OBSERVATIONS ON THE BIONOMICS OF THE INDIAN MACKEREL, *RASTRELLIGER KANAGURTA* (C.), CAUGHT IN THE LAWSON'S BAY, NEAR WALTAIR ; ANDHRA COAST*

By K. V. NARAYANA RAO**

Department of Zoology, Andhra University, Waltair, India

THE Indian mackerel, *Rastrelliger kanagurta* (C.), is one of the important pelagic, shoaling marine fishes of our country. Although its distribution is known to extend both on the west and east coasts, the area between Quilon and Ratnagiri on the west coast is the most productive from the mackerel fishery point of view. Compared with the magnitude of the mackerel landings in this sector, the occurrence of the species on the east coast in small quantities is of no significance. However, additional knowledge on the biology of the species from various sections of the coastline should be of considerable value to the proper understanding of the bionomics of the mackerel populations over the entire range of their distribution.

Most of the earlier investigations on the biology of the Indian mackerel were confined to the west coast of India. Most important among them are the contributions made by Devanesan and John (1940), John and Menon (1942), Chidambaram (1944), Bhimachar and George (1952), Chidambaram *et al.* (1952), Pradhan (1956) and Sekharan (1958). In contrast, our knowledge on the biology of this species from the east coast is particularly lacking. In recent years, Rao and Basheeruddin (1953), have reported the occurrence of young mackerel from Madras. Subsequently the food habits of the young and adult mackerel have been studied by Kuthalingam (1956) and Rao and Rao (1957) from Madras and Waltair respectively.

It is evident from the foregoing account that the biology of the Indian mackerel is not fully understood from the east coast, and a detailed knowledge of the food habits, maturity and spawning habits, size composition and rate of growth of the species from this region may throw some light in the proper understanding of its biology.

In the local waters, the mackerel, was never taken in commercial quantities, probably because of its sporadic and sparse occurrence. Although the adult fish was taken in the Lawson's Bay as stray specimens during November 1954, they were more abundant during February and March, 1955. Young mackerel ranging in size from 3.5 to 14.5 cm. were also recorded during the above period. Both the juvenile and adult fish were captured in shore-seines (*Pedda Vala*) and boat-seines (*Iraga Vala*), and sometimes in gill nets (*Oddi Vala*).

The present report is based on the samples collected from the Lawson's Bay landings during the year 1954-55. As there is no detailed information on the biology of the species from this region, the results are published in the present paper.

MATERIAL AND METHODS

Due to the sporadic occurrence of the mackerel in the local waters, the programme of collecting samples at weekly intervals during the year 1954-55 was not quite successful. In spite of this a total of 593 fish were collected during the above period and were duly examined. As stated earlier they were collected from various gear employed at different seasons of the year. The size range of

---

** Present address : Central Marine Fisheries Research Centre, Cannanore.

the mackerel in the samples varied from 3.2 to 24.3 cm., in total length. After recording total length, weight, sex and stage of maturity for each fish, individual stomachs were examined separately for their stomach contents and analysed volumetrically based on the procedure adapted by Pearse (1915). According to this method, the contents of each stomach is considered as unity, the various items being expressed in terms of percentage by volume as estimated by inspection under a binocular microscope. The analysis of the individual stomachs separately at the initial stages helped to find out the differences in the food habits of mackerel of different sizes. They were accordingly grouped and analysed in the subsequent samples. During the course of this analysis, it was noticed that in the fish collected from the seine nets, several items like young ones of other fishes which were caught in the nets along with mackerel, and sometimes fish scales, sand etc., were found in the proximal region of the mackerel stomach, although none of them were found in the stomachs of the fish analysed from the gill nets. These items are considered to have been swallowed by mackerel by accident during their struggle in the seine nets, and hence they are not considered as their normal food.

The maturity of the fish was determined by using the standard adapted by the International Council for the Exploration of the Sea. The growth of ovarian ova in the different stages of maturity was studied by taking the diameter measurements of the ova with the help of an ocular micrometer. All the measurements were taken from formalin-preserved material.

The rate of growth of the mackerel was studied by analysing length-frequency data. The samples were grouped at 1 cm. intervals and each sample was analysed separately instead of grouping several samples at monthly intervals. This was felt desirable, since the time intervals between the samples collected were not uniform and that any pooling of data at monthly intervals, it is felt, will distort the real picture. This method can be used profitably when the samples are few and are collected at unequal time intervals, especially so in a rapidly growing species. The mathematical relation of length and weight of mackerel was calculated by using the formula $W = cL^n$ for both the sexes.

Food Habits

The food habits of the Indian mackerel on the west coast have been investigated in some detail by Devanesan and John (1940), John and Menon (1942), and Chidambaram (1944). Of recent and more detailed studies on this aspect were those of Bhimachar and George (1952), Chidambaram *et al.* (1952), and Pradhan (1956). These authors have not only studied the food habits of the fish in different months but also have correlated their findings with the biological environment. From these studies it is evident that the mackerel on the west coast feeds normally and regularly on both zoo- and phyto- plankton according to their availability in the area. However, Chidambaram (*l. c.*), while studying the food habits of mackerel from West Hill area, points out the carnivorous habits of juvenile mackerel. On the contrary Bhimachar and George (1952), Pradhan (1956) and George and Annigeri (1960) believe that the food habits of the juveniles do not differ much from that of the adults.

