FOOD OF THE INDIAN MACKEREL, *RASTRELLIGER KANAGURTA* (CUVIER) TAKEN BY DRIFT-NETS IN THE ARABIAN SEA OFF VIZHINGAM, SOUTH KERALA

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Being one of the most important neritic pelagic species, the Indian mackerel, *Rastrelliger kanagurta* (Cuvier), has been the object of investigations by many fishery biologists. On the West Coast of India, while this species supports a rich commercial fishery, its distribution on the East Coast is only of biological interest. Most of the earlier works (Devanesan and John, 1940; Devanesan, 1942; John and Menon, 1942 and Chidambaram, 1944) are of brief notes dealing with the nature of food of the mackerel on the West Coast of India. In recent years, Chidambaram *et al.* (1952) have studied in detail the fat variations, size composition, maturity and food habits of the mackerel. Bhimachar and George (1952) have given a detailed account of the seasonal fluctuations in the food of this species from Calicut. Mention should be made of the comprehensive works of Pradhan (1956) and Sekharan (1958) on the fishery and certain biological aspects of the mackerel from the Konkan Coast. Our knowledge on the biology of this species from the East Coast of India is confined to the recent works of Kuthalingam (1956) from Madras, Rao and Rao (1957) and Rao (1962) from Waltair.

It should, however, be mentioned here that all the earlier accounts on the food and feeding habits of the mackerel were based on the samples examined from the inshore fishery where the size of the mackerel hardly exceeds 25 cm. in total length. Therefore any information on the food habits of the mackerel above this size range captured from more open waters should be of considerable interest since it supplements our knowledge on the food habits of the species from the inshore environment.

Off Vizhingam, three types of drift-nets known as *Noovala*, *Vangadavala* and *Vakkuvala* in the local dialect, operated in 18–25 F. area for fishes like horse mackerel, frigate mackerel, tuna and seer, often capture large-sized adult mackerel in small quantities. These small quantities of mackerel at Vizhingam have been incidental catches by the above units fishing for other fishes.

The present communication relates to the preliminary studies carried out on the food habits of the mackerel taken in drift-nets off Vizhingam, during the months October–April in 1958–59. Mention is also made of the maturity condition of the samples studied.

Material and Methods

The material for this study was sampled from the drift-net catches at Vizhingam, once in every week, during the months October–April 1958–59. The units were operated generally in 18–25 F. area, although sometimes they went beyond 25 F. limit. The total number of specimens thus collected and examined during the present investigations is 720, of sizes ranging from 24 cm. to 32 cm. and weight from 250–450 gm.

As the drift-net fishing at Vizhingam is done at night, the catches are always landed at the early hours of the day. The material collected from these catches are immediately brought to the laboratory for examination. The total length of the individual fish was measured to the nearest millimeter and the measurements then grouped into 1 cm. size classes. Before the stomach was removed from the individual specimen, its weight, sex and stage of maturity were recorded. Later the stomachs were carefully removed and preserved in 5% formaldehyde solution for subsequent analysis.

The volume of the stomach contents was determined by displacement method. Then the stomach contents were made to a known volume. All the macroplanktonic organisms, when present, were first separated and counted and then an aliquot of 1 ml. was pipetted out from the known volume into a counting chamber and analysed by *Numerical Method* and *Points Method* (Hynes, 1950 and Pillay, 1952). While determining the relative importance of various types of food items, the points so allotted are scaled down to percentages so as to obtain volumetric percentage composition of different organisms.

It should be pointed out here that all the information so far obtained on the food habits of the mackerel, as in the case of other fishes, is primarily based on the examination of the stomach contents. This method has its own limitations since all the stomach contents might or might not represent its natural diet in certain circumstances; especially when the fish are under trying conditions. It has been the common experience of the author, whenever mackerel samples were examined from boat seine and shore seine catches which are mixed, to find several organisms like juvenile stages of clupeids, leiognathids and packets of scales of other fishes especially those of clupeids

