GROWTH VARIATIONS IN THE INDIAN OIL SARDINE, *SARDINELLA LONGICEPS* VALENCIENNES

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A study of the variations in the rate of growth of economically valuable fishes forms an important aspect of their biology. In the Indian oil sardine, *Sardinella longiceps*, this has not received due attention so far, although brief references to growth-variations have been made by some of the previous workers. Hornell and Nayudu (1924) stated that growth is tremendous in the first year and negligible subsequently. Devanesan (1943), from a study of the growth rings on the scales, gave the sizes of the different year-classes. Chidambaram (1950) has given the maximum sizes and size-progression of the age-groups in successive years. Nair (1953) has noted that age-groups in the fishery "showed variations in their rate of growth" and subsequently stated (Nair, 1959) that length-frequency data "show differential rate of growth during the first year (Nair, 1953)". Apart from these nothing substantial is published hitherto on variations in the growth of this fish. Hence the present paper dealing with differences in its growth rate in successive years of its life in the fishery, those within each season and in between seasons, as well as different phases of its life-history may be of interest. The investigations were made during 1961-1964 at Cannanore, one of the important oil sardine fishing centres in the Malabar zone of the south-west coast of India.

Procedure

The data for the present paper are from length-frequency analyses made during the period, drawn from the two principal gears in operation at Cannanore, namely, *arakolli-vala* and *mathikolli-vala*, both boat-seines. Size-composition data revealed that both the gears exercised the same selectivity for sizes. For length-frequency and other biological purposes two random samples from each gear were studied every week. The total lengths of the specimens were grouped under 10 mm. intervals and the percentage frequencies were studied month by month. When more than one age-group was present the studies were made separately for each of them. Maturity stages were determined based on the key used by the International Council for the Exploration of the Sea, given by Lovern and Wood (1937). The term juvenile is given to indeterminate and/or immature sardines with gonads in their formative stages I—II and the term adult to maturing mature, spawning, spent, (stages III—VII), recovering and recovered individuals. Data on the food and feeding habits of both

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juveniles and adults and on the planktological and hydrographical conditions off Cannanore, being published elsewhere, were also collected and analysed.

