THE FOOD AND FEEDING HABITS OF THE INDIAN MACKEREL, *RASTRELLIGER KANAGURTA* (CUVIER) AT KARWAR

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INTRODUCTION

INVESTIGATIONS on the food and feeding habits will throw more light on the migratory and shoaling habits of pelagic species of fish, and it is particularly important for a species of high commercial value such as the mackerel. There are many references on the food and feeding habits of the mackerel and a list on the main contributions on this subject from the Indian and other coasts of the Indo-Pacific area is available in the recent review, "Our current knowledge on the food and feeding habits of the Indian mackerel, *Rastrelliger kanagurta* (C)" by George (1962). At Karwar, Pradhan (1956) while dealing with the mackerel fishery of this place made certain observations on the food and feeding also. The present account deals briefly with the food and feeding habits of the mackerel at Karwar.

MATERIAL AND METHOD

Stomachs of 294 mackerel collected from specimens landed by '*Yendi*' (Shore-seine), '*Patte balae*' (Gill-net) and '*Rampan*' (Shore-seine) were studied during the period April 1960 to March 1961.

Total length, sex and stages of sexual maturity* of each fish were recorded prior to the removal of the stomach. Stomachs were carefully taken out and fixed in 5% formalin. Later they were dried in folds of filter-paper, and split open by a pair of scissors. Since they were preserved in formalin and dried in filter-paper the contents of the stomach remained as a dry solid lump which could easily be handled by forceps. The displacement volume of the stomach contents was determined in each case by dropping the lump into a known volume of 5% formalin in a graduated 10 ml. measuring jar. The samples were standardized. After stirring well a sub-sample of one ml. was taken with a graduated pipette and evenly spread over a counting slide. It was examined under a binocular microscope and the

* After Pradhan's (1956) key.

number of each species recorded for determining the relative importance of various food elements. Plankton samples used in this study were collected from the inshore area off Karwar with a simple half meter net, and the plankton volumes were determined by displacement method.

Nature of Food

Plankton exclusively formed the diet of the mackerel. The variations in the occurrence of planktonic organisms seemed to reflect upon the gut contents of mackerel. Table 1 shows the monthly fluctuations in the food constituents in the gut of mackerel as estimated by the number method. An account of the various food elements is given in Table I.

Diatoms.—Occurrence of diatoms in the gut content of mackerel was at its peak in April. *Chaetoceros coarctatus* was the dominant item. Mackerel was observed to feed actively on diatoms during July and August also when *Chaetoceros* spp., *Fragilaria oceanica*, *Thallassiothrix frauenfeldii* and *Nitzschia seriata* were found abundantly. Later, diatoms were sparsely represented in the stomach contents and they were practically absent in the gut in November and early December. From the latter half of December to March, diatoms were met with in the stomach, but their fraction in the diet of mackerel was lean, except for a small rise in the first fortnight of February consequent to the occurrence of *Chaetoceros* sp. and *Nitzschia seriata*. Diatoms other than those mentioned above, which generally occurred in good numbers in the gut of mackerel were *Thallassiosira* sp., *Coscinodiscus jonesianus*, *Rhizosolenia* spp., and *Nitzschia longissima*. Other forms present in smaller numbers were *Stephanopyxis palmeriana*, *Coscinodiscus* sp., *C. gigas*, *Lauderia granulata*, *Schroederella delicatula*, *Bacteriastrum hyalinum*, *Bellarochea malleus*, *Ditylum* sp., *Lithodesmium undulatum*, *Triceratium favus*, *T. reticulum*, *Biddulphia sinensis*, *B. heteroceros*, *Hemidiscus hardmannianus*, *Asterionella japonica*, *Navicula* sp., *N. forcipata*, *Tropidoneis* sp. and *Nitzschia sigma* var. *indica*.

Algae.—*Trichodesmium erythraeum* was found in the stomach contents in April-May and then in November–February. Its occurrence in the gut was always scanty though it appeared in swarms in the coastal waters.

