STUDIES ON THE FOOD AND FEEDING RELATIONSHIPS OF THE INSHORE FISHES OFF CALICUT ON THE MALABAR COAST

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INTRODUCTION

THE importance of the study of the food of fishes with its bearings on the different aspects of their biology like shoaling and migratory habits, feeding adaptations, growth, etc., is well known and considerable work has been done on this subject abroad since the close of the last century. Though very little was known hitherto about the food of fishes in Indian seas, there has been some addition to our knowledge in recent years. Some of the earlier papers dealing with the subject are on the food of *Sardinella longiceps* (Hornell and Nayudu, 1924), *S. gibbosa* (Devanesan, 1932) and perches of the Madras coast (Job, 1940). Chidambaram and Venkataraman (1946) and Devanesan and Chidambaram (1948), in their accounts of the marine food fishes of the west coast and common food fishes of the Madras Presidency respectively, have given brief notes about their food. Chacko (1949), in his account of the food and feeding habits of the fishes of Gulf of Mannar, has given a historical resume of the papers pertaining to the food of fishes in Indian waters published till then. Since then Bapat and Bal (1950, 1952) have investigated the food of some young clupeids and other fishes from Bombay waters and Bhimachar and George (1952) have observed in detail the seasonal fluctuations in the food of mackerel, *Rastrelliger canagurta*. Prabhu (1950), Nair (1951, 1952) and Bapat *et al.* (1951) have briefly reported on the food of the ribbon fish (*Trichiurus haumela*), the sardines (*Kowala coval* and *Sardinella longiceps*) and the Bombay duck (*Harpodon nehereus*) respectively. Pillay (1952) has given a critical review of the methods employed for the qualitative and quantitative estimation of the food of fishes. Some of the more recent contributions on the food of fishes are by Vijayaraghavan (1951, 1953), Sarojini (1954), Kuthalingam (1955, 1956), Karekar and Bal (1958) and Tampi (1958). The present author (1956) in a paper on the biology of the common anchovy, *Thrissocles mystax*, has mentioned in detail the different food items encountered in its stomach and their fluctuations in the stomach contents during different periods of the

year. Mention may be made here of the observations of Kow (1950) on the food and feeding relationships of the fishes of Singapore Straits which is of special interest as it bears considerable similarity to the present investigation.

The present communication relates to the investigation carried out during the years 1948–53 on the food and feeding habits of some common fishes obtained from the inshore region off Calicut on the Malabar coast.

Material and Methods

The study was based on material obtained from the bi-weekly departmental fish catches made at a depth of 2–8 fathoms in the inshore region off Calicut during the years 1948–53. But the bulk of the data presented in this paper is drawn from the examination of the specimens obtained during the year 1952–53. The catches were obtained by the boat-seine and the gill net, the two common nets used along this coast. The specimens which were usually caught in the morning hours were immediately brought to the laboratory and analysed for their species, size and sex. For the size, the total length of the fish from the tip of the snout to the end of the longest ray of the caudal fin was measured. The intensity of feeding was recorded basing the state of distension of stomach and the amount of food contained in it, as follows: E = 'empty' when the stomach was empty, P = 'poor' when the stomach contained a little food and was not distended, M = 'medium' when the stomach was half-full and was slightly distended, G = 'good' when the stomach was full and distended, H = 'heavy' when the stomach was gorged with food and was fully distended. The stomach contents were carefully removed and examined in fresh condition as far as possible or else preserved in 5% formalin for subsequent study. The food elements were identified as far as possible up to species or up to the genus or family, depending upon the completeness of the organism and the extent of digestion. If the digestion had progressed to an advanced stage and the food organism was mixed with large quantities of mucus making identification difficult, it was treated as digested matter.

The state of maturity of gonads was generally determined following the maturity scales fixed by the International Council for the Exploration of the Seas, taking into consideration the size and colour of the gonads.

In evaluating the different food organisms the *points method* of Swynnerton and Worthington (1940), as reviewed by Haynes (1950), with some modifications was followed. Under this method, the different food items were either counted or assessed by eye and listed under the categories swarms,

plenty, common, few, little and rare; due consideration being given to the size of the food organism as well as its abundance. Points 50, 40, 30, 20, 10 or 5 were allotted to each category. Points were allotted to the stomachs also depending upon the degrees of their fullness and the points gained by each food item were either proportionately increased or decreased to the total allotted to the stomach and then summed up. The summations of the points obtained by each food item for each month were then scaled down to percentages to show the composition of the food items for different months. This method is essentially a volumetric one and was preferred to many others as it had the advantage of giving roughly both the quantitative and qualitative data without the need for very detailed counts.

The following example will explain how the method works: The stomach of one fish is full and contains three prawns, six polychætes and fifty cladocerans. The prawns, as they are greater in volume, are put in the category of 'plenty' and are given 40 points, the polychætes, whose bulk is less than that of prawns, are put in the category of 'common' and given 30 points, and the cladocerans, though more numerous than prawns and polychætes, are lesser in volume and hence put in the category of 'little' and given 10 points. The total comes to 80. Since the stomach is full, it is allotted 40 points and the points allotted to each of the food items are scaled down proportionately to bring the total to 40. It works out as follows: Prawns 20, polychætes 15 and cladocerans 5. The stomach of another fish contains the same food in the same proportions, but is half-full. A half-full stomach gets 20 points and the points allotted to each of the food items work out to: prawns 10, polychætes 7 and cladocerans 3.

Analysis of the Food of Different Species

During the course of the present studies the stomach contents of 7,328 specimens belonging to the following 47 species were examined.

Dussumieria hasselti Bleeker

This fish is fairly common in the inshore waters off Calicut during November–February. A total of 145 specimens of size 129–162 mm. were examined of which 77 contained empty stomachs.

The intensity of its feed was poor during the greater part of the year inasmuch as out of a total of 145 specimens examined 53% had empty stomachs. This is in agreement with the findings of Kow (1950) who has also noticed the same feature in the specimens of this species caught from Singapore Straits. It is seen from Fig. 1 *a*, that the sergestid, *Lucifer*,

formed favourite food, as it was dominant practically during all the months. Prawns formed a significant portion of the feed from November–January while teleosts occurred in the stomach contents in good quantities only in January. Heavy feeding on the stomatopod, *Squilla*, was noticed in February. Copepods and crab megalopa were also observed in its stomach, the former in November and the latter in January.

Sardinella fimbriata (C. & V.)

This forms a major inshore fishery of the region during the post-monsoon and the summer months. In all, 581 specimens measuring 100–177 mm. were examined of which 39 did not contain food in their stomachs.

