THE GROWTH PATTERN OF INDIAN MACKEREL

T. M. YOHANNAN
Calicut Research Centre of C.M.F.R. Institute, Calicut.

ABSTRACT

The modal values for 1970-74 indicate that the mackerel grows to about 21 cm by the end of 8 months and by the completion of first year the length is about 22 cm. The growth equations derived from 12 months and 24 months data were not fund to explain growth pattern satisfactorily. An examination of the specific growth-rate have shown that the rate of growth decreases considerably after about 8 months. The indication is that as the gonadial growth sets in there is a drastic reduction in linear growth. Hence, separate growth equations were derived for the premature and mature phases. These equations fit well with the observed values of growth during the corresponding phases.

INTRODUCTION

The Indian mackerel, *Rastrelliger kanagurta* (Cuvier) had been under investigation for the last four decades. The first attempt to study its age and growth was made by Pradhan (1956). Subsequently, quite a good amount of work has been done in this direction. But, still, controversies exist on the growth pattern of this commercially important fish. In this context, a detailed study of the length-frequency data on mackerel collected from Mangalore area during the seasons 1970-74 was made and the results are presented in this report.

MATERIAL AND METHODS

Mackerel landed by non-selective gears viz., 'rampani,' 'kairampani,' cast net and trawl net, at different centres of the Mangalore area, were sampled regularly for studying the length-frequency distribution. The identity of the dominant modes observed in each sample has been preserved and plotted against the date for the following reasons:

1. To avoid the confusion created by mixing of different broods that contribute to the fishery.

2. To get a clear picture of the growth pattern during the premature phase when the growth was suspetced to be very fast; the pooling of the data for the month will leave gaps in the growth line creating bias in the interpretation of the data.

From the resulting figure a general pattern of the shifting of modes could be discerned. Along this general pattern, in a season, two or three growth curves could be drawn. These curves moving closer as they progress exponentially almost unite and loose their identity or run parallel to each other very closely after they reach about 20 cm. These individual lines are taken to represent different broods. Wherever the data permit tracing of the progression of the modes without much gap a growth curve is drawn for the particular brood. If the size of the modal length of the brood is sufficiently small when it first appeared in the fishery the month of their birth has been fixed by extrapolating to length 0 as shown in Fig. 1. From this curve the length of each brood in different ages (in months) can be read. The data for all the broods in different seasons have been pooled and the average length at age in months have been taken for calculation of growth parameters.

RESULTS

The modes observed in different months of three seasons and the growth curves drawn along different broods are given in Fig. 1. During the seasons 1972-73 the mackerel fishery was a failure. The occasional landings that took place comprised of individuals of above 21 cm length so that the broods could not be distinguished or the growth studied. Hence, the data for this season are not given. Broken lines are drawn to show the probable growth pattern before their appearance in the catches taking into consideration the following facts:

1. Brood A of 1970-71 which appeared at a modal length of 102 mm in July is seen at a modal length of 192 mm in October showing an increase of 90 mm within a span of 3 months, the increase in length during the first, second and third months being 35 mm, 30 mm and 25 mm respectively. The growth rate of mode B is more or less the same. The brood A1 of 1971-72 grew from 167 mm to 197 mm in 30 days, showing an increase of 30 mm. The brood A2 of 1973-74 grew from 152 mm to 217 mm in 60 days, the increase being 65 mm. Since it is well known that the growth will be generally faster during the earlier part of the life history it is only logical to presume that the growth rate prior to their appearance in the fishery should have been more than 30 mm per month.

2. Sekharan (1958) has observed a mode at 6 cm in June at West Hill and Pradhan (1956) has recorded mackerel with a length ranging from 8-9 cm in the same month at Karwar. Balakrishnan (1957) has reported a mode at 7 cm at Vizhinjam in June.

3. Silas (1974) has recorded pro-larval and post-larval stages of mackerel ranging in size from 1.73 mm to 8.8 mm in the month of May which may be about less than one month old. Balakrishnan (1957) has observed a mode at 4 cm in the same month at Vizhinjam.

It can be seen from Fig. 1 that the growth curves touch length 0 during different months from April to July giving a clear growth pattern. From these curves the modal length of each brood at different ages in months can be read. These values for different broods have been pooled and averages are given in Table 1

The table shows that the mackerel grows very fast in the first eight months. Then a drastic reduction in the growth rate is apparent and the variations in the modal sizes of different broods disappear slowly and by the end of one year the modes for different broods are seen between 21 and 22 cm. A further increase of about 3 cm is observed during the second year reaching to a size of about 25 cm by the end of second year.