Dinoflagellates.—They were encountered in almost all stomachs examined and were found all the year round. In July–August there was a peak in their occurrence when *Peridinium* spp. dominated. In November and 1st part of December they were very rare and were practically absent in some stomachs. There was another period of good occurrence in December–February, when species of *Ceratium* were abundant. A good number of

TABLE I

Showing the fluctuations in the food constituents in the gut of mackerel

Months	Diatoms	Algae	Dino-flagellates	Tintinnids	Noctiluca	Polychaete larvae	Bivalve larvae	Gastropod larvae	Egg of decapod crustacea	Decapod larvae	Copepod eggs	Copepod nauplii
April ..	11,92,072	72	84	1	·	·	8	3	·	1	66	5
May ..	560	19	214	1	·	1	3	3	·	+	25	6
June ..	no specimens available											
July ..	3,54,318	·	2,011	64	·	·	3	9	·	2	332	189
August ..	2,52,461	·	570	8	·	+	13	2	·	2	34	4
September ..	167	·	54	·	23	·	11	·	·	·	1,184	3
October ..	8,780	·	31	·	·	·	3	2	·	·	5	2
November ..	10	+	2	1	·	·	6	1	+	+	10	14
December ..	611	5	759	15	+	+	3	1	1	8	42	366
January ..	815	+	432	191	+	+	17	1	4	2	129	362
February ..	12,145	+	2,578	386	·	+	21	20	3	9	169	446
March ..	500	·	154	3	·	·	17	21	3	1	99	7

TABLE 1 (*Contd.*)

Months	Cirripede nauplii	Cypris larvae	Cladocerans	Copepods	Chaeto-gnaths	Appen-dicularians	Fish eggs	Other zooplankton	Fish scales	Sand	Digested food	Organic debris
April ..	·	·	·	916	·	·	·	4	1	·	+	·
May ..	·	2	1	58	·	·	·	3	5	·	+	+
June ..	no specimens available											
July ..	6	6	32	1,522	·	1	2	12	51	12,791	+	+
August ..	11	351	·	438	·	6	2	9	·	730	+	+
September ..	6	12	756	635	·	9	1	+	·	2	+	·
October ..	·	7	16	69	·	3	·	23	271	1,16,205	+	·
November ..	1	1	+	50	+	·	+	8	51	33,929	+	·
December ..	1	1	2	84	+	1	1	2	116	9,868	+	·
January ..	2	6	3	870	·	1	+	12	38	23,334	+	·
February ..	2	3	15	759	·	2	·	11	7	9,273	+	+
March ..	·	·	·	5,187	·	·	·	20	16	2,240	+	+

The figures show the numbers present in 0·1 ml. of the total gut content. '·' shows nil, '+' shows presence.

Peridinium sp. and a few *Dinophysis homunculus* and *D. mile* were also present then. *Ornithocercas* sp. was present in the gut in January in highly negligible numbers. The following were the species of *Ceratium* found in the stomachs: *Ceratium candelabrum, C. furca, C. fusus, C. dens, C. tripos, C. breve, C. Massiliense, C. macroceros, C. vultur, C. trichoceros.* Besides these, some other *Ceratium* spp. were also often encountered.

Tintinnids.—There was a minor peak in their occurrence during the period July–August. The major peak was in December–March. *Tintinnopsis nucula* dominated in these peak periods. In September and October tintinnids were absent. In April, May and November they occurred in highly negligible numbers. *Cyttarocylis ehrenbergi, Tintinnopsis gracilis, T. radix, T. tocantinensis,* and *T. karajacensis* were also encountered in the gut contents.

Noctiluca miliaris.—Though *Noctiluca* was found in the plankton in plenty its occurrence in the stomach was scanty. The peak in the occurence of *Noctiluca* in the inshore waters was in September. It occurred regularly in the plankton in November–March. *Noctiluca* occurred in the stomachs in September and December–January.

Polychaete larvae.—They were present in the plankton throughout the year. But their occurrence in the gut was scarce. A few of them occurred in the stomachs in August and in December–February.

Molluscan larvae.—These larvae were found to occur in the stomach all the year round. They occurred in good numbers in August–September and in January–March. In March they were found abundantly in the gut. Bivalve larvae and gastropod larvae were occurring and of these two the former contributed more to form the food of mackerel.

Eggs and larvae of decapod crustacea.—These contributed much to the dietary especially during the period November–March; when they were abundant in the plankton also. Eggs of Penaeid prawns and their larval stages such as the nauplii, protozoea, zoea and mysis stage were found in the stomachs. Zoea and mysis stage of *Mysis, Acetes* and *Lucifer* were found. Zoea of crab, megalopa larva, and phyllosoma larva were encountered occasionally.

Eggs and nauplii of copepods.—They formed important food elements contributing to a good percentage of the food of mackerel.

Cirripede nauplii and cypris larvae.—These larval forms were found to occur in fair numbers. There were, however, a few occasions when the fish were observed to have fed almost exclusively on the cypris larvae.