and sometimes even the scales of their own kind in the mackerel stomachs. These are likely to have been swallowed by the fish fortuitously when they were enclosed in the bag of the net, since none of the above items were ever found eaten by the mackerel taken in the gill-nets although they were operated in the same area where boat seines were also operated. The incidence of fortuitous feeding in other fishes when they are enclosed in the trawls and the bagnets; and the bias it brings in the understanding of their normal food habits have been well recognised by the earlier workers (Menon, 1950 and Pillay, 1952). Organisms taken fortuitously by the mackerel can be recognised by their freshness and also by their anterior position in the stomach forming a distinct column from that of the normal food which occupies a more posterior position; and should not be taken into consideration because of this habit. The structural development of the organs associated with feeding in a particular species may also sometimes help us in understanding the type of foot it normally takes. In the Indian mackeral the highly developed gill rakers forming an efficient sieving system is an indication that this species normally feeds on planktonic organisms by filtration.

The state of maturity of gonads of the specimens examined was generally determined by adopting the scale of maturity given by Pradhan (1956) with slight modification. For the sake of convenience the different stages of maturity observed are grouped into the following five categories, *i.e.*, immature (I–II), maturing (III), Mature (IV–V), Spawning (VI–VI *b*) and spent (VII).

Food and Feeding Habits

From the analyses of stomach contents of the mackerel caught in the Arabian Sea off Vizhingam by drift-nets operated in the 18–25 F. area, it was found that the planktonic crustacea constituted by far the greater part of the food consumed (Table I). Of the crustacean diet, copepods formed the predominant item being eaten throughout the period of observation in good proportion. Copepod eggs and nauplii were also often eaten, especially during the months December, January and February. Except in March in all the other months copepods constituted the major element in the food of mackerel. Among copepods, *Eucalanus*, *Oithona*, *Pseudodiaptomus*, *Temora*, *Euterpina*, *Acartia*, *Centropages* and *Labidocera* were the most common genera noted in the diet of mackerel.

Stomatopod larvae represented by erichthus and alima stages come next in importance to copepods among the crustacean diet of the mackerel. They were consumed throughout the period with maxima during December, March

and April. Decapod crustacea mainly represented by larval stages like zoea, megalopa, mysis and prawn (*Lectochelia* sp.) larvae were also eaten in considerable numbers regularly. Sergestids represented by *Acetes* and *Lucifer* were also eaten by mackerel, sometimes in good quantities. Thus *Acetes* constituted a good proportion of its diet during January and April. Though *Lucifer* was noted regularly in the stomach contents of mackerel it occurred in good proportion only during November, February, March and April. The other important items among the crustaceans regularly taken by mackerel are the amphipods. They were represented by *Lycea pulex* and *Hyperia bengalensis,** occurring in good numbers from November to December and from February to March.

Pelagic tunicates formed a substantial portion of the diet of the mackerel throughout the period, with maxima during November and March. The most important forms of pelagic tunicates recorded in the diet of mackerel are *Pegea confederata, Ritteriella amboinensis* and *Thalia democratica.*† *Oikopleura longicauda* was observed in lesser number in certain months.

The major portion of the molluscan fraction of the mackerel food was contributed by the larval stages of pelecypods, gastropods and to some extent by *Dentalium* and *Cavolina.* Except in November they were recorded in the stomach contents of mackerel regularly. Pelecypod larvae were especially numerous during December and April.

Phytoplankton represented by diatoms and dinophyceae was recorded as a regular item in the food of mackerel, although it was more abundant during the months October, November and February. Among the diatoms *Fragillaria, Coscinodiscus, Thallassionema, Nitzschia, Rhizosolenia* and *Biddulphia* were the most important forms noted; while *Peridinium, Dinophysis* and *Ceratium* were found to be the commonest Dinophyceae in the diet of mackerel.

During the months February and March, a good portion of the stomach contents of mackerel was constituted by the brown and red algae.

Among the secondary food elements which were noted in the stomachs of mackerel occasionally are *Evadne, Penilia,* fish eggs, Cypris larvae, phyllosoma larvae and isopods.

Volumetric percentage composition of various food items.—The variations in the volume of food consumed by the mackerel and the volumetric per-

* Kindly identified by Dr. N. Krishna Pillai of the Marine Biological Laboratory, Trivandrum.