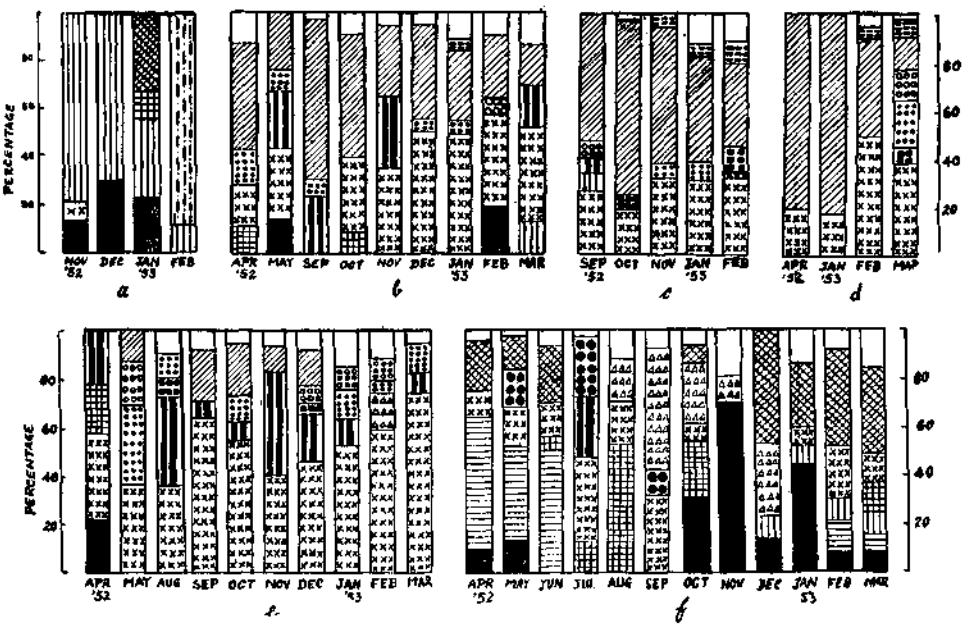

FIG. 1. Percentage composition of different food organisms during April 1952 to March 1953 in the stomach contents of (*a*) *Dussumieria hasselti*; (*b*) *Sardinella fimbriata*; (*c*) *Sardinella longiceps*; (*d*) *Sardinella albella*; (*e*) *Kowala coval* and (*f*) *Opisthopterus tardoore*. (In Figs. 1 to 4, food organisms forming less than 5% have been included in 'others'.)

It is seen from Fig. 1 *b* that the fish is primarily a plankton feeder phytoplankton and copepods constituting the chief items. During September–October, phytoplankton was the most important component showing a peak rise in their percentage occurrence, the commonest species being *Coscinodiscus*, *Fragilaria*, *Nitzschia*, *Ceratium*, *Biddulphia*, *Trichodesmium*, etc., a few of which at times occurred in swarms. Copepods occurred consistently in its stomach and they were generally abundant

during October–March. Some of the common copepods met with were *Temora*, *Acartia*, *Pseudodiaptomus*, *Euterpina* and *Oithona*. The cladocerans, chiefly *Evadne*, formed a conspicuous part of its diet during May, September and November. Some minor food items encountered were small penæids, larval bivalves, decapod and cirripede larvæ, *Lucifer*, fish eggs, etc. The presence of sand grains in the stomach contents on a few occasions may be accidental as there is no evidence of this fish having fed at the bottom.

Sardinella longiceps Val.

This forms a major fishery along this coast and they were obtained in the departmental catches during the months September–February. Out of a total of 150 specimens with a size range of 126–211 mm. examined for the stomach contents, all were found to contain food.

It is seen from Fig. 1 *c* that phytoplankton was the dominant food item, while copepods formed the next important food. Nair (1952) has observed this fish to be a plankton feeder, feeding predominantly on phytoplankton. The present observations show that this item of food was abundant in its stomach contents during the months of September–November, but in the subsequent months of January and February it was less plentiful. Some of the phytoplanktonic forms commonly met with in its stomach were the diatoms, *Fragilaria*, *Coscinodiscus*, *Nitzschia*, *Pleurosigma*, *Biddulphia*, and dinophysids like *Pyrophacus* and *Ornithocercus*. Among the diatoms, *Fragilaria* was common. Copepods occurred during September–February, with slight increase in their abundance from November onwards. Other items observed were cirripede larvæ, larval bivalves, fish eggs, *Evadne*, *Lucifer*, etc. The presence of sand grains in the stomachs of this fish also may be accidental as it is a surface-feeder.

Sardinella albella (C. & V.)

Generally *Sardinella albella* was less abundant in the inshore catches than *S. fimbriata* and *S. longiceps*. 60 specimens of size 125–160 mm. were examined and all contained food in their stomachs.

Phytoplankton (54·91%) constituted the main food of this fish while copepods (36·25%) ranked next in importance (Fig. 1 *d*). Fish eggs, larval bivalves and cirripede larvæ were occasionally observed in its stomach contents in small quantities. Less occasionally sand grains were also met with in its stomach. Vijayaraghavan (1953) found zooplanktonic elements, especially smaller crustaceans like copepods, to predominate in the stomach contents of this fish caught from the Madras coast.

Kowala coval (C.)

This was one of the common species occurring in the inshore area and was obtained in the catches almost all through the year except during the months of June and July. 586 specimens were examined in total of which 113 were found with empty stomachs. Their size range was from 51–120 mm.

It is seen from Fig. 1 *e* that the fish was mainly a zooplankton feeder. Copepods were found to be the more favourite food item forming 49·8% of the total food. They were less plentiful in the stomachs during April, May and August but during September–March, they occurred in abundant numbers in the stomachs. *Pseudodiaptomus, Temora, Acartia, Eucalanus* and *Corycæus* were the common copepods met with. Phytoplankton formed a good portion of its diet during the months of May and September–December. The common phytoplankton forms observed were *Coscinodiscus, Fragilaria, Nitzschia, Rhizosolenia, Chætoceros, Ceratium* and *Pyrophacus. Coscinodiscus* and *Fragilaria* were more plentiful in the stomachs during September, while during October *Nitzschia* and *Rhizosolenia* were more predominant. Cladocerans (chiefly *Evadne*) formed conspicuous part of the food in August and November. Larval bivalves, cirripede larvæ and fish eggs were observed in the stomachs during the greater part of the year. Small quantities of penæid prawns, polychætes and decapod larvæ were also occasionally met with. Nair (1951) has observed this fish to be a plankton feeder, the juveniles preferring the cladoceran, *Evadne.*

Opisthopterus tardoore (C.)

This is another common fish in the inshore waters, occurring almost throughout the year. 712 specimens of size 48–197 mm. were examined f which 62 were with empty stomachs.

A large variety of food organisms was encountered in the stomachs, but the main constituents were penæid prawns, *Acetes,* copepods, fish post-larvæ and polychætes (Fig. 1 *f*). Copepods occurred in the stomachs throughout the year, however, with their percentage values relatively higher during July and September. The common copepods observed were *Pseudodiaptomus, Acartia, Temora, Eucalanus* and *Labidocera.* The maximum occurrence of prawns was in October, November and January. *Acetes* formed the main food during summer months, April and May and the first half of June. Post-larval fishes, especially of *Thrissocles, Anchoviella, Leiognathus* and *Ambassis* were plentiful in the stomachs during the months December–March. Adult fishes also were encountered at times in the stomachs. Polychætes (mainly *Prionospio pinnata*) were common from August–December,

their maximum occurrence being in September, October and December. Good feeding on amphipods was noticed during May and July. The percentage of decapod larvæ was high during the month of August. *Lucifer* was a common food item from December–March.

Anchoviella tri (Bleeker)

Of the genus *Anchoviella*, *A. tri* alone was contributing considerably to the inshore fishery of the region. They were present in good numbers in the catches during the months of June–March. Of 658 specimens ranging in size from 47–95 mm. examined, 21 were found with empty stomachs.

It is seen from Fig. 2 *a* that the fish is mainly a plankton feeder, with copepods and larval bivalves forming the major constituents of its food.