Cladocerans.—They were observed in the stomachs during September–February, when they appeared abundantly in the inshore area. Between *Evadne tergestina* and *Penilia avirostris* which occur along this coast, mackerel seems to prefer the former one. The peak in the occurrence of cladocerans in the stomach was in September when *Evadne* was dominating the plankton. When *Penilia* started appearing in the plankton the abundance of cladocerans in the gut dwindled.

Copepods.—They formed the major element in the food of mackerel. They were present in the gut practically throughout the year. The fraction of copepods in the food was good in the period after the monsoon and the maximum feeding on them was from January–March. During monsoon it was low. *Acrocalanus longicornis*, and *Oithona oculata* were the most important copepods which formed the food of the mackerel. *Pseudodiaptomus* sp., *Schmakeria serricaudata*, *Temora turbinata*, *Paracalanus aculeatus*, *Acartia erythraea*, *Euterpina acutifrons* and *Oithona plumifera* were observed in good numbers. Those present in lesser numbers were *Nannocalanus* sp., *Centropages furcatus*, *Temora stylifera*, *Acrocalanus gibbor*, *Eucalanus* sp., *Pontella* sp., *Pontellopsis* sp., *Calanopia* sp., *Macrosetella gracilis*, *Microsetella rosea*, *Saphirina gemma*, *Corycaeus giesbrechti*, *C. speciosus*, *Oithona setigera*, and *Oncea* sp. A few *Caligus* sp. and some other parasitic copepods were also encountered in the stomachs along with the food.

Chaetognaths.—Chaetognaths were encountered in the stomach very rarely even though they were present in the plankton in sufficiently good numbers. *Sagitta enflata* and *S. bedotei* were found in the food of mackerel in November and December in highly negligible numbers.

Appendicularians.—Occurrence of appendicularians in the gut when compared to the numerical abundance of them in the plankton was poor. They were present in the plankton in good numbers. *Oikopleura* was abundantly found. *Fritilaria* sp. was also rarely present in very small numbers. In the stomachs *Oikopleura* was found during July–September and November–February. In October appendicularians were absent both in the stomach and plankton.

Other zooplankton elements.—Many other zooplankters such as foraminifers, ctenophores, amphipods, *Mysis*, and small crab were found rarely in the gut. A few specimens of *Pyrocypris* sp. were found in the gut of mackerels got in the trawl net operated 19 km off Karwar. Occurrence of *Lucifer hanseni* even though quite frequent, their number was poor.

Fish eggs and larvae.—Eggs were encountered in the stomachs in small numbers when they occurred in the plankton also. Fish larvae were totally absent from the dietary. A small *Stolephorus commersoni* which was 31 mm in length and 0·2 ml in volume was found in the gut of a mackerel of 20·7 cm size. The fish might have been swallowed by the mackerel accidentally.

Digested food, fish scales and sand.—Along with the various food items mentioned above, almost all stomachs contained digested food material. Apart from food, fish scales, organic debris and sand also were found in the stomachs. In *Patte balae* samples they were negligible, and were practically absent. In the samples from '*Yendi*' and the '*Rampan*' they were abundantly present. Stomachs of mackerel from '*Rampan*' net were gorged with sand. Fish scales that occurred in the guts of the samples from '*Rampan*' were observed to be that of mackerel. In samples from '*Yendi*' ctenoid scales of Sciaenid fishes that were hauled together were also occurring. The numerical ratio of the fish scales which occurred in the stomachs of mackerel taken from '*Yendi*' and '*Rampan*' was 1 : 2. The amount of sand and scales varied in '*Rampan*' itself with the variations in the period of impounding.

General Observations and Discussion

Mackerel at Karwar feed on plankton and as previously observed by Pradhan (1956) they feed both on phytoplankton and zooplankton, the one or the other dominating at different periods of the year. Mackerel studied at Karwar are not carnivorous, but are exclusively plankton feeders as fish larvae and vertebrate materials were totally absent in the guts. Since post-larvae and juveniles of mackerel were not obtained here, it is not possible to say whether any difference exists in the food of the young and adult. Pradhan (1956) occasionally observed some fish eggs in the stomachs he examined. A few fish eggs were encountered in the stomachs in the present study, but there was no regular preference for fish eggs and it is likely that they constitute the diet when abundant in the plankton.