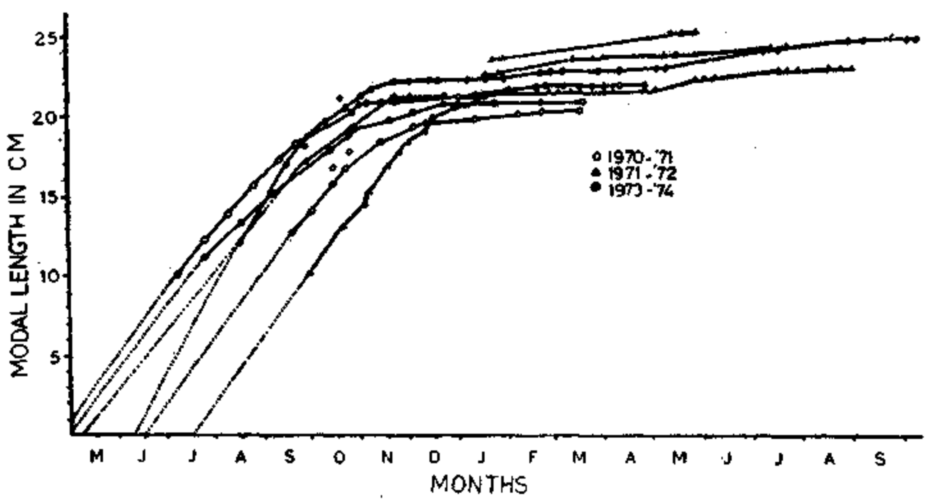

FIG. 1. Modes observed in different months and the growth curve of each brood.

The average length at different ages in months given in Table 1 has been taken to describe the growth pattern in mathematical form using the well known L. von Bertalanffy's equation:

$$L_t = L_\infty \left(1 - e^{-K(t-t_0)}\right)$$

The equation was worked out for the first 12 months. The resulting growth parameters were calculated using 24 months data and the resulted curve is shown in Fig. 3. It can be seen that the values of L_∞ calculated from 12 months (235.5 mm) and 24 months (247.9 mm) data are much lower than the length of fish generally observed in the fishery. Mackerel measuring up to 265 mm are common in commercial catches. Hence, these values can not explain the pattern of growth during its most important phase (i.e., the exploited phase). Table 1 shows that after 8 months of age there is a drastic reduction of growth

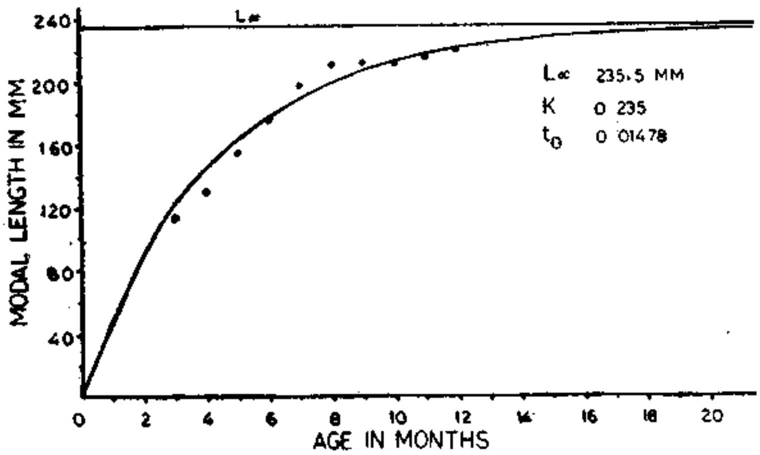

FIG. 2. Growth curve fitted to the growth pattern of first 12 months.

rate in mackerel. To clarify this point the monthly specific growth-rate was calculated from observed pooled average length at age in months. The specific growth-rate, g or G can be expressed as:

$$YT = Yt.\ e^{g\ (T-t)},\ \text{or}\ G = 100\ g = 100\ \frac{\text{Log e YT - Log e Yt}}{\text{Yt}}$$

where YT and Yt are lengths recorded at times T and t, T being later than t (Plantulu 1962).

