present study, high variation was noticed between the size classes and the percentage of fish in the stomach. This may be due to the changes in the environment that affect the feeding behaviour of fishes. The occurrence of penaeid prawns was observed as the fish grew beyond 210 mm TL and its percentage also increased with the size of the fish. Juveniles of crabs were observed mostly in the stomach of the young ones and occasionally in the large fishes. Among the crustaceans, *Acetes* spp., prawns and crabs formed the principal diet. *Acetes* spp. was the main crustacean component found in the stomach throughout the year. Penaeid prawns that formed the food were *Parapenaeopsis stylifera*, *Metapenaeus affinis* and *Fenneropenaeus indicus*. Apart from that *Apogon* sp., *Coilia* sp., ribbonfish as well as digested fish and prawn were also observed in minor quantity. Rao (1985) observed that prawns followed by teleosts formed major food component of *O. cuvieri* along the Saurashtra coast. Prawn landings by trawlers are highest along the Suarashtra coast with peak during April-May and September-October (Kagwade, 1967), and *Acetes* spp. is a dominant species making it one of the main components of the food item. Vaidya (1960) observed adults to be a carnivore feeding on crustaceans, teleosts and cephalopods, while postlarvae and juveniles are surface feeders feeding chiefly on crustaceans. Karandikar and Thakur (1951) observed that sciaenids are carnivores and feed on fishes, crustaceans, molluscs and annelids. The present study showed that sciaenids exhibit a general uniformity in feeding habits and are carnivorous showing primary preference to crustacean diet, especially in the juvenile stage. With increase in size, they gradually supplement it with fish (Manojkumar, 2003). The present observation clearly indicates that fish forms their primary food and crustaceans are a secondary food item, while molluscs are taken in occasionally in the diet of *O. cuvieri* (Table 2).

Pampus argenteus

Studies along the east coast indicated the importance of small crustaceans, algae and semi-digested pulp in the diet of *P. argenteus* (Kuthalingam, 1963; Rao, 1964). The present study revealed that *P. argenteus* feed largely on zooplankton (Table 2). Crustacean zooplankton has been reported to form the largest proportion in the diet of the silver pomfret along the Indian coasts as well as in the Arabian Gulf (Kuthalingam, 1963; Dadzie *et al*., 2000). A high proportion of semi-digested pulp, which contributed the largest proportion by weight to the food item, rendered the identification and sorting of food components very difficult. The reason for these difficulties while sorting food components was due to the uniqueness of the gut in pomfrets (Abdurahiman *et al*., 2006). Pati (1977) described that pomfrets possess toothed esophageal sac, which acts as grinding mill to make food pulpy and hence making the identification of food components very difficult. None of the fishes could be positively identified but fish scales were frequently encountered which remained undigested in the gut. However, copepods constituted the major proportion of zooplankton in semi-digested pulp (Table 2). Basheeruddin and Nayar (1961) recorded semi-digested pulp in which scales, bones of fish, copepods and *Acetes* spp. were entangled in the gut of silver pomfret. In a similar species , *Parastromateus niger* (a carangid), Sivaprakasam (1967) observed that food was present in highly macerated and in advanced state of digestion. Copepods are the most important diet source to silver pomfrets. Their significance in the diet was greatly emphasised in many other studies. Kuthalingam (1963) in his study from north-west part of Bay of Bengal observed copepods and other crustaceans as the main items of food in addition to ostracods, amphipods, larval crustaceans, polychaetes, *Sagitta* sp., fish scales, algal filaments, *etc.* Similarly, Rao (1964), while studying the feeding habits of *P. argenteus* observed a high percentage of copepods along with amphipods, ostracods, other crustacean zooplankton, gastropod larvae and fish remains. Dadzie *et al.* (2000) from Kuwait waters investigated the feeding habits of silver pomfrets and stated that copepods were the most favorite food of silver pomfrets. Being a basic copepod feeder, the silver pomfret preferred them in all the seasons. They are a very important part of the diet both in the pre-monsoon and post-monsoon seasons. Occurrence of fish scales, though in fewer quantities, indicates that small fishes formed diet in all the seasons. Dadzie *et al.* (2000) observed more variety of food items in summer than in winter indicating the seasonal change in feeding according to the availability of prey organisms in the environment. Seasonal variation in major food components, especially copepods is highly distinct in the Chinese pomfrets (Pati, 1977) and black pomfrets (Sivaprakasarn, 1967). Size-wise feeding intensity analysed in the present study revealed that in all the size groups (150-549 mm TL) higher percentage of empty stomach was observed and no full and gorged stomachs was observed during the study period (Fig. 3). Size-wise prey difference analysed during the study period provided the details on the dietary variants during the ontogenetic changes (Fig. 4). An ontogenetic shift to increased consumption of copepods is observed to be the reason for decrease in the proportion of semi-digested pulp in large length groups. Kuthalingam (1963) observed rare occurrence of large crustaceans such as *Penaeus* spp., *Acetes* spp., *Squilla* spp. and anomurans in addition to copepods in large sized silver pomfrets (>260 mm) as against the juveniles which were mainly feeding on small