Mackerel is a filter feeder (Hardenberg, 1956) and normally feeds at the surface. Fish scales and sand without any trace of fish bone were observed in the guts at Karwar but it cannot be attributed to their feeding at bottom and the habit of feeding on dead fish as observed by Devanesan and Chidambaram (1953). As Pradhan (1956) says, the inclusion of sand grains in the stomachs might be due to the particular mode of fishing. The percentage of scales in the stomachs of mackerel caught in different nets varied markedly. In samples from '*Rampan*,' scales were abundant. In the

brush up during impounding in '*Rampan*' more scales are likely to be shed which may easily find their way into the stomach in their throes of death. Scales that are shed by moving shoals are also likely to be filtered along with other food. Occurrence of fish scales in the guts of stray specimens of mackerel caught in '*Patte balae*' could be because they are stragglers from the main shoal moving near about.

As Panikkar (1952) and Bhimachar and George (1952) observed elsewhere, the present study confined to the inshore waters off Karwar also shows the shoreward migration of mackerel to be mostly due to rich plankton production near the coastline. As Pradhan (1956) stated, the wind and current also influence their shoreward migration.

Mackerel is observed to feed well when they are immature (Stage I). When it starts maturing (Stage II) feeding also increases and at Stage III of maturity it is observed to be highly intense. Later, in Stage IV, a slackening in feeding appears, and in advanced stage of sexual maturity (Stage V) feeding is poor. These observations (Fig. 1) fully endorse the findings of Bhimachar and George (1952). During spawning season, Bhimachar and George (1952) and Chidambaram *et al.* (1952) say, that the feeding may be restricted. In the present study, mackerel in spent condition (Stage VII) are observed to feed more than the fish in Stage V. Observations on the feeding intensity in relation to different stages of growth show that, the mackerel feeds well when it is small, and while growing it feeds more and while maturing it feeds the most. Whether the fish about to spawn abstain from feeding is yet to be known. However, the present observation that it is restricted during spawning agrees with the feeding habits of other fishes studied by other workers.

Little attention has been given to the study of intensity of feeding of mackerel of different size groups by most of the previous workers. Chidambaram *et al.* (1952) have discussed the feeding intensity of mackerel of 17·0–25·0 cm size groups during different months of the year. Mackerel of the size groups 18·5–25·0 cm were investigated at present and their intensity of feeding as indicated by the volume of stomach contents showed an alternation of high and low feeding in successive size groups except in 24·0 cm group as shown in Fig. 2. In the 24·0 cm group the feeding appears to be very low.

The intensity of feeding in both the sexes is observed to be almost the same.

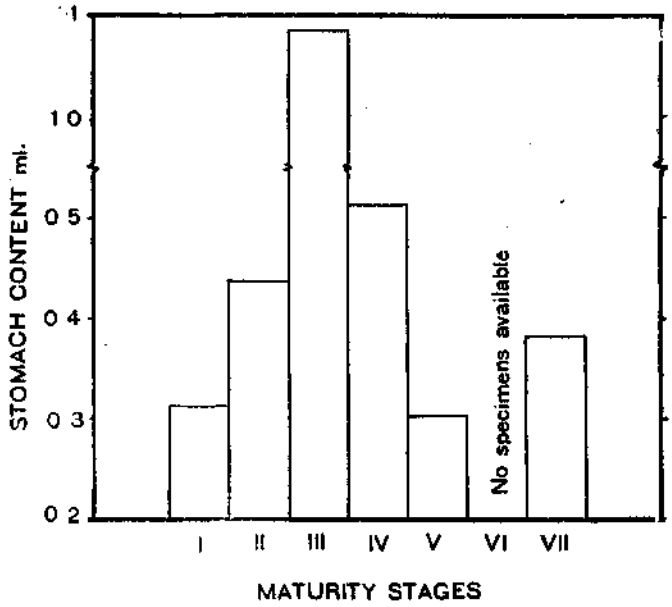

FIG. 1. Relation between the maturity stages and the feeding intensity.