† Kindly identified by Shri P. V. Bhavannarayana of the Andhra University, Waltair.

TABLE I

Percentage composition of stomach contents of the Indian Mackerel, Rastrelliger kanagurta *(Cuv.) caught in the drift-nets at Vizhingam*

Stomach contents	1958		1959								Average
	F	M	A	O	N	D	J	F	M	A	
AVR. Vol. in ml. ..	2·93	3·35	2·75	0·98	0·87	1·02	2·05	3·21	3·54	2·96	
PHYTOPLANKTON ..	4·57	4·45	17·19	21·40	12·50	8·66	9·11	12·99	3·24	4·39	9·85
Bacillariophyceae ..	3·06	1·68	15·28	16·36	5·00	5·32	6·98	11·65	2·12	3·97	7·14
Dinophyceae ..	1·51	2·77	1·91	5·04	7·50	3·34	2·13	1·34	1·12	0·42	2·71
ALGAE ..	55·38	1·35	..	..	..	..	..	11·07	..	..	6·78
Brown algae ..	38·08	1·35	..	..	..	..	..	7·37	..	..	4·68
Red algae ..	17·30	..	..	..	..	..	..	3·70	..	..	2·10
CRUSTACEA ..	37·57	48·12	59·26	76·14	71·45	76·01	86·40	65·11	42·26	82·47	64·48
Cupepods ..	26·38	19·68	19·87	67·08	27·25	51·40	38·64	38·72	20·68	35·75	34·54
Cupepod eggs and Nauplii ..	1·36	..	..	..	0·75	2·29	1·08	3·90	..	..	0·94
Acetes sp. ..	..	1·03	..	..	2·25	..	10·45	..	0·85	8·52	2·31
Lucifer spp. ..	0·18	8·47	8·25	1·68	25·25	2·78	1·76	5·92	5·17	2·50	6·20
Evadne sp. ..	..	..	..	1·66	..	0·84	..	..	..	..	0·25
Penilia sp. ..	..	..	..	0·70	..	..	..	..	..	..	0·07
Amphipods ..	0·33	10·25	0·51	..	2·50	1·95	1·16	2·33	5·76	0·51	2·53
Stomatopod larvae ..	0·53	1·68	28·12	1·02	2·00	9·70	5·50	3·69	6·07	31·20	8·95
Prawn (*Lectochelia*) Larvae ..	8·52	4·51	..	..	5·45	..	20·67	5·95	1·67	..	4·68
Zoea ..	..	0·52	..	2·00	3·00	1·65	2·94	..	..	0·81	1·09
Megalopa ..	0·17	0·74	1·76	..	..	3·00	0·64	1·08	0·44	2·43	1·03
Cypris larvae ..	0·08	0·51	0·75	..	..	1·00	..	0·06	0·64	0·75	0·38
Other crustacean larvae ..	0·02	0·73	..	2·00	3·00	1·40	3·56	3·46	0·98	..	1·51
PELAGIC TUNICATES ..	2·33	36·88	6·19	1·66	16·05	7·39	3·00	10·22	51·45	2·64	13·78
Pegea confederata ..	1·24	18·93	..	..	..	..	1·70	4·68	26·73	..	5·33
Ritteriella amboinensis ..	1·09	10·37	..	..	8·87	5·24	0·90	2·80	14·43	1·07	4·48
Thalia democratica ..	..	7·58	..	1·66	6·13	..	..	1·87	10·29	0·20	2·77
Oikopluera longicauda ..	..	..	6·19	..	1·05	2·15	0·40	0·87	..	1·37	1·20
MOLLUSCAN LARVAE ..	0·12	0·11	17·36	0·80	..	7·11	1·35	0·44	0·32	10·50	3·81
Pelecypod Larvae ..	..	0·04	17·36	0·80	..	7·11	1·35	..	..	7·85	3·45
Gastropod larvae ..	0·09	..	..	..	..	..	..	0·20	..	1·40	0·17
Pteropods ..	0·03	0·07	..	..	..	..	..	0·24	0·32	1·25	0·19
MISCELLANEOUS ITEMS ..	0·03	9·09	..	..	..	0·83	0·14	0·17	2·73	..	1·30
Isopods ..	0·02	..	..	..	..	..	..	0·05	..	..	0·01
Phyllosoma ..	..	0·26	..	..	..	0·56	..	..	2·68	..	0·35
Fish eggs ..	0·01	0·07	..	..	..	0·27	0·14	0·12	0·05	..	0·07
Digested matter ..	..	8·76	..	..	..	..	..	..	..	..	0·87