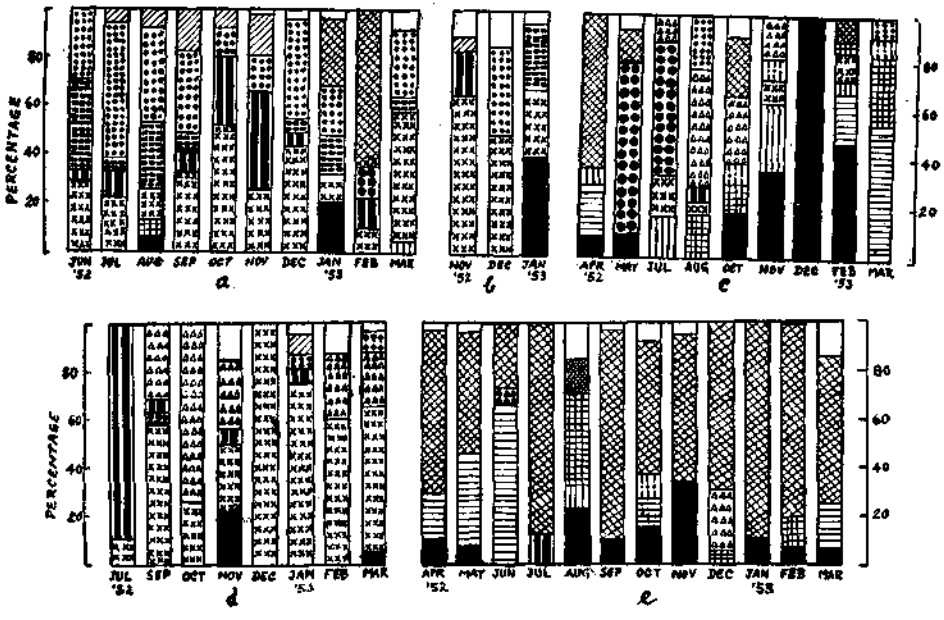

FIG. 2. Percentage composition of different food organisms during April 1952 to March 1953 in the stomach contents of (*a*) *Anchoviella tri*; (*b*) *Anchoviella heteroloba*; (*c*) *Thrissocles malabaricus*; (*d*) *Ambassis gymnocephalus* and (*e*) *Lactarius lactarius*.

The former was present in appreciable numbers in stomach contents during June and July and also from September–March, except, January and February. The commonest copepods observed were *Acartia*, *Pseudodiaptomus*, *Oithona* and *Paracalanus*. Larval bivalves were dominant in the stomachs during June–September, December, January and March. Of the rest, cirripede larvæ and cladocerans were the most frequent, of which the latter was abundant in the stomachs in November. Among the diatoms,

Coscinodiscus was favoured most and occurred in good numbers in September and November. Decapod larvæ, *Lucifer* and crab zœa constituted small proportions of its food. Occasionally it was found to feed on small penæids, fish post-larvæ and amphipods.

Anchoviella heteroloba (Rupp.)

Although *A. heteroloba* contributes, when compared with the previous species, a fishery of lesser importance in the inshore waters, heavy catches were obtained on a few occasions. 193 specimens of size 70–93 mm. were examined, of which 9 had empty stomachs.

It is seen from Fig. 2 *b* that copepods formed a major food constituent, occurring abundantly during all the three months examined. Larval bivalves were in abundance in December while penæid prawns were plentiful in January. Good numbers of cladocerans, mainly *Evadne*, were met with in the stomach contents in November and cirripede larvæ in January. Forming part of its food, at times, were *Lucifer*, fish post-larvæ, crab megalopa and phytoplankton.

Thrissocles malabaricus (Bleeker)

The species, though not as common as *T. mystax*, were obtained in small quantities almost all through the year. 317 specimens of size 71–184 mm. were examined, of which 40 had empty stomachs.

Its food consisted of a wide variety of organisms, the more common forms being penæid prawns, polychætes, copepods, *Acetes*, decapod larvæ and *Lucifer* (Fig. 2 *c*). The prawns were generally abundant during the post-monsoon and summer months. The common species observed were *Parapenæopsis stylifera*, *Penæus indicus* and *Metapenæus dobsoni*. *Acetes* was plentiful during February–April and polychætes during August and October–November. Occasionally, it fed heavily on amphipods, the common species being *Cheiriphotis megacheles*. Forming part of its feed on some occasions were *Hippa*, larval bivalves, *Squilla*, crab megalopa, etc.

Ambassis gymnocephalus (Lac.)

This small fish is the most common perch in the inshore waters off Calicut, though not of much economic importance. It occurred in the catches practically all through the year. Altogether 374 specimens measuring 45–91 mm. were examined of which 27 were with empty stomachs.

It is seen from Fig. 2 *d* that copepods were a very important constituent of its food, their average for the entire period being 52·6%. They were

plentiful in the stomach contents during September–March, with the exception of October and November, when there was a slight decrease in their occurrence. The common copepods recorded were *Centropages*, *Pseudodiaptomus*, *Eucalanus*, *Acartia* and *Oithona*. Polychætes (chiefly *Prionospio pinnata*) also appeared to be a favourite food as they were generally abundant during the post-monsoon months. The cladocerans were most abundant in July, though small quantities were noticed during few subsequent months. Decapods, mainly post-larval and young penæids, were also taken by this fish in small quantities. Cirripede larva was intermittently present in the stomach contents. Diatoms were generally rare. On a few occasions small numbers of *Sagitta*, *Hippa*, amphipods, larval bivalves, fish post-larvæ and fish scales were also met with.

Lactarius lactarius (Bl. & Schn.)

It is a common fish in the inshore region, small quantities of which were obtained throughout the year. 410 specimens were examined of which 26 had no food in their stomachs. The size ranged from 43–206 mm.

Figure 2 *e* shows that this fish is a carnivore, fish forming the most prominent diet practically during all parts of the year. Post-larvæ and

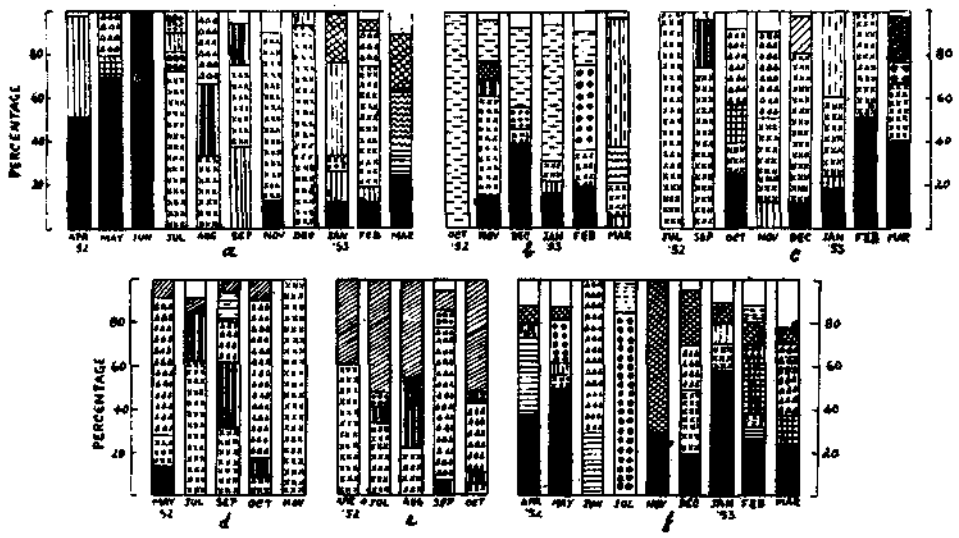

FIG. 3. Percentage composition of different food organisms during April 1952 to March 1953 in the stomach contents of (*a*) *Caranx* (*Selar*) *kalla*; (*b*) *Caranx* (*Selar*) *djedaba*; (*c*) *Leiognathus insidiator*; (*d*) *Leiognathus bindus*; (*e*) *Leiognathus splendens* and (*f*) *Pseudosciæna sina*.

adults of *Thrissocles*, *Leiognathus*, *Anchoviella*, *Cynoglossus*, etc., were noticed in its stomach. Another common item was small and large-sized penæids,

mainly *Parapenæopsis stylifera*, *Penæus indicus* and *Metapenæus dobsoni*. *Acetes* was found plentiful in the stomachs from March to first half of June. Polychætes and decapod larvæ were conspicuous during December and February respectively. Copepods, amphipods, *Lucifer*, *Squilla*, *Hippa*, *Mysis* and cladocerans were also occasionally met with.