The food habits of the Indian mackerel on the east coast have also been studied in some detail by Kuthalingam (1956), and Rao and Rao (1957). According to the former author, the post larvae (5-6mm.) are strictly herbivorous, becoming omnivorous when they become juveniles (15-25 mm.), while the adults (35-225 mm.) are confirmed carnivores. The studies of Rao and Rao (*l. c.*) have revealed that the juvenile fish (32-89 mm.) are carnivorous in their food habits while larger fish (90-243 mm.) are not.

In the course of the present investigation 593 fish belonging to various sizes (3.2-24.3 cm.) were examined. A preliminary examination of their stomach contents showed that the young

fish (3.2-8.9 cm.) have different food habits from that of the larger fish (9.0-24.3 cm.). Consequently their stomach contents were analysed and studied separately. (Table 1., Fig. I., A and B).

TABLE 1

Volumetric percentage composition of stomach contents of the Indian mackerel, *Rastrelliger kanagurta* of different size groups.

Stomach Contents	*Size Groups*	
	3.2–8.9 cm.	9.0–24.3 cm.
Diatoms	2.66	22.21
Dinophyceae	1.01	8.92
Copepod, and Copepod nauplii	12.85	38.80
Lucifer sp.	25.56	0.34
Stomatopod larvae	3.29	10.01
Decapod larvae (Total)	5.94	12.65
Megalopa larvae	0.00	3.71
Mysis larvae	1.75	1.16
Zoea larvae	2.21	2.66
Prawn larvae	0.00	0.37
Other larval decapods	1.98	4.75
Molluscan larvae (Total)	0.06	4.24
Pelecypod larvae	0.06	3.70
Gastropod larvae	0.00	0.53
Pteropods	0.00	0.01
Fish larvae (*Anchoviella* sp.)	46.11	0.00
Miscellaneous items (Total)	2.52	2.83
Fish eggs	0.00	0.02
Amphipods	0.71	0.36
Cypris & Cypris larvae	0.08	0.09
Isopod remains	0.00	0.11
Evadne sp.	0.00	0.10
Polychaete larval remains	0.00	0.14
Tintinnids	0.00	0.05
Radiolarians	0.00	0.02
Oikopluera sp.	0.01	0.03
Salps	0.00	0.07
Trichodesmium	0.00	0.24
Digested matter	1.72	1.60

The Juveniles (3.2–8.9 cm.) :—

From the qualitative and quantitative analyses of the stomach contents of the juveniles, it is seen that the bulk of their diet was composed of larval white bait (46.11%), and *Lucifer* sp. (25.56%). Next in importance were copepods and their nauplii (12.85%), decapod larvae (5.94%) and stomatopod larvae (3.29%). The decapod larvae were represented by zoea, mysis and other stages. The erichthus stage of *Squilla* sp. was the main item representing stomatopod fraction. Forms like pelecypod larvae, amphipods, cypris larvae and *Oikopleura* sp. were also eaten occasionally. The phytoplankton fraction represented by *Coscinodiscus*, *Rhizosolenia*, *Biddulphia* and *Dinophysis* contributed a minor proportion (3.67%) in their diet (Table I, Fig. 1, A).

The Medium-sized and Adult mackerel (9.0–24.3 cm.) :—

The results of the stomach contents analyses of the above size group are given in Table I, and shown diagrammatically in Fig. 1,B. From these it is evident that the food of this size group consisted mainly of copepods and their nauplii (38.80%), phytoplankton (diatoms and dinophysids) (31.13%), decapod larvae (12.65%), stomatopod larvae (10.01%), and molluscan larvae (4.24%). While forms like *Lucifer* sp., amphipods, *Cypris* larvae, larval polychaetes, tintinnids,

Evadne sp., radiolarians, salps, *Trichodesmium* and fish eggs were eaten occasionally in lesser quantities.

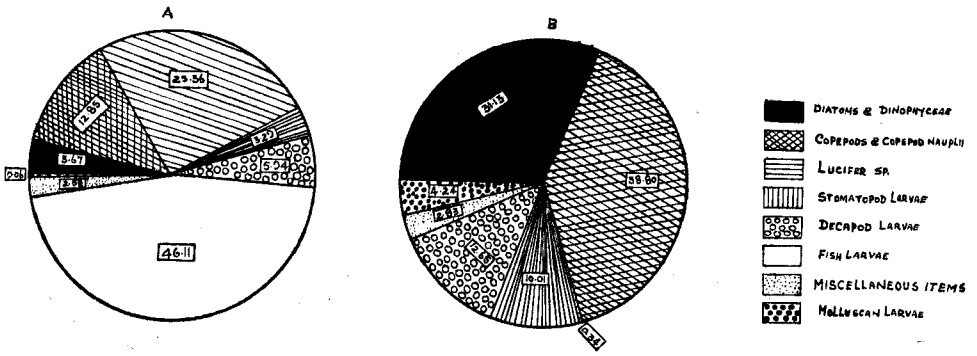

Fig. 1. Percentage composition of various food items of Young (A) and Adult (B) Indian mackerel, *Rastrelliger kanagurta*.