centage composition of different organisms constituting its diet during various months are given in Table I and Fig. 2.

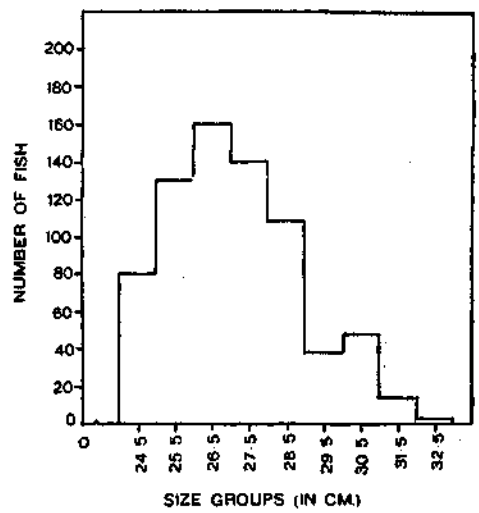

FIG. 1. Size composition of the mackerel in the samples examined from the drift-net catches at Vizhingam.

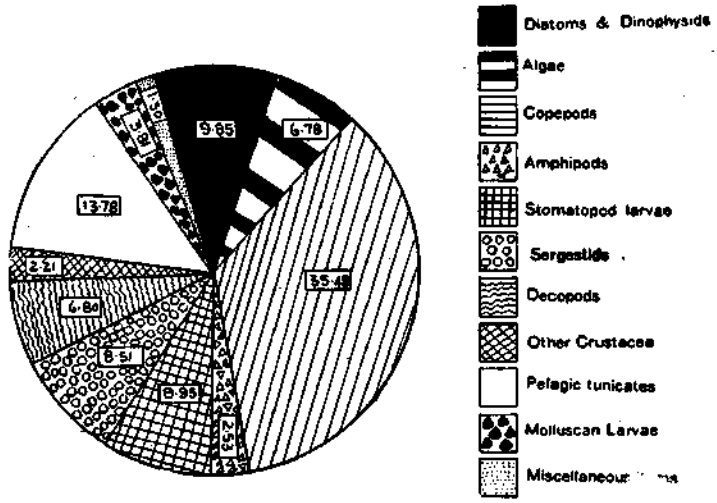

FIG. 2. Pie diagram showing volumetric percentage composition of the major groups of food items of the mackerel, *Rastrelliger kanagurta* (Cuvier).

It can be seen that the feeding activity of the mackerel was at its peak from February to April when most of the stomachs examined were either

full or gorged with food. The feeding was lowest during October–December period coinciding with the height of spawning activity of the mackerel (*see* Fig. 3). From the average displacement volume of the stomach contents, during different months, it is seen that it varied from 0·87 ml. in November to 3·54 ml. in March which was the highest recorded during the period. Even during its peak spawning, the feeding was never stopped by mackerel, although it was at a reduced level.

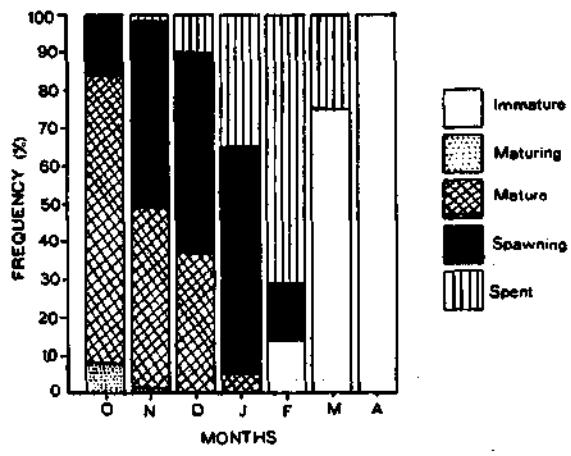

FIG. 3. Gonadial condition of the mackerel examined from the drift-net catches at Vizhingam.