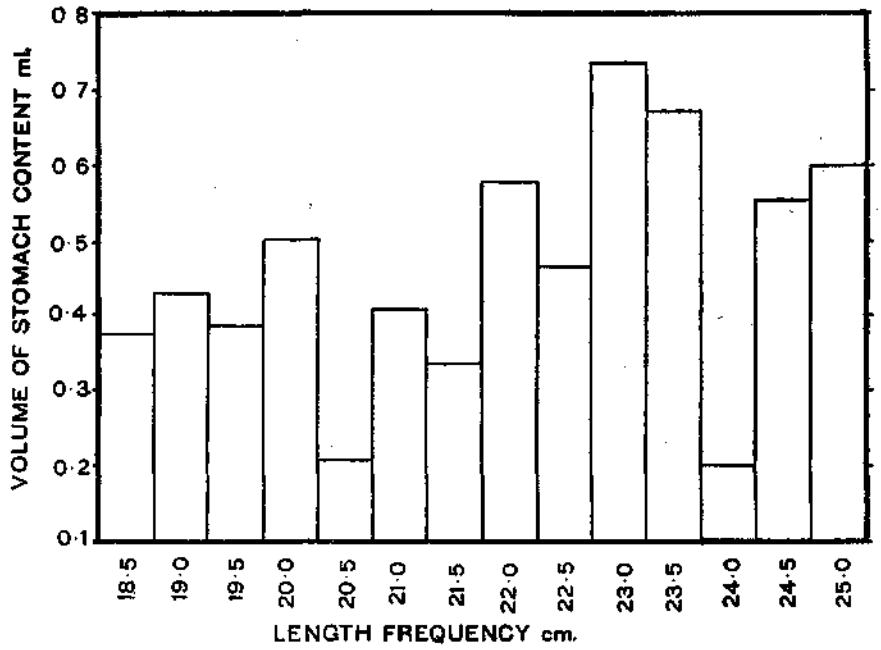

FIG. 2. Relation between the size groups and the intensity of feeding.

As has been observed by Chidambaram *et al.* (1952) and Bhimachar and George (1952) two maxima in the feeding intensity of mackerel were observed at Karwar also. Figure 3 evidently shows that the food present in the gut is almost directly proportional to the production of plankton in the inshore area as Chidambaram and Menon (1945) observed in Calicut Coast. At Karwar mackerel were observed to feed actively in April. During September–January another peak appears. Stomachs with negligible quantity of food or occasionally empty stomachs were encountered in November.