Caranx (*Selar*) *kalla* C. & V.

Of the 8 species of carangids recorded in the departmental catches, *C. kalla* was the commonest species. 645 specimens of size range 64–158 mm. were examined and 159 had been found with no food in their stomachs.

Figure 3 *a* shows that copepods formed a chief part of its food during greater part of the year, the common species being *Acartia*, *Centropages*, *Pseudodiaptomus*, *Temora* and *Paracalanus*. Prawns were next in importance, the maximum occurrence of which was from April–June. *Acetes* was observed in March in small quantities. *Lucifer* was found abundant in April and September while Polychætes and cladocerans were plenty in August. Good quantities of fish post-larvæ were found during January and March while on a few occasions fish scales alone were noticed. Heavy feeding on *Squilla* was evident in January while in March the stomachs of a large number of specimens were found gorged with pteropods (chiefly *Creseis* sp.). Other animals met with were mysids, ostracods, crab megalopa, cirripede larvæ and larval bivalves.

Caranx (*Selar*) *djedaba* (Forsk.)

The pattern of occurrence of this fish was more or less similar to that of *C. kalla*, though its fishery is less in magnitude than that of the latter in the inshore waters. 284 specimens were examined in all, of which 106 were with empty stomachs. Their size range was 54–190 mm.

Feeding was observed to be poor in this fish, about 43% of the stomachs being found empty. Its food comprised mainly of prawns and copepods (Fig. 3 *b*). The presence of a large number of fish scales without any trace of the soft or bony parts of the prey on numerous occasions is particularly striking. It may be that the fish is habitually feeding on the offal left over by other fishes. Copepods like *Temora*, *Pseudodiaptomus* and *Centropages* formed a conspicuous part of its food in November while some quantities of penæid prawns were noticed from November–February. It was found also to have fed heavily on amphipods in February, the presence of which along with sand grains showed that it fed at the bottom during this month. The stomachs of all the specimens examined towards the close of March

were found gorged with echiurid worms, a feature observed in the stomachs of many other species during this period. Larval bivalves, fish post-larvæ, cladocerans, decapod larvæ, *Lucifer* and pteropods were noticed in its food on some occasions. Kuthalingam (1955) has found crustaceans to form the main food of this species caught off Madras coast, the same being the case here also.

Leiognathus insidiator (Bl.)

Of the six species of *Leiognathus* obtained in the departmental catches, *L. insidiator* was the most common. In all 354 specimens of size 37–104 mm. were examined, of which 26 did not have any food in their stomachs.

From the high percentage figures noticeable in Fig. 3 *c* it is evident that the fish favoured copepods during greater part of the year. The common species were *Acartia*, *Paracalanus*, *Temora*, *Pseudodiaptomus*, etc. Small penæids also were frequently met with and were next in importance. Polychætes (mainly *Prionospio pinnata*) were dominant in October and November while in January many specimens were found gorged with *Squilla* larvæ. *Evadne*, *Lucifer*, larval bivalves, fish post-larvæ, decapod larvæ, amphipods and diatoms were also observed. Bapat and Bal (1952) have found that polychætes and copepods formed the main food of this fish in its younger stages.

Leiognathus bindus (C. & V.)

This forms a good fishery in some years. 241 specimens measuring 51–114 mm. were examined, of which 36 were without food in their stomachs.

The food, like that of the other species of *Leiognathus*, comprised mainly of copepods and polychætes, supplemented at times by cladocerans and diatoms (Fig. 3 *d*). The maximum occurrence of copepods in the stomach contents was in November, the common ones being *Acartia*, *Centropages*, *Pseudodiaptomus* and *Eucalanus*. Polychætes were abundant in May and October and cladocerans in July and September. Small quantities of diatoms were observed in its food on few occasions. Penæid prawns and fish scales were also noticed in insignificant quantities.

Leiognathus splendens (C.)

This too is a common silver-belly contributing a rich fishery in some years. 173 specimens of size 57–119 mm. were examined, of which 14 were with empty stomachs.

It is seen from Fig. 3 *e* that unlike in other species of *Leiognathus*, diatoms constituted a significant portion of the food of this fish, some of

the common forms being *Fragilaria, Nitzschia, Coscinodiscus* and *Pleurosigma*. Copepods too formed a good portion of its food in April, July and August. Cladocerans were noticed from July–October with maximum occurrence in August. Good feeding on polychætes took place in September and October as evidenced by the stomachs of a large number of specimens gorged with them. Stray numbers of decapod larvæ, fish eggs and larval bivalves were also recorded in the stomach contents.

Pseudosciæna sina (C. & V.)

This is a common sciænid in this area. 500 specimens of size 43–180 mm. were examined, out of which 39 specimens were found with empty stomachs.

A large variety of organisms was noticed in the stomachs, the chief of which were prawns, polychætes, teleosts, amphipods and *Acetes* (Fig. 3*f*). Prawns were abundant in April and May and from November–March while *Acetes* was plentiful in April and June. Polychætes and adult and post-larval fishes formed a good part of its food during the post-monsoon and summer months while the former alone was abundant in June. At times it was found to feed heavily on amphipods. Some of the other items observed in small quantities were copepods, *Squilla, Lucifer, Mysis, Sagitta*, larval bivalves, echiurid worms and diatoms. The presence of debris comprising of fragments of mud and sand grains indicates their feeding at the bottom.

Johnius belengeri (C. & V.)

This fish was caught in lesser quantities than *P. sina* in the departmental catches. 91 specimens of size 56–173 mm. were examined and six of them were with empty stomachs.

Figure 4*a* shows that prawns and polychætes formed the chief item of its food, *Squilla*, *Acetes*, amphipods and copepods occurring occasionally. Debris and sand grains were observed on some occasions.

Otolithes ruber (Bl. & Schn.)

This fish formed only a minor fishery in the inshore waters. 124 specimens of size 56–253 mm. were examined, out of which 13 were with empty stomachs.

This is mainly a carnivorous fish, teleosteans forming a major item of its food in almost all the months when specimens were examined (Fig. 4*b*). Ranking next in importance were prawns which were plentiful from April–July and again from December–March except February. *Acetes* formed

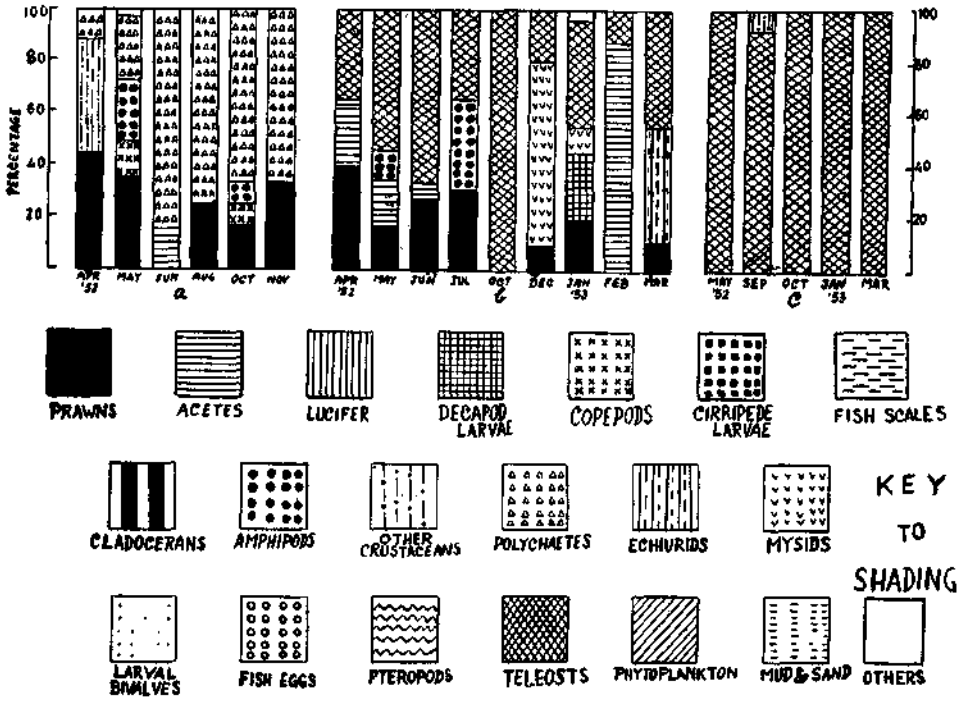

FIG. 4. Percentage composition of different food organisms during April 1952 to March 1953 in the stomach contents of (*a*) *Johnius belengeri*; (*b*) *Otolithes ruber*; (*c*) *Scomberomorus guttatus*.