copepods and diatoms. Hence it is evident that diet change with ontogenic development is common in silver pomfret. The low trophic level values determined for all length groups and seasons are directly related to the prey item consumed. Most of the preys such as semi-digested pulp (except for fish items in the larger length groups) found in the stomachs themselves occupy lower trophic levels (Vivekanandan *et al.,* 2009).

Priacanthus hamrur

The gut content analyses indicated a highly carnivorous nature of *P. hamrur*. Stomach examined for different months showed empty, half as well as full stomachs (Fig. 5). There was no preferential feeding. Size-wise feeding intensity analysed during the study period shows higher percentage of full stomachs in the size classes of 350-399 mm TL (Fig. 3). Higher percentage of empty stomach was observed in the size classes of 200-249 mm TL. Size-wise prey variation in the feeding habit analysed during the study shows higher percentage of crustaceans in all the size classes (150-399 mm TL). Fishes of the size class 150-199 mm TL shows higher percentage of fish in their diet, but the trend reduced when the size classes increased (Fig. 4). Anchovies, small crustaceans and parts of cephalopods were the usually found food items (Premalatha, 1997). In the present observation, *P. hamrur* was found to feed mainly on pelagic crustaceans followed by fishes and smaller molluscs (Table 2). Among crustaceans, *Acetes* spp. was the most preferred food item followed by penaeid shrimps. Fishes were represented by a variety of species such as *Bregmaceros* sp., *Decapterus* sp., *Leiognathus* spp., *Saurida* spp. and *Nemipterus* spp. Molluscan food items were dominated by juveniles of squids. In most cases, food was in a digested condition, which may be due to the delay in landing the catch. Similar observations were made in *P. hamrur* (Philip, 1994, 1998; Premaletha, 1997), in *Priacanthus tayenus* (Rao, 1967) and in *Priacanthus macracanthus* (Rao, 1984). However, a closer examination of the dominant food items clearly indicated more of a deep water habitat of the species (Sivakami *et al*., 2001). Thus, according to Philip (1994; 1998), the food items were represented by mesopelagic fishes (*Bregmaceros* spp., *Acropoma* spp.) and deep sea prawns (*Solenocera* spp.), while according to Bande *et al.* (1989), *Priacanthus* spp. feed voraciously on pelagic shrimps (*Leptochela* spp.) of the deep scattering layer (DSL) ascending to epipelagic realm during night. Peter (1982) and Mc Farland (1991) state that priacanthids are reef dwelling nocturnal planktivorous fishes which locate their food items through their sense of vision. Hobson (1991) reports that *P. cruentatus* from the Hawaiian reef migrate seaward to feed up on pelagic organisms such as cephalopods and crab megalopa larvae.

Saurida tumbil

The size-wise feeding intensity observed in the study period shows higher percentage of actively feeding fishes in the size group 150-199 mm TL. Moderate feeding activity was recorded in the size group 250-299 mm TL and 350-399 mm TL. Fishes were observed to be poorly fed in the size group 400-449 mm TL (Fig. 3). Size-wise prey variation analyses shows higher percentage of fishes in all the size groups with 150-449 mm TL. Crustaceans contributed the second highest percentage of the prey groups, showing a decreasing trend against the size classes increase (Fig. 4). The study revealed that *S. tumbil* has a carnivorous feeding nature. It mainly feed on fishes, shrimps and molluscs (squid and cuttlefish). It is seen that the overall percentage of fish species in the stomach of *S. tumbil* is high as compared to shrimps (Table 2). This indicates that fish is the main component of their diet and considered to be their preferred food. During the study period, digested matter which includes fish scales, fish bones and eyeballs often encountered in the diet are evidently the remnants of the fish normally eaten by *S. tumbil*. Bakhash (1994) reported that the principal food item of lizardfish is fish; particularly lizardfish and sardine occurrence were 70 and 22%, respectively. The most important prey items he observed in stomach of *S. tumbil* were *Nemipterus japonicus*, Carangids, Scombroidea, *S. undosqamis*, squid and shrimps (*Penaeus semisulcatus* and *Metapenaeus monoceros*). Raje *et al*. (2004) reported that *Decapterus* sp. was the predominant item followed by *Nemipterus* sp., *S. tumbil* and *Apogon* sp. The food items recorded during the present study were fishes (*Apogon* sp., Bombayduck, *Cynoglossus* sp., *Decapterus* sp., *Leiognathus* spp., *Nemipterus* spp., *Platycephalus*, *Sardinella* spp., *Saurida* spp., *Thrissocles* sp. and white bait), shrimp (*Acetes* sp., *Metapenaeus* sp. and *Solenocera* sp.) and molluscs (*Loligo* sp. and *Sepia* sp.). In the present study, the highest quantity of fish in gut content of *S. tumbil* was recorded during April (82.14%) followed by November (79.51%) and October (74.78%) while the lowest percentage was recorded in January (23.91%). Raje *et al.* (2004) reported that teleost fishes were the dominant food item in almost all the months except during February and December along the coast off Mumbai.