It is most striking to notice the complete absence of fish larvae in the diet of this size group, while it was taken as a staple food by the juvenile mackerel. It is also interesting to note the higher proportion of phytoplankton in the diet of larger fish than in the younger ones.

Copepods like *Euterpina, Paracalanus, Eucalanus, Oithona,* and *Schmackeria* were the common genera observed in the diet of this size group. Among the decapod crustacea, larval forms like zoea, mysis and megalopa, and adults like *Lucifer* and *Mysis* were commonly observed and they together constituted a good proportion of the mackerel diet. The molluscan fraction was mainly represented by bivalve larvae. While the stomatopod fraction was represented by erichthus and alima stages of *Squilla* sp.

Maturity and Spawning Season

Our present knowledge on the maturity and spawning season of the Indian mackerel is mainly based on the investigations carried out on the west coast of India (Devanesan and John, 1940; Devanesan and Chidambaram, 1948; Chidambaram *et al.*, 1952; Pradhan, 1956 and Sekharan, 1958). According to them the mackerel matures and spawns on the west coast during the months April to September, coinciding with the South West Monsoon.

However, evidence of mackerel spawning during the North East Monsoon on the east coast, in contrast with the condition on the west coast is forthcoming by the records of juvenile mackerel from Madras (Rao and Basheeruddin, 1953) and from Waltair (Rao and Rao, 1957) at that time.

During the 1954-55 season samples of mackerel ovaries were collected with the view of studying their maturity condition. In the local waters adult fish could be obtained during the period November-March. The fishes examined in November 1954 were in advanced state of maturity, referable to Stages IV-VI. This shows that the species might start spawning in November or slightly earlier. The adults were absent in the catches of the subsequent months until February-March 1955 when they were captured in good quantities. The samples examined during the above period contained several spent fish (Stage VII) in addition to some fully mature fish (Stages V and VI). Unfortunately no adult fish could be examined after March 1955 since they were completely absent from the catches. However due to the fact that several spent fish (Stage VII) were recorded during February-March period, it is reasonable to assume that the spawning season of the species might extend to a month or two thereafter.

It is clear from the foregoing account that the spawning season of the mackerel, in the local waters commences by about October or November and lasts until April or May, coinciding with the North East Monsoon and with the upwelling in the local waters (La Fond, 1954).

As has been stated earlier, maturity studies were based on the ova-diameter measurements. Ova samples taken from the preserved ovaries in different stages of maturity were measured following the procedures adapted by Clark (1934) and De Jong (1940).

TABLE 2

Percentage frequency of ova diameter of the Indian mackerel, *R. kanagurta* in different stages of maturity

Maturity stage of the ovary	Ova diameter in mm.						
	0.1	0.2	0.3	0.4	0.5	0.6	0.7
I	99.64	0.36					
II	84.37	14.28	1.35				
III	75.73	8.98	5.17	8.85	1.27		
IV	61.53	7.02	7.99	5.38	11.20	7.06	
V	42.99	14.74	11.00	13.86	5.16	11.93	1.32
VI	80.78	11.52	4.51	2.59	0.15	0.05	

The ova diameter frequency polygons of ovaries in Stages I to V and VII are given in Fig. 2. No spawn-ripe ovary representing Stage VI was obtained during the present study., although several males with oozing gonads (Stage VI) were observed right from November onwards.

The ova in the immature ovaries (Stage I) are transparent and hardly exceed 0.2 mm. in diameter. The frequency polygon representing this stage has a unimodal nature (Fig. 2, A). As the season advances the ovaries start maturing, increasing in size due to the increase in size of the internal ova. By the time the ovary reaches Stages II and III, a batch of ova has started growing simultaneously in size and turn opaque forming a distinct group from the main stock of immature ova. The ova diameter frequency polygon representing this stage has a characteristic bimodal nature, one representing the immature and the second the maturing opaque ova (Fig. 2, C). In this stage the largest opaque ova measured up to 0.5 mm. with a mode at 0.4 mm. The progressive growth of the maturing group of ova could be seen in the subsequent stages. As the ovary reaches Stage IV, already another batch of ova started growing from the main stock of immature ova. At this stage the frequency polygon has a different shape from that of the previous stage. The two modes seen in the polygon at this stage at 0.3 mm. and 0.5 mm., represent the two maturing groups of opaque ova (Fig. 2 D). In the next stage (V) (Fig. 2, E), these two modes have further shifted to right indicating further growth in the two batches of mature ova, which will ultimately, become ripe and be spawned. Now the two modes could be seen located at 0.4 mm. and 0.6 mm.