a significant part of its diet in April, May and February. Large numbers of mysids and echiurid worms were met with in December and March respectively. Amphipods, fish post-larvæ and crab megalopa also formed part of its feed during some months.

Scomberomorus guttatus (Schn.)

Only stray numbers of juvenile specimens of this fish were caught in the departmental catches. 133 specimens of size 136–496 mm. were examined, out of which 86 were with empty stomachs.

The high percentage of empty stomachs may be due to poor feeding of the juvenile fishes in the inshore waters. The probable ejecting of food at the time of capture was not noticed. It was found to feed only on fish and occasionally ostracods (Fig. 4 *c*).

Anodontostoma chacunda (Ham.)

No. of specimens examined	..	64
No. with empty stomachs	..	30
Size range	..	81–163 mm.

A few copepods and diatoms along with bits of digested material and debris were found.

Anchoviella commersonii (Lac.)

No. of specimens examined	.. 41
No. with empty stomachs	.. 1
Size range	.. 54–122 mm.

It was found to feed heavily on larval bivalves. On a few occasions, copepods, amphipods, prawns, crab megalopa, cirripede larvæ and *Evadne* also were noticed. On rare occasions the stomachs were found gorged with polychætes.

Thrissocles purava (Ham.)

No. of specimens examined	.. 16
No. with empty stomachs	.. 1
Size range	.. 114–160 mm.

It fed heavily on prawns, especially during the months of April and May. The other items present in the stomachs were decapod larvæ, amphipods and *Lucifer*.

Thrissocles setirostris (Brouss.)

No. of specimens examined	.. 5
No. with empty stomachs	.. 2
Size range	.. 97–133 mm.

Copepods were present in the stomachs in abundance along with a few cladocerans.

Thrissocles dussumieri (C. & V.)

No. of specimens examined	.. 35
No. with empty stomachs	.. 1
Size range	.. 111–135 mm.

It was found to feed mainly on prawns, copepods and *Lucifer*. Brachyuran larvae, cladocerans and diatoms were also observed in some numbers.

Chirocentrus dorab (Forsk.)

No. of specimens examined	.. 26
No. with empty stomachs	.. 8
Size range	.. 262–476 mm.

On many occasions *Anchoviella heteroloba* and *A. commersonii* were found in its stomach. It is interesting to note its preference to white-baits. On one occasion fragments of prawn were encountered.

Tachysurus dussumieri (C. & V.)

No. of specimens examined	..	13
No. with empty stomachs	..	4
Size range	..	23–145 mm.

Eight stomachs, out of the thirteen examined, were found to be packed with polychætes, while the stomach of one specimen contained large numbers of ophiuroids, bivalves and sea-weeds.

Osteogeneiosus militaris (L.)

No. of specimens examined	..	10
No. with empty stomachs	..	5
Size range	..	91–210 mm.

The stomachs of 5 were gorged with polychætes of the genera *Sternaspis* and *Lumbriconereis*. One prawn was observed in one of the stomachs.

Mugil speigleri Bleeker.

No. of specimens examined	..	11
No. with empty stomachs	..	1
Size range	..	53–180 mm.

The food of this species consisted of diatoms like *Coscinodiscus, Fragilaria, Pleurosigma, Rhizosolenia, Cyclotella,* etc., and other algæ and copepods. Sand grains were observed in the stomachs of most of the specimens. The presence of algæ bits and sand grains indicates their browsing habits.

Polydactylus heptadactylus (C.)

No. of specimens examined	..	39
No. with empty stomachs	..	8
Size range	..	77–153 mm.

The food of the species mainly consisted of prawns and polychætes. Copepods, crab megalopa, amphipods, *Lucifer* and *Evadne* also formed part of the food. A medium-sized fish, *Therapon jarbua* was present in the stomach of a specimen caught on 19th June 1952.

Polydactylus plebeius (Brouss.)

No. of specimens examined	.. 42
No. with empty stomachs	.. 15
Size range	.. 99–185 mm.

Most of the specimens examined were found with their stomachs gorged with *Emerita asiatica* which is a common crab occurring in the muddy bottom in the inshore regions.

Eleutheronema tetradactylum (Shaw)

No. of specimens examined	.. 23
No. with empty stomachs	.. 1
Size range	.. 100–285 mm.

The stomachs of this species were usually packed with prawns. Teleosteans formed the next important constituent of its food. Occasionally it was found also to feed heavily on polychætes, the chief of which was *Prionospio pinnata.*

Lutjanus vaigiensis Q. G.

No. of specimens examined	.. 1
Size	.. 167 mm.

The stomach of the only specimen examined contained one fish post-larval *Caranx (Caranx) sexfasciatus* (Q. G.)

No. of specimens examined	.. 4
No. with empty stomachs	.. Nil
Size range	.. 96–157 mm.

The stomach of one specimen was gorged with *Acetes* while in another a partly digested *Leiognathus* was observed. Fragments of fish, decapod appendages and *Squilla* were noticed in the stomachs of the rest of the specimens.

Megalaspis cordyla (L.)

No. of specimens examined	.. 41
No. with empty stomachs	.. 2
Size range	.. 111–335 mm.

Fish formed the most favourite food of the species and the stomachs of as many as 21 specimens were seen packed with it. 3 partly digested *Anchoviella*

were observed in the stomach of one specimen. It was also found to feed on amphipods, copepods, crab megalopa, *Lucifer* and *Hippa*.

Decapterus russelli (Rupp.)

No. of specimens examined	.. 2
No. with empty stomachs	.. Nil
Size range	.. 154–160 mm.

The stomach of one of the specimens contained some fish scales, copepods and *Evadne* while in the other there were a few fish scales and diatoms like *Fragilaria* and *Coscinodiscus*.

Chorinemus tala (C. & V.)

No. of specimens examined	.. 5
No. with empty stomachs	.. 3
Size range	.. 124–174 mm.

Fragments of decapods were noticed in the stomachs of both the specimens.

Leiognathus ruconius (H. B.)

No. of specimens examined	.. 9
No. with empty stomachs	.. Nil
Size range	.. 53-87 mm.

The analysis of the stomach contents showed that this species was mainly a plankton feeder, copepods, cirripede larvæ and *Evadne* being common. The polychæte, *Prionospio pinnata* was abundant in the stomachs of two specimens.

Leiognathus blochi (C. & V.)

No. of specimens examined	.. 35
No. with empty stomachs	.. 1
Size range	.. 62–109 mm.

This species was found to feed on copepods, small penæids and *Evadne*. Polychætes were occasionally found. In a few specimens, a few fish scales and diatoms like *Coscinodiscus* and *Fragilaria* were noticed.

