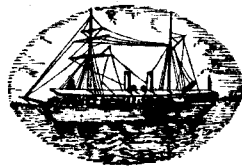


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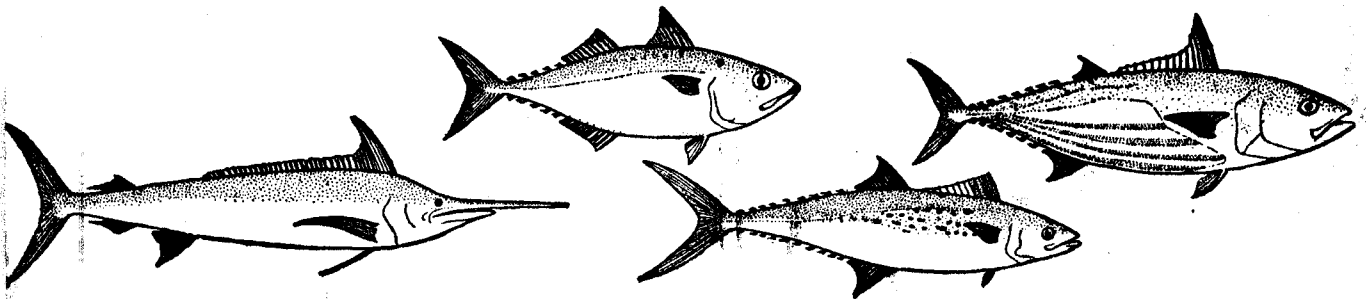
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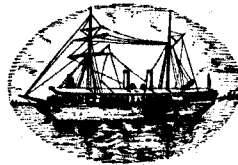
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PART II



SYMPOSIUM SERIES I
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OUR CURRENT KNOWLEDGE ON THE FOOD AND FEEDING HABITS OF THE INDIAN MACKEREL, *RASTRELLIGER KANAGURTA* (C.)*

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IN the present communication, an attempt is made to piece together almost all the available information on the food and feeding relationship of the mackerel, *Rastrelliger kanagurta* (C.) from the relevant notes and publications available in the Indo-Pacific area, in order to get a clear picture of the ecology of feeding of the fish so that future work could be planned to yield maximum benefit in the understanding and management of this important fishery. A study of the literature on the topic has shown that most of the data on this aspect have resulted from observations made during studies on the biology of common food fishes. Often these investigations are based on examination of a few samples from restricted areas and not covering all sizes of growth. Nevertheless, the available information is useful for a general assessment of the major elements that constitute the diet of the Indian mackerel.

PRESENT STATUS OF STUDY

From the West Coast of India, the main contributions on this subject are of Devanesan and John (1940), Devanesan (1942), John and Menon (1942), Chidambaram (1944), Devanesan and Chidambaram (1948), Bhimachar and George (1952), Pradhan (1956), George, *et al.* (1959), and George and Annigeri (1961). The feeding habits of mackerel from East Coast of India were studied by Chacko (1949), Kuthalingam (1956), and Rao and Rao (1957). The compilation of data made at the Central Marine Fisheries Research Institute (1957) towards a critical appraisal of accumulated data on the biology of the Indian mackerel has also brought to light certain salient features of the feeding pattern of the fish. The information made available from the Philippine waters by Durand (1949), from the Japanese area by Kishinouye (as quoted by Durand), from the Singapore Straits by Kow (1950), and from the Java Sea by Hardenberg (1955) add considerable interest to the problem when viewed for the Indo-Pacific area as a whole.

As can be seen from the Tables, the investigations carried out at the various centres on the feeding relationships of the mackerel do not lend themselves to a uniform pattern. The studies carried out in some detail from the West Coast of India (Bhimachar and George 1952) undoubtedly point towards the planktonic nature of the food taken by the fish. These authors have also assessed the relative importance of the different food elements by the 'points method' and have shown that copepods, cladocerans and diatoms are normally encountered. Some of the notes published on the food of mackerel, earlier and subsequent to the above mentioned investigation, also lead to the general conclusion that the mackerel is mainly a plankton feeder. The studies carried out in the Philippine waters (Durand 1949) and in the Java Sea (Hardenberg 1955), also are in general agreement with this observation.

There is a large area of disagreement among the various workers regarding the details of the feeding pattern, the proportion of the various food elements and in the choice of favourite items. Devanesan (1942) is of the opinion that the mackerel normally feeds on fish eggs, although this statement was not accepted by John and Menon (1942) who could not find any fish eggs in the guts

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TABLE
Summary of Observations on the Feeding Relationships in *Rastrelliger kanagurta* (C.)