However, from the shape of the ova diameter frequency polygon of the fully spent ovary (Fig. 2, F) it could reasonably be assumed that these two batches of mature ova seen in Stage V, after growing to the final stage of ripeness would have been shed ultimately. At this stage the ovary is blood shot and flabby containing several residual opaque ova. The ova diameter

frequency polygon representing this stage has a characteristic unimodal shape with its right arm extended due to the presence of residual mature ova.

According to Steven (1949), in the Atlantic mackerel, *Scomber scombrus*, the ovarian ova are ripened and released in batches during its spawning season.

The present studies indicate that the ovarian ova of the Indian mackerel, as in the Atlantic mackerel, are matured and released in batches, since the ova diameter frequency curves exhibit multiple modes in the final stages of maturity. Sekharan (1958) also believes that a similar phenomenon is a possibility. It could be seen that mature ova are seggregated in two distinct groups in the final stages of maturity (Fig. 2, D and E), suggesting that the individual fish matures and spawns probably two batches of ova during its spawning season.

According to De Jong (1940), the second batch of mature eggs is more likely to be disintegrated and reabsorbed than it will ever reach maturity, since he found that the number of eggs in the second batch was always smaller than the first, and that there was an excessive number of degenerating eggs. During the present study no evidence was found to support this view. On the other hand it was observed that the proportion of the remaining mature ova after the first batch is released was so high (see Fig. 2, E) that it is very unlikely that all of them will be reabsorbed, although some reabsorption of the residual ova was observed after the first batch of eggs is spawned.

Rate of Growth and Age

Our knowledge on the rate of growth and age of the Indian mackerel was a matter of surmise until very recently. The first attempt ever made to assess the rate of growth and age of mackerel by length frequency was that of Pradhan (1956). He believes that in the first year of its life the mackerel grows to a size of 10 cm. and 18 cm. or more in its second year. Later, Sekharan (1958) studied the size composition of the commercial landings of mackerel off West Hill area on the west coast. He states that ' the normal modal size of one-year-olds could be assumed to be 12-15 cm. ', and that these so called one-year-olds after supporting the commercial fishery, grow to a modal size of 21-23 cm., completing the second year of their life.

The size of the fish studied during the course of this investigation, varied from 3.2 to 24.3 cm. The data are grouped into 1 cm. size classes, and due to the reasons already explained under the section 'Material and Methods', the samples were analysed separately instead of grouping them at monthly intervals, and the modes are alphabetically marked (Fig. 3).

It could be seen from Fig. 3 that the juvenile mackerel measuring 3.5-5.5 cm. in total length and with a modal size at 4.5 cm. were first recorded on 28th February 1955 (mode C). These young ones obviously would have hatched out from the same season's spawning, since the species spawns actively during the period November-February. In the subsequent samples collected on 13th March and 10th May in the same year the modal size of the above brood stood at 5.5 cm. and 11.5 cm. respectively, indicating rapid progression in the modal size during the period. If the progression of the mode C, in the different samples collected between 28th February and 10th May 1955, represents the rate of growth of the group within that period, then it becomes obvious that these juveniles have grown about 7.0 cm. in length within a period of 72 days., i.e. growing at an average rate of about 3 cm. per month. Obviously these young ones (mode C) belonged to 0 year class and would have been born probably in January 1955. This is in conformity with the fact that the peak spawning for the species in the local waters, coincides with the November-February period.

It may be noted, however, that another group of slightly older fish with a size range of 8.5-13.5 cm. and having modal size at 10.5 cm. was first recorded on 8th October 1954 (Fig. 3, mode B).