Pomadasys hasta (Bloch)

No. of specimens examined	.. 12
No. with empty stomachs	.. 4
Size range	.. 75–99 mm.

Polychætes were observed in abundance in the stomachs of 5 specimens, while in the rest a few copepods and *Coscinodiscus* were noticed.

Otolithes argenteus (C. & V.)

No. of specimens examined	.. 39
No. with empty stomachs	.. 1
Size range	.. 92–216 mm.

Penæid prawns and fish formed the main items of food. The common prawns were *Parapenæopsis stylifera* and *Metapenæus dobsoni*. Good numbers of *Acetes* were consumed during March and April. Occasionally polychætes were also seen in their food.

Trichiurus haumela (Forsk.)

No. of specimens examined	.. 31
No. with empty stomachs	.. 7
Size range	.. 262–752 mm.

This is a carnivorous fish and its food was mainly comprised of teleosteans.

Rastrelliger canagurta (Cuv.)

No. of specimens examined	.. 44
No. with empty stomachs	.. Nil
Size range	.. 132–216 mm.

This fish was found to feed exclusively on plankton, both zoo- and phyto-plankton elements being noticed in its stomachs. The common elements were copepods, decapod larvæ, cladocerans, larval bivalves, fish eggs and larvæ, peridinians and diatoms.

Scomberomorus commersonii (Lac.)

No. of specimens examined	.. 9
No. with empty stomachs	.. 7
Size range	.. 138–207 mm.

Teleosteans were seen in both the stomachs with food.

Cybium interruptum C. & V.

No. of specimens examined	.. 14
No. with empty stomachs	.. 11
Size range	.. 150–298 mm.

The stomachs of the three specimens which had food were seen gorged with teleosteans.

Solea ovata Rich.

No. of specimens examined	..	9
No. with empty stomachs	..	4
Size range	..	67–84 mm.

In the stomachs of four specimens, amphipods were found in plenty while in the remaining one numerous copepods were found.

Cynoglossus semifasciatus Day

No. of specimens examined	..	17
No. with empty stomachs	..	3
Size range	..	87–140 mm.

Sand grains and mud fragments were found in plenty in its food which indicates its bottom feeding habits. Polychætes, chiefly *Prionospio pinnata*, were frequently found in its stomach. Amphipods, decapod fragments and diatoms like *Coscinodiscus* and *Fragilaria* were noticed on some occasions.

General Observations

Feeding habits.—From the foregoing analysis of the food, it is evident that the inshore fishes possess diverse feeding habits. Some are plankton feeders, while others are carnivorous or omnivorous. When some are surface-feeders, others feed constantly at the bottom. Again among the plankton feeders, while fishes like *Sardinella longiceps* and *S. albella* have a special favour for phytoplankton elements, those like *Anchoviella* spp., *Dussumieria hasselti* and *Ambassis gymnocephalus* appear to prefer zooplankton and yet others, *viz.*, *S. fimbriata* and *Leiognathus splendens* feed on both phyto and zooplankton without any apparent discrimination. The presence of larger swimming forms like young prawns and polychætes in their stomachs suggests that plankton feeders at times resort also to particulate feeding, though their general feeding habit is by filtration enabled by their gill-rakers.

A large majority of the inshore fishes are carnivores and are cosmopolitan in their tastes. But a few of them like *Lactarius lactarius*, *Chirocentrus dorab*, *Scomberomorus guttatus* and *Trichiurus haumela* and *Pseudosciæna sina*, *Johnius belengeri* and *Opisthopterus tardoore* exhibit chiefly piscivorous and carcinivorous tendencies respectively, inasmuch as fish and crustaceans predominated in their stomachs during greater part of the year. The majority

of the carnivores, excluding those that are chiefly piscivorous, show considerable vertical feeding as evidenced by the presence of surface animals like *Acetes dispar* and fish post-larvæ and benthic forms like bottom dwelling polychætes and amphipods in the stomach contents. The presence of mud and debris in the stomachs of many of these fishes furnishes evidence about their feeding at the bottom. Though none of the carnivores examined show any exclusive vermivorous tendency, worms like polychætes formed often times a significant part of their diet. Only *Mugil speigleri* and *Tachysurus dussumieri* are found to be omnivorous, feeding both on animal and vegetable matter. The soles, *Cynoglossus semifasciatus* and *Solea ovata*, are particularly bottom-feeders as mud and debris along with bottom dwelling polychætes and amphipods were frequently met with in their stomach contents.

Seasonal variation in the food of fishes and its correlation with its availability in the environment.—In order to find out the seasonal variation in the food of the fish population as a whole, a "Food Index" was worked out following the method adopted by Kow (1950). Such food organisms that occurred in abundance or in good numbers in the stomach contents of a particular species of fish were marked by a *plus* sign against the respective species. The food indices were arrived at by calculating the ratio of the totals of the *plus* signs entered against each food organism for each month to the total number of species examined during that month multiplied by 100. As Kow (*op. cit.*) puts it the food index "signifies the level of utilisation of a particular group of food organism by the fish population present in the habitat under consideration". The food indices of different food organisms for each month from April 1952 to March 1953 are shown in Table I and their percentage figures graphically represented in Fig. 5.

The analysis of the food as a whole shows that crustaceans (58·9%) formed the largest group, the others in the order of their importance being teleosts (15·7%), polychætes (9·2%), phytoplankton (8·3%), Molluscs (4·1%) and the rest (3·8%). It is seen from the higher food indices values (Table I) obtained by prawns, *Acetes*, copepods, polychætes and teleosts during March–June that they formed the major food in that period. But in the subsequent months of July and August a considerable decline in the food indices values of prawns and *Acetes* and a significant rise in the values of cladocerans and copepods were noticed. Occasional heavy feeding on polychætes and amphipods was also observed in this period. During September–February, the food indices figures for several food elements including prawns, copepods, polychætes, etc., rose showing a general increase in their feeding activity.

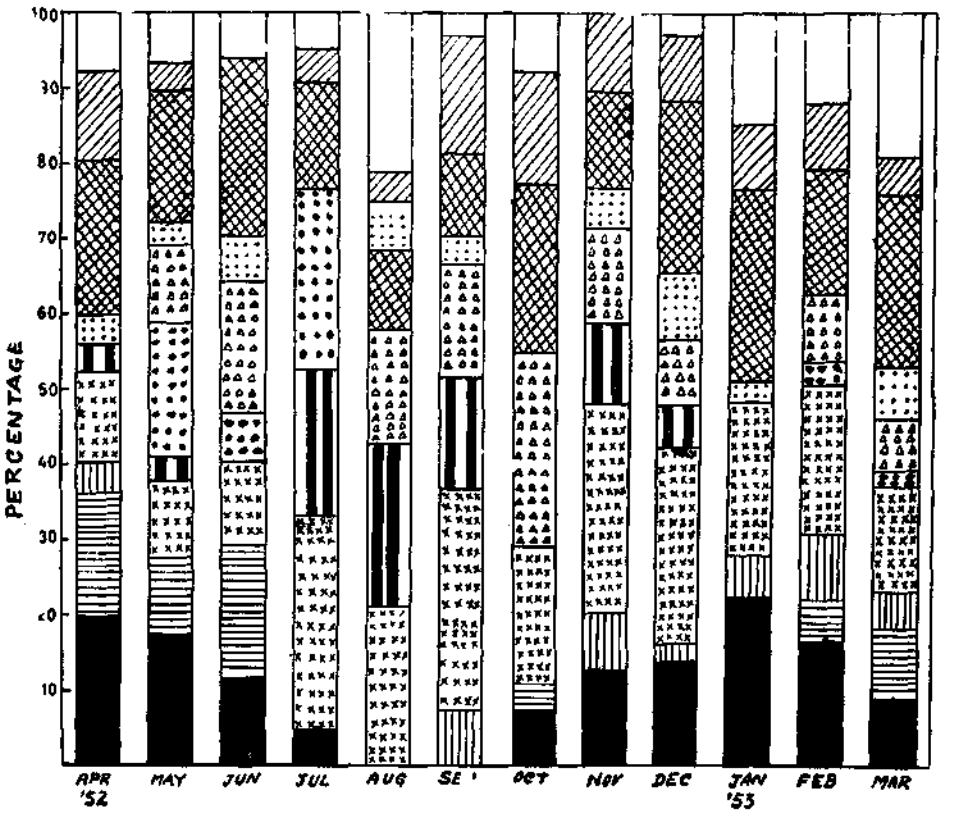

FIG. 5. Histogram showing percentage figures of food indices of different food organisms from April 1952 to March 1953.