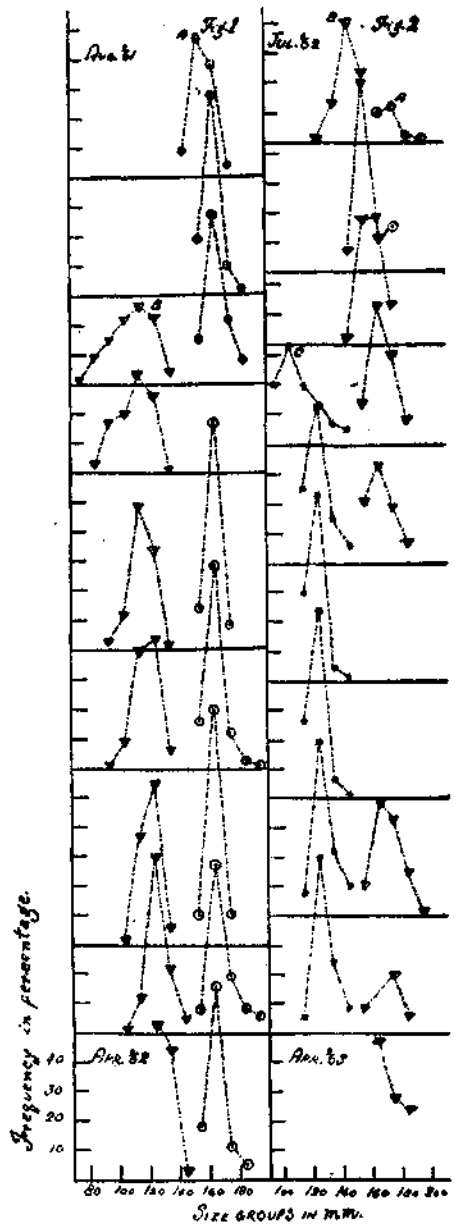
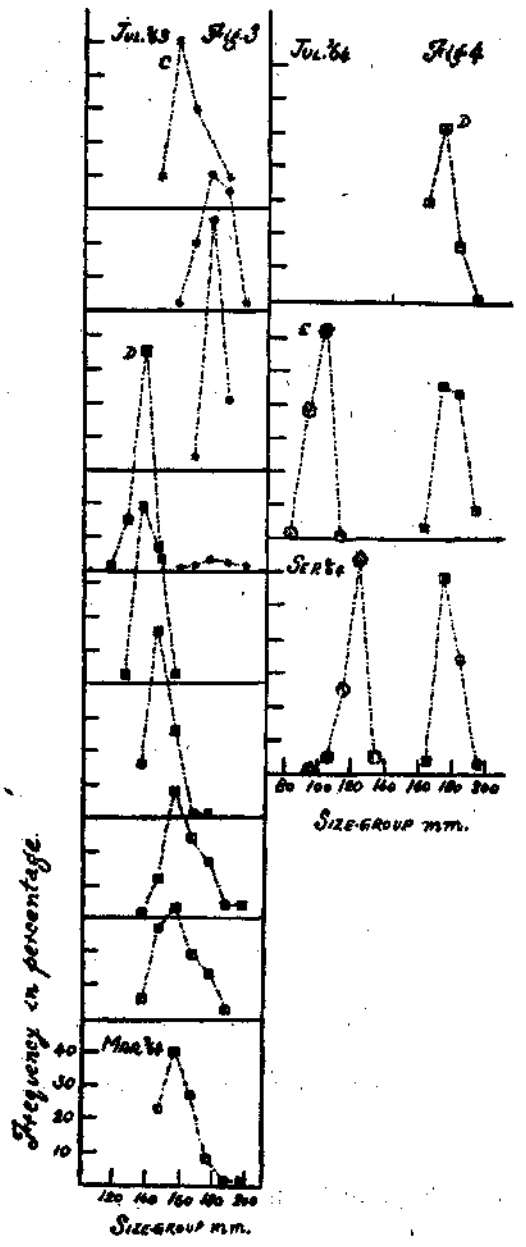


FIG. 1. Length-frequency of the oil sardine at Cannanore during 1961-62 season
FIG. 2. Length-frequency of the oil Sardine during 1962-1963 season. A, B and C indicate the year-classes.



FIGS. 3 & 4 Length-frequency of the oil sardine at Cannanore during 1963-64 and the beginning of 1964-65 seasons respectively. C, D and E indicate the year-classes.

YEAR-CLASSES IN THE FISHERY

Only a single year-class, namely *A*, was present at the commencement of the 1961-1962 season. This was made up of mature and spawning sardines (stages IV—VI) from August to October 1961. Thereafter till the end of the season the individuals were in spent (stage VII), recovering and recovered (stages I and II). In the succeeding season, 1962-'63, *A* reappeared as mature and spawning (IV—VI) sardines in July '62, having attained maturity for the second time.

The year-class *B* was recruited into the fishery in October '61. This was composed of indeterminate and immature sardines (in formative stages I and II) till the end of the 1961-'62 season. With the commencement of the 1962-'63 season *B* reappeared in July '62. The sardines were mature and spawning, the latter lasted till November, after which the individuals were in recovering and recovered gonadial conditions.

During 1962-'63 season the year-class *C* entered the fishery in October '62. This class comprised indeterminate and immature juveniles till the end of the season. *C* reappeared in the 1963-'64 season as mature and spawning sardines. *D* entered the fishery as juveniles in the 1963-'64 season. As usual when *D* reappeared in the succeeding season, 1964-'65, it was composed of mature and spawning individuals. The year-class *E* represented the juveniles recruited in the 1964-'65 season.

RATE OF GROWTH

The rate of growth of the oil sardine in the successive years of its life in the fishery is represented in Fig. 5. As may be seen from it, the year-classes *B*, *C* and *D* have increased in length of 30, 50 and 40 mm. respectively in the first year of their life. The year-class *A*, obviously in its second year during 1961-'62 season, has increased by 20 mm., and a similar increase of 20 mm. was registered by *B* and *C* in their second year. The year-class *D* was represented only for a brief period in its second year. On the other hand the class *A* was represented even in its third year, although for a brief duration. It is obvious from the above that an average growth of 40 mm. is made by the oil sardine in its first year of life and of about 20 mm. in the second year.