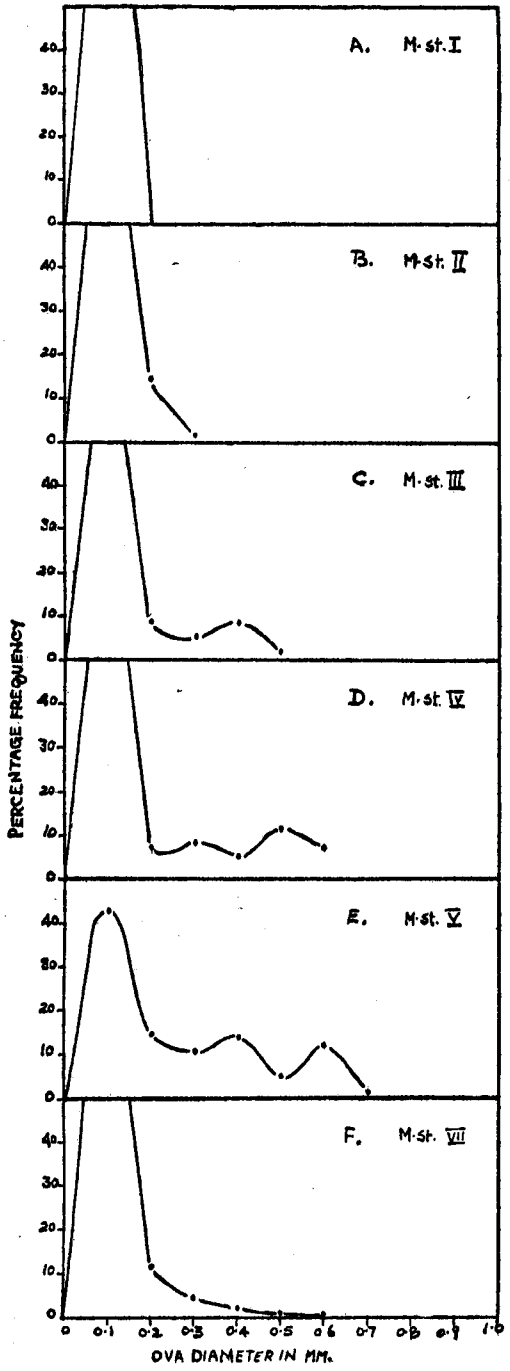

Fig. 2. Ova diameter frequency of mackerel, *R. kanagurta* in different stages of maturity.

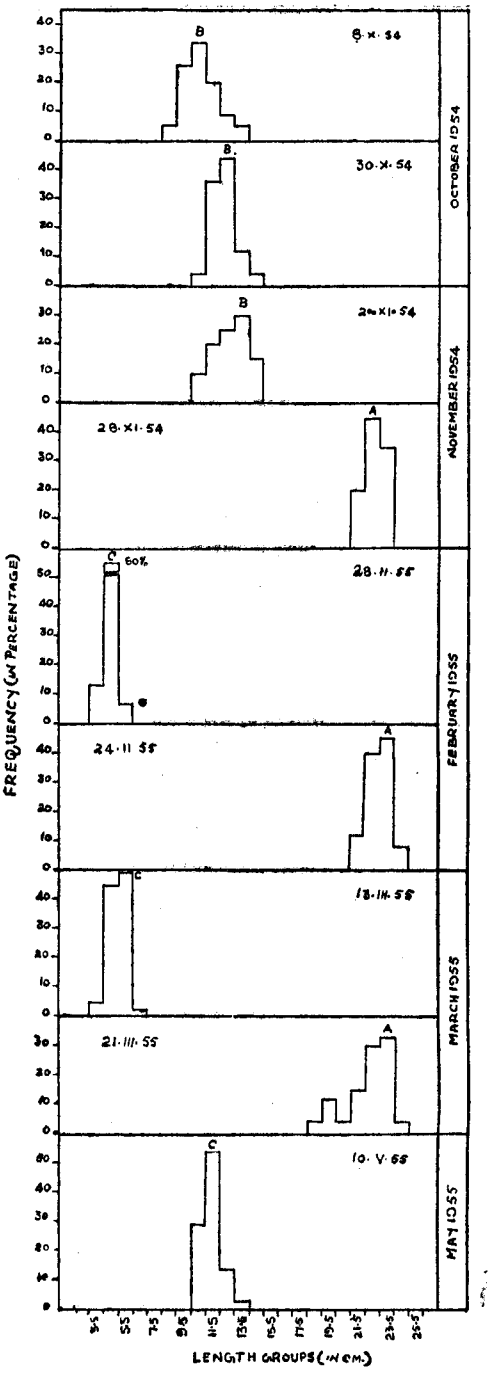

Fig. 3. Length frequency of the Indian mackerel, *R. kanagurta* collected from Waltair Coast in 1954-1955.

The modal size of this group in the samples collected subsequently on 30th October and 21st November of the same year, stood at 12.5 cm. and 13.5 cm. respectively. The progression of the mode B in the samples collected during the period may be noted. It shows that the modal size of this brood, from the time it was first recorded on 8th October 1954 to the time it disappeared from the catches on 21st November 1954, has increased by 3.0 cm. In other words these young ones (mode B) are growing at an average rate of about 2.0 cm. per month.

Taking into account the modal size (10.5 cm.) of this brood, when it was first recorded on 8th October 1954, and its rapid rate of growth notwithstanding, it is reasonable to presume that it does not belong to the same season's (1954-'55) spawning. On the other hand the rate of growth of the juveniles (mode C) indicates that the young ones recorded on 8th October 1954 (mode B) would be the products, probably, of the previous season's (1953-'54) tail-end spawning.

The adult fish were recorded only in November 1954 and in February and March 1955. The size of these fish during the above period varied from 21.5 to 24.5 cm. (mode A). The rate of growth of the adults appears to be very slow from what could be observed by the progression of their modal size.