From the volumetric percentage composition of the different organisms, it is evident that the copepods as a group occupied 35·48% of the stomach contents of mackerel. The other important items that constituted the food of mackerel were pelagic tunicates 13·78%, phytoplankton 9·85%, stomatopod larvae 8·95%, sergestids 8·51%, algae 6·78%, decapod larvae 6·80%, molluscan larvae 3·81% and amphipods 2·53%. The variations in the composition of the various items that constituted the food of mackerel in different months could be seen from Table I.

GENERAL OBSERVATIONS AND CONCLUSIONS

Drift-nets which are operated in the 18–25 F. area off Vizhingam during the months October–April, capture fairly large-sized mackerel ranging from 24–32 cm. in total length. This is evident from Fig. 1 which shows the size composition of the fish examined from this gear during the above season in 1958–59. Previous studies on the maturity of the species have been mostly confined to smaller fish, less than 25 cm. in length, usually captured in the

inshore area. It is, therefore, of interest to obtain information on the maturation of the older fish which are not normally taken in the inshore waters.

The maturity condition of the mackerel examined during the course of the present investigation is given in Fig. 3. It is evident from the figure that the majority of the fish examined in October were in advanced stages of maturity, while some were in maturing stage. The catches examined in the subsequent months November, December and January comprised mostly of mature and spawning fish; although some individuals were already in spent condition. Mackerel with spent gonads were first recorded, in small numbers, in the catches during the later half of November and they continued to occur in increasing proportion in the subsequent months. During February most of the fish examined were in spent condition. Mackerel with ripe gonads continued to occur in small numbers in the landings till the end of February. Thereafter and until the close of April all the fish examined were found to be spent or recovering from the recent spawning.

From these observations of gonads it may be inferred that the large-sized mackerel captured in the drift-nets, spawn in the waters off Vizhingam from about October until the end of February. The occurrence of juveniles measuring 3·0–6·0 cm. in the inshore waters during the above period provides additional support for this view. Earlier investigations from the same place indicate that during 1955 and 1956 this species spawned in the local waters from early March to July (Balakrishnan, 1957). It may be mentioned, however, that the dominant size of the adult fish examined by him varied from 22 to 24 cm. (*loc. cit.*, p. 2). Indian mackerel found elsewhere on the West Coast of India are generally believed to spawn mostly during the South-West Monsoon months, although slight differences in the spawning season of the species were recorded at different centres (Devanesan and John, 1940; Chidambaram *et al.*, 1952; Pradhan, 1956 and Sekharan, 1958). On the East Coast, however, the spawning season of this species is considered to coincide with the North-East Monsoon months (Rao and Basheeruddin, 1953; Basheeruddin and Nagappan Nair, 1961 and Rao; 1962). This variation in time of spawning of the mackerel in the Indian waters may be connected to some extent with latitude, or it may be a race-connected characteristic. Differences in the spawning periods of different races of the same species in the same or similar localities have been observed in other species of fish, such as the European herring (Lissner, 1934) and Pacific surf smelt (Schaefer, 1936).

The present study on the food habits of these fish has indicated that they were feeding on a variety of both micro- and macro-planktonic organisms available in the environment at the time. The seasonal abundance of the various planktonic organisms occurring in the waters off Trivandrum Coast was discussed in a comprehensive manner by Menon (1945). From the analysis of the stomach contents of mackerel caught in drift-nets off Vizhingam it was found that the planktonic crustacea formed its principal diet. Pelagic tunicates, phytoplankton and molluscan larvae were the other important items noted in the food of mackerel. The constant presence of copepods, stomatopod larvae, *Lucifer*, *Acetes*, decapod larvae, amphipods, pelagic tunicates, molluscan larvae, diatoms and dinophysids in good quantities in their stomachs would suggest that the mackerel regularly and normally feed on these planktonic organisms.