GROWTH-VARIATIONS

These may be considered under the following:—

(*a*) *Growth-rate during various phases:*

The life-span of the oil sardine as observed in the present investigations may be divided into four phases, namely, (1) the phase of the juvenile, (2) the

phase of first transformation to maturity and spawning, (3) the phase of recovery after first spawning and (4) the phase of second transformation to maturity and spawning (Fig. 5).

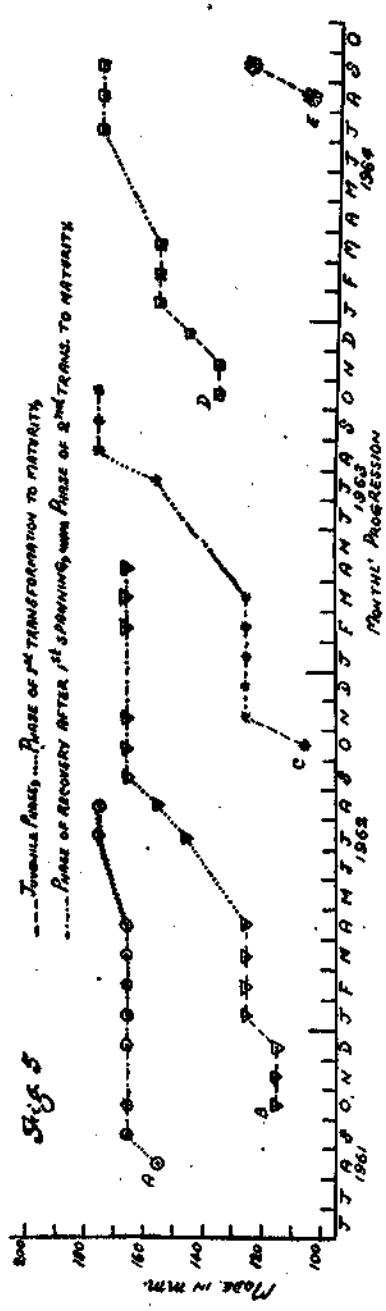


Fig. 5 Progression of modes of the year-classes A, B, C, D and E during different phases of life in the fishery intra-seasonally and in between seasons shown by the dominant modes at the end of one season and beginning of the succeeding season.

Growth during the juvenile phase in year-classes *B*, *C* and *D* is spread over a period of 5 to 6 months from October to April, during which growth of 10, 20 and 20 mm. respectively is registered. The phase of first transformation to maturity and spawning extends from April to August or September roughly, a period of 5 to 6 months, when *B*, *C* and *D* have made further growth of 40, 50 and 50 mm. respectively. During the phase of recovery after first spawning lasting approximately 5 to 6 months from September-October to March-April, no growth is registered as observed in the case of *A* and *B*. Duration of the second transformation to maturity and spawning in the year-classes that are represented in the third year of their life in the fishery, is the same as for the first. Growth during this period observed in the case of *A* is only 10 mm.

It is apparent from the above that the phase of first transformation to maturity marks the period of most rapid growth, an average of 47 mm., the juvenile phase is marked by an average growth of 17 mm., the second transformation to maturity accompanied by a growth of about 10 mm. and the period of recovery after first spawning by no growth at all.

(*b*) *Intra-seasonal growth :*

Within each season the oil sardine shows periods of growth and no-growth. Individual variations in the duration of these periods are also noticed. Thus the year-class *D* showed growth from November to January and *C* and *B* from October to November and December to January respectively. Broadly speaking the growth period of the oil sardine in the first year of life in the fishery lasts from October to January. This is followed by a period of no-growth from January to March or April.

In the case of the oil sardine in the second year of life in the fishery, as observed in the case of *A*, *B* and *C*, the growth period lasts from July to September. The year-class D in the second year of its life has not increased in length. The no-growth period generally extends from September to April in these cases. It may be noted in this connection that paucity of growth in them lasts for a longer duration than in sardines in the first year of their life in the fishery.