Rao and Basheeruddin (1953) have recorded the occurrence of mackerel of different size-groups from Madras coast during March-April period. Their data indicate four dominant size-groups at 8-9 cm., 13-14 cm., 20 cm. and 22-23 cm. Although the authors have not indicated the spawning season for the species in those waters, it is reasonable to presume, on the basis of the occurrence of young fish, that it may be quite comparable with the condition recorded at Waltair. Sekharan (1958, p. 19) has commented on the size composition of mackerel collected in 1954 from Vizagapatnam. The above place is situated about 3 miles north of Waltair. His data refer to three samples of mackerel collected during May to July period and indicate two dominant sizes at 5-6 cm. and 15-16 cm. In view of the fact that the juvenile fish of the species grow very rapidly as suggested by the present studies it can be stated reasonably that the lengths 5-6 cm. and 15-16 cm. represent about 2 months' and 7-8 months' growth respectively. They obviously belonged to 0-year class but born in different months. In this connection it should be remembered that the species spawns in the local waters during the period October-April coinciding with the North-East Monsoon, unlike in the west coast where it was reported to spawn during April-September period coinciding with the South-West Monsoon (Devanesan and John 1940 ; Chidambaram *et al.* 1952 ; Pradhan 1956 and Sekharan 1958).

LENGTH-WEIGHT RELATIONSHIP

In the course of the present investigation, the length-weight relationship of the mackerel was determined separately for males and females. The size range of the fish considered for this purpose varied from 10 to 24 cm. However in figure 4, the observed data for the entire size range recorded are presented ; and a free hand curve is fitted to it.

It was in 1871, after a good deal of empirical study that Herbert Spencer stated his ' Cube Law ' of the length-weight relationship, which states that the weight of a fish is equal to some constant times the cube of its length, i.e., $W=c\,L^n$, where W stands for the weight of the fish, L its length, and c and n are constants.

Recent investigations in this direction on various fishes have revealed that the law gave the best fit in each case and the constant n is observed to vary between 2 and 4.

Applying the above formula, the calculated length-weight relationship of male and female mackerel in the present material was found to be $W=.004983\ L^{3.2628}$, and $W=.004784\ L^{3.2785}$ respectively. In each case the fit is found to be good. From this relationship it could be seen that the relation observed deviates slightly from the Cube Law. According to Pradhan (1956), the length-

weight relationship of the Indian mackerel occurring at Karwar was found to be $W=0.005978\ L^{3.1737}$. This relationship, obviously, is more closer to the Cube Law than is obtained in the present study. It only suggests that repeated studies of this kind may be carried out on this species

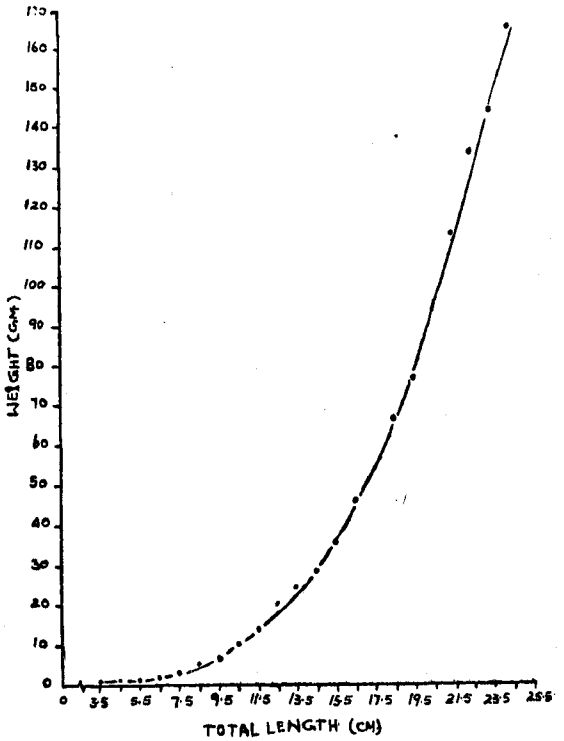

Fig. 4. Length-weight relationship of the Indian mackerel *R. kanagurta*.

at different places, based on random sampling, so that the formula obtained may be of ready applicability.

It may be noted however that the rate of increment in weight per unit length of mackerel is very slow up to a size of 10-12 cm., thereafter increasing very rapidly (Fig. 4). This slow rate of increase in weight of the young fish is due to the fact that they are in rapidly growing condition.

PARASITES

During the course of the present studies, no external parasites were recorded. However several species of trematodes, and larval forms of cestodes were recorded as internal parasites.

Among monogenetic trematodes, species of *Acanthocotyle* (Fam. : Discocotylidae) have been observed from the gills. A single specimen resembling *Kuhnia* sp. was also recorded from the same region. The above parasites were not very common, however.

Among digenetic trematodes, parasitic hemiurids belonging to the genera *Lacithocladium*, and *Lecithochirium* were very common in the stomach of mackerel. Species of the genus *Podocotyle* (Fam. : Allocreadiidae) have also been recorded very frequently in the midgut.

Pleurocercoid larvae of *Ligula* sp., representing the cestode parasites were observed often in the body cavity.

The only other record of parasites from the Indian mackerel was that of Devanesan and John (1940). They had collected their material from the west coast. According to them only free scolices of tape-worms or metacestodes were observed in the gut and body cavity.