The smoothened values of G for different ages (in months) are given in Fig. 4. A definite decrease of growth-rate is discernible after 8 months of age. Since this slowing down of growth occurs abruptly and not exponentially it can-

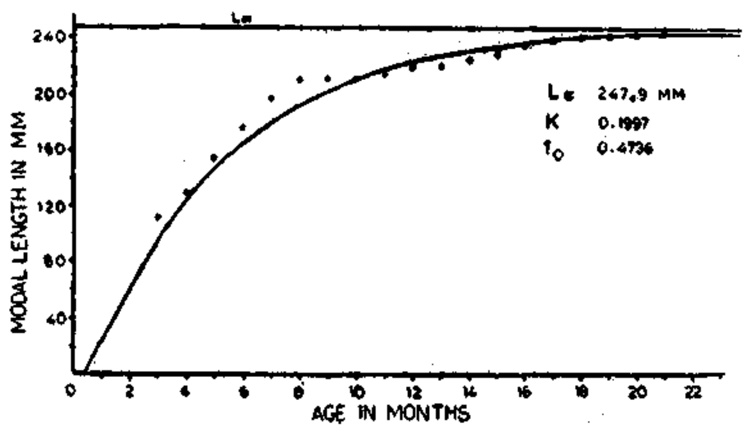

FIG. 3. Growth curve fitted to the growth pattern of 23 months.

TABLE 1. *Observed and estimated lengths of mackerel in different ages in months*

Age in months	*Observed pooled average size* (in cm)	*Estimated size* (in cm)	
		Premature phase	*Mature phase*
3	11.2	11.1	—
4	12.9	13.3	—
5	15.4	15.3	—
6	17.6	17.6	—
7	19.7	19.4	—
8	21.0	21.1	—
9	21.1	—	21.1
10	21.1	—	21.5
11	21.5	—	21.8
12	22.0	—	22.1
13	22.1	—	22.5
14	22.6	—	22.8
15	23.0	—	23.1
16	23.7	—	23.3
17	24.0	—	23.5
18	24.2	—	23.8
19	24.2	—	24.0
20	24.5	—	24.2
21	24.7	—	24.4
22	24.7	—	24.6
23	24.7	—	24.8

not be explained by a curve. This influences the calculation giving a very low value of $L\infty$ from 12 months data. After about 12 months there is a minor increase in growth rate resulting in a slightly higher $L\infty$ value when 24 months data are used. Following Taylor (1958) if the life span of mackerel is calculated from the $L\infty$ value of 247.9 mm it will be equal to the time taken by the fish to attain about 236 mm in length (about 16 months). Hence, both these calculated growth curves do not seem valid. This may be due to the discontinuity of growth observed after 8 months. This phenomenon generally observed in fishes can be either due to recruitment migration to the exploited area resulting in a change of type or abundance of food or the physiological changes resulting from the onset of maturity. Yohannan (MS) has observed that ".... mackerel measuring less than 200 mm are immature. Individuals in 200-209 mm group are mostly immature and maturing. Mackerel measuring more than 210 mm comprised of all stages of maturity...." In the present study the life span of mackerel has been devided into premature and mature phases. The premature phase has been theoretically fixed as the time taken by the fish to reach 21 cm. Table 1 shows that mackerel reaches this size by the end of 8 months. The mature phase commences afterwards when rapid gonadial growth takes place and a sudden decrease in linear growth-rate is observed. The average values of specific growth-rate for premature and mature phase are given in Fig. 4. The figure shows a sharp decline in the specific growth-rate as the fish pass from the premature phase to mature phase. Thus, it is evident that the maturation and the sudden decrease in the growth-rate are closely related.

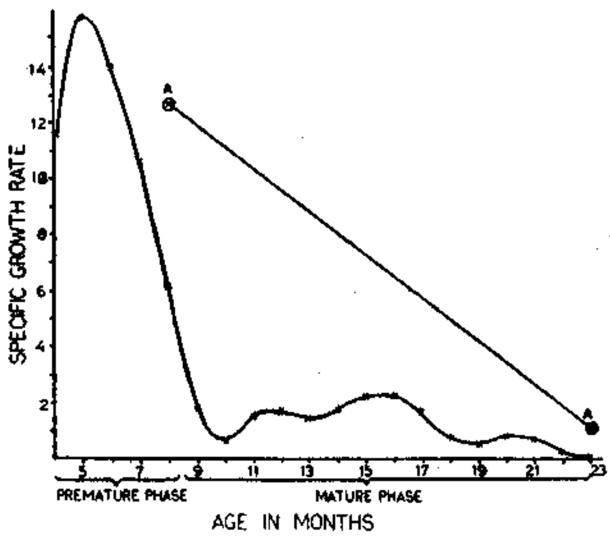

FIG. 4. Specific growth-rate of mackerel in different ages calculated from pooled average values and average specific growth rate (A) for premature and mature phase.