(*c*) *Inter-seasonal growth :*

The period in between two consecutive seasons when the oil sardine is absent from the Malabar coast lasts for 4 to 7 months (from March or April to July or September). Based on length-frequency data previous workers have estimated the growth registered by year-classes during this period.

In the present studies fish between the first and second years have shown increase in growth of 20, 30 and 20 mm. as observed in the case of *B*, *C* and *D* respectively. On the other hand in the inter-seasonal months for oil sardine in

between second and third years, the increase is only 10 mm., as shown by *A*. The inter-seasonal period, it may be noted in this connection, forms part or sometimes even the whole of the transformation period to maturity and spawning.

Discussion

The fact that the oil sardine makes its appearance along the Malabar coast by the month of July, August, September or October and disappears by the month of March or April of the succeeding year is observed by all workers on this fish. It is also recognised from the biological studies made by Chidambaram (1950) and Nair (1953) that the juveniles disappearing at the end of one season reappear in the succeeding season as mature and spawning sardines, followed by the appearance of the newly-recruited juveniles. Similar condition has been observed in the present investigations also.

Hornell and Nayudu (1924) stated that "oil sardines attain sexual maturity and almost full adult size at the age of one year, when they measure on the average 15 cm." standard length (about 175 mm. total length) and that "growth during the second year is extremely slow and amounts to only 1 cm. in length on the average". The sizes of the year-classes given by Devanesan (1943), based on his study of the growth rings on the scales are open to question, as according to Nair (1953) "he had counted the false rings also along with the true ones for determining the age of the oil sardine". The length-frequency studies made by Chidambaram (1950) and Nair (1953), however, have shown that growth by the end of the first year is about 10 cm. only. Chidambaram (1950) has given the maximum sizes and size-progression of the groups in their first, second, third and fourth year which is 10, 14.5, 18.2 and 20.5 cm. respectively. Nair (1953) concludes that the fish grows to 10, 15 and 19 cm. in the first, second and third year respectively. On the other hand Sekharan (1962) states that "the 10-15 cm. group, i.e., one year olds" contribute to the abundance of the near-shore fishery at Calicut. It is obvious from the above that growth-rate is higher in the first year than in the subsequent years. This is natural to be expected, as the younger stages (juvenile phase) of animals in general are known to have more rapid growth-rate than the older in the case of the Indian mackerel also Radhakrishnan (*Adv. Abst. Contr. Fish. Aquat. Sci. India*, 1(4):14) has stated that growth in the younger stages is faster than in the older. By the commencement of the second year of life in the fishery, the oil sardine has attained adulthood, as may be seen in the present studies. The major part of the second year is marked by spawning and recovery of the gonads. This is accompanied by much less growth. It is probable that the metabolic processes contributing towards growth is far less in the second year than in the first, as a major part of it is diverted towards reproduction.

It has been observed in the present investigations, (being published elsewhere), that the period of November-December to February-March is one of low feeding activity for the oil sardine, both juveniles and adults. This period is also characterised by low plankton production in the coastal Arabian Sea (George, 1953), when there is "a great decrease in the supply of food organisms" (Hornell and Nayudu, 1924). It is likely that one of the causes for the paucity of growth during this period is poor feeding due to scarcity of food elements.

The months April-May to June-July or August comprising the period of most rapid growth of oil sardine is marked by their absence from the Malabar coast. Chidambaram (1950) has correlated the appearance and disappearance of oil sardine with the onset of favourable and unfavourable hydrographical conditions. He has also pointed out that these phenomena follow a regular pattern. Thus the disappearance begins first in the northern areas and gradually extends south-wards. Similarly the shoals appear first in the south and then in the north. Although the question whether the population touching the coast first in the south move up northwards or whether the fish strike the coast straight from offshore regions is still debated, it is obvious that the fish during April-July recede to favourable grounds elsewhere. Chidambaram (1950) from a study of the temperature of the sea water from Calicut coast to Cape Comorin, stated that the higher temperature in the north drive the shoals to the south. The "paucity of phytoplankton..... observed during the summer months extending from March to May" (Nair, 1953) may also be another factor for the disappearance of the oil sardine from the Malabar zone.