It is noteworthy that, among the macroplanktonic organisms, pelagic tunicates represented by *Pegea confederata*, *Ritteriella amboinensis* and *Thalia democratica* were regularly consumed by the mackerel in large numbers; especially during the months November, February and March when they occurred in quantities in the local waters. This is in contrast with the food habits of mackerel in the inshore area where this item was rarely eaten by the mackerel (John and Menon, 1942; Bhimachar and George, 1952 and Rao and Rao, 1957). In the open sea where the pelagic tunicates abound, the mackerel living in the area probably resorts to this diet normally.

The occurrence of large quantities of brown and red algae in the stomach of mackerel during the months February and March was, no doubt, puzzling; since it does not normally resort to this diet. The specific identity of the algal item found in the stomachs could not be determined. In the absence of this information it cannot be stated with any certainty whether this item was derived from the bottom habitat or from the surface. But in view of the fact that the other organisms including the amphipods found in the stomachs are planktonic and that the mackerel were captured in the drift-nets from the surface and subsurface layers it is probable that the fish would have fed on the above algae when they are floating at the surface. The occurrence of this item in the stomachs during the restricted period can only be due to the indiscriminate feeding on the part of the fish and may be considered as exceptional. Cladocerans, fish eggs, phyllosoma larvae and cypris larvae were also recorded in certain months in negligible numbers and the occurrence of these items is only incidental.

Thus the present investigation confirms the normal pattern of the planktonic diet and of the plankton feeding habits of the mackerel as has been

reported by the earlier workers (Bhimachar and George, 1952; Rao and Rao, 1957 and Pradhan, 1956) with the difference that the food consumed by the fish living in different waters vary to a certain degree depending upon the exigencies of the environment. Even in the case of the European mackerel, *Scomber scombrus* (L.), whose food habits have been investigated in detail (Allen, 1897; Bullen, 1908 and Steven, 1949) it was found that this species, as in the case of the Indian mackerel, normally feeds on the planktonic diet; although, at times, it resorts to fish diet, especially in the winter season when the surface layers are devoid of suitable food.

Devanesan and Chidambaram (1948) have suggested that the Indian mackerel occasionally supplements its planktonic diet by feeding at the bottom on the dead and decaying fishes; since they found, sometimes, fish scales and sand in the mackerel stomach. According to Kuthalingam (1956) the mackerel is piscivorous in its habits; for in their stomachs were found larval and juvenile stages of several fishes. It is doubtful whether the above items can be considered as the food of the mackerel, since they are likely to have been taken fortuitously; a habit often observed in mackerel when they are enclosed in the boat seines and shore seines. It is unfortunate that the above workers have not mentioned the gear from which the material was examined by them.

The feeding activity of the mackerel appears to have distinct correlation with its spawning phase. During the period October–December, when the spawning activity of the mackerel was at its peak, the feeding intensity was low. The feeding activity was found to reach its maximal level during February, March and April when most of the fish were in spent and recovering condition.

Summary

The food and feeding habits of 720 mackerel caught in drift-nets operated in 18–25 F. area off Vizhingam, during the months October–April in 1958–59 season, were studied. The size of the fish varied from 24–32 cm. in total length.

The possible sources of error and the precautions to be taken, while examining the samples drawn from different gear, in the mackerel food studies were discussed.

It is observed that the mackerel taken from 18–25 F. area off Vizhingam fed on a variety of both micro- and macro-planktonic organisms, depending on their availability and abundance in the area at the time. Planktonic

crustacea represented by copepods, stomatopod larvae, decapod larvae, *Lucifer*, *Acetes* and amphipods formed by far the greater part of the food consumed. Bacillariophyceae, dinophyceae and macro-planktonic organisms, like pelagic tunicates, were also eaten by the mackerel regularly in large numbers. In certain months, brown and red algae, larval cerripedes, *Evadne*, *Penilia* and fish eggs were also eaten.

The maturity condition and spawning season of the mackerel examined during the present investigation have been mentioned.

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