The foregoing observations lead to a conclusion that there are two different patterns of growth in mackerel - a faster one in the premature phase which slows down suddenly as the process of maturation sets in. Beverton and Holt (1957) have observed that "....sometimes however, it may be necessary to fit an equation to each phase of growth. For example if there is a marked change in growth at the onset of maturity at age t_n where $t_n > t_p$ there would be two distinct patterns of growth in the exploited phase. In this case it would be possible to obtain values ${}_1W_\infty$, ${}_1K$ and ${}_1t_0$ for the premature phase and ${}_2W_\infty$ ${}_2K$ and ${}_2t_0$ for the mature phase...." for the calculation of yield from the population. In the case of mackerel t_n was found to be greater than t_p (age at the exploited phase). Hence, separate growth parameters were calculated for the premature phase (up to 8 months) and mature phase (after 8 months). The values are given below:

Premature phase	*Mature phase*
${}_1L_\infty$ = 485.2 mm	${}_2L_\infty$ = 271.82 mm
${}_1K$ = 0.0612	${}_2K$ = 0.659
${}_1t_0$ = -1.28 months	${}_2t_0$ = 13 7 months

Both these growth curves are shown against the observed values in Fig. 5 and the values are given in Table 1. It can be seen that the equation fits well with the observed values. The abnormally high L_∞ value of the premature phase is of no significance, since the equation can not be used to explain the growth after the age of 8 months. The t_0 of the mature phase is also of no consequence since, the equation explains the growth pattern only after the fish has reached 9 months of age.

Discussion

Pradhan (1956) after analysing the length-frequency distribution of mackerel at Karwar concluded that the average length of the one-year-olds is 10 cm. Later, Sekharan (1958) examined the length-frequency data collected from Malpe and West Hill and his conclusion was that the mackerel reaches a size of 12-15 cm by the end of first year. This conclusion was later supported by Rao, et al (1965), and Rao (1964). Seshappa (1958 and 1970) by studying the growth rings on scales fixed the age of mackerel to be one year when reaching a size of 12 to 16 cm. These conclusions were arrived at on certain assumptions. Pradhan (1956) based his conclusions on the assumption that the spawning season of mackerel lasts from June to September and hence, the juvenile mackerel ranging between 6 and 11 cm recorded during July to September are presumably the offsprings of fish which spawned in the previous year. Sekharan's (1958) contention was that the spawning activity of mackerel is at its maximum

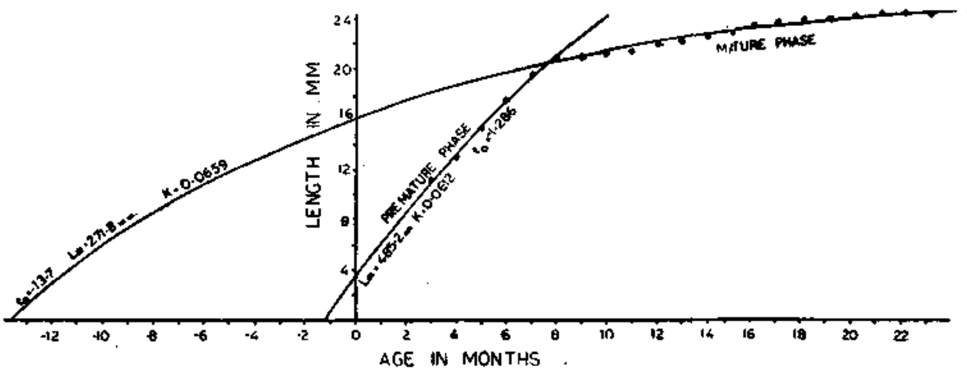

FIG. 5. Growth curves calculated for premature phase and mature phase separately and the observed values.

during the south-west monsoon period or sometime prior to it. So, the mackerel varying in size from 12 to 14 cm occuring in July are one-year-olds Many workers have subsequently followed this method in fixing the age of mackerel. Conclusions made by Yohannan (MS) earlier on the growth of mackerel were also influenced by this line of thinking. Hence, an examination of the data presented by these authors seemed to be pertinent here.