As may be seen from the table given by Chidambaram (1950), temperature along the Trivandrum coast during April to July (average 28°C) is not unfavourable for the oil sardine, considering the temperature in the months of peak landings (average 28°C) given by Chidambaram (1950) and Nair (1953) as well as observed in the present investigations. It may be noted in this connection that the Trivandrum coast, in common with the Quilon-Cape Comorin sector, is different from the rest of the west coast in that this area gets heavier showers during the north-east monsoon period (Menon, 1946). Planktologically also this zone is rich during the March-June period, as Menon (1946) while observing the marine biological conditions of the Trivandrum coast states that from the month of March onwards there is a sudden increase in the abundance of diatoms and copepods. From the above considerations it appears quite probable that the waters off the southern region afford favourable grounds for the oil sardine, both hydrographically and nutritionally, to remain until the conditions become normalised in the further northern areas with the commencement of the south-west monsoon. Samples of oil sardine from Quilon and further south examined during April to June have revealed that feeding intensity is high in them. It is during this period that maturity also sets in and spawners enter the coastal waters of Malabar in July, "the stimulus for breeding activity is

given by the outbreak of the monsoon which alters the hydrological conditions considerably" (Nair, 1953). Extensive studies on the size-composition and maturity of the oil sardine from the Quilon—Cape Comorin sector are necessary to confirm this.

Variations in the growth-rate of fishes, particularly temperate species, are known to express themselves on the skeletal parts such as scales and otoliths. Growth rings on the otoliths and scales of *S. longiceps* were noted by Nair (1949) and Balan (1959) respectively. Nair (1949) opines that the rings on the otoliths "are formed annually, probably during December to April when scarcity of planktonic food has been noted". If the nature and periodicity of formation of the rings are proved, the low feeding activity of the oil sardine during this period would render additional support for this.

The probable modal groups of oil sardine at different ages and maturity in the light of the growth-variations observed may be briefly discussed in this connection. The higher rate of growth of the juveniles in the fishery (105-135 mm. modal length) compared to that of the adults (above 135-145 mm. modal length) and the fact that the period April-September is one of rapid growth of the oil sardine as observed earlier, show that growth-rate during the pre-recruitment phase (below 105 mm. modal length) should be far greater than that of the rest of the juvenile phase. From this it appears as though the juveniles recruited into the fishery in a given year are the offspring of the same year's spawning. They do not appear to belong to the brood of the preceding year since growth does not appear to be so slow as to cover a modal length of only 105 mm. in about 1¼ years. If so, the juveniles that re-enter the fishery having become mature and spawning for the first time in the succeeding year (modal length 145-155 mm.) would have just completed one year. By the end of the second year the oil sardine is observed to attain a modal length of about 175 mm. having become mature and spawning for the second time. Individual variations may occur within reasonable limits and some specimens may even live to see the third year as observed in the case of *A*. It may be seen from the above that the present studies though they substantiate the views expressed by Hornell and Nayudu (1924) regarding the total life-span and age at the time of recruitment, differ from them on the size of the fish at the end of each year of life.

SUMMARY

Studies on the biology of the oil sardine during 1961-1964 showed that the fish grows very rapidly, about 40 mm., in the first year of its life leading to maturity. In its second year the rate decreases to about 20 mm. only. The transforming phase of the juvenile to its first maturity is marked by most rapid growth, about 47 mm. in about 6 months. On the other hand transformation for the second time is accompanied by about 10 mm. growth only.

Growth during November to April is observed to be absent. This period is also marked by poor feeding, probably due to the low plankton abundance. The growth-checks noted on the scales and otoliths of the oil sardine by other workers, if annual in periodicity, might have been formed due to poor feeding in these months.

The probability that the oil sardine disappearing from Malabar coast during summer months due to unfavourable hydrographical and nutritional conditions recede to the favourable grounds off southern areas (Quilon—Cape Comorin sector) is pointed out.

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