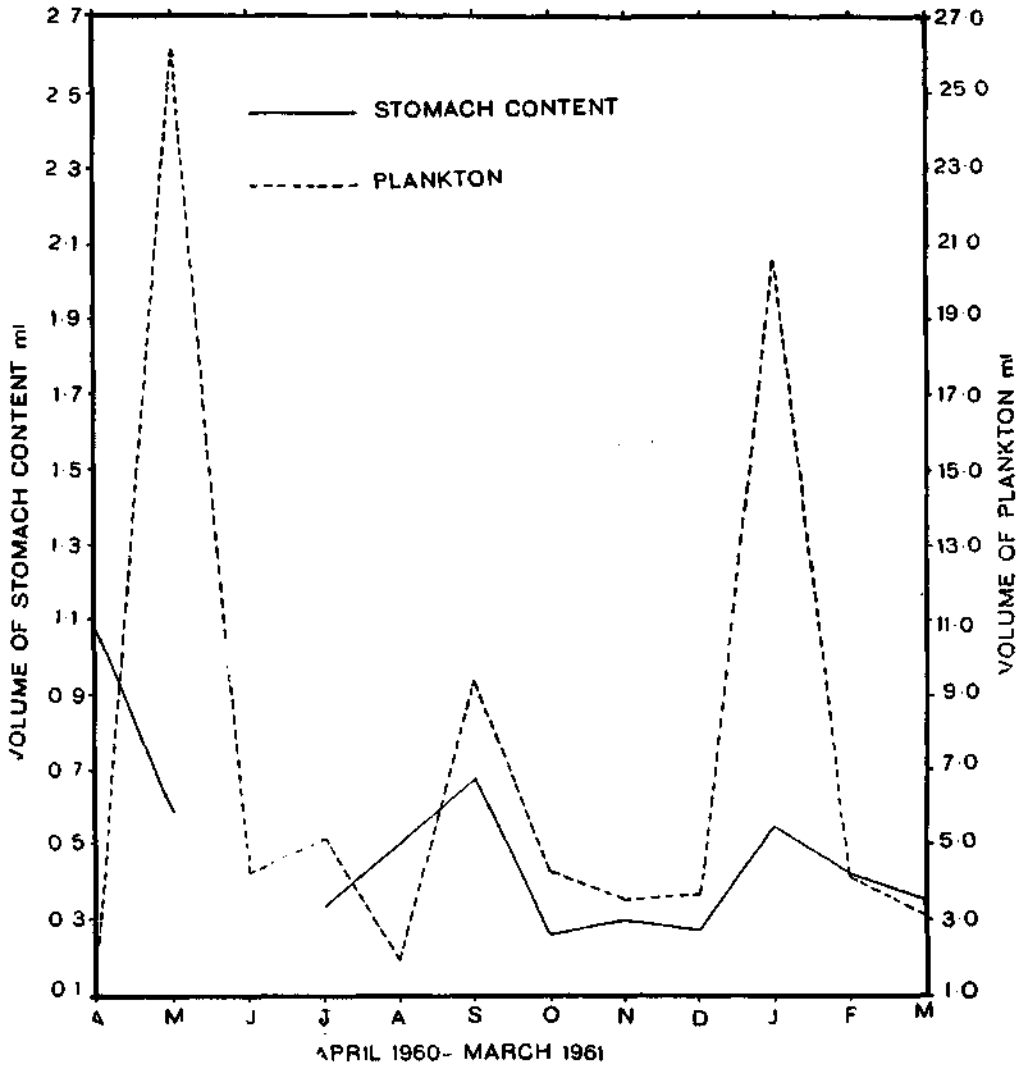

FIG. 3. Variations in the total volume of stomach contents, and the total volume of plankton from the inshore waters.

But there appears no obvious period of fasting in mackerel. The maximum volume of stomach content in a mackerel was 3·5 ml.

Mackerel at Karwar were observed to consume more phytoplankton in April, July and August. Among diatoms *Chaetoceros* spp., *Thallassiothrix frauenfeldii*, *Fragilaria oceanica* and *Nitzschia seriata* were abundantly consumed. During other months zooplankton dominated in the dietary. In zooplankton copepods were the most important item. Bhimachar and George (1952) found them to form 50% of the food. *Acrocalanus longicornis* and *Oithona oculata* dominated among the copepods. Dinoflagellates, copepod eggs and larvae and cladocerans form the next important food items. Besides these, many marine larval forms and adults were present in the stomachs as minor elements.

Bhimachar and George (1952) observed a close similarity between the food constituents and the planktonic elements during different seasons of the year. But as Pradhan (1956) has already indicated, at Karwar, 'the order of abundance of various planktonic organisms is not always the same in the corresponding analyses of gut contents.' Probabilities are there that mackerel which have fed in other grounds where the abundance of plankton organisms is in different proportions, to have moved into the inshore waters. Here, a knowledge of the rate of digestion of food in mackerel and the speed of migration of the shoal will be useful. Pradhan (1956) found the shoals to move at a speed of 13–19 km an hour. In an attempt to study the rate of digestion in mackerel impounded in '*Rampan*' net it was observed that the death struggle and the fright during impounding to enhance their digestion.

Bhimachar and George (1952) differentiate the planktonic organisms into edible and non-edible elements and say that the mackerel discriminate between the two. Pradhan (1956) found no *Noctiluca* in the diet and Bhimachar and George (1952) encountered only six of them in one case. During the present study mackerel were observed to avoid *N. miliaris*. A total of 2,250 specimens were found in altogether 11 samples of gut contents. Chidambaram (1942 and 1944) ranked *Trichodesmium* as a food item of mackerel. But as has been noticed by Bhimachar and George (1952) at Calicut, mackerel at Karwar also avoided *Trichodesmium erythraeum*. The observation that the chaetognaths are not favoured as food (George, 1952) is so at Karwar too. Besides these, medusae, ctenophores, and polychaete larvae were also avoided by the mackerel. That all the above forms are not favoured as food by the mackerel is apparent, because their number in the stomach was negligible even when their population was high in the coastal waters.

SUMMARY

The results of the investigations carried out at Karwar from April 1960 to March 1961 are presented. The relative importance of various food elements have been determined by the number method. Mackerel feeds on plankton. Copepods and diatoms form the main food constituents. Dinoflagellates and cladocerans are the next important food items. Larvae of bivalves, gastropods and decapods, cirripede nauplii, cypris larvae, *Lucifer*, mysids, appendicularians and fish eggs form minor elements. *Trichodesmium erythraeum*, *Noctiluca miliaris* and chaetognaths appear in negligible numbers. The quantity and quality of the food of mackerel vary with the variations in planktonic elements in the inshore area. The intensity of feeding differs in different parts of the year. Feeding is good in immature specimens, while maturing it is intense, and when mature feeding is poor. But in the spent condition feeding is comparatively more than in mature specimens. An alternation of high and low feeding intensity appears in successive size groups except in 24·0 cm group where it is very low.

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