LOCALITY (1)	AUTHOR (2)	FEEDING PATTERN (3)
WEST COAST OF INDIA		
1. <i>Ratnagiri</i>	George, P. C. and G. G. Annigeri (1960)	Small-sized mackerel feeds on zoo—and phyto- planktonic elements; mostly diatoms, dinophy- sids, copepods and penaeid protozoa. Feeding pattern not different from that of adults.
2. <i>Karwar</i>	Pradhan, L. B. (1956)	Adults are plankton feeders. The food ele- ments recorded from the stomachs are encountered in the inshore plankton; but the order of abun- dance not always in proportion; shows certain amount of selectivity.
3. <i>Mangalore</i>	George, P. C., M. H. Dhulked and V. Ramamohana Rao (1959)	In the estuary adult fish feeds on zoo—and phytoplankton; copepods dominant; no indi- cation of feeding at bottom.
4. <i>Calicut</i>	Devanesan, D. W. (1942)	Mackerel 'regularly and normally feeds on fish eggs occurring in the plankton'.
5. <i>Calicut</i>	Chidambaram, K. (1944)	Confirms the observations of Devanesan (1942).
6. <i>Calicut</i>	Devanesan, D. W. and K. Chidambaram (1948)	'Young ones are carnivorous while adults are not'; Mackerel feeds habitually on fish eggs and supplements diet by occasionally feeding at the bottom on dead and decaying fishes.
7. <i>Calicut</i>	Bhimachar, B. S. and P. C. George (1952)	Mackerel feeds almost exclusively on plankton organisms. Composition of food varies accord- ing to fluctuations in the planktonic elements. No appreciable difference between food of young and that of adult.
8. <i>Trivandrum</i>	John, C. C. and M. A. S. Menon (1942)	Fish eggs never observed in the gut contents in spite of regular occurrence of fish eggs in plank- ton during mackerel season.
EAST COAST OF INDIA		
9. <i>Mandapam</i>	Central Marine Fisheries Re- search Institute (1957)	Plankton feeder; copepods, diatoms, dino- flagellates and also blue green algae common; mackerel may spend much of the feeding time nearer bottom when in inshore waters.
10. <i>Gulf of Mannar</i>	Chacko, P. I. (1949)	Plankton feeder; mostly diatoms and zooplank- tonic elements.
11. <i>Madras</i>	Kuthalingam, M. D. K. (1956)	Surface feeder throughout life; post larva fishes strictly herbivorous, juveniles omnivorous, adults confirmed carnivores.
EXTRA INDIAN		
12. <i>Waltair</i>	Rao, K. V. N. and K. P. Rao (1957)	Juveniles carnivorous and selective; above 90mm. plankton feeders.
13. <i>Philippines</i>	Durand, J. (1949)	Stomach generally filled with a green pulp, probably formed of microscopic algae.
14. <i>Japan</i>	Kishinouye, K. (Quoted by Durand 1949)	'These frisk near the surface in shallow water feeding actively on small planktonic organisms'.
15. <i>Singapore Straits</i>	Kow, Tham Ah (1950)	Mainly plankton feeder; sometimes stomachs packed with ' <i>Stolephorus</i> '.
16. <i>Java Sea</i>	Hardenberg, J. D. F. (1955)	Plankton feeder; mostly on copepods with negligible fraction of diatoms; feeds on medusae also.

of mackerel during their studies made from the Trivandrum coast. Devanesan and Chidambaram (1948) have also stated that their later researches showed that the mackerel feeds habitually on fish eggs in the plankton and that this habit would have an adverse effect on the population of the fishes on whose eggs it feeds. Kuthalingam (1956) has stated that his studies from the Madras Coast did not reveal any fish eggs in the guts of the mackerel. But on the other hand, he found that adult mackerel feeds on post-larval and juvenile forms of certain fishes. Rao and Rao (1957) suggest that the juvenile mackerel is carnivorous and selective in the food habits and that the adult ones are plankton feeders consuming large quantities of phyto-plankton along with some zooplankton. Durand (1949) found the stomachs of mackerel filled with a green pulp formed from microscopic algae. The mackerel obtained from the Singapore coasts were found to feed on diatoms, copepods and decapod larvae (Ah Kow 1950). Hardenberg (1955) agrees with the conclusions of Bhimachar and George (1952) that 'there is a close correlation between organisms in the gut contents of the mackerel and those occurring in the plankton collections, both in respect of species and their relative abundance.'

The food of the young mackerel was not found radically different from that of the adults by many workers. Pradhan (1956) has agreed with the observations of some of the earlier workers and stated that there is no marked difference between the food constituents of the young and adult mackerel. However, Kuthalingam (1956) is of opinion that the 'post larval fishes are strictly herbivorous feeding on diatoms, algae and other green matter, whereas the juveniles are omnivorous, feeding on all prey available at the surface such as copepods, *Lucifer*, ostracods, larval polychaetes, veliger larvae, diatoms and algae.' He also states that the omnivorous juveniles gradually become confirmed carnivores when they reach the adult stage, and that 'the adults feed on *Acetes*, copepods, young *Squilla*, *Penaeus*, and post larval and juvenile fishes.' Rao and Rao (1957) have stated that the food of juvenile mackerel, ranging in total length from 32 to 90 mm., is different and that the change in the food habits of the fish could be correlated with the change in the relative length of its alimentary canal. Several workers favour the idea that the food of young mackerel is influenced by the relative abundance of the planktonic elements in the environment than due to definite selectivity. George and Annigeri (1960), after studying a large sample of mackerel below 100 mm. from the Ratnagiri Coast have found that the food of the small-sized mackerel consisted of diatoms, dinophyids, copepods and penaeid proto-zoea, and are of opinion that the feeding pattern of the young mackerel is not different from that of adult ones. The small-sized mackerel collected from Madras Coast by Rao and Basheeruddin, (1953) were re-examined by the present writer and the food taken was found to be quite similar in quality and quantity to that of young mackerel collected from Ratnagiri Coast.