It is seen from Fig. 5, that the occurrence of prawns in the stomach contents extended from October–July, the maximum being from January–May when also the prawns have been observed in plenty in the inshore region off Calicut, the species dominant both in the stomach contents and in the area referred to being *Parapenæopsis stylifera*, *Metapenæus dobsoni* and *Penæus indicus* (Bhimachar and Venkataraman, 1952; Menon, 1953). Another common food element is the small shrimp, *Acetes dispar* whose abundant occurrence in the stomachs extended from March–June and correspondingly in the same period this shrimp has been found to occur in plenty in this region (Bhimachar and Venkataraman, *op. cit.*).

During September–February copepods formed a major food of these fishes and a corresponding abundance in the plankton is also noticed at this period (George, 1953). There was a slight decline in their occurrence in the stomachs in the succeeding months of March–June, during which period the copepod fraction in the plankton also declines (George, *op. cit*,

TABLE I

Food indices for different food organisms for each month from April 1952 to March 1953

Main food	1952									1953		
	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Penæid prawns	.. 42	36	22	7	..	..	13	26	29	47	33	25
Acetes	.. 33	21	33	..	..	..	7	..	..	..	11	25
Lucifer	.. 8	..	..	..	..	14	..	16	6	12	17	13
Decapod larvæ	.. 8	..	..	..	9	..	7	..	..	6	11	19
Copepods	.. 25	21	22	43	36	57	33	58	53	42	39	38
Cirripede larvæ	.. ..	..	11	..	9	..	7	..	..	12	6	..
Crab megalopæ	.. ..	7	..	..	9	..	..	..	..	..	..	..
Cladocerans	.. 8	7	..	29	36	29	..	21	12	..	..	6
Sqilla	.. 8	..	..	..	..	..	..	..	..	12	6	6
Hippa	.. ..	..	..	7	9	..	..	..	..	..	..	..
Mysids	.. ..	..	..	..	..	..	..	..	6	..	..	..
Amphipods	.. ..	36	11	29	..	..	..	..	..	..	6	6

Polychætes	..	..	21	33	..	27	29	47	26	18	..	17	19
Echiurids	..	..	..	..	..	..	..	..	..	..	..	..	13
Pteropods	..	..	..	..	..	..	..	..	..	..	..	..	13
Larval bivalves	..	8	7	11	7	18	7	..	11	18	6	..	19
Fish post-larvæ	..	8	7	11	..	..	7	7	..	12	18	11	25
Fish eggs	..	..	7	..	..	..	..	..	..	..	..	..	6
Teleosts	..	33	29	33	21	9	14	33	26	35	35	22	31
Phytoplankton	..	25	7	..	7	9	29	27	21	18	18	17	13

Though copepods are generally scarce in the plankton during the monsoon period, George (*op. cit.*) has observed their sporadic appearance in large numbers in the plankton during the same period and the high values of them seen in July and August can be attributed to their presence in large numbers in the stomachs of *Leiognathus* spp. and *Anchoviella* spp. whose principal season of fisheries is during the rainy months. *Acartia, Pseudodiaptomus, Temora, Eucalanus, Euterpina, Oithona, Centropages* and *Paracalanus* were some copepods commonly met with both in the stomachs and in the plankton.

The fair occurrence of phytoplankton in the stomach contents from September–March coincided with its moderate abundance in the coastal waters in the same period. The slight rise in its food index value in April may be correlated with its minor peak noticed in summer months (George, *op. cit.*). While a phytoplankton bloom is observed during the monsoon months in the coastal waters (George, *op. cit.*: Subrahmanyan, 1959), a corresponding high incidence of phytoplankton in the stomach contents was not noticed, which may be due to the fact that sufficient numbers of major phytoplankton feeders could not be examined. Some of the common diatoms observed both in the plankton and in the stomach contents were *Fragilaria oceanica, Nitzschia, Coscinodiscus, Rhizosolenia, Chætoceros* and *Pleurosigma.*

Teleostean fishes, both post-larval and adult forms, which form a major food for many inshore fishes, occurred in the stomachs all through the year, though post-larval ones were more common in the stomach contents during December–June coinciding with their abundant occurrence in the inshore waters during the same period (Bhimachar and Venkataraman, *op. cit*). The common species met with both in the stomach contents and in the environment were *Thrissocles* spp., *Leiognathus* spp., *Kowala coval, Anchoviella tri, Ambassis gymnocephalus, Pseudosciæna sina, Otolithes ruber* and *Cynoglossus semifasciatus.*

Another major food element, polychætes (especially *Prionospio pinnata*) occurred abundantly in the stomachs during September–May in which period they have also been observed in plenty in the inshore region (Seshappa, 1953). Occasional heavy feeding was noticed in other months also. Amphipods were commonly met with in the stomachs in February–July, when they have been found to occur abundantly in this area, the common amphipod both in the stomach contents and in the environment being *Cheiriphotis megacheles.*

Good numbers of *Lucifer* and decapod larvæ were frequently observed in the stomach contents respectively, from November and January onwards till the end of April, when both of which are found abundantly in the plankton. Larval bivalves and cirripede larvæ which have been observed in the plankton throughout the year were noticed in the stomach contents also almost all through the period. The cladocerans formed an important food item during July–November and it is during the same period that they have been observed abundantly in the coastal waters off Calicut (George, *op. cit.*). Of the two cladocerans, *Evadne* and *Penilia*, the former was more common both in the stomach contents and in the plankton. Among miscellaneous food, brachyuran larvæ, chiefly zœa and megalopa stages, and the stomatopod, *Squilla*, were frequently observed in the stomachs during December-May when they were common in the plankton also.

Feeding intensity.—Table II shows the particulars about the feeding intensity of 20 species that were most common in the catches for all the 12 months. As already stated, the degree of feeding of each fish was noted as under one of the five categories: heavy, good, medium, poor or empty depending upon the state of distension of the stomach and the amount of feeding. The degree of feeding shown for each month is the highest degree noticed during that month. Taking these fishes as representative of the fish fauna of the area, a factor known as 'Feeding Index' is worked out after Kow (*op. cit.*), in order to assess the feeding intensity of the population as a whole. The feeding index for any one particular month is the ratio of the number of species whose feeding intensity was either heavy or good to the number of species examined during that month multiplied by 100. By this method it is possible to know "the level of the observed feeding intensity of the population during any one month".