Saurida undosquamis

During the present investigation, totally 713 fish specimens were examined for studying the food and feeding habits of *S. undosquamis*. Table 2 shows the diet composition of *S. undosquamis*. Feeding intensity in relation to size classes based on degree of stomach fullness is shown in Fig. 3. Higher percentage of feeding intensity was recorded in the size classes of 150-199 mm TL. Sharp decreases were observed in feeding intensity of the size

classes 250-299 and 350–399 mm TL. The percentage occurrence of empty stomachs fluctuated from 5% in the size class 200-249 mm to 34 % in the size class 250-299 mm TL. Size-wise prey variation in the diet of *S. undosquamis* shows considerable quantity of fish, fish larvae, scales and eggs. They were present in high percentage (79%) of total stomach examined in size group 250–299 mm TL and 74% in size group 150–149 mm TL (Fig. 4). This high percentage occurrence could be attributed to the feeding behaviour of the fish. Food of *S. undosquamis* was composed of fishes, crustaceans and molluscs. The fish component comprised of *Cynoglossus* sp., *Decapterus* sp., *Nemipterus* spp., *Saurida* spp., and *Thrissocles* sp. The food analysis done by the method of index of preponderance indicated that the fishes ranked 1st (73.90%) in the gut contents of *S. undosquamis* followed by shrimps (21.40%). Molluscs such as squid was represented by *Loligo* sp., contributing 2.6% and cuttlefish was represented by *Sepia* sp., contributing only 1.3% among the food items. The size of food fishes encountered in the guts varied from 29-78 mm. As some percentage of food material was digested beyond recognition, it could not be identified and were excluded for the IRI estimation. Euzen (1987) studied the food content of two species of *S. tumbil* and *S. udosquamis* and found that they prey up on Theraponidae (*Helotes sexlineatus*), Cynoglossidae (*Cynoglossus macrolepidotus*), Nemipteridae (*Nemipterus japonicas* and *Nemipterus tolu*), Leiognathidae., Clupeidae (*Ilisha indica*) and Carangidae (*Caranx leptolepis*). Rajkumar *et al*. (2003) also reported the same results as observed in the present study, that *S. undosquamis* off Visakhapatnam is a carnivore, feeding predominantly on fishes (*Sardinella* sp., *Stolephorus* sp., *Pentaprion* sp., *Rastrelliger kanagurta*, *Upeneus* sp., *Leiognathus* sp., *Nemipterus japonicus* and *Apogon* sp.), crustaceans (*Acetes* sp., *Metapenaeus* sp., *Solenocera* sp. and juvenile crabs) and squid (*Loligo duvacelli*).

The analysis of the food of nine important demersal finfish species has shown that most of them are predators on actively moving invertebrates (dominated by crustacean) and teleost fishes. Although 7006 fish guts belonging to nine fish species were analysed during the 2 years of study, the number of positively identified preys was only 37. Unidentified and partly digested prey of many predators made the analysis difficult, in particular the analysis of *Pampus argenteus* stomach contents, which were always in partly or fully digested condition. Altogether the gut contents of the fish varied in number, weight, and their frequency of occurrence from species to species. The study showed that prey items that were smaller in size constituted the major bulk, while the large size prey items were eaten in fewer numbers. The composition of the diet indicated that the fully adult fishes were carnivores feeding on small marine animals, mainly teleosts, crustaceans and molluscs. *P. hamrur*, *N. japonicus* and *N. mesoprion* chiefly fed on *Acetes* sp., prawns and juvenile finfishes only; whereas *S. tumbil*, *S. undosquamis*, *O. cuvieri* and *J. glaucus* fed mostly on fishes, fish larvae, prawns and *Acetes* sp. The food of *A. thalassinus* and *P. argenteus* comprised detritus, crustaceans and fishes. *Acetes* sp., prawns and juvenile finfishes were the most important food items consumed by the majority of the fish species. The values of the feeding index did not show any significant variations in the different months during the two years of observation (Fig. 5). However, the feeding intensity was slightly higher during the period of September to December. Longhurst (1957) observed that the fishes of Sierra Leone River, which feed on benthic infauna and epifauna and fishes, showed no evidence of seasonal variations in the feeding activity. Among the inshore fishes of Malabar coast, Venkataraman (1960) noticed that the feeding intensity in common, is correlated with the abundance of plankton in the environment and also with the maturity stages of many species studied.