The intensity of feeding in the different size groups of mackerel was studied by Chidambaram *et al.* (1952). They have found two periods of intense feeding ; one in October-December and the other in March-April. Bhimachar and George (1952) have pointed out that there is no period of the year when the mackerel may be said to abstain from food and that feeding intensity was low during the pre-spawning and spawning periods.

DISCUSSION

As can be seen from the above chapter, the data so far available are mostly of a qualitative nature except for the studies on the Calicut Coast by Bhimachar and George (1952) and by Kuthalingam (1956) on the East Coast. A quantitative study of the gut elements of the mackerel extending to the different seasons of the year and including the various sizes of the fish, from representative areas is necessary to understand clearly the various aspects of the feeding pattern of the fish. To assess correctly the feeding behaviour of the fish, this study of the fluctuations of the actual food should be correlated with a quantitative study of the seasonal fluctuations of the available food in the environment. This was possible to some extent for Calicut Coast where a study of the seasonal abundance of the various planktonic groups was also carried out during the period of the investigations on the food of the mackerel (George 1952). If similar comparative studies

are carried out in representative centres in the area where the mackerel fishery is active, the results should yield very useful information on the various aspects of feeding of the fish and may throw more light on the problem of feeding migrations. Hardenberg (1955) states that the mackerel tend to follow the highest densities of plankton on the West Coast of Borneo. The movement of mackerel in dense shoals in the inshore waters during the post-monsoon season is also considered by Bhimachar and George (1952) as for purposes of feeding although Sekharan (1958) found difficulties in the acceptance of this view.

The feeding selectivity of mackerel and other pelagic fishes depend, among other things, on the spacing of gill rakers and other physical limitations and adaptations and hence it is not difficult to explain certain inclusions as (accidental ?) deviations from the normal food. The mackerel is to be considered as normally a surface and a column feeder. The chances of their resorting to bottom feeding in shallow waters is not improbable, but in deeper waters they may not do so. The presence of scales in the gut with the conspicuous absence of any remains of bones (Devanesan and Chidambaram 1948) tend to show that these scales might have been taken in, as they fell off from the moving shoals and need not necessarily be due to 'carnivorous' habits. The mackerel may also snap at moving or darting fleshy masses like medusae or doliolids or cephalopods, and has also been observed to take baits from lines. Impounded mackerel have been observed to gulp in almost anything when disturbed and chased. This explains the apparent differences found in the food of the mackerel caught by different gears and tackles from the same zone.

Swynnerton and Worthington (1940), Hynes (1950), Bhimachar and George (1952), Pillai (1952) and Holt (1958) have discussed the relative merits of the methods of quantitative analyses of gut contents. From these studies it is evident, that for plankton feeding fishes, the 'Number Method' of analysis cross checked with 'Points Method' should be more advantageous. This is particularly desirable because the same methods could be followed for the estimation and study of the seasonal abundance of the planktonic elements and for computation of the forage index and similar assessments. When once the nature of relationship between the actual food preferred by the fish and the available food in the environment is fully understood, it should yield useful information on selectivity and also on growth rates related to food consumption. Any comparison of actual food of the fish with the available food in the environment should also give allowance to the fact that often pelagic shoals may move into a fishing zone after having fed from an adjacent area that might have a different planktonic composition.

Much of the difficulties in the apparent contradictions in the various publications on the food of mackerel are to a great extent due to free use of the terms denoting feeding habits. If a fish takes to a diet of planktonic organisms, it is always preferable to call it a 'plankton feeder', irrespective of the fact that either zoo or phytoplankton dominated in the diet. The increased proportion of zoo plankton in the diet can be a case of selectivity, but should not be confused with 'carnivorous' diet. It may be better to set apart the term 'carnivorous' to real flesh eating habits involving tearing or active devouring of prey. The occurrence of planktonic fish larvae in the diet need not necessarily be due to 'piscivorous' habits unless the fish resorts to a normal diet of fish and fish remains. It can only be a case of 'feeding on planktonic elements' with fish larvae as a favourite item. An agreed definition of the various terms, is a prerequisite in any comparative study on feeding, and if scrupulously followed could help to avoid much of the difficulties in the piecing together of information collected from different centres and also may facilitate easy interpretation of results.

SUMMARY

The present status of our knowledge on the food and feeding relationship of the Indian mackerel, *Rastrelliger kanagurta* (C.) is discussed based on available publications from the Indo-Pacific area. It is pointed out that the mackerel is normally a surface and a column feeder. The food of the young mackerel appears to be not radically different from that of the adult and that the changes in the fluctuations in the food elements depend to a great extent on the fluctuations of the planktonic organisms in the environment.

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