It is seen from Table II and Fig. 6 that during the post-monsoon months of September–December, consistent with the greater availability of edible plankton and other food elements, there is a marked rise in the feeding intensity, the average feeding index for these 4 months being 67. It is during this period that maximum feeding is observed. In the subsequent months of January–May the feeding intensity continues to be high during which

TABLE II

Feeding intensity and feeding index

Species	1952									1953		
	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
Anchoviella tri	M	G	G	G	M	G	H	G	M	P	G
Anchoviella heteroloba	..	..	..	..	..	..	..	G	G	M	..	..
Dussumieria hasselti	..	..	..	E	..	..	..	P	P	P	P	..
Thrissocles malabaricus	M	G	P	P	G	..	G	G	H	.	M	M
Opisthopterus tardoore	G	G	G	M	P	P	M	H	G	G	G	G
Kowala coval ..	P	P	..	..	G	M	G	H	G	M	G	M
Sardinella albella ..	M	..	..	..	..	..	..	..	..	M	M	P
Sardinella longiceps	..	..	..	..	..	G	G	G	..	H	M	..
Sardinella fimbriata	M	M	..	..	..	G	H	G	M	M	G	M
Leiognathus insidiator	..	..	..	M	..	G	G	G	G	G	M	M
Leiognathus bindus	..	H	..	H	E	G	H	G	E	..	..	..
Leiognathus splendens	M	..	..	M	M	G	G	..	..	..	..	..

Ambassis gymnocephalus ..	..	..	..	G	..	H	G	H	G	G	M	G
Caranx kalla ..	M	P	P	G	M	G	E	G	M	M	G	G
Caranx djedaba ..	..	..	..	..	..	..	P	M	M	P	P	M
Scomberomorus guttatus	E	M	E	E	E	P	H	..	..	P	E	P
Pseudosciœna sina	H	M	M	P	..	..	..	M	G	G	H	H
Otolithes ruber ..	G	G	M	M	E	..	H	..	G	G	G	H
Lactarius lactarius	H	H	H	M	M	P	M	M	M	M	H	H
Johnius belengeri ..	G	G	M	..	M	..	H	G	..	..	..	..
Feeding index ..	42	50	33	31	27	58	75	75	60	38	44	50

H = heavy; G = good; M = medium; P = poor; E = empty.

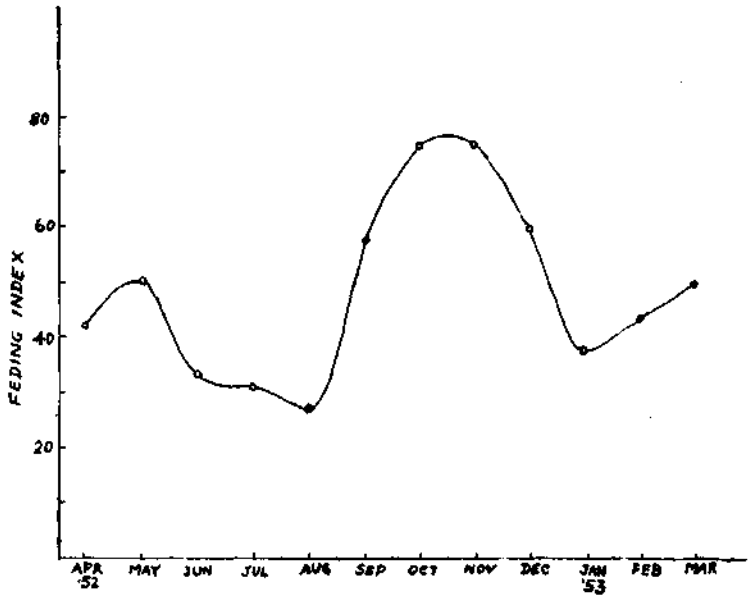

FIG. 6. Graph showing feeding index for 12 months from April 1952 to March 1953.

Food in relation to fisheries.—From the foregoing account interesting correlations between the nature of the fishery and the availability of particular types of food in the inshore waters can be made out. The peak of the fishery in this area, chiefly supported by plankton feeders like sardines and mackerels, is generally attained during the months of September–December, when the inshore waters are rich in plankton comprising of a large variety of phyto- and zooplanktonic elements. It is this season that George (*op. cit.*) has observed "to be a period of abundance of rich 'edible plankton' in the coastal waters". The recolonisation of the inshore sea bottom by a large variety of animals, an important member of which is *Prionospio pinnata*, takes place after the monsoon in September. Coinciding with this settlement of the bottom animals, the commencement of the fishery of the Malabar sole, *Cynoglossus semifasciatus* which is chiefly a bottom feeder and whose favourite food is *P. pinnata* also takes place in September (Seshappa and Bhimachar, 1955). The Malabar sole fishery continues to be good during the subsequent months of October–May in the region under discussion during which period the inshore sea bottom also sustains a rich bottom fauna including *P. pinnata.* Seshappa and Bhimachar (*op. cit.*) while referring to the movements of this fish into the inshore waters mention "that food factor plays an important role in the large-scale appearance of the fish" and "it seems particularly to favour polychætes usually

dominated along this coast by *P. pinnata* during the post-monsoon months".

In the months of January–May, the inshore fishery is rich characterised by the abundant occurrence of a large variety of fish like sciænids, engraulids, polynemids, etc., and this is to a large extent contributed by the presence of their favourite food, prawns, polychætes, amphipods, etc., in the inshore region at this period. Another food element which contributes to their rich fishery in the inshore waters is the small shrimp, *Acetes dispar*, whose plentiful occurrence is from March–May. In the monsoon months, there is a good fishery of the silver-bellies and white-baits whose favourite food is copepods, the large scale occurrence of which in the plankton at this period leads to infer that they contribute to a considerable extent to the rich fishery of the two fishes. Thus it is seen that the availability of particular types of food forms one of the factors governing the migratory movements of many of these fishes into the inshore waters.

Summary

This paper relates to the investigations carried out during 1948–53 on the food and feeding relationships of some of the common inshore fishes caught off Calicut on the Malabar coast. 7,328 specimens belonging to 47 species were examined for their stomach contents. A detailed qualitative and quantitative analysis under *points method*, of the food of 20 species and a general account of the food of the rest are given.

The inshore fishes possess diverse feeding habits. Some are plankton feeders while others are carnivorous or omnivorous. When some are surface-feeders others feed constantly at th bottom. Among plankton feeders, while fishes like *Sardinella longiceps* and *S. albella* have a special favour for phytoplankton, those like *Anchoviella* spp., *Dussumieria hasselti* and *Ambassis gymnocephalus* show a preference for zooplankton, and yet others, *viz.*, *Sardinella fimbriata* and *Leiognathus splendens* seem to feed both on phyto- and zooplankton without any discrimination. A good number of inshore fishes are found to be carnivores and excepting a few, which exhibit chiefly piscivorous and carcinivorous tendencies, the rest are cosmopolitan in their tastes, feeding on a large variety of organisms.

An account of the seasonal variation in the food of the fishes as a whole is given. A close correlation between their food and the food available in their environment could be made out. During the months of September–February the plankton of the coastal waters has been observed to be rich, characterised by the moderate abundance of phytoplankton and increased

occurrence of edible zooplankton elements and correspondingly these were noticed in abundance in the stomach contents of the plankton feeders like sardines and the mackerel. Large numbers of bottom animals recolonise in the inshore area in September after the monsoon break, and occur in abundance in this region then onwards till May. It is in this period that they were noticed in good numbers in the stomachs of those fishes which feed at the bottom. Prawns and *Acetes* have been found to occur abundantly in the inshore waters from January and March till May respectively and this is reflected in their abundant occurrence in the stomach contents also in the same period. During the monsoon months, large scale occurrence of copepods has been noticed in the coastal waters and these constituted the main food of silver-bellies and white-baits in this period.

The feeding intensity is noticed to be high during the post-monsoon and summer months while it is low in the monsoon months, the maximum feeding observed being in the months of September–December. The period of intense feeding is noticed to coincide with the maturing period for many of these fishes.

The relationship between the food and the fisheries is given. It is seen that the availability of particular types of food in the inshore area forms one of the factors governing the migratory movements of many of these fishes into the inshore waters.

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