DISCUSSION

The present studies indicate that the Indian mackerel, *Rastrelliger kanagurta* (C.), is a plankton feeder foraging normally and regularly on both zoo-and phyto-planktonic organisms depending upon their availability in the environment. It is noteworthy however, that the diet of juveniles (3.2-8.9 cm.) consisted mostly of fish larvae and *Lucifer* sp. indicating their preference to this diet ; while copepods, stomatopod larvae and diatoms constituted only a minor fraction of its diet. In contrast, no fish item has been observed in the diet of the adults. They were, however, found feeding mostly on copepods, diatoms, dinophysids and larval decapods and stomatopods.

Chidambaram (1944) records similar differences in the food habits of the juvenile and adult mackerel from West Hill, on the west coast. On the other hand Bhimachar and George (1952) and George and Annigeri (1960) suggest that the food habits of the juvenile mackerel do not differ much from that of the adults. Based on his studies on the food and feeding habits of the mackerel from Madras on the east coast, Kuthalingam (1956) suggests the carnivorous habits of the adult mackerel. It may be noted however, that his adult fish ranged in size from 3.5 to 22.5 cm. (see p. 1). Rao and Rao (1957) have observed differences in the relative length of the alimentary tract of the juvenile and adult mackerel, and they believed it to be associated with the different food habits of the juvenile and adult fish.

Future studies based on more extensive data on juveniles can only show whether the difference in the food habits of young and adult mackerel is of local significance or represents a normal feature.

As stated earlier the adults were recorded only during November-March period when they were spawning in the local waters. The occurrence of mature fish right from November 1954 onwards and some spent individuals in February and March 1955 would suggest that the species spawns in the area, probably, from October to April coinciding with the North East Monsoon. This is also confirmed by the fact that very young stages of mackerel were recorded in large quantities during the months of February and March. According to Devanesan and John (1940), Chidambaram *et al.* (1952), Pradhan (1956), and Sekharan (1958), the mackerel population on the west coast spawns during April to September period coinciding the South West Monsoon. The spawning period of the species in the local waters is protracted as elsewhere. This, at least in part, is due to the peculiar mode of maturation and liberation of ova in batches by the individual fish, and partly due to the reason that all the individuals may not mature simultaneously during the spawning season. The ova diameter frequency polygons of the mature fish showed the existence of two distinct groups of mature ova, suggesting that these ova are matured and released probably in two batches.

It is evident from the rates of progression of the modal sizes of the juveniles (Fig. 3, modes B and C), that the mackerel, when they are young grow very rapidly ; i.e. at the rate of about 2 to 3 cm. per month.

Sekharan (1958, p. 15) states that the normal modal size of one-year old mackerel could be assumed to be 12-15 cm. According to him these one-year olds grow to a size of 21-23 cm. at the end of the second year of their life. This means that the rate of growth of the mackerel during the first year of its life is more or less similar, with what has been recorded during its ' second year '. While considering the rates of growth of tropical fishes, Panikkar (1949) states that ' if we are to

go by the size of fish and the rapid growth under tropical conditions, where the rate of metabolic activities increases at least three times what it is in colder latitudes, the maximum size to which most species grow may be attained within a course of 10-12 months.' The observation of Hardenberg (1938), that ' most (tropical) species attain a length of 10-15 cm., during a period of seven months or less ' is noteworthy in this connection.

Even in colder latitudes, the Atlantic mackerel, *Scomber scombrus* was recorded to attain a size of 12-15 cm. within a period of 3-4 months (Dunn, 1893, Dannevig, 1948). According to Steven (1952), the same species attains a size of about 24 cm., in the English Channel, during the first year of its life.

In the Indian mackerel, it was recorded that the rate of increase in weight per unit length of fish is slower in the younger size groups than in the larger ones (see fig. 4). This is due to the fact that the juvenile mackerel were in a rapidly growing condition.

It may not be surprising, on the basis of available evidence, that if future studies based on extensive data on juvenile mackerel show that 10-14 cm. fish actually belong to 0-year class.

It is interesting that several species of trematode parasites were recorded from the Indian mackerel occurring in the Lawson's Bay, while none of these parasites have so far been recorded from the fish examined on the west coast (Devanesan and John 1940).

Summary

The present study was based on 593 specimens of the Indian mackerel, *Rastrelliger kanagurta* collected during the year 1954-55 from the fish landing centre at Lawson's Bay, Waltair.

The food of the mackerel collected in the area at the time consisted mostly of planktonic forms such as copepods, diatoms, dinophysids, and crustacean and molluscan larvae. The young mackerel (below 8.9 cm. size) fed preponderantly on white bait larvae and *Lucifer* sp., indicating its preference to this diet.

A small portion of the mackerel stock on the east coast spawn, in the local waters, during the period October to April. The nature of the ova diameter frequency polygons of mature fish strongly suggests fractional spawning, and that individual fish may spawn, probably twice in the spawning season.