Fig. 6 shows the shifting of the mode B of Sekharan (1958) at 12 cm in July 1935 to 23 cm in Aug-Sept, 1936. The figures shows a monthly growth rate of 2.7 cm from July to October. Acepting his conclusion that the mode at 12 cm in July represent one-year-old fish will mean that the growth rate prior to this was only 1 cm per month. But, as per the general presumption that the growth-rate will be higher during the earlier part of the life history ws can expect a growth rate of more than 2.7 cm per month prior to July. He himself has recorded a mode at 6 cm in June, 1940. The mode at 12 cm in the figure is traced back to 6 cm in June. The line looks quite normal. In the same manner the modes given by Pradhan (1956) for the seasons 1949-'50 are also traced which also shows more or less the same pattern and the figure indicates they are products of spawning in April or May. By next May the modes are seen at 21 or 22 cm which indicates that they are one-year-olds. Silas (1974) has collected prolarval and postlarval stages of mackerel from along the west coast of India in May, 1964, indicating spawning in the same month or a little prior to it. Balakrishnan (1957) has collected young mackerel in length range of 27 to 50 cm from Vizhinjam in March, 1955. These may be the products of spawning in February or March. The present data include off-springs of spawning from April to July.

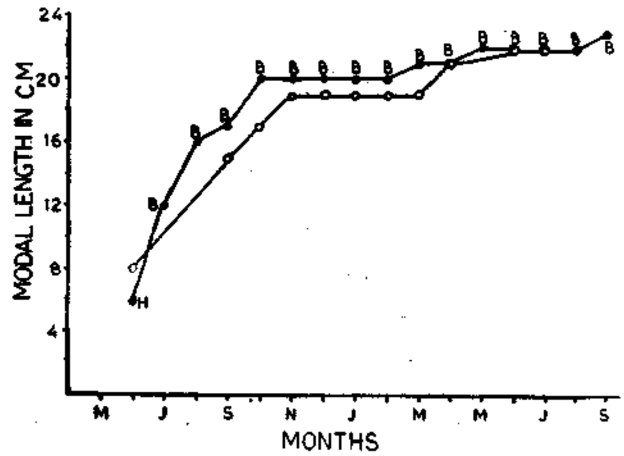

FIG. 6. Diagrammatic representation of the data presented by Sekharan, 1958 (closed circles) and Pradhan, 1956 (open circles).

The growth pattern of Indian mackerel resembles that of the anchoveta, *Centengraulis mysticetus* in the gulf of Panama. The drastic retardation of growth after four or five months of hatching, which corresponds to the time that the gonads mature and reproduction takes places, in this species, is strikingly similar to that of the mackerel. Consequently, the difficulties faced while fitting the von Bertalanffy growth curve in mackerel is encountered in this species also. While Bayliff (1957) has observed a growth of 172 mm in 39 months in this species the $L\infty$ values given by him for different periods were 149.5 mm and 169.8 mm. Howard and Landa (1958) observed that "Evidently, the growth of the anchoveta is too rapid during the early months of its life in relation to that in succeeding months to be able to represent its curve by the Walford transformation." The points plotted in Fig. 1 in the months from December to March fall on a plateu. This may be due to the utilisation of more food resources for the maturation of gonads than on linear growth (Qasim and Bhatt 1966). This may result in the formation of a ring in the scales. Seshappa (1969) has observed a ring in the scales of small percentage of sepcimens in 21-22.9 cm group, while a large percentage among those above 23 cm total length showed the rings. However, a detailed study of the physiological changes during maturation, the dynamics of its food and feeding habits, shoaling behaviour and migration only will give conclusive evidence to its cause.

The phenomenon of growth compensation — the tendency for small fish to grow more rapidly than the larger fish of the same age group as the group gets older — is observed in mackerel. The difference of about 6 cm in length observed between the smallest and the largest fish during August-September is reduced to about 2 cm by February-March. From Fig. 1 it can be seen that the later broods grow faster than the earlier broods.

The present observation support the view expressed by George and Banerji (1964) that the mackerel grows to 22 cm by the end of first year. But, the growth parameters calculated by them do not seem to explain the growth pattern well. The $L\infty$ given by them for different regions fall between 21.77 cm and 23.26 cm, when they themselves have observed that the fish may, probably, attain about 24 cm at the end of second year. A growth curve drawn from the parameters given by Rao et al (1965) will be more or less similar to the growth curve drawn in Fig. 5 for mature phase because they depended mostly on the maturing fish for their calculation. They did not take into consideration the phase of rapid growth before the maturation started which led to the conclusion that mackerel grows to only 15 cm by the end of first year.

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