The annual average %IRI was used to identify the predator feeding similarities within each fish (predator). Based on the predator feeding similarities within each predator, six sub-groups and three major groups were identified by the cluster analysis (Bray-Curtis similarity). The six sub-groups are 'shrimp and *Acetes* feeder', *Acetes* and shrimp feeder', 'pisces and *Acetes* feeder', 'detritus and copepod feeder' and 'detritus and pisces feeder (Fig. 6). Further, these six sub-groups were grouped into three major groups. The first major group *i.e.*, group I 'detritus feeder' included *P. argenteus* and *A. thalassinus*. Group II, designated as 'pisces feeder', was the largest group identified and included *S. tumbil*, *S. undosquamis*,

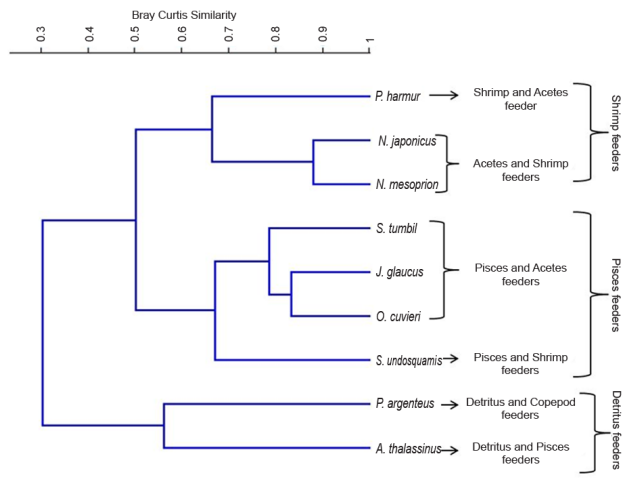

Fig. 6. Dendrogram showing the categorisation of demersal finfishes based on the predator's feeding preference and % values of index of relative importance; using group average clustering (Bray-Curtis similarity)

O. cuvieri and *J. glaucus*. Group III, named as 'shrimp feeder', consisted of *P. hamrur*, *N. japonicus* and *N. mesoprion* (Fig. 6). MDS of different prey taxa supports the results of cluster analysis as the points represented by each predator-formed group were either entirely or almost entirely discrete from each other (Fig. 7). Vivekanandan (2001) reported crustaceans like penaeid prawns as the major food of *N. japonicus* (and that their body is morphologically adapted to predate such crustaceans) and hence they were grouped into 'shrimp feeders'. The role of *Acetes* spp. as a major prey organism in the diet of almost all the demersal finfishes (except in *S. undosquamis*) anlaysed in the study was the highlight (Table 2). Jaiswar and Chakraborty (2005) reported similarly that *Acetes indicus* is the most abundant species among the sergestid shrimps and it is the preferred food of fishes along the north-west coast of India. It is clear from the observation that, even though diverse prey types were found, usually two or three prey types were dominant in the diet of the selected nine demersal finfish species off Veraval coast. They may be a preferred prey for the predators or they may be available in plenty in an environment where the predator feed.

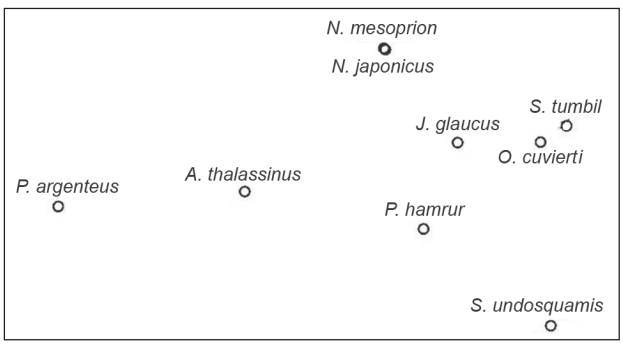

Fig. 7. Ordination of Multi-dimensional scaling (MDS) of demercial finfishes off Veraval into major groups based on similarities. The low stress value (0.04) indicated a good separation among the groups.

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