The length-frequency data of juveniles indicate that they grow very rapidly in length probably 2-3 cm. per month.

Several genera of trematode parasites and pleurocercoid larvae of *Ligula* sp. were recorded from the mackerel.

Acknowledgements

I am grateful to Dr. K. Pampapathi Rao, Professor of Zoology, S. V. University, for suggesting the problem, guidance and encouragement throughout the period of this study ; and to Dr. S. Jones, Director, Central Marine Fisheries Research Institute, for encouragement and help in the preparation of this report. Thanks are due to Drs. V. Krishnamurthy and K. Hanumantha Rao, Andhra University, for their help in the statistical analysis of the data, and in the identification of the mackerel parasites respectively.

REFERENCES

BHIMACHAR, B. S. AND P. C. GEORGE 1952. Observations on the food and feeding habits of the Indian mackerel *Rastrelliger kanagurta* (Cuv.). *Proc. Indian Acad. Sci.*, **36** : 105-118.

CHIDAMBARAM, K. 1944. Food of the Indian mackerel *Rastrelliger kanagurta* Russell of the west coast of Madras presidency. *Curr. Sci.*, **13** : 214-215.

CHIDAMBARAM, K., *et al.* 1952. Studies on mackerel fat variations and certain biological aspects. *Proc. Indian Acad. Sci.*, **35** : 43-68.

CLARK, F. N. 1934. Maturity of the California sardine (*Sardinops caerulea*) determined by ova-diameter measurements. *Calif. Fish Game. Fish Bull.*, No. **42.**

DANNEVIG, A. 1948. Spawning and growth of young mackerel on the Norwegian skagerak coast. *J. du Cons. Internat. Explor. Mer.*, **15** (21) : 218-20.

DE JONG, T. K. 1940. A preliminary investigation on the spawning habits of some fishes of Java Sea. *Treubia*, **17** : 307-27.

DEVANESAN, D. W. AND V. JOHN. 1940. On the natural history of *Rastrelliger kanagurta* with special reference to its spawning season and eggs. *Curr. Sci.*, **9** : 462-64.

DEVANESAN, D. W. AND K. CHIDAMBARAM. 1948. The common food fishes of the Madras Presidency. *Madras Government Publication* : 1-207.

DUNN, M. 1893. The mackerel. *Rep. Roy. Cornwall, Polytechnic Soc.* : 1-55.

GEORGE, P. C. AND G. G. ANNIGERI 1960. On the occurrence of small-sized mackerels, *Rastrelliger kanagurta* (Cuv.), off Ratnagiri coast. *Curr. Sci.*, **29** : 319-20.

HARDENBERG, J. D. F. 1938. Marine biological and fishery problems in the tropics. *Arch. Neerland. Zool.*, **3** suppl. (Nierstranszvol) : 65-73.

JOHN, C. C. AND M. A. S. MENON 1942. Food and feeding habits of oil sardine and mackerel. *Curr. Sci.*, **11** (6) : 243-244.

KUTHALINGAM, M. D. K. 1956. Observations on the food and feeding habits of the Indian mackerel, *Rastrelliger kanagurta* (Russell). *J. Zool. Soc., India*, **8** (2) : 99-106.

LA FOND, E. C. 1954. On Upwelling and Sinking off the East Coast of India. *Memoirs in Oceanography, Andhra Univ.*, Waltair, **49** (1) : 91-101.

PANIKKAR, N. K. 1949. The biology of pelagic fishes. *Proc. Indo. Pac. Fish. Coun.*, Sec. **4**, 123-132.

PRADHAN, L. B. 1956. Mackerel fishery of Karwar. *Indian J. Fish.*, **3** (1) : 141-185.

PEARSE, A. S. 1915. On the food of small shore fishes in the waters near Madison. *Bull. Wis. Nat. Hist. Soc.*, **13** : 210-221.

SEKHARAN, K. V. 1958. On the South Kanara coastal fishery of mackerel, *Rastrelliger kanagurta* (Cuvier) together with notes on the biology of the fish. *Indian J. Fish.*, **5** (1) : 1-31.

RAO, K. V. AND S. BASHEERUDDIN 1953. Occurrence of young mackerel *Rastrelliger kanagurta* (Cuv.) off Madras coast. *Curr. Sci.*, **22** : 182-83.

RAO, K. V. N. AND K. P. RAO, 1957. Differences in the food of the young and the adult Indian mackerel, *Rastrelliger kanagurta* (Cuv.). *Nature*, **180** : 711-712.

SPENCER, H. 1871. *The principles of Biology*. **1**, New York.

STEVEN, G. A. 1949. Contributions to the biology of the mackerel, *Scomber scombrus* L. II. A study of the fishery in the southwest of England, with special reference to spawning, feeding and 'fishermen's signs', *J. Mar. Biol. Assoc.* U.K., **28** : 555-581.

——— 1952. Contributions to the biology of the mackerel, *Scomber scombrus* L. III. Age and growth. *Ibid.*, **30